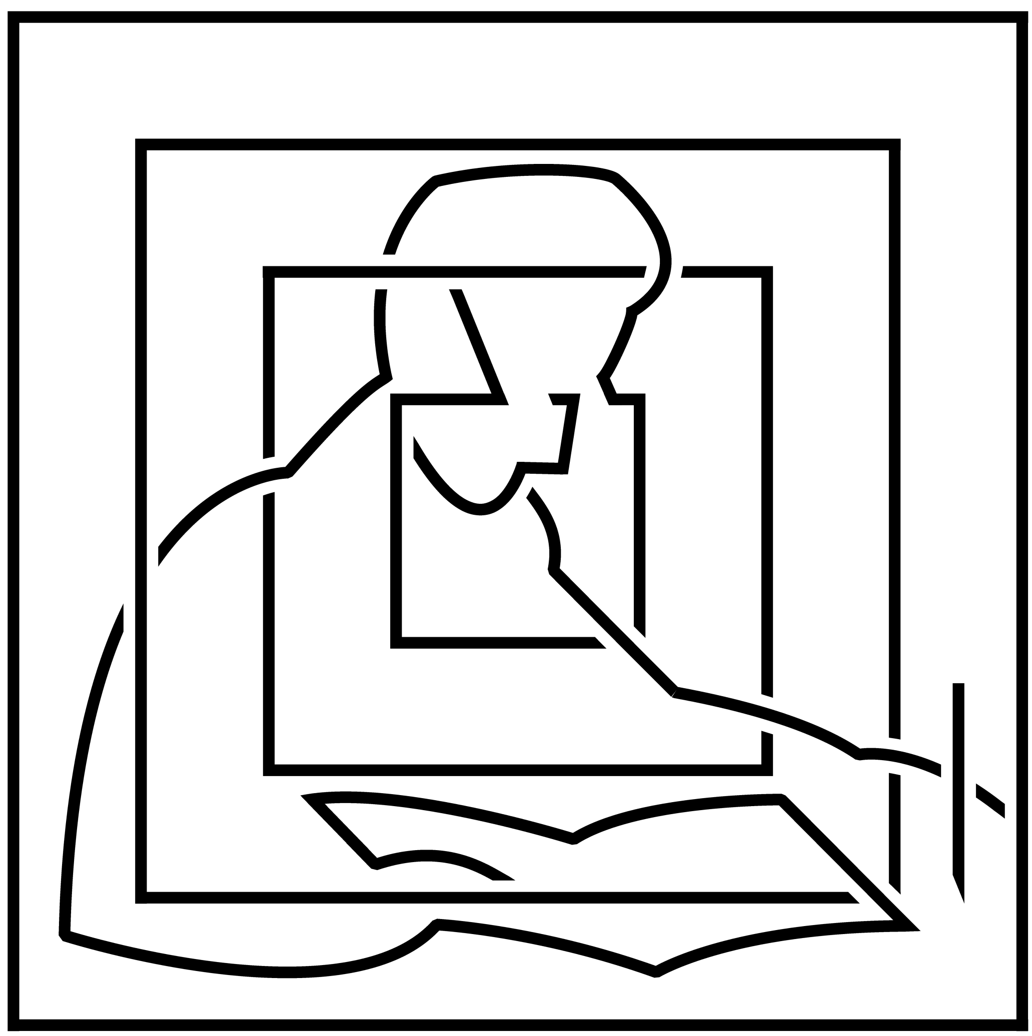
WAYS

TO STUDY AND RESEARCH



URBAN, ARCHITECTURAL AND TECHNICAL DESIGN

EDITED BY T.M. DE JONG AND D.J.M. VAN DER VOORDT

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DUP SCIENCE / 2002

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Book production and design: J. Boeijenga

Cover and frontispiece design: J.L.H. Breen
Inspired by the painting *Le baron Francis Delbeke*, by Jules Schmalzigaug (1917)

Published and distributed by: *DUP Science*

DUP Science is an imprint of
Delft University Press
P.O. Box 98
2600 MG Delft
The Netherlands
Telephone: +31 15 27 85 678
Telefax: +31 15 27 85 706
E-mail: Info@Library.TUDelft.NL

ISBN 90-407-2332-X

Printed in The Netherlands by: A-B Druk

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PREFACE

Within the range of a technical university the object of design – in terms of (urban) architecture and technique – is the design subject that is amongst all others most sensitive to context. The programme of requirements is not only derived from an economical and technical context, but also from contexts hailing from political, cultural, ecological en spatial considerations; on many levels of scale.

This applies as well for the effects not foreseen in the programme of requirements for a soil-bound object with the longevity of a building or a neighbourhood. The survey in this wide context of the effects of the built environment requires long-term perspectives envisaged on all these domains, from where boundary conditions may be read for forecasting effects; with, or without, a method; for within one perspective the effects of the built environment might work out much differently than in another.

It may be expected from a built environment that it was designed in such a way, that it may function in several perspectives without too many negative effects. This aspect of an architectural design is termed 'robustness'. It does entail much more than flexibility and adaptability: it encompasses multi-functionality and diversity as well, and freedom for users and exploiters to come to choices. The principal of an architectural object does not usually require a predictable, average solution; but rather one matching the identity of the principal and the unique potential of the location. This implies that the architectural designer should not only display a many-faceted sensitivity to context, but also great creativity, and a will to explore ever again new ways. This is the technical-scientific challenge to the architectural engineer.

For getting one's bearings in all these contexts, while providing at the same time spatially integrating proposals, one single, unequivocal scientific method is not available. During the innovation of education of the early nineties this question was put to the first Committee of Methodology of the Faculty of Architecture which methods would be essential in this respect. Opinions diverged.

On one side of the argument, Priemus advocated the idea, formulated in Chapter 26 of the present book, that the classical empirical-scientific method and its expansion into system theory would be sufficient for the scientifically trained architectural engineer. On the other side, Tzonis mentioned his opinion that there were as many as two hundred methods, all of them could be ranked as 'scientific'; each of them at times needed to be applied to location-bound challenges and tasks. The Committee agreed to a preliminary recommendation to work out further eight categories of methods for education and study. This mixed application of methods was sorted out, during the following ten years, in order to come, for the benefit of many years in the future, to a rather more conscious synthesis.

A second Committee of Methodology has been working, since the turn of the millennium, on methodological matters. Your reading eyes are focusing on its results. This methodological book has been divided into the eight previously distinguished sections of scholarly methods, each of them addressed individually by different authors of the same Faculty along individual lines:

A.: Naming and describing
B.: Design research and typology
C.: Evaluating study
D.: Modelling

E.: Programming and optimising study
F.: Technical Study
G.: Design study
H.: Study by design

Design study is the daily practice of design studios not designing exclusively on the basis of intuition. They tend to document their design decisions, in order to be able to evaluate the design process afterwards because of a sense of responsibility. Study by design is the ultimate challenge, ever-changing boundaries and one to be expected anywhere, at any design institution. However, by definition, it entails that one must reach beyond the known scientific domain and methods, at the risk of being considered unscientific. However, if that risk is not taken, no ways are to be found into an unknown territory .

How does this architectural challenge and task relate to other Faculties of a Technical University? The context within which a designed product must function is always the source of its programme of requirements; and at the same time, the victim of its unintended effects. For the programme of requirements of most technical products the context of financial economics is central. It reaches from global forces on markets via efficiencies and effectiveness on the personal level to economical use of materials; on a smaller level still within the object to be designed.

This cultural context also impinges more greatly upon other technical products than architectural ones in terms of social acceptance and implementation. A product may fail, even if it has got a market for itself.

Designing personal goods must allow for a different cultural context than the design of capital goods that should be accepted in various entrepreneurial and governmental cultures.

To designers of components the technical context is particularly important. Within each technical discipline they are beholden to agreements about dimensions, inter-connections and to performance requirements within the design as a whole. Usually the technical context of relatively small complete products may be adapted by way of an interface or housing to be fitted locally. In this sense, the built environment is the final layer; the site may be adapted in one way or another, but the climate is a global, ecological, context beyond the influence of the designer; as is the social climate in its many perspectives, or scarcity of space.

In all technical sciences, therefore, also in architecture, these contexts may be recognised; but in building & architecture they seem to attain maximal extension and significance. Restriction to the site, scale and longevity of the object of design is playing a rôle. The (urban) architectural object as a whole can not look for a free market, unlike a mobile product. It functions, by itself, as a context for human activity and the industrial products connected to it. By the same token the architectural object does not only feature external, but also internal political, cultural, economical, technical, ecological and spatial contexts. They are the ones determining the programme of requirements; they will undergo the future, long enduring effects – both intended and un-intended – of the object designed. Any imaginable effect will, sooner or later, strike a local human chord. Then it may be understood that architectural objects do enjoy, nowadays, social visibility. A great many local interests are coming to the fore in order to contribute to the design process or delegate interest to the government level concerned.

Therefore, this wide and multi-faceted context is playing a much grander rôle in the design process of those who are building, than in the solution of those who are facing problems as there are (air)-conditioning, separating, joining and carrying. Since the three millennia preceding us, solutions do already exist; but we may vary them. By the way: the architectural engineer, in all this, is showing his might: repeating existing solutions does not equal the kernel of the task that is a design.

The number of architectural solutions and possibilities of usage within classical contexts is larger than the number of atoms in the universe. If the 'Windows' icon with its 16 x 16 pixels of 256 colours is equalling all 256 * 256 possibilities of use for design, the designer of a 3-dimensional location with 300 possible building materials is finding himself in a multiple universe of possibilities. Only partially technical specification directs the numberless design decisions; in as many uncertain contexts facing the architectural designer.

The explosion in terms and numbers of combinations as offered by the scale of a building or a neighbourhood and the differentiating character of their commissions does establish a scientific challenge; this book provides elements to meet it. In addition, it supplies its readers with perspectives on innovating architectural thought. However, the prime importance and achievement of this book is that the scientific debt of a mix of methods honed to one single location needed for this task have been eased and facilitated. Methodological components are accessible and may be pointed out.

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1 INTRODUCTION

TAEKE DE JONG
THEO VAN DER VOORDT

This methodological book describes eight forms of study as they relate to design:

- Naming and describing;
- Design research and typology;
- Evaluating;
- Modelling;
- Programming and optimising;
- Technical study;
- Design study;
- Study by design.

These eight sections are the spine of the work. Its compartmentalisation is based on the work of two Methodology Committees of the Faculty of Architecture at the Technical University of Delft (in 1990 and in 2000 AD) and establishes, in this sense, the list of the methodological end-terms of the education. The sequencing of the sections and the chapters within them is showing a certain space for conditioning. Design research, for instance, is impossible without a description of the designs to be studied; in its turn describing study pre-supposes that the components and concepts in these designs can be named and retrieved (naming).

1.1 OBJECTIVE

The book contains suggestions for making project and study proposals as well as for the scientific design and study work itself. That will always be an inter-play of several methods, systematically explained here. The possibility to refer to this book makes the methodical founding of new study projects operational, transparent and accessible. The book addresses scholars, teachers and students. The scientific ambition and the comments on these forms of design related study have been worded additionally in the following Chapter ‘Criteria for Scientific Study and Design’ (see page 15).

Each of the eight sections comprises several Chapters, written by some fifty authors of one and the same Faculty in a vocabulary and idiom that is already, for that reason, a common one to a certain degree. A cluster of Chapters is always preceded by an introduction to the section as a whole. These introductions establish together a systematic survey which is not repeated in the present introduction. The reader may start with it and get an idea of the multi-faceted content while leafing through. The book may be considered as a systematically structured encyclopaedia for design related study on the field of architectural, urban and technical design.

Next to this systematic approach the book attains a kind of completeness with some six hundred references to literature on the subject. An effort was made to highlight contradictory and complementary views on design and study in this domain and their contrasts. It is precisely by this that one totality emerges. It is difficult to give, within one book, the floor to people who consider themselves to be in conflict with others. Usually different opinions are published in separate books.

Although two potential authors refused co-operation on these grounds, the power of the book is that it is giving access to different opinions. However, that aspect also created a size that may be rather daunting at first sight. For that reason a lot of attention was given to ease of access and use. By way of cross-references authors are pointing to one another and readers may investigate different opinions or perspectives on the same subject. The book is equipped with some five hundred illustrations, most of them especially drawn, facilitating searching by paging through.

The table of contents of the book as a whole, its detailing at the start of each section and at the start of each Chapter provide a detailed systematic gate of access. The Index (page 531) is an unusually extensive, alphabetical entry to some 10.000 names and terms referring to the first or most important page where the key-word is explained or mentioned in a context relevant to its significance. This Index is not restricted to names and nouns. Adjectives and verbs in various guises have been admitted as well; even parts of sentences. For the technical sciences of designing and making especially, verbs cannot be avoided. This Index provides the book with a source facilitating the methodology and terminology of the empirical and designing study itself as an object of study and debate: 'What does 'typology' mean, according to Leupen, to Van Duin, to Breen?' However, first of all it is functioning as a vocabulary for the first objective of the present book: the facilitating of working scientifically and of co-operating.

Scientific study is facing the task to unmask tacit pre-suppositions in order to make deliberate choices or to lift the blockade of designing. In its turn, it is the scientific task of designing to create from there new possibilities and conceptual spaces; and to initiate therewith renewed study. If this book contributes to broadening the horizon of the true 'Universitas', its second objective has been reached.

This provides the link to its third and final objective: facilitating such a productive cycle between studying and designing: study by design. How are we getting, at the same time, the components as well as the composition as a whole in motion, the objects as well as their context, the means as well as the objective? With this we are not throwing light on one or both, but on their relation. If we just vary the context in order to generalise types that may be employed anywhere (typological research), we are not making as yet a design that can be realised, although the type itself may be the object of study. If we are varying just the object in order to generate the right fit in a given context (design study), we only find incidental solutions, although we may document, analyse and generalise them (design research). If we continue to limp on both thoughts, we are on our way, but not yet at our destination. Also with this book that destination has not yet been attained, but the ingredients are ready. 'Anchors aweigh': there is a chart and there is a rudder.

1.2 PROBLEM

As a whole the book embodies a classical empirical problem formulation: a hypothesis; and it facilitates the oldest method to operate at the frontiers of science: fair debate. They are addressed in the following.

If design is left to creative powers and does not need to comply with scientific criteria, each and every university design education lacks its right to exist. The Faculty's Methodology Committee and the editors of this book state as a central hypothesis, that a form of scientifically based designing exists, transferable to education and not exclusively based on empirical or logical knowledge. It is the duty of technical universities to lay the foundations for this. If they do not appear to be able to do this, the assumption that design courses are not at home in the university is as justifiable as the certitude that they do belong there.

The implicit question is: Are the current logical-empirical methods and research techniques generally accepted everywhere in the university world, satisfactory for study by design, the production of a design or design variants and the studying of the effects? Priemus answers this question in this book in the affirmative (see page 249) and offers a null-hypothesis:

'For many decades a generally accepted research methodology, for behavioural sciences and for technical sciences has been in existence, which has been taught in scientific education faculties and institutions for many decades. In all those educational programmes the letters M&T form a permanent part of the foundation courses; research methods and techniques are part of the standard equipment of every student, and certainly of every graduate.

The Architecture Faculty of the TU Delft, in the year 2000, is pursuing a personal methodology for architecture, in other words: its very own design methodology. Up until now this did not take place using knowledge of and reference to the classic research methodology from other faculties, nor jointly with faculties in other countries where architecture is also being taught and design skills are adopted, nor jointly with other TUD- (sub) faculties where construction (CiTG) and/or designing (IO) is central, nor even jointly with their sister- Architecture Faculty of the TUE.

Is this sensible? No. Is this effective? No. Are there good reasons for such a self-containing eccentric approach? No.'

The international character of the Faculty from which this book originates belies the isolationism suggested by Priemus. However, the dividing line is genuine and international. It runs straight through the Faculties, albeit with extensive boundaries. Therefore, there is sufficient reason to study primarily its polarity in that diverse tension area. The criticism that the world of designers takes no interest in accepted scientific business is being taken seriously here.

Equal amounts of attention are paid to the empirical-scientific methods, of importance for architectural designing, and to authors firmly convinced that these methods are insufficient to learn designing. Some people even think that such methods can impede the design thought and that, maybe, new scientific opportunities can, and must, be developed. The onus lies with them to prove this. However, in order to do this, they must be able to understand empiricists and their methods. The antithesis is required in order to be conclusive. This is a purpose of this book. Methodology means understanding and valuing each other's methods. New scientific possibilities do not necessarily contradict empirical research; they can also be complementary, or place empirical research in a broader context.

1.3 FAIR DEBATE

Fair debate is founded on a division of responsibilities between *proponent* and *opponent*. This division prevents a case where two propositions are substantiated in turn without any empathising with, and intervention into, the other person's proposition. This substantiation may seem like an attack on the other proposition, but, in essence, it is not (consider the 'talking at cross-purposes' we see in our television debates). The division of tasks between proponent and opponent has two important hygienic consequences: the proponent is not identified with the proposition that he is defending, and the opponent steeps himself in the other's proposition. Thus the process becomes a mutual investigation into the question whether this proposition is 'defensible'. If the proponent loses the debate, he is not considered a suspect; he simply participated in an investigation.

Counter-examples

Thus, the above is the first pre-condition of fair debate. The technique is also based on a sequence of steps that should not be deviated from. The first is that the proponent explains his proposition. Experience teaches that the most foolish thing the opponent can do at this point is attack immediately, since there is not yet any communal foundation for dismissing this proposition. This opponent has to elicit this communal foundation.

His first question towards this end should be: "Do you mean, by this proposition, that…?", often based on counter-examples. With questions like these, he establishes that proponent and opponent are talking about the same thing. If the opponent presents the most extreme and implausible interpretation of this proposition in the opening question, it is wise to give the proponent the opportunity to *specify* his proposition through denial ("No, that's not what I mean" – "Then what do you mean?").

Rebuttal

After specifying the proposition, which may involve various steps, it is again foolish for the opponent to open his attack immediately, since only a part of the communal foundation has been established at this point. Thus the second kind of question for the opponent is: “Do you agree with me that…?” This usually involves a more general proposition from which, on the basis of a particular postulation, a possibly implausible conclusion can be derived. This phase may also involve various steps, whereby the proponent can make the reservation that he agrees just for the duration of this part of the debate.

Tenability of a proposition

Only after a communal foundation has been laid this way should the opponent open his attack by demonstrating a contradiction between the proposition (or an implausible derivation from it) and that which has been agreed upon. If he manages this, he should give the proponent the opportunity to return to his reservation. If he does this, the proponent must look for another communal foundation. If he does not, the opponent must give him one more chance: “Was the specified proposition actually what you meant?” If the proponent says “yes”, he has lost, or rather the debate has demonstrated that this proposition is not defensible. If he says “no”, the proponent must switch to a new specification so that the debate can be repeated from that point onwards. This may result in a formulation that is indeed defensible. In this case, everyone has the feeling that this debate helped science, technology or politics to take a step forward.

Science entails translating reality into transferable thought, while design and technology is translating thoughts into reality. This book concerns the possibility of these human projects in urban, architectural and related technical design. Dijkhuis’ contribution addresses the possibilities and pitfalls of translation as such.

2 LANGUAGES
FOREWORD BY THE TRANSLATOR

WILLEM DIJKHUIS

This book is the result of a concentrated effort to harness knowledge, insight, expertise, lore and (sometimes, perhaps) the wisdom of some four dozen professional Europeans on the topic of design & study in architecture for the benefit of a truly international audience. None of the contributions was written in English by a native English speaker, although every single author is steeped in reading it: the text is a translation into that most peculiar language: English.

The Dutch translator of this book, who is not a native speaker of English, was asked to translate and edit in terms of language the heterogeneous mass of Dutch sources (design, technology, science, humanities and social sciences) as precisely as possible into a uniform English; whilst using the same words consistently for the same meanings to enhance retrieving from the index. In this way the text should become readable and comprehensible for non-native speakers and users in scientific practice. It should create a common language to different scientists from the same school.

The translator insisted of course, being a non-native speaker himself, that his toil should be reviewed extensively and carefully by a native speaker of English, qualified to perform that vital function. David Baynton, a retired British Headmaster and a native of Kent, England, played that rôle with precision and prudence. In that way the text was cleansed from mistakes and inconsistencies in English usage, grammar and idiom; approximating better a *Lingua Franca* for an international audience.

2.1 LINGUA FRANCA

Above the gate allowing entrance to Plato's place in the country, '*Academia*', where he taught pupils, a motto was chiselled into the stone lintel, reading: '*Without Mathematics let no one pass*'.

Similarly, above the gate allowing entrance to understanding foreign communities, a hundred human generations later, a motto may be chiselled into a digital lintel, reading: '*Without English let no one pass*'. That language is deemed to be the '*Lingua Franca*' of the third millennium of the era. Before the Second World War, in a smaller world, German provided that communicative function from the time of the Romantic Movement.

'*Lingua Franca*' – literally 'a free tongue' – hails from the Latin. After the decline and fall of the Roman Empire and the so-called 'Dark Ages' a scholarly, artificial Latin emerged. One millennium ago, thorough academic learning could not be attained in Europe without the Latin tongue; in both languages: that of the ear, speaking, and that of the hand, writing.

The Latin of Vitruvius, secular Patron of Architecture, but also of Cicero and Virgil had ceased to be the mother tongue for anyone. No one using Latin in order to come to grips with his peers in the sub-continent could use the language as 'native speaker', since it was nobody's mother tongue. The academic '*lingua franca*' of places of learning in olden days was perfectly egalitarian, not discriminating between peoples, regions and nations. Any two 'students' or 'scholars' – the indications being roughly equivalent at that time – say, one from Cracow, the other from Oxford - capable of understanding one another using Latin, had acquired that facility by formal education; by studying and imitating schoolmasters rather than their mothers.

In this respect the Latin of the start of the second millennium differs profoundly from the English of the start of the third; regardless of the immense value of having access to that language in writing and speaking. Native speakers of the English language presently enjoy - and will for the foreseeable future – unique intellectual, political and cultural advantages.

Some observations by way of introducing the present book are necessary. The famous Dutch physicist Prof. Dr. Hendrik Casimir – for decades Director of the equally famous Physical Laboratory of the Philips Company –in 1965 delivered a speech at a formal dinner of the International Institute of Electrical Engineers. It was entitled '*When does jam become marmalade?*'.[a] The non-native speaker of English reflected, in English, on the problem of the two cultures, the one of the sciences and the other, of the humanities, "*so eloquently formulated by C.P. Snow*". Casimir's after dinner talk is as witty as it is illuminating.

Reflecting on the fastidiousness with which Britons reflect on fine distinctions between 'jam' and 'marmalade', – the Dutch consider 'marmalade' a sub-species of 'jam', whilst that other breed of men at the other side of the North Sea entertain different views – the physicist and scholar offered considerations on "*the amazing richness of the language which tempts the English to make distinctions where others look for general concept. Now I should like to suggest that the so-called difference between the two cultures is largely a case of jam and marmalade. There exists in Dutch, in German and in the Scandinavian languages a word* Wetenschappen, Wissenschaften, Videnskaber *that includes all branches of learning. In English* 'science' *usually refers to the natural sciences only. […] We Dutchmen will emphasise the common elements in all* 'wetenschappen'*: the collection and systematic arrangement of data, the search for general principles and for relations between initially unrelated subjects, the willingness to dedicate one's efforts to the pursuit of knowledge and so on. A scholar and an natural scientist are both* 'wetenschappelijk' *because they accept similar criteria, have in many ways a similar attitude.*"

Since, in our western tradition the roots of designing architecture are not only embedded in the soil of the natural sciences and physical crafts, but also in the humanities and social sciences, the observations of Casimir establish a perfect context for the origin of the present book: in the Faculty of Architecture of a Technical University in the Netherlands.

Casimir's wit has been a beacon while translating and editing the original Dutch texts of contributions to this book into British English. Of all the world's languages, that language, a great borrower from all languages: Celtic, Norse, Saxon, Norman French, Latin, Greek and Dutch; features the largest vocabulary by far of any language. Still, the single Dutch word '*doel*' has a wealth of almost equivalent words in English, well schematised in the contribution by Priemus and de Jong in Chapter 27.

The richness of (almost) verbal equivalence in English – a richness of its own – is perhaps best surveyed by the life-work of Peter Mark Roget (London, 1779 – West Malvern, 1869): his *Thesaurus of English Words and Phrases* (1852) is a comprehensive classification of synonyms and verbal equivalents. Roget was a physician as well as a philologist. His book was the harvest of his retirement as an active medical practitioner, although his system of classification dates back to 1805. Roget's Thesaurus has been kept up-to-date and was expanded since its first edition by publishers on both sides of the Atlantic in a concerted spirit along the lines of lexicographical diversity.

The lemma 'Enquiry', number 459 in a modern edition, occupies two large pages printed in small type; one following it, 'Knowledge', number 490, in the same chapter, entitled 'Intellect: the exercise of the mind', needs the same generous amount of typographical space. It stands to reason that both lemmas are main ones in a scholarly work on studying design and designing study in architecture. Reading those pages at leisure is an experience that should overwhelm those who are trying to translate the written results of pondering in a foreign tongue into English.

This enormous vocabulary is made operational, after '*1066 and all that*', by way of one of the sketchiest of grammars, in a vast semantic cloud of idiom, allusions and associations. Many languages have contributed essential elements to the present structure and content of English and its expressive potential. This uniqueness presented both peculiar prob-

[a] Weber, R. L. and E. Mendoza (1977) *A random walk in science: an anthology*. p. 1-3.

lems and promising opportunities during the translation and evolution of the manuscripts leading to the present volume.

2.2 STUDY AND DESIGN

By way of example, take the English word 'study'. It may be a noun, indicating a room in a building equipped for a specific activity; or the activity itself. Or, it may be a verb, used in a wealth of (in)dependencies given its syntactical context. Then there is, for instance, the rather new-fangled, rather American noun 'research', nowadays seldom understood in its most literal sense 're-search': to search again. Following the Second World War the American term 'research' should be considered to be one of that nation's most successful and crucial conceptual exports.

George Bernhard Shaw termed the United Kingdom and the United States three generations ago two nations separated by the same language. That chasm may have become rather less wide by now, but there is no doubt that it is still dominating the international landscape of scholarship, sciences, and technologies. Both branches of the same trunk share the property that the conceptual distance between substantial and verbal use of one and the same word is very often subtle, sometimes slight.

For the word 'design' much the same applies. Noun and verb mirror one another. While 'study' derives via Norman French from classical Latin, 'design', historically of a much more recent vintage, entered the English language from the Florentine language of the Renaissance '*disegno*'. The word will not be found in the big bang of Western architecture, Vitruvius' Ten Books. Coined in the environment of Giorgio Vasari, it was understood to be the umbrella sheltering the tripod - painting-sculpture-architecture. It came to share quite readily the vigour and flexibility of English words in the wide compass between adjectives and nouns. All things considered it is remarkable that meaningful questions exist in the language such as: "What are you doing?", to be answered by "I am designing"; or "What are you bringing to this project?" by "Just designing".

It should be added, that in the life and times of Dutch founding fathers of modern architecture like H.P. Berlage, J.J.P. Oud and their little band of peers, the word 'design' could not be found – as yet - in contemporary Dutch dictionaries. Their work, and reflection on it, employed the term '*ontwerp(en)*' and that endemic linguistic network is still alive and kicking, next to the successful import form the Anglophone world: 'design(ing)'.

The present contribution by no means attempts to survey exhaustively all the difficulties a translator faces in providing an English equivalent for a Dutch text on Study and Design. However, still one more example should be mentioned. At the end of the Middle Ages, the English verb 'to ken' went out of common usage. For a long time it had complemented another verb, 'to know'. A verbal pair like that, with the same implications, was demonstrated – and still is - in most languages spoken on the Continent: Dutch '*kennen*' – '*weten*'; German '*kennen*' – '*wissen*'; French '*connaître*'- '*savoir*'; Spanish '*connocer*'-'*saber*'; and so forth. The distinction between the two is eminently meaningful and useful. Today, the English verb 'to know' is facing the awesome task of serving two fundamentally differing meanings.

2.3 CONTEXT

Seen particularly from the perspective of the study of architecture the linguistic panorama is vast. In the Victorian era, English words like 'learning', 'scholarship' or 'professional' entailed meanings not co-inciding with their meanings more than a century later. Meaning can never be associated with timelessness: a letter is nothing without a word, a word is nothing without a text; and a text is nothing without a context. The text of the present book tries to follow British English usage; also in its most modest and concrete aspect, spelling. However, its intellectual, conceptual and academic context and tradition hails most decidedly from the European mainland.

These observations are not meant to be an excuse or apology for its possible lack, now and again, of easy-going parlance that could be addressed to any sixteen-year old native speaker of English anywhere. In addition, equalling, or even surpassing masters of great and elegant prose ranked low on the list of objectives at which the authors were aiming.

Just as the subject of this co-operatively created work endeavours to investigate and chart in a new way, as clearly as possible, the confines of thinking about, and working with, the meaning of designs and designing to architecture and architects, the language by which this subject is addressed explores occasionally a new semantic domain, sometimes beyond common usage of terms. It is not just because of academic idiosyncrasy, quirk or whim that the contributors and editors owe to the essence of architecture, as it encompasses arts, sciences, humanities and social studies: intellectual and professional life itself.

3 CRITERIA FOR SCIENTIFIC STUDY AND DESIGN

TAEKE DE JONG
THEO VAN DER VOORDT

Could a design be the product of scientific work to be compared with a scientific report? If so, under which conditions and when? The topic is eagerly discussed both within and outside of faculties of architecture. On the web-site of the Design Research Society (DRS) there is a lively debate on what a design study and a study by design really are and when a designer can also be designated a scientist. These questions stood central during the 1996 EAAE Congress organised by the Delft Faculty of Architecture on the theme 'Doctorates in Design + Architecture'.[a] In order to answer these questions we discuss first the terms 'research' and 'study' and the usual pre-requisites that must be met for study to be designated 'scientific'. Next, similarities and differences between designing and studying are dealt with. Following that, we discuss the usual way in the scientific community of looking at the criteria for a design to be branded as a product of scientific study. For that purpose a summary is given of the requirements the Technical University in Delft associates with a the rôle it played during the initiative leading to this handbook of design related study. Finally we give a specimen of criteria for evaluation of a scientific architectural design (ex post) and of a proposal for a design related study (ex ante).

3.1 STUDY AND RESEARCH

Study is a collective term for generating knowledge by thoroughly thinking through a problem, carrying out experiments and collecting, processing and analysing data. When the primary purpose of a study is to know more, it is termed a fundamental study. When a study is mainly focused on practical usefulness – e. g. making better buildings, or contributing to more effective and efficient building processes – one speaks of an 'applied' study. If a study is mainly aiming at making a new product – a prototype of a (industrial) product, a constructive solution or a building method – it is termed (product)development.

In a sense, each and every one of us deals one time or another with study. Even the student studying Ernst Neufert's *'Architect's Data'* to ascertain how large a class-room should be, busies himself with study. In that case searching, re-searching and retrieving come to the fore.[b] For a study, generating new knowledge is typical. The contrasts are not always well-defined. Just looking up something may develop into a lot of retrieving and you might find yourself in a genuine study.

In scholarly circles the term 'research' is often employed, rather than the concept 'study'. Designers also use both terms; e. g. the 'Design Research Society', and its 'Design Research Newsletter', the 'Journal of Design Research' and the magazine 'Design Studies'. Another term is 'inquiry', as in the title of John Zeisel's book 'Inquiry by Design'.[c] Related terms are 'survey', 'investigation' and 'examination'. This book is trying to conform itself to the British English distinction between study and research. Research is roughly the empirical form of study. The term 'research' originated some hundred years ago and is used a synonym for the older term 'study', especially in the USA. Britons tend to employ the term 'study' for looking for something that does not exist as yet, in a broad sense: such as for subjects from non-empirical branches of logic and mathematics, but also for studies of Rembrandt, designers and students.

3.2 DESIGN RELATED STUDY

A design does not follow unequivocally and reproductably from a programme like a scientific prediction repeatable from its basic assumptions, *'ceteris paribus'*. In making a design, the preliminary investigation and its conclusion, the programme of requirements, direct the solution only partly. Even within the boundaries of a strict programme, unexpected and un-

a The European Association for Architectural Education (EAAE) is an international organisation of European educational institutes in the field of architecture. Its aim is exchange of ideas and results related to architectural education and study. For the benefit of the EAAE conference on Doctorates in Design + Architecture a conference book ('Book of Abstracts') has been published. The proceedings comprise two volumes, edited by Theo van der Voordt and Herman van Wegen: Voordt, D.J.M. van der and H.B.R. van Wegen (1996) *State of the Art, Proceedings of the Doctorates in Design and Architecture conference, vol. 1;* Voordt, D.J.M. van der and H.B.R. van Wegen (1996) *Results and Reflections, Proceedings of the Doctorates in Design and Architecture conference, vol. 2.*
b Kuypers, G. (1984) *ABC van een onderzoeksopzet; 2e dr.*
c Zeisel, J. (1985) *Inquiry by design: tools for environment-behavior research.*

predictable alternatives are possible in design. Most design decisions about form, subsequent structure (set of necessary connections and separations to keep the form) and even subsequent function (freedom of unexpected use) must be made without empirical evidence. This is most explicit in building design. The choice of a final alternative is determined by the total context of the object to be designed. The programme of requirements reflects only a small part of that context. Location, market and designer (context of invention) belong to the broader present and future managerial, cultural, economical, technical, ecological, and mass-space-time context and perspective of the object. ‘Context’ is different on different levels of scale and cannot be foreseen completely in the programme.

The number of imaginable alternatives for buildings, mostly with a long term multi-functional programme of (conflicting) demands, is unconceivably large, subject to a combinatoric explosion (see page 208) of possible forms. Buildings and urban designs have a long period of use and are earthbound. So they have to function in a changing context that is unpredictable and not influenced by the programming authority, designer or user. From the viewpoint of durability they should be able to accommodate varying programmes and the daily changing aims of inhabitants and users. This quality of building design is called ‘robustness’. ‘Flexibility’ is only part of it. So, from all artefacts, buildings have the most context sensitive function for use, perception and market, not to be evaluated without that context and, therefore, hardly comparable to each other (sometimes even unique).

Even with a comparable programme of requirements, not only the diversity of solutions, but also the diversity of contexts or perspectives to function in, is very large. Consequently, the diversity of rational reasons (determined by context) to opt for a final alternative is even larger. So, building design research often has the character of an n=1 study (case study) with limited general value to other designs. Design research, based on more examples than one, is often ignored by designers, because on location many design relevant circumstances appear different from what the examined examples had in common. The principal often demands a unique design, ‘exploiting’ rare and distinctive qualities of context. The descriptive interpretation of context by researchers differs from the imaginative interpretation of designers that stresses possibilities rather than probabilities.

	OBJECT *Determined*	*Variable*
CONTEXT *Determined*	Design research	Design study
Variable	Typological research	Study by design

1 Types of design-related study

In a University of Technology, designs are made not only intuitively, but based upon study (design study) and documented, examined and evaluated (design research). Design research concerns determined objects within determined contexts. ‘Study by design’, in a broad sense, varies either the object (design study) or the context (typological research) or even both (study by design). The terms from this matrix may be explained as follows:

Design research

Design research describes and analyses existing designs with a known context, often in the form of comparative study. For that reason it is evaluating study ex post. Not only their function is involved, but also their form, structure and the way they were made, the design tools employed in each stage and the way in which they were applied: the making proper.

Typological research

Whenever the identical architectural form, structure, technique, function or concept is recognised in different contexts the notion of a ‘type’ is involved. A type only becomes a consistent model if it has been elaborated for evaluation by design in a context. A type is a design tool, not yet a model. The study of such types, their use in the making of designs (a special kind of models) is called typological research.

Design study

Making a design in a relatively well-known context of potential users, investors, available techniques, building materials, political, ecological and spatial restrictions, entails many stages of a type of study termed in this book 'design study'. If, in the case of grand projects, parts of it are sub-contracted, the parlance is 'study for the designing' or 'research driven design'.

Study by design

Characteristic for this type of study is generating knowledge and understanding by studying the effects of actively and systematically varying of both design solutions and their context.

Only if both context and object have been determined (design research ex post), pure empirical study may be largely depended upon ; although that should also be done with the eye – and sometimes the hand – of the designer. Empirical (historical) design study is sometimes calling for a design re-construction of the design or of the design process.[a]

For the other three guises of study the designing itself must play a crucial rôle, although an empirical component will remain present in the form of researching inventories, descriptions, programming or evaluating research. Also, for the broader context of these studies the designing study may be the object of design.

In the case of a type of study with a determined object or context, the typology and the design study (daily practice of the profession) a lot of experience has been attained. When both are variable (study by design), a way out may be found in inter-changing typological research and design-study. This way, now the object, then the context is varied. However, it can not be excluded that this study can also stand on its own legs without using both methods of study. The first signs are the studies of Vollers[b] and of Frieling[c]. Vollers' point of departure is the means for design as they manifested themselves in the usage of Computer Aided Design, from where possible objects and contexts for application are getting shape. Frieling's point of departure is a dynamic public weighing between projects on a small scale (objects) and perspectives on a grand scale (contexts), within the domain of coming to decisions for the Delta Metropolis. Graduation – when those who graduate are allowed to determine themselves context and object – has resulted in an archive of experiments, some more successful than others, exactly in the field of study by design.

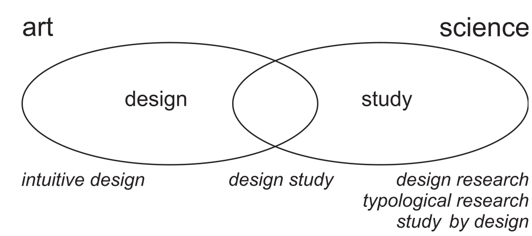
Taken together, these modes of study are termed 'design related study'. Because of the inter-action between designing and studying, the borderline between both is not always clear cut. Actually a gliding scale between art and science applies.

In figure 2 studying and designing both feature their own domain; while the two overlap. At that point one may imagine study activities without design and design without activities of study.

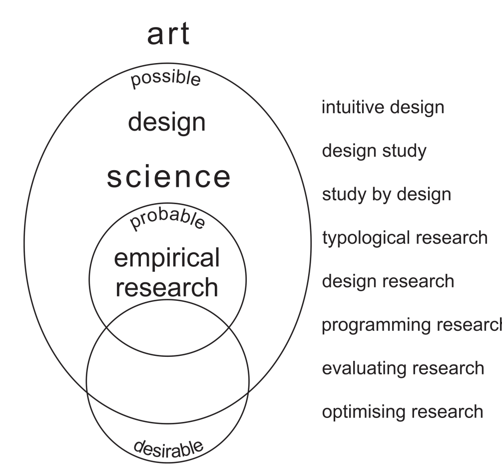
One may also maintain that all empirical study pre-supposes a designed hypothesis (possibly put to work by way of a model) and a toolbox of research, so that empirical study pre-supposes some kind of designing as well; for the model of the reality (hypothesis) to be checked against that reality and the toolbox enabling observing, checking and predicting must have been designed earlier themselves. Without these conditions study cannot be imagined. In this sense the telescope as well as several branches of mathematics have been designed for modern empirical astronomy; next they were a condition for it; and finally it pre-supposes them. In that way design is always pre-supposed in study and research.

If these pre-suppositions are forgotten one forgets as well that their reliability is always open for discussion.

Experimental empirical research can also produce unexpected possible futures, however, only because it pre-supposes the design of the experiment and its instruments. Bacon[d], cited by Kant[e] in his Preface (*Praefatio*), states that science has not to be concerned as opinion, but



2 Domains according to Van der Voordt



3 Domains according to De Jong

a Jong, T.M. de and J. Achterberg (1996) *25 plannen voor de Randstad*. This study compared twenty-five designs by re-design for one million inhabitants.
b Vollers, K. (2001) *Twist & Build, creating non-orthogonal architecture*. See also Chapter 0 in the present book.
c See Chapter 0 in the present book.
d Bacon, Francis (1620) *Instauratio magna; The Great Instauration*; (1645) *Novum organum scientiarum*.
e Kant, I. (1787) *Critik der reinen Vernunft*.

as work (*'…non Opinionem, sed Opus…'*). Elsewhere Bacon states that nature has to be forced to answer the question of the scientist. The scientist has firstly to design the experiment in order to produce improbable events in some future. Kant states in his preface that scientists before Bacon understood that human reason only recognises what it produces itself by design (*'…das die Vernunft nur das einsieht, was sie selbst nach ihrem Entwurf hervorbringt.'*).

Thomas Kuhn, who created the 'paradigm' concept, associates his description of scientific revolutions closely with making tools and instruments.[a] Van der Meer, the Dutch engineer who designed for the Geneva Cyclotron the type of improvement that caused the discovery of crucial new facts in nuclear physics, got the Nobel Prize, not for those facts, but for bringing them to light. When one regards mathematics as a tool box for working models, mathematics and models built with it are also design instruments in need of design. This happens during empirical study and is caused by it. All statistical checks came into existence this way. In its usual, more narrow sense, designing does not relate to models simulating probable futures, but possible futures; even if they are not likely. This narrower sense of 'designing' is emphasised in this book.

3.3 A DEFINITION OF SCIENCE

An important question is now: when may a study be termed 'scientific'? And especially: when is design-related study scientific? In order to answer this question, one must first define what 'scientific' entails. Although several definitions are current, over and over again a number of properties are returning in almost all definitions. This leads to the following definition:

> *"Science equals any collection of statements that features a reliable relationship to reality, a valid mutual relationship and a critical potential with regard to other statements in the same domain."*

The term 'reliable' may not only relate to 'true' and 'probable' in empirical sciences, but also to 'feasible', 'working', and, therefore, 'possible' in technical sciences. In both cases 'reliable' pre-supposes 'verifiable', 'documentable' and by the same token a public domain and accessibility of sources and methods (see page 92).

The term 'valid' (see page 92) pre-supposes the validity with which lines of reasoning may be constructed out of propositions and propositions out of statements (logic, see Chapter 23, page 189) or the completeness with which the context is taken into account in a proposal or demonstration. This last criterion is particularly important for technical sciences. Completeness not only concerns a larger, but also a smaller context of gaps filled with tacit suppositions. Incomplete knowledge is half truth: incomplete technology is failure. In empirical science the completeness may be partly covered by the '*ceteris paribus*' pre-supposition ("for so far the rest is equal"); in technical sciences this is seldom feasible. Completeness can never be reached entirely and is by the same token a relative concept, but a given proposal (like a design) may be more complete than another (like considering more contextual effects of the proposal).

The term 'critical' pre-supposes that it is possible to make a statement that refutes other (e.g. 'popular') statements and that it is also possible to refute the statement itself (see paragraph 3.4, open to criticism, able to criticise).

The term 'domain' relates to the collection of subjects from reality evoking a statement. The term 'statement' encompasses propositions about a probable reality as well as proposals for a possible reality. The term 'reality', therefore, has a wider meaning than empirical 'existing reality' (think of notions like realistic e.t.q.). The concept 'potential with regard to' is wider than the concept 'connected to'.

Many other definitions are current.[b] We choose this one in order to give technical sciences a place next to empirical sciences (here denotated by 'empiry'). Scientific study is the activity needed to arrive at scientific statements. Not all study is scientific. It is character-

a Kuhn, T.S. (1962) *The structure of scientific revolutions*. Dutch translation: Kuhn, T.S. (1972) *De structuur van wetenschappelijke revoluties*.

b See: Kroes, P.A. (1996) *Idealbeelden van wetenschap, een inleiding tot de wetenschapsfilosofie*.

istic for scientific study that its results are reliable, valid, capable and open to criticism. In the case of empirical research these criteria may be further specified.

3.4 CRITERIA FOR EMPIRICAL RESEARCH

Reliability

Empirical reliability entails that repetition of a measurement under unchanged conditions renders identical results of measurement. A 'face value' assessment of the constructive quality of a building is less reliable than measuring its physical shortcomings. 'internal reliability' is the parlance if the same investigator judges a particular situation more then once and each time comes to the same conclusion.

'External reliability' means that different investigators judge the same situation with the same results. Only if reliable instruments of measurement are used can a sufficient degree of objectivity apply.

Reliability necessitates formulation of a criterion of objectivity. Those who study, or are engaged in carrying out a particular project study, should strive to keep personal opinions from influencing the study and refrain from making personal value judgements. Someone else should be able to get the same results when using the same method. The instruments of measurement are thus severely tested. In a study of notions hard to measure, like architectural quality, or importance of a specific intervention in urban design, complete objectivity can hardly be realised. A careful description of concepts and measuring instruments, additional independent measurements (e. g. repetitive measurements by different investigators) and intermediary verification of findings by third parties does increase the probability of objectivity, often alluded to as 'inter-subjectivity'.

A second criterion derived from reliability is verifiability. In order to qualify as a scientific study the structure of the study, the collecting of data, analysis of the material and interpretation should be made comprehensible to outsiders: it should be clear how the investigator reached his conclusions. This enables scientific debate. What is more: it offers other investigators opportunity to repeat the study; in different times, at different places. Naturally the requirement of verifiability requires a clear presentation and publication of the study.

While interpreting the data of a study and drawing conclusions, it is almost impossible to exclude personal (pre-)suppositions. Therefore, it is recommended to separate in the report of the study as much as possible the factual study results from the interpretation and conclusions. This leaves the possibility open to reach different conclusions based on the same material.

The term 'value free' is closely related to objectivity. This entails that the end – scientifically founded knowledge – justifies the undertaking of study, even if its results would clash with prevailing norms and values, or if the study would work out negatively for segments of a community. These days, practically everyone agrees that study can not, and should not, be value-free. Norms and values are important while choosing the inquiries of the study and the application of the study results. This does not preclude that within the given context the reasoning should be valid.

Validity

A second primary criterion for scientific study is validity. Amongst others, it means that what is measured is what is reported to be measured. Does measurement of temperature and humidity entail comfort? Who studies the effect of the presence of a 'major domus' (caretaker) on the intensity of vandalism in an apartment building by way of asking his opinion on it runs the risk to study rather the legitimacy of his appointment than the real effect. Measurement of costs of repair before and after his appointment is a more valid instrument of measurement.

This leads to the derived criterion that the investigator should think about the way how he might find efficiently and effectively the answer to the study question: he is looking for a methodical way, allowing research. Detours to reach a conclusion should be avoided. They might result in mistakes in the reasoning difficult to verify. Yardsticks are efficiency (using not more measurements, means or pre-suppositions than is necessary) en effectiveness (the method should be the answer to the question of the study). This requires thorough analysis of the problem, an inventory of sources of information available, a clear and unequivocally formulated statement of the problem and the purpose of the study, and critical reflection on the most appropriate study methods.

Over the years an extensive methodology of research has been developed. Presently there is a large variety in methods and techniques of research. For a survey and reflection on advantages and disadvantages as well as considerations as to selection we refer to the professional literature.[a] A methodological approach, by the way, does not mean that each step to be taken may be thought out in advance. Often progressing insight manifests itself while new steps are developed during the study. Additionally, rather accidental finds occur, some of them inspired by creative 'flashes' of insight: *serendipity*.

Open to criticism, able to criticise

A study may be reliable and valid, and yet not assessable. An important criterion of demarcation is Karl Popper's 'refutability' (openness to criticism, possibility of negation, falsification) of study results.[b] At stake is the possibility of counter-examples undermining the general conclusion.

For a long time the opinion prevailed that it would suffice, if the study results could be checked by others (verification). However, certain statements have been formulated in such a way that they may be verified always: speaking for themselves and by themselves. A well-known example is: "Everything is tripartite". When an investigator shows in refutation a safety match, the object is broken into three by way of verification. Statements of that type are adding nothing scientific to existing knowledge, according to Popper. In contrast an example of refutable knowledge is Einstein's theory of relativity, stating that light is bent by mass. Only in the years following publication of the theory this could have been refuted, if at a solar eclipse it would show that a star behind the sun would appear precisely on the moment predicted by the calculations of its course. The star appeared a little earlier, verifying the theory of relativity. Essential in this is that at that moment the possibility existed that the theory was refuted. The proposition was risky

In adddition to verifiable and open to criticism by third parties, scientific statements should also be critical themselves. The falsification principle of Sir Karl Popper is not only a passive, but also an active one. This means that science is open to both confirming and refuting existing opinions and views, for the time being seen as hypotheses. By checking them empirically or in terms of logical consistency, these hypotheses can be unmasked with more certainty as true or false. The potential to get away from myths is an important characteristic of science. This brings the criterion of scientific relevance into view.

Scientific relevance

Scientific study should widen and deepen development of the scientific discipline. The renewal or deepening may comprise contributing to the development of theory (generation of new knowledge, refuting or amending existing views), new methods and techniques of study, policy instruments and product development. Study limited to inventory of data is widely disregarded as scientific study. Even if the criteria of a methodological approach: reliability (objectivity, verifiability) and validity are honoured, scientific relevance is low, if it cannot criticise any existing suppositions. By itself this has nothing to do with social relevance or ethical

a Readily accessible methodological books include: Baarda, D.B. and M.P.M. de Goede (2001) *Basisboek methoden en technieken*. Baarda, D.B., M.P.M. de Goede et al. (1996) *Basisboek open interviewen*. Baarda, D.B., M.P.M. de Goede et al. (2001) *Basisboek kwalitatief onderzoek*. A little less recent, but with more examples on the field of construction is the book by Korteweg, P.J., J. van Weesep et al. (1983) *Ruimtelijk onderzoek: leidraad voor opzet, uitvoering en verwerking*. Especially for design related study is Zeisel, J. (1985) *Inquiry by design: tools for environment-behavior research*. For a systematic approach to formal (plan)analysis see, for instance: Clark, R.H. and M. Pause (1985) *Precedents in architecture*.

b Popper, K.R. (1963) *Conjectures and refutations: the growth of scientific knowledge*. Partly translated in Dutch: Popper, K.R. (1978) *De groei van kennis*.

admissibility: the contribution to improvement of the quality of life. At a level of low scientific relevance this might be high.

3.5 DIFFERENCES BETWEEN RESEARCH AND DESIGN

In spite of kinship between research and design differences apply:

The primary product of research is general knowledge in the form of probability. In a more narrow sense it is also the description of existing reality or truth belonging to it. This knowledge may, or may not be applied in (design) practice. The primary product of designing is the representation of a possibility; also if it is not a likely one. A design demonstrates what is possible and thus may become reality. Knowledge of what is probable is always incorporated in a design, often implicitly; e.g. that a brick can endure a well defined pressure.

Research deals mainly with analysis; with a design process the focus is on synthesis. Analysis (etymologically 'loosening') severs a phenomenon from circumstance (context, set of conditions) and components (reductions) that are different elsewhere, in order to retain what may be made comparable fit for study (operational). That enables (*ceteris paribus*) statements that may be generalised. Synthesis integrates diverging requirements and interests, but adds in passing also conditions leading to new consequences for use and experiencing. Continuously the design process offers new opportunity, not be described ex ante and often not in words.

Research strives towards development of knowledge that may apply in several contexts. Research deals mainly with reality and experiences (empiry). Thus, this research is empirically orientated and its thrust is towards probability. What the reality should be like may also be subject of research. From social goals and norms (points of departure) one reasons backwards to means for reaching them (normative study). The personal opinion of the researcher, however, is not allowed to play a rôle in the interpretation of the data of the study (objectivity). In order to restrict an explosion of possibilities caused by combinatorics, designing is almost by definition coloured by personal preferences (selective attention for empirical facts) of the designer (subjectivity). Designing may be normatively biased; a characteristic it shares with the arts.

Usually different methods and techniques are employed in research and design. For instance: research of the literature, polls, interviews, measurement of characteristics of a building, and experimenting are common study methods. Common design methods include usage of metaphors, adapting existing types, or application of design principles. Lynch proposes for example design principles in order to create a 'legible built environment'.[a]

3.6 DESIGN AS A SCIENCE

Given what was suggested until now, it is obvious, that designing as an activity, and a design as a product of this activity can only pass muster as a science, if the usual criteria for scientific activity have been obeyed. In an Advice of the Working Group Criteria Designing Disciplines (December 1999) this position is taken.[b] If a (tentative) design applies for being branded as result of scientific activity, it should comply with general requirements put to the scientific approach, to wit: inter-subjectivity, reliability and verifiability in an empirical sense. 'Intersubjective' was defined by that group as 'interpreted by different people in the same way'. 'Reliable' means here that the design demonstrates under different circumstances determined ex ante, behaviours that also determined ex ante. Verifiable points to the description of the design in terms of the grounds on which the decisions have been taken, including validity and tenability. Additionally, 'verifiable' includes, that the design can be specified according to concrete situations and can be generalised to possible applications in different situations or contexts. The working group derived the following concrete criteria:

- Novelty *vis-à-vis* state of the art of technique and originality
- Design methodological approach with a subjectivity that is argued

a Lynch, K. (1960) *The image of the city*.
b Werkgroep Beoordelingscriteria Ontwerpdisciplines (December, 1999) Advies van de Werkgroep Beoordelingscriteria Technische Universiteit Delft.

- Construction and materialisation in reality, if applicable
- Evaluation of actual performance of the design, compared to the performance intended
- Integration of design, development and study
- Integration of designing on different levels of scale (vertical integration)
- Integration of partial designs and aspects (horizontal integration)
- A vision on future development of the domain – in terms of design, discipline and science – the programme deals with.

To judge a design on these criteria, its presentation should include a description giving attention to these aspects.

During the EAAE Congress, mentioned earlier, 'Doctorates in design and architecture', comparable criteria emerged. Many scientists and designers agree that a design as a produce of scientific work should be based on a transparent process that may be assessed; a logically valid argumentation and accessible source of documentation. Originality, validity, economical use of means, clarity as to the underlying values and openness *vis-à-vis* verification and refutation are widely accepted criteria.

Nevertheless these conventional criteria allow some remarks. They have been strongly suggested to non-designing, truth directed disciplines with a preference for general knowledge. This may be a consequence of the fact that a lot of design related study has been done by social scientists, organisation experts, historians and technicians, not by the designers themselves. There must be something left over concerning design itself.

Restrictions to reliability

For multi-functional facilities or facilities used during a very long period, leaving open more possibilities of usage than foreseen, causes the requirement of reliability to be discussed. Someone immediately sees these possibilities, someone else after some time. A great number of possibilities of use and freedom to choose between them restricts reliability. The value of a multi-functional design sometimes increases with the number of possibilities of use in different contexts (robustness). By the same token, a conflict between this robustness and the reliability of the assessment may exist when evaluating an architectural object. Mono-functional facilities like a public water closet on the other hand may be evaluated reliably up to a point.

Restrictions to validity

Usage of an architectural design is, then, even more context sensitive than, for instance, usage of a petrol engine and consequently difficult to generalise. What works in one spatial, ecological, technical, economical, cultural and political context needs not to work the same way elsewhere. While architectural designers are hired particularly for solving, in a unique way, problems connected to place and context in a dynamic and many-faceted society, the classic empirical scientific striving towards statements that can be generalised may be frustrated.

There is an important distinction between the modalities 'to be' and 'can'. Everyone senses the incorrectness of the statement "That is not so, therefore it cannot be done this way". Between empirical and technical sciences there is an important difference in modality.[a] What is probable inter-subjectively is per definition possible, but what is possible is not always probable. Improbable possibilities are seldom inter-subjective, as long as they have not been demonstrated by realisation. Before demonstration just a belief applies (with the possibility of realisation).

Designing concentrates on discovering these improbable possibilities. This puts the criterion of inter-subjectivity into jeopardy. Even after realisation proving the possibility of spatial construction inter-subjectively, the use of the facilities built in its parts is in principle unpredictable, as long as one believes in the freedom to choose on behalf of users. The value of

a The concept modality has a well-described function in philosophy (Aristotle, Kant), logic (modal logic) and linguistics (verbs of modality) to express the difference between probability, likelihood, possibility or desirability. See also Chapter 0 on logic .

an architectural design is determined by the degree in which the design offers its user new possibilities to choose from. A home does not cause homing, it just makes homing possible. By the same token, design thinking is less focused on causality than on conditionality.[a]

Restrictions to evaluative potential

A final remark regards verifiability in the case of categories which are not to be compared. Each and every design features elements like usefulness, beauty and sturdiness, that cannot be compared.[b] Nevertheless, it is precisely the way in which these incomparable categories have been unified consistently within a specific context that determines the value of the design. Before the building can demonstrate its value on the market ex post, the validity of considerations between these principally incomparable categories and defending them can not be objectified. Even if a building proves its value this way, this does not ensure that the experiment will lead to the same result somewhere else. In addition, it often happens that context specific reference material is lacking against which a design before execution (ex ante) can be checked, when thorough evaluations of comparable cases after realisation (ex post) are absent.

3.7 CRITERIA FOR DESIGN RELATED STUDY EX POST

A scientific design should not be required to meet the criterion that its result is probable, as is the case of a study carried out in an empirical context. This puts a number of scientific criteria mentioned into jeopardy. There is even no need to require that a design is desirable, while improbable innovations often may not be imagined before they are proposed in a design. This is a crucial function of scientific design. As long as one does not know what is possible, one cannot know what one wants.

However, one must require that realisation of the design in one context or another is possible. The question is whether it must be socially possible at the same time. What is socially not feasible at present may become so when the possibilities have been brought into light. Even the question whether a design is economically feasible at present is no scientific yardstick, although a perspective may be required within which realisation may become possible at a certain time. Associated with this one should not require that the design has also been developed in a goal-directed way based on a statement of problems and aim ex ante (programme of requirements or brief). Rather, paradoxically, this pre-supposes an imagination of the result ex ante (hypothesis). It may be an experimental study orientated to a means with uncertain functions as a result.[c]

It is in order to ask which criteria remain. There are less of them than in empirical study, but from a viewpoint of the requirement of completeness there are also more. A suitable and extensive survey has been given by Eindhoven Technical University.[d] We restrict ourselves here to a minimum based on experience with evaluating matriculation designs and designs in other educational projects.

The following general criteria for technical university design on the level of a dissertation could apply to all technical sciences:

A. The scientific design should be understandable to others in the culture given so that it can be judged by them (to be expressed in a rich way) and, therewith, open to control, criticism and refutation.[e] The scientific design has been drawn up, documented and discussed by the designer with a clarity sufficing for a potential refutation. A possible refutation by third parties does not need to be a blemish on the proof of academic competence. To this criterion belongs the possibility of retrieving the sources on which the design and its argumentation is based. The requirements of the design drawing as a document to be judged scientifically are further detailed in Chapter 21.

a Jong, T.M. de (1992) *Kleine methodologie voor ontwerpend onderzoek*. This book further develops this conditionality in a technical sense. It is shown that conditionality implies also a sequence that was ascribed previously exclusively to causality.

b Vitruvius and M. Morgan (1960) *Vitruvius: The ten books on Architecture*.

c In the case of a means-orientated study the design solutions are generated first, and next is studied which aims could benefit from them (e.g. ' designing as an art to seduce').

d BCO, Bestuurscommissie Ontwerpers- en korte Onderzoeksopleidingen (1994) *Op weg naar promotie op proefontwerp*.

e 'Culture' is defined here as the set of tacit pre-suppositions while communicating; for example the meaning of the units of the legends in the drawing.

B. The academic design should bring possibilities to light that are essentially new (‘invention’ or ‘find’). This novelty value should show by comparing it to an added, accompanying, inventory of similar existing designs in order to provide the person evaluating with the wherewithal for his task. The technical-scientific design should bring improbable possibilities, those not to be deducted by mere prognosis. With this, the novelty value exceeds new knowledge (discovery) of phenomena at empirical study, probable by themselves.

C. It should be made acceptable that these possibilities are presently technically viable, at a future time economically and in any perspective as well as socially. The design should include a vision on the range of technical execution and social implementation in that perspective.

D. The design should include an effect analysis (for an evaluation ex ante, see Chapter 18) of this book). This analysis should minimally include a physical (spatial, ecological, technical) and a social (economical, cultural, political) effect in different perspectives. These effects may be intended in the first stage (potential of the site, intention, social need for the programme) and unintended afterwards. The effect analysis comprises particularly the unintended effects; for the intended ones, relevant during the comment on the design and the argumentation, would lead to circular reasoning. Unintended effects may be judged negatively afterwards in certain perspectives. They cannot be a basis for discrediting design and study competence. If demonstrated by the designer himself, on the contrary, it should be regarded as a proof of a scientific propensity. Additional illustration on effect analysis is given in Section C.

E. The intended social effect should be admissible in terms of ethics. Of the unintended effects the ethical admissibility should be checked.

3.8 CRITERIA FOR DESIGN RELATED STUDY EX ANTE

One should also distinguish – next to evaluations before and after execution – between evaluations of a design related study ex post and a proposal for such study to that effect before a design has been made. Judging a study proposal in advance is more difficult since there is less material at hand: it is just a promise of a study. In spite of that many study committees daily face the task of judging the potential and relevance of study proposals. Authorities distributing budgets always wrestle with the difficulty that a study proposal can not yet be judged on its result: the criteria of paragraph 3.7 can not be applied.

This book was written in the framework of the pilot project ‘The Architectural Intervention’; a number of workshops where teachers and students study and publish together.[a] The project proposals have been judged ex ante as a study proposal by the Methodology Committee of the pilot project for admission to the pilot project according to the following criteria.

A Affinity with designing

Affinity with designing can be shown from at least two images (photo’s, drawings), which are somehow comparable, or which in previous studies stood for reference or design model for an important field of interest from the participating researchers/graduate(s) and for the studio as a whole. The images may be a portrayal of different locations (at any scale), but also from the same location in two development phases. A correct way to do this is an entry in the *Interactive Archive of Architectural Interventions* (IAAI, see the Internet site).[b]

B University latitude

University latitude can arise from a specification of the context and the perspective of the research, from participating disciplines and contacts with (inter) faculty research and gradu-

a See publications of the Architectonische Interventie.
b http://iaai.bk.tudelft.nl

ating in the studio. An external referee can take on the rôle of an imaginary assignment initiator if (s)he is prepared to remain involved with the research/ graduation up until the final publication.

C Concept formation and transferability.

Concept formation with regard to design-orientated thinking follows the course of describing to accurate formulation in key-words. Concepts are defined, or, if they cannot yet be defined, receive a conditional 'position' (see page 41). Implicit, not commonly accepted assumptions such as the supposedly self-evident conditional and causal connections are made explicit. Scale falsification and overlapping concepts are avoided. What is stated as desirable, possible or probable is differentiated as such. That which can be expressed in an image, is not solely verbally expressed. In this case an image is made accessible by means of an unambiguous legend or drawing code.

D Retrievability and Accumulating Capacity

A correct way to reach retrievability and accumulating capacity is a personal internet site for each individual researcher with respect to the research/graduation and a site for the researcher studios and projects as a whole.

Referring to other authors

Provisional literature lists should be equipped with a number of key-words per title, from which it can be deduced that the proposal makes an input, uses, assesses or attempts to reject.

Making one's own publications retrievable

An accurate, distinct and sigificant title for the project and for the sub-researches within the project should be found. A determination of identity, not a solitary example but the placing within or beside an existing research, as well as a series of key-words, which reproduce the fascination, knowledge and the presentation of the researchers' questions are required. Reference words or distinguishing features relative to the design in the drawings and sub-projects, allow them to be retrieved in an image archive by differently orientated researchers. A few of these key-words can be elaborated upon in an explanation, which reproduces the theme, the study question and the study approach.

E Methodical accountability and depth

Such accountability, of the way in which (using which method) one will arrive at a result, should make possible that someone else using the same method *can* (not: *will*) arrive at a similar outcome.

There should be evidence to which extent the study is aim-orientated or means-orientated, empirically orientated or orientated towards the development of means of design. In the first case the starting points must contain a problem proposition and an objective proposition. An hypothesis and a research method must be specified.

A collective starting point for means orientated study can be perceived as follows: a location or a category of locations should become more meaningful using the design - for whatever purpose - than the current interpretation. The hypothesis of means-orientated research is always 'There are means of design for different purposes to come', which must be proven by the design.

The depth of means-orientated research can be proven with at least two criteria of each drawing, whereby they can be compared. Their differences or transformation can be evaluated and an explanation of the manner in which (method used) they can be compared.

This explanation can concentrate on the framework, the research field to which the comparison is reduced (for example a building physics, history and functionality comparison). This can also be used in order to specify which internal or external study programmes will be linked to.

F Ability to be criticised and to criticise

Ability to be criticised (ability to be refuted) offers others the opportunity to selectively make progress by building upon technical scientifical know-how and knowledge (accumulation) obtained through study. Statements are only of a scientific interest when they are bold and do not solely use risk-free citations, self-evident aspects or even clichés, on the contrary, statements must question these. This daring must not only be apparent in the project design but in particular during execution.

Ability to be criticised can be shown from a readiness and initiative to expose the results in their consecutive phases, to publish them for instance on the internet in a refutable manner, and in this way open them to criticism in all phases of the research even though these phases are unripe. Drawings and arguments must not conceal their weaknesses.

G Convergence and limitations

A proposal for the nature of the end product is required with a summation of the sub-projects. Questions to be answered in the proposal are:

- Who is ultimately responsible, who takes part, how often do they meet, what do they organise, how do they divide the common tasks, how is a synergy created, which facilities are desired?
- How is it to be represented (on the website, in book form, in a conference)?
- How do the sub-projects converge?

NAMING AND DESCRIBING

A NAMING AND DESCRIBING

An important condition for scientific work is a conceptual framework and careful description of the subject to be studied. Naming, describing and referring are also essential constituents of study related to design.

Naming components and concepts

In their contribution, De Jong and Rosemann stress the importance of concepts in design, as well as their focus, supposed scale, possible overlaps. The lack of concepts in naming the mountain of possible forms and transformations whilst communicating on design actually is a problem for the science of designing. It causes a proliferation of neologisms, often not to be fathomed by outsiders. Definition does not always offer a solution. For that purpose the constituent concepts fail that are presumed when a definition is in the making. Defining is preceeded by the conditional positioning of concepts A and B *vis-à-vis* one another: which concepts A pre-supposes concept B to be defined? May concepts A be named?

It is important to avoid a change of level of abstraction in a discourse or use of 'legenda', the 'things to be read', in construction. Mistakes preceding logical ones like these often play a rôle when designs are discussed. Designers tend to use rather paradoxical expressions whilst commenting on their design, like 'concentrated deconcentration'. Words often fail to suggest the world of shapes.

Retrieval and reference

The contribution of de Jong and van der Voordt dovetails both practically and theoretically with suggestions *vis-à-vis* citations of scientific results and facilitating that.

Descriptive research

Lans and Van der Voordt explore the value of a painstaking description of reality for theory development and the practice of designing. They argue to describe facts or designs in such a way that, 'ex ante', a minimal amount of inter-connections is suggested. That description should be clearly distinguished from the interpretation of facts and the establishment of relationships. Criticism by way of comparing different interpretations of the same material depends on this in order to exist at all. Concrete examples of study illustrate advantages and disadvantages of the phenomenological approach. The authors advocate to raise the dominant form of design study – analyses of plans and comparison of previous cases – to a higher level. In addition, process description is discussed by way of two examples: the planning process of the '*Bijlmermeer*' project of the City of Amsterdam in the sixties, and the individual one, and one of thought as well, of a designer of architecture. Both studies yielded relevant insights for the theories of planning and of architecture.

Historical research

Máčel shows that the results of historical research depend on the interpretation of history as a science. His contribution consists of three parts: 1) heuristics (how to deal with historical sources and references), 2) analysis (how to analyse text and drawings dating from the past), and 3) interpretation (focusing on issues such as context, typology, style and meaning). Finally he reflects on architectural history as a social science and the relationship between historical research and architectural criticism.

Map Study

Moens' contribution focuses on the formal and functional description of the earth's surface, on the basis of aerial photographs and maps. It discusses several types of maps; how they are made and how they may be used as support of design decisions. In addition, traps and foot holes are indicated in order to prevent faulty interpretation of the towers of map-making. Without interpretation, it could not be done at all. Just think about the ‘things to be read’, the units of the legend and choosing them. The degree and measure of interpretation is then at stake; and to what level they are suggested. Only after description the topographical facts should be placed into mutual relations according to a model. In the case of topographical maps of the military the problem becomes clear. Different connections are already pre-supposed in them; no longer susceptive to design decisions.

Casuistry resulting in laws

Most ancient social application of induction, a distinct set of cases within one general ruling, is the law. The juridical method where casuistry leads to jurisprudence is a predecessor of the scientific method. Facts, their modelling, debate and inter-subjective judgement play an important rôle.

Hobma and Schutte discuss the importance of legal study in the context of designing. On one hand they make practical distinctions, based on straight application of legal research: essentially retrieval and sorting; for instance for getting a building license. On the other, they deal with scientific legal study, explicitly aiming for a more general kind of knowledge.

The Chapter is consolidated in this section, while this prolegomenon from quarters not exclusively empirical gives a feeling for a scientific approach as it applies in the domain of architecture. An exclusively empirical approach fails to give a solution for many problems in this respect.

Conclusion

Together, the five sections reflect the value of descriptive study, the necessity of a clear, unambiguous terminology, and checking points to pre-empt all too subjective interpretations, or even faulty ones, of reality.

4 NAMING COMPONENTS AND CONCEPTS

TAEKE DE JONG
JÜRGEN ROSEMANN

Specific terminology exists in each scientific discipline enabling effective description and specialist communication. In some disciplines the number of defined concepts is relatively small (as in logic, mathematics, physics, history and geography, even though with the last two the number of names is uniquely large), in others (chemical nomenclature, medical science and above all in biology and ecology) this is very large. This has partly to do with variation in the phenomenon to be explained.

What can be done when a designing discipline, such as architecture, is expected to *create* these phenomena and to increase their variation (especially in form and structure)?

A few technical architectural dictionaries exist[a] (concepts) and encyclopaedia (concepts and names); however there is little interest for them in architectural design; they are mainly of historical interest. This by no means covers the topicality of new design assignments. In architecture there is an infinite number of proposals created; partly expressed by drawings and pictures. It is thought that from each drawing new concepts and conceptions may be derived allowing parts of the design process to be subject of discussion. However, their number is so large, that this vocabulary will never become widely accepted.

A research project into reference words, which summarise the competence of professors in architecture[b], brought to light that many subjects and dilemmas of study by design, design, design research and typology could hardly be reproduced in everyday language or technical language. The number of new terms (neologisms) in this profession is, therefore, large.

Designers show a distinctive creativeness in using neologisms for the explanation of their designs, neologisms like that empirical researchers simply dismiss as of no use in their jargon (family structure, age, income). However, it is of utmost importance that these concepts are taken seriously because they show the inadequacy of empirical jargon. They can herald a change in focus demanding another concept definition. Intensive defining is, therefore, not always the right thing to do. Conditional positioning is an alternative for precise defining.

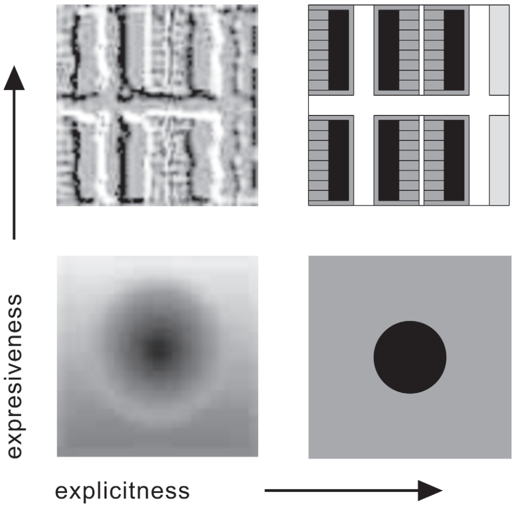
The sheer size of the Index of this book (see page 531) is an indication of the prime importance of naming in the science of design. The first naming of components, concepts and design activities in the transformation of the earth's surface is determining the focus from where the remainder is named and considered. That this focus may be chosen differently, implies that a number of vocabularies are possible and desirable. Naming, typing and making legends are hiding an implicit, often blockading classification within which both study and design will express themselves subsequently and necessary. Already a seemingly objective description comprises in its terms at least one tacit pre-supposition that one should be conscious on in order to be able to speak in a different language about the same phenomenon.

The importance of naming and therefore implicit classification for design comes nowhere so directly to the fore as in the Chapter of the section technical study 'Classification and Combination' (see page 345). In it, the discussion, of a standing measured by decades, about naming the building materials and components is described as well as the shortcomings of any classification for a design opting for a different selection of building blocks in order to get to new designs. Any designer is facing, in each compositional task, such tacit, sometimes stimulating, but usually blockading pre-suppositions with which components have been named or imagined traditionally.

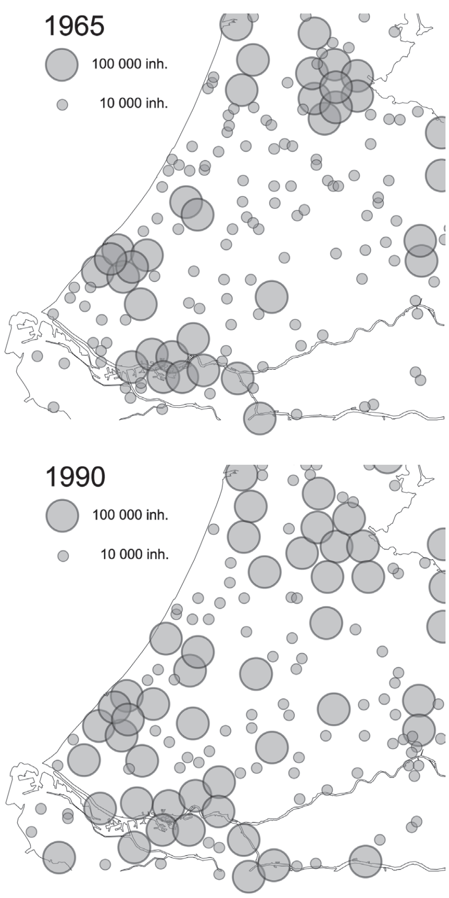
This Chapter gives some indications how the components of an image and their reconstruction into a concept may be delimited and named. This way it is becoming possible to talk about them and to retrieve them.

a Venturi, M. (1950) *Town Planning Glossary; 10.000 multilingual terms in one alphabet for European Town Planners;*
- Kay, N.W. (1955) *The Modern Building Encyclopaedia, an authoritative reference to all aspects of the building and alied trades;*
- Graf, Huber et al. (1956) *Das Kleine Lexikon der Bautechnik (im Anhang DIN-normen im Bauwesen);*
- Saylor, H.H. (1962, 1952) *Dictionary of Architecture;*
- Académie D'Architecture (1963) *Lexique Des Termes Du Batiment;*
- Barbier, M., R. Cadierques et al. (1963) *Dictionnaire Technique du Batiment et des Travaux Publics;*
- Burke, A.E., J. Dalzell et al. (1963 / 1959 / 1955 / 1950) *Architectural and Building Trades Dictionary;*
- Kinniburgh, W. (1966) *Dictionary of Building Materials;*
- Frommhold, H. (1967) *Begriffsbestimmungen aus dem Bauwesen;*
- Koepf, H. (1968) *Bildwörterbuch der Architektur;*
- Koch, W. and G. Kötting (1971) *Termen en Begrippen in de Bouwkunst;*
- Cowan, H.J. (1973) *Dictionary of Architectural Science;*
- Killer, W.K. (1973) *Bautechnisches Englisch im Bild;*
- Meling, G. (1973) *Naturstein Lexikon; Werkstoff, Werkzeuge und Machinen, Wirtschaft und Handel, Gestaltung und Technieken von der Antike bis heute;*
- Walker, J.A. (1973) *Glossary of Art, Architecture and Design since 1945;*
- Hall, J. (1974) *Dictionary of Subjects and Symbols in Art;*
- Harris, C.M. (1975) *Dictionary of Architecture and Construction;*
- Villena, L. (1975) *Glossaire Burgenfachwörterbuch des mittelalterlichen Wehrbaus;*
- Curl, J.S. (1977) *English Architecture;*
- Baumgart, F. (1978) *DuMont's kleines Sachlexikon der Architectur;*
- Stein, J.S. (1980) *Construction Glossary an Encyclopedic Reference and Manual;*
- Bak, L. (1983) *Vademecum ruimtelijke planning;*
- Mohr, A.H. (1983) *Vestingbouwkundige Termen;*
- Logie, G. (1986) *Glossary of land resources;*
- Stichting Bouwresearch, P. Erasmus et al. (1989) *Terminologie van de voorbereiding en de kwaliteit in de bouw;*
- Nederlands Normalisatie Instituut (1991) *Algemene termen in de bouw;*
- Reinders, C.G. (1992) *Vaktaal; vaktermengids bij kerkgebouwen;*
- Renes, J. (1992) *Historische landschapselementen;*
- Wilde, E. de and H. Volker (1995) *Prisma Vakwoordenboek Bouw*;
- Haslinghuis, E.J. and H. Jense (1997) *Bouwkundige termen.*

b Jong, T.M. de (1997) *Hoogleraren Bouwkunde in trefwoorden.*



4 Information content of a drawing



5 Succession of sprawl

4.1 COMPONENTS AND CONCEPTS IN DRAWINGS

A picture says more a thousand words, but which words are these? This question is of importance for the scientific status of drawing, its documentation and retrievability.

A drawing is made in order to read something from it. Legibility is dependent upon explicitness and expressiveness. That is not the same. An explicit drawing, like a black circle on a grey field with for legend units 'black = built' and 'grey = vacant', for instance, may be very explicit, but is not expressive. The upper plot divisions are more expressive, while their legends (vocabulary) are more comprehensive and have been spread in more than one legend plane in the drawing (information content). When the borders between the legend units are drawn vaguely, the drawing may be more expressive, but it is less explicit. The precise positioning of legends planes has more tolerance (see paragraphs 24.10 and 24.11). Less explicit drawings make sense for creating an impression, but say less in a scholarly than in a poetical sense. Nevertheless they are essential in the designing process.

While consulting an archive of drawings it is only important to retrieve the drawing from which may be read what one wants to know. So it is not only important from a scholarly viewpoint to know what a drawing is depicting, but especially which properties, attributes and operations may be read from what is depicted.

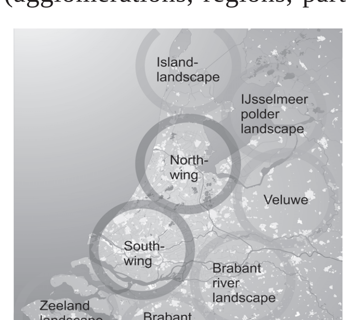
4.2 FOCUS: SEED OF COMPONENTS AND CONCEPTS

The chosen focus primarily determines the viewpoint from which components and concepts are defined. During the design process, the interpretation of the location determines in a major way the first components with which the composition of the design is created. This way, over the years the interpretation of the urban area in the Randstad has changed focus. During the process the selection of the constituting and surrounding components of the image and the concepts related thereto did change. In the figure below the Randstad is represented in units of 100 000 and 10 000 people (large and small circles) in 1965 and 1995 respectively.

The large circles have a radius of 3km and represent reasonably well the urban surface area, which on average in the Netherlands is occupied by 100 000 inhabitants. This also applies to the small circles of 10 000 inhabitants. Where the circles overlap a higher than average population density for the Netherlands exists. The interpretation of this urban area throughout the years is similar to the formation of a different structure of the stars into a different constellation. Through this a different political, design technical and scholarly grasp on the composition also originates. In 1965 the Randstad was made up of a few large and a few small towns, recognisably separated by buffer zones and a 'Green Heart' between them. In 1995 it was mostly called a 'north-wing ' and a 'south-wing'. The Green Heart is becoming thought of less as a component. The 'focus' is shifting. Now it is generally called a 'Deltametropolis'.

A different focus is created upon the surrounding landscape based on the concept of a Deltametropolis, than one based on the concept of a north- and south-wing of the Randstad with Green Heart. The placing of the first components in the composition of the Netherlands determines the concept formation for the rest. In the figure below these concept shifts are represented using larger units (agglomerations, regions, parts of the country).

6 Big cities around the Green Heart



7 North and South wing

8 Deltametropolis

Historical sciences show more examples of limited object constancy. Languages, people, nations and social categories appear, thrive, diminish, disappear or shift on the map in relation to their territory. The ability to free oneself from old categories, to choose a new focus, is the hallmark of creative researchers and designers (see also page 390).

4.3 UNRAVELLING SCALE

Changes in abstraction within a reasoning can lead to paradoxes like the statement "I am lying". If I am lying, I speak the truth and vice versa. It is a statement and at the same time a statement *about* the statement *itself*. Such self-reflexive statements were banished from the set theory at the beginning of the last century by Russell.[a] He would not allow changes in abstraction using a mathematical argument: "A set of sets may not contain *itself*". This wisdom has by no means entered into everyday language, not even in science.

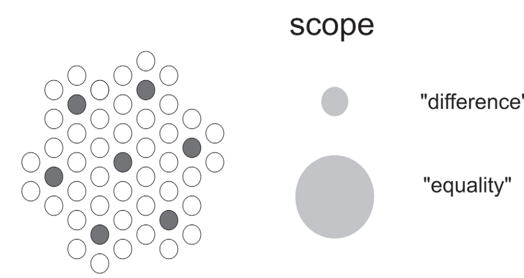
The accompanying figure shows a spatial example of concept confusion, based upon a difference in the scale of consideration (scale paradox). It is shown here that identical spatial patterns allow different conclusions to be drawn when elements are involved in the consideration using a differing scope (scale level, largest frame, smallest texture grain).

For example if in figure 9 one takes one circle each time and the surroundings into consideration then one must ascertain a difference, although equality should be ascertained when one repeatedly compares groups of seven with the surroundings. Something similar applies to the consideration from inside to outside and from outside to inside. The paradoxical concept 'homogenous mixture' indicates precisely which dilemma this entails: it is homogenous at a specific scale level, at a lower abstraction level it is heterogeneous.

The concept 'bundled deconcentration', well known in Dutch urban planning, is another example. For concepts like that the question must be asked immediately: "using which scale for one, and which scale for the other?" Moreover, this figure shows that such confusion of tongues is possible using a factor three linear scale level difference. Between the grains of sand and the earth lie 7 decimals; therefore there are more than 14 concept confusions lurking.

This gave rise to allocation of a frame and a grain which differ systematically to other scale levels by a factor of around three for architectural categories, (discourses, drawings, uniformity in legends, concepts and objects) in the urban development[b] and the technology of building[c] in order to enable the *context* of the category in question to be defined (such as on other scale level).

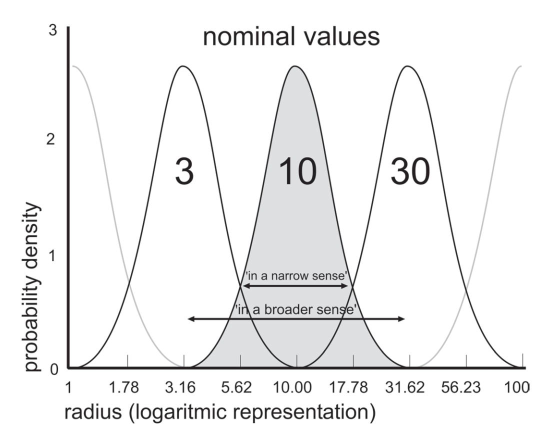
The frame stated is labelled with a measurement, e.g. '10 m radius'. Such a 'nominal measurement' may be interpreted as 'flexible' up to the measurement of the adjacent radius, e.g. '3m up to 30m radius'.



9 Scale paradox

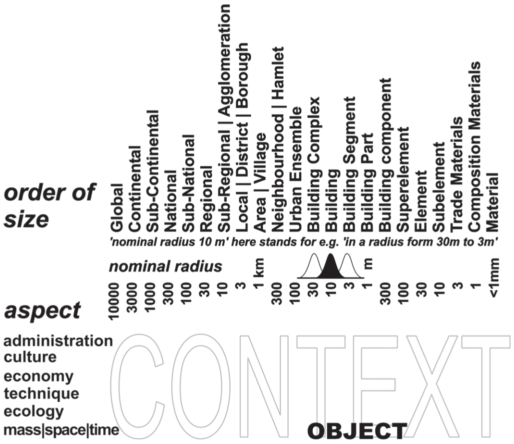
FRAME	*NOMINAL RADIUS*	
Global	10000	
Continental	3000	
Sub-continental	1000	
National	300	
Sub-national	100	
Regional	30	
Sub-regional	10	
Local | District | Borough	3	
Area | Village	1	km
Neighbourhood | Hamlet	300	
Ensemble	100	
Building complex	30	
Building	10	
Building segment	3	
Building part	1	m
Building component	300	
Superelement	100	
Element	30	
Subelement	10	
Supermaterial	3	
Material	1	
Submaterial	<1	mm

10 Scale articulation

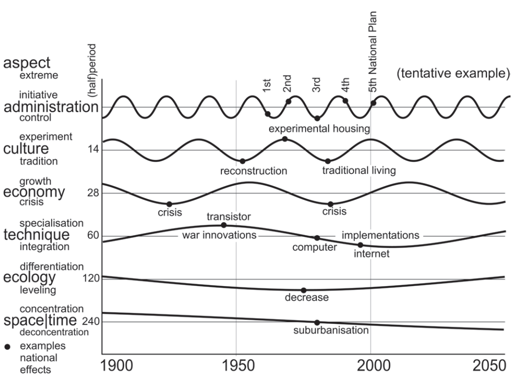


11 Scope of nominal measures

a Russell, B. (1919) *Introduction to mathematical philosophy*.
b Jong, T.M. de and M. Paasman (1998) *Een vocabulaire voor besluitvorming over de kaart van Nederland*.
c See Eekhout, A.C.J.M. (1998) *Ontwerpmethodologie*.



12 Object and context



13 Different dynamics and perspectives

radius						m				mm
frame stage	300	100	30	10	3	1	300	100	30	10
initiative										
programme										
development										
design										
effect analysis										
execution										
usage										
maintenance										
evaluation										
demolition										

14 The context during the building process

4.4 CONTEXT: GROUND OF COMPONENTS AND CONCEPTS

As soon as one has 'placed' an architectural proposal, object, concept, conception, research or design on a scale level or 'radius', the rest is 'context'. The concept has obtained an 'interior' (everything which is smaller than the texture grain of the object) and an 'exterior' (everything which is greater than the frame of the object). This does not just mean in the widest sense of 'spatial context', but, also, more specifically, an 'ecological', 'technical', 'economical', 'cultural', or 'managerial' context. These contexts are also scale sensitive.

When naming the scale boundaries a concept is, from a particular viewpoint, spatially 'placed', regardless of the way a similar problem exists in the time. The concept 'Perspective' in time exists here as an analogy for 'context' in space, which becomes significant when the intended and unintended effects of a design are to be interpreted, named and estimated. In which perspective does this happen, with which plan horizon and under which assumptions with regard to external developments (initiating or controling government, an opportunity- or tradition directed culture, growing or stagnating economy, technology which is successful using function combinations or on the contrary using function separation, an increasing or decreasing spatial pressure).

Articulation of scale can clarify the concept 'goal' and 'mean' on the level of policy: if the State wants to reach a goal through a subsidy, this mean may be a goal for more local authorities. In this way economies are sub-divided in micro, meso and macro economies. Concepts like 'loss', 'profit', 'savings' and conclusions about them may not be inter-changed between them, even if the used words sound the same. Something similar is valid in time: if a goal has been reached, the result has become a mean for a goal further away. It needs no mentioning that the meaning of a concept depends on the context and the perspective within it is used and that it is often used 'removed from its context'.[a]

The building process always takes place in a social and material context and in a perspective based thereon. Each stage can have a different political, cultural, economical, technical, ecological and spatial context and employ, by the same token a language game.[b] The resulting conceptual confusion can often be solved by asking on which scale level the ambiguous concepts have been intended.

4.5 UNRAVELLING OVERLAPS

Once the perspective and context of the architectural system of concepts have been determined, one must check as to how far the concepts overlap. Overlapping concepts are lucrative in the acquisition of research, because one is allocated a budget in order to research the same thing using another name and possibly with slightly different limitations. However, they actually hinder retrievability and accumulation of research results and therefore growth of knowledge and proficiency. With this in mind one must not disallow new concepts (and then for example create a 'thesaurus' using permitted and well-defined concepts.) After all, the value of university research is in extending boundaries, shifting perspectives and changing focus.

The domain of overlapping concepts can be divided by giving the overlap a new name of its own. Supposing that, in a building one makes a distinction between load bearing, dividing and finishing structures to determine their effect on the required design-effort, their effect on manpower by production or to divide the budget between three participating parties. Then overlapping can lead to disagreement.

a The functional CIAM separation 'living, working, recreation and traffic' resulted into separation of living and working on a much larger distance (1000 metres) than was called for by the hinder between both (100 metres).

b A term of Wittgenstein, L. (1953) *Philosophische Untersuchungen*. Recent edition: Wittgenstein, L. and G.E.M. Anscombe (1997) *Philosophical investigations*.

Set theory offers in this case symbols for ‘without’ (asymmetric difference, represented using \) and the ‘overlapping between’ (diametre, represented using $\cap$). This results in 5 exclusive concepts: (1) supporters\partitions (2) supporters $\cap$ partitons (4) partitions $\cap$ finish, (5) finish\partitions and (3) partitions\(supporters $\cup$ finish), whereby $\cup$ stands for ‘union’ (in this case from two disjunctive sets which are not considered to be overlapping). One can here also use concepts like (1) ‘non-partitioning supporters’, (2) ‘partitioning supporters’ etc.

Things become more complex, when a designer creates (6) a bearing construction as a finish. The Venn-diagram then indicates three overlapping circles with the categories ‘bearing and finishing’ and ‘bearing and dividing and finishing’ If this was unforeseen during the budget apportionment, to which budget must the time spent on the design be charged? Who makes the profit during execution? Therefore, in practice, an incorrect concept formation leads to confusion, let alone in science. This is very much the case when one wishes to compare different situations whereby the overlapping areas are not specified. It is also plausible in this case that an implicitly overlapping system of concepts is an obstacle for combined architecture innovations.

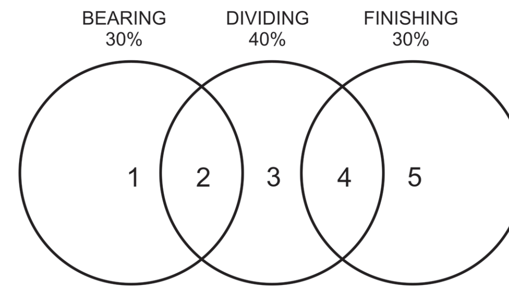
Neologisms may be required on the road to unambiguity, if one locates their domain in such a manner with respect to other concepts, (for example using Venn-diagrams) in order to accomplish a system of concepts. The requirement to avoid overlapping areas applies again to the other concept location.

The procedure is: to divide the domain of overlapping concepts once again into exclusive concepts and, if required, summarise them in order to accomplish a system of inclusive concepts giving insight into abstraction levels. The question “can one imagine ‘B’ without ‘A’ “, combined with the reverse question can aid this and yields surprising results especially with an inclusive system of concepts.[a] If the answer to both questions is negative and/or affirmative then these are respectively overlapping and/or exclusive concepts. If the answer is different, these are inclusive concepts with an asymmetric relation.

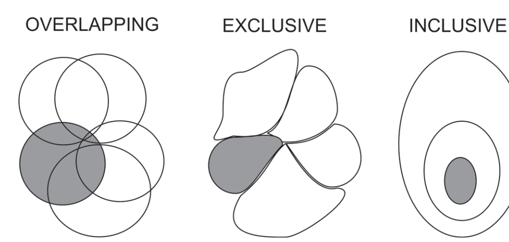
An irritating concept confusion exists when one places non-equivalent categories of different abstraction level against each other such as ‘man and society’ or ‘man and the environment’ and then also includes this in a schedule, which conceals more than it clarifies. A good example of this is Udo de Haes’[b] environmental definition, however, almost every scientist was an accessory to this.

However the technical environmental professors (Duijvestein, De Jong and Schmidt) present a ‘technical definition’.[c] After all, one cannot imagine a society without an environment, but one can imagine an environment without people. The first schedule is, therefore, misleading from a technical point of view. Maybe this definition difference is typical for a contrast in language games between empiricists and designers, the way in which they reduce reality. The example puts the problems of the relations between concepts up for discussion. The second representation implies an actual asymmetry in the relationship between man and the environment, lacking in the first representation.

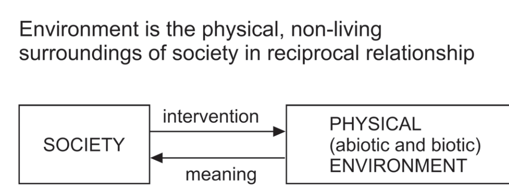
Does defining consist of making connections with other concepts? Are concepts therefore nothing more than a summary of potential connections (valencies) with the rest, their context? Is a property something different from a relation, an action that shows the feature? What name should we give to such actions? Does the naming of actions form another sort of concept than the naming of objects? It is quite similar to the physics argument: whether light is a wave- (action-) phenomenon versus is light a particle- (object-) phenomenon.



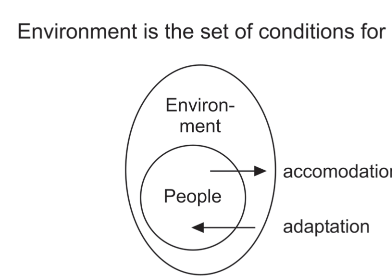
15 Overlapping concepts



16 Exclusive and inclusive concepts

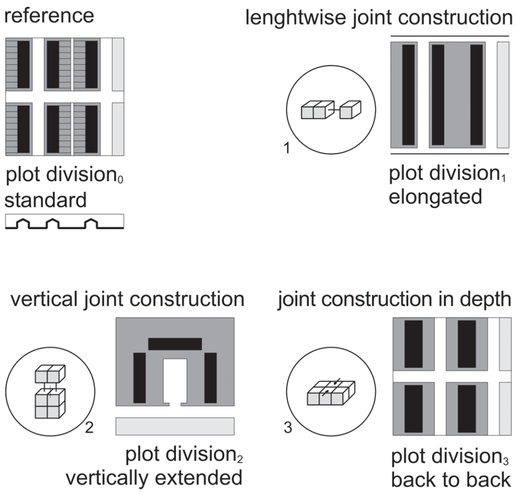


17 Environment according to Udo de Haes

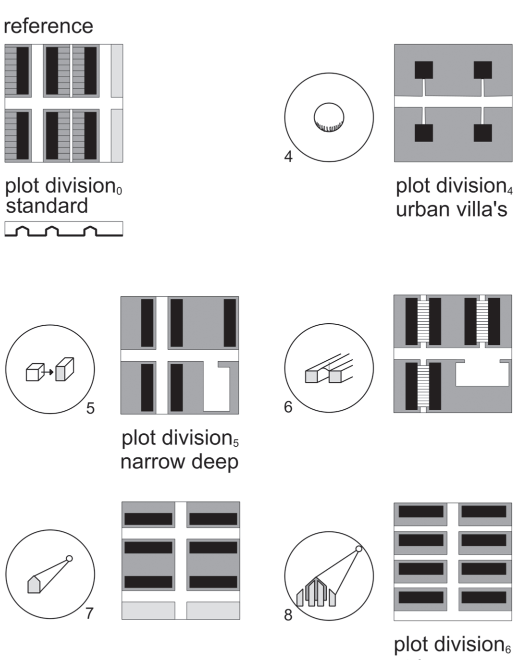


18 Environment in technical sense

a Jong, T.M. de (1998) *Sustaining design*.
b Boersma, J.J., J.W. Copius Peereboom et al. (1984) *Basisboek Milieu*.
c Jong, T.M. de (1997) *Inleiding technische ecologie en milieuplanning*.



19 Three transformations on one reference



20 Transformations difficult to name

a Latin for: 'other things being equal'.
b In logic it is usage to place in this notation (full-sentence function) the operations (the verbs) outside the brackets. In order to be able to retrieve drawings with such full-sentence functions, it would be better to place the result (the object) outside the brackets.
c The legends for a drawing may be regarded as its vocabulary.
d Between the result and the reference no space is written.
e Latin for 'part for the whole'.

4.6 NAMING TRANSFORMATIONS: INSTRUMENTS OF CONCEPT FORMATION

Figure 19 shows a reference plot division$_0$ with 48 houses on one hectare with an operation $O_{1..3}$ transformed into another plot division$_{1..3}$ with the same number of houses per hectare (*ceteris paribus*[a]).

All representations (images, nouns, adjectives and verbs) in this figure are concepts, abstract representations. They represent a collection of examples in reality (extension of the concept) and do not form the image of one specific situation. The square images are plot divisions: possible layout distribution of built-on space and a few categories of open spaces with mutual bearing. The open space is split into public landscaped areas and private grounds (light and dark grey) and public road space (white). They maintain a *bearing* upon each other *within* the plot divisions in the sense that if the built-on area (independently) varies, then the open space will also (dependently) vary. It can also be said that: open space y is influenced by, or an action of, built-on space x: y(x) open space(built-on space). The expression y(x) is called a sentence function. As soon as this connection is operational then the concept has become a function: y=f(x), composed of operations between variables (see paragraph 24.19). A Mathematical operationalisation would be: open space = total space – built on space. However, there are innumerable qualitative design-operationalisations (transformations) possible within this quantitive rule.

From the diagram with the plot division transformations the operation of lengthwise joint construction, can be read on a reference: long blocks(plot division). Such a notation object(subject) where the brackets mean 'as operation of', is also a full-sentence function that has become independent.[b] The operation is dependent on the way in which one builds adjacently: in the length, the width or the height of the building block. The function can be used as key-word for the drawings specified by transformations.

The noun 'plot division' and its depiction are comprising here this way the constituent legend units[c] (constituent concepts) and (spatial) connections between the legend units. In the word 'plot description' this stays implicit, in the picture it is explicit. Focus can change by alternative grouping if 'private space' is a legend unit composed of built-up area and gardens. The meaning of 'plot-division' changes accordingly, perhaps better named by 'parcelling'.

The verb (evoked in the circles) pre-supposes an imaginary connection within time between the plot divisions mutually: first, the reference, then the operation and then the result. If one is opting for a different reference (for instance neighbourhoods rather than houses), the same operations would have a different result. This connection can more generally be described as 'plot division' as operation of a reference: plot division(reference).[d]

The adjectives give one property of the plot division, or actually of the built part of it (*pars pro toto*[e]). However the concept 'plot division' is a set of properties; most of them lack verbal equivalents. A property can be described as an operation. Zoning is an operation of the plot division: resulting in a property zoned(plot division(reference)). If a property serves the identifying of a depiction, this property is termed an attribute.

In figure 20 operations are visualised using the same reference plot division, however these can not be reproduced using just an existing verb. However, naming the transformation by a sentence function result (origin) could be efficient for retrieval.

Design operation$_4$ could be called 'compact building' or 'concentration' in three dimensions (length, height, and depth) on a scale level of one quarter of a hectare. This results in urban villas measuring 15x15x15m. On a scale level of the hectare as a whole, however, the concentration (*ceteris paribus*) would accommodate one building measuring 24x24x24m. So, the term 'concentration' is a scale sensitive transformation

Operation$_5$ is a form of concentration in length. The result being a narrow and deep dwelling when using an equally sized plot division surface (*ceteris paribus*). This has a number of effects upon the open space and its technical facilities.

Operation$_8$ results in southerly directed strip plot divisions, therefore, enabling all of the houses to be orientated towards the sun and, therefore, can also be internally zoned for warm and cold rooms. This operation is difficult to describe using a verb; this is why it is visualised with the aim of this operation (zoning), which requires a reference point outside the plot division (the sun, the south).

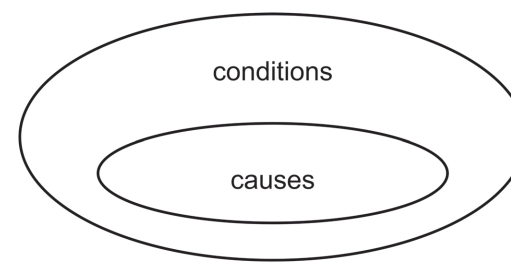
The adaptations of the plot divisions are mainly geared towards the built-on space, but at the same time they also have a spatial effect, which is difficult to define, on the public landscaped areas, paving and the open private space. The result is known as an effect on the built-on space, but the result of the adaptation is much broader.

In architectonic and urban development, designing always contains an intervention in an existing situation, focusing on specific effects. When one is in the position to name these interventions as design operations (transformations), then one can summarise many patterns as result of a few transformations on every reference. The concept ‘concentration’ is an example, if one specifies this concept per scale level and direction.

4.7 CONDITIONAL POSITIONING OF CONCEPTS

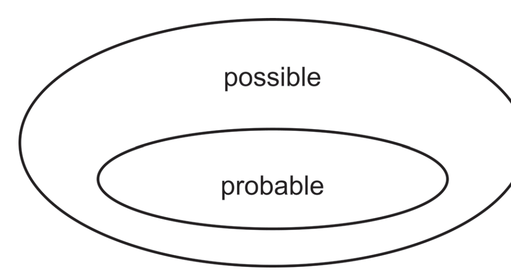
What is called ‘assumption’ in our imaginative capacity is, in reality, a ‘pre-condition’. If I am driving a car, I assume that there is petrol in the tank. This is also a pre-condition to actually being able to drive. If something does not ‘work’, then one of the conditions for its working is lacking, in this example the petrol. Such a pre-condition is a ‘cause of failure’, the ‘cause’ of a non-event that one had indeed expected (assumed). Yet, the classical notion of ‘cause’ does involve an ‘occurring event’, even though one does not expect it (for example, the cause of a fire). With the concept of ‘cause’, then, one is actively thinking about an event that has come before and that caused perceived consequences (active cause).

All these causes are a condition for something to happen, but not all conditions are also causes.



21 Not every condition is a cause, but every cause is a condition for something to happen

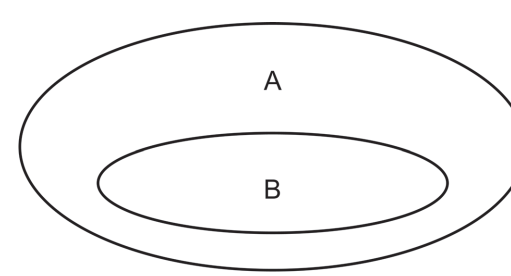
There are many more conditions than there are causes. Petrol, for example, is not the only pre-condition necessary to be able to drive a car. There also have to be pipes that supply the petrol to the engine, there must be an engine, and this engine must be able to transfer its capacity to the wheels. And, indeed, the car must have these wheels. The design of the car is actually the collection of pre-conditions needed for one to be able to talk about a car. These are object pre-conditions, but there are also a basically infinite number of context pre-conditions. I cannot drive a car if I am sick, if there are no cars or roads for me to drive upon, or if someone prevents me from doing so for whatever reason. Thus, the context is a collection of pre-conditions for the architectural object.



22 Any probable event is per definition possible, but there are improbable possibilities

Studying the context and object pre-conditions does not result exclusively from the linear logic of causal thinking. Under certain conditions, something *can* happen, or in the case of a certain cause it *probably will* happen. Conditional logical does not always unlock the probable, but it does unlock the possible.

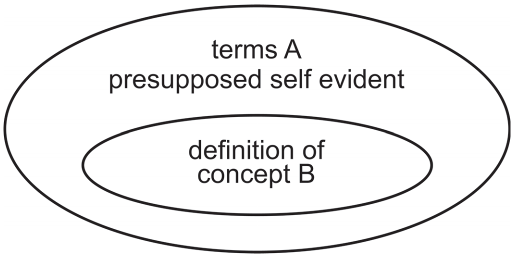
This logic fits in with study by design. Just as there are chains of cause and effect, there are also pre-conditional chains by which, under certain circumstances, patterns and processes are not so much predictable, but rather imaginable. This imaginability is introspectively verifiable using the test, “if I can imagine A without B, but not B without A, then A is the pre-condition for B”.[a] We call it ‘conditional analysis’.



23 ‘A not imaginable without B’

Petrol is the pre-condition for a working petrol engine, but a petrol engine is not a pre-condition for petrol. This is not a case of causality since petrol is not the cause of the working, but only one of its conditions. A load-bearing structure is the pre-condition for a roof, but a roof is not a pre-condition fort a load-bearing structure. Thus, one can pre-conditionally position

a Jong, T.M. de (1992) *Kleine methodologie voor ontwerpend onderzoek*. Here, quite a few concepts from design and research are compared by conditional analyses.



24 Terms A pre-supposed in a definition of B

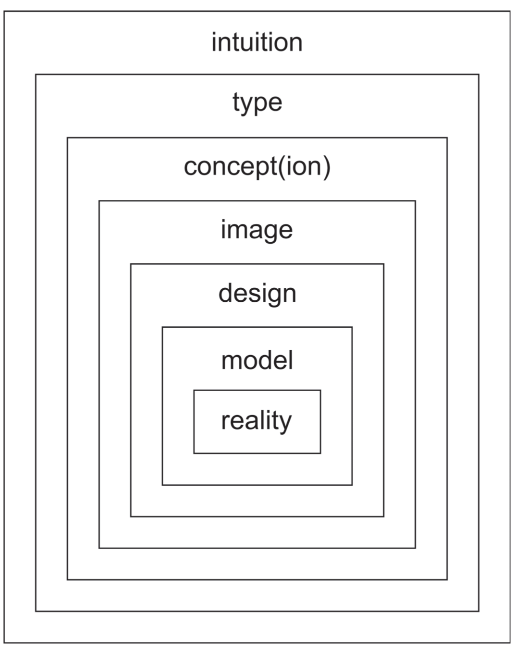
design elements in regard to one another. Aspects of the context can be studied as pre-conditions for parts of the design. Design study and study by design considers variations in pre-conditions. Within the design process, results from certain design phases are pre-conditions for a continuing of the design.

Mutual conditional positioning of concepts shows the very possibility of definition itself. One can not define a concept in terms that pre-suppose the concept itself. Whether the concept to define is contained in the defining terms or not is brought into light by conditional analysis.

The conditional analysis goes:

1 “Could you imagine terms A without B?”
2 “Yes.”
3 “Could you imagine B without terms A?”
4 “No.”
5 “Then terms A are pre-supposed by B.”

B could be defined using terms A.



25 Stairs of imagination

Conditional analysis can help positioning terms for defining abstract and vague concepts. A useful example is given in figure 266 ‘From possibility to norm’. In the next sections of this book crucial concepts in describing design processes could be positioned like in figure 25.
However, in this figure the focus is on imagination of not yet existing objects produced in a design process. It is a designer’s focus defining a model in terms of design. An empirical scientist perhaps pre-supposes a reality without which s(he) can not imagine models. S(he) will position the terms the reverse and define a design in terms of a model. To understand differences in focus one should enter a higher level of philosophical abstraction of discussing such differences on itself. In Chapter 44 (see page 413) we will discuss them in the perspective of idealism and materialism.

4.8 CONCLUSION

In this Chapter we tried to discuss naming concepts and components in a conditional way. It started with focus as pre-condition of choosing components, frame and grain, getting grip on context, unraveling overlaps, naming transformations and conditionality in technical design and in defining concepts. So the sequence supposes conditionality on a higher level of abstraction than the subjects discussed, the level of the discussion itself. Should we start on that level of discussing discussions with conditionality and end with focus? That kind of focus perhaps goes beyond imagination. Anyway, the Bible starts with naming.

5 RETRIEVAL AND REFERENCE

TAEKE DE JONG
THEO VAN DER VOORDT

Knowledge from study may be transferred in different ways: in words and images, via lectures and exhibitions, in the form of articles or books; and electronically.

For the time being, the form used most frequently is written publication in text and illustration. However publishing on CD-ROM and the Internet are witnessing rapid development. Maybe this is going to have important consequences for the way in which people are searching for information. In this contribution we discuss some points needing attention for optimal accessibility of knowledge from study and suitably dealing with the sources used. We refer to handbooks for the conventional playing rules of reporting in writing such as clear and interest evoking titles of chapters and paragraphs, clear structure and table of contents, avoiding unnecessary jargon, a clear summary and their like.[a,b] The emphasis in this Chapter is on adequate pointers to references and the use of key-words.

Before embarking, first, something about the way to stimulate potential readers to take notice of the information. It starts already with the cover and the titlepage. These give a first impression of what is waiting for the potential reader. With this author, text or images present themselves. One glance should make clear what the subject is; although it is sometimes attractive to confuse the reader. Starting from cover and title page, the reference data (copyright notice, year of publication, ISBN number, place of issue and publisher), table of contents, foreword (written by a recommending outsider or referee) and introduction, the reader is introduced from his own world into the world of the author. The author and those responsible for the lay-out should picture themselves in this process and shape the publication from the vantage point of potential readers (the target audience), their questions, their pre-suppositions, or lack thereof.

Possible pre-suppositions of the reader should be supplemented or corrected. With this it is prevented that potential readers are thinking after a while “What the hell is this?” A clear text on the back cover, an index of key-words, a list of references and a sensible use of footnotes and final-notes are important conditions as well in order to achieve a publication that invites reading.

5.1 REFERENCES

Reference to texts, illustrations or electronic publications is an important condition for the possibility of judging a publication. To the reader it is an indication of the degree to which the discourse of the author is supported by insight from other sources, or checked against them. Referencing employs key-words. The name of the authors and year of publication are the most important ones. With these two data: for instance (Jong, de and Van der Voordt, 2002) the text of a publication usually refers to a list of literature or a reference list in the final part of the publication: it is a citation. At that spot more key-words per publication should be provided in order to enable the reader locating it in a library or ordering it in a bookshop. For architecture, images and electronic publications are greatly important, so that ‘References’ should rather be used as a term than ‘Literature’. This chapter is usually not numbered along with the chapters of content, although just on conventional, not rational grounds.

List of references

The place of issue, the name of the publisher, the ISBN number and possibly the web address (URL) are important key-words in order to find the publication. If these have been left out in the referral data or in the list of references, the potential reader is de-motivated to look for the publication and consult it himself. When one, for instance, wants to point at this article (Jong, T.M. de and D.J.M. van der Voordt, 2002) this can be done by including in the reference list the following data:

a Elling, R.B., B. Andeweg et al. (1994) *Rapportagetechniek. Schrijven voor lezers met weinig tijd*. Tips and tools for writing reports, feasability studies, procedures and so on, particularly focussing on technical and business administration education.
b Blokzijl, W.J. (2001) *Schriftelijk rapporteren voor bouwkunde*.

Book section:

Jong, T.M. de and D.J.M van der Voordt (2002) *Retrieval and Reference* in: Jong, T.M. de and D.J.M. van der Voordt; eds. (2002) Ways to study and research urban, architectural and technical design (Delft) Delft University Press.

Edited book:

Jong, T.M. de and D.J.M. van der Voordt; eds. (2002) *Ways to study and research urban, architectural and technical design* (Delft) Delft University Press.

Time and place have here been bracketed and are separating in this way clearly authors, title and publisher. This reference has been made with the computer programme Endnote. This database programme is popular in academic circles and used in Maastricht, Rotterdam and other places. It is plugged in in the word processor, and is maintaining all references, preserves them for future publications, provides access to the literature databases on the Internet and edits them according to any desired lay-out (different for each author or publisher) of the reference list in the document processed.

Making a personal database

The present list of reference was made first in Excel, and then exported[a] to Endnote. It is recommended to start a personal list of books and articles, read or consulted, from the start of a study and to maintain it, keeping it up-to-date. It does not only serve recollection of what has been read; it is also lowering the threshold of referring to others when reporting. In Excel the list looks as showed in the enclosed table.

Per publication (row) 30 data may be stored, e.g. number of pages, ISBN-number, abstract, key-words, notes and so on. They need not all to be taken up into the list of literature of a book or article to make the reader find the publication. They are of especially good service in electronic retrieval, if they have been filled in correctly. It is not always necessary to fill in all columns. However, it is important that this possibility remains open. It may also be used collectively.[b] Some staff members of the Faculty of Architecture of TUD ordering a book are supplying key-words with which the content of the book may be characterised according to him. These are added to the list, with the name of this reviewer and are made available to students of certain modules of the curriculum. If they find a title, they may ask the staff member with this title on his shelves: 'Is this a publication answering my question?'

Filling in a list like this requires following some conventions in order to come to a consistent list of literature, so that a computer programme can do its work later. Names of the authors or editors that wrote or edited a publication should be separated from one another by a semicolon (;). One mentions first the surname of the author, without prefixes (like 'Van der') and after a comma (,) the Christian names or initials with prefixes (see the example given).

Reference Type	Author	Year	Title	Secondary Author	Secondary Title	Place Published	Publisher	Volume	Number of Volumes
Book Section	Jong, T. M., de; Voordt, D.J.M. van der	2002	Retrieval and reference	Jong, T. M., de; Voordt, D.J.M. van der	Ways to study and research	Delft	Delft University Press	-	-
Edited Book	Jong, T. M., de; Voordt, D.J.M. van der	2002	Ways to study and research	-	-	Delft	Delft University Press	-	-

26 Conventions of reference according to Endnote

Different reference types

The first row of the preceding list contains standard fieldnames a computer programme can recognise. In database jargon each next row is a record (a document card in a box) with 30 fields (data on each card).[c] The first field is each time the reference type (a book, book section, edited book, article in a magazine, conference proceeding, etc.) In the example two reference types have been used. In the first row (record) the first field reads 'Book Section'. This is an article in a book with articles by different authors, put together by editors (listed under 'Secondary Author'). In the second row an 'Edited Book' is listed. Herein the editors are included as 'Author'. In the literature list they can be recognised as editors by the added 'ed.'. A computer programme such as Endnote adds this automatically to an Edited Book, but not to a reference type 'Book'. This type has just one author, unless his book is part of a series with series' editor. In that case this editor is mentioned in the column 'Secondary Au-

a Excel files may be translated in text-files (.txt) with tabs and may be 'imported' along these lines to practically all database programmes. Endnote only needs adding one line with the word 'Generic' at the start of such a textual file.

b On the Faculty of Architecture of Delft University of Technology such a list of some 1300 titles used in education (also in the first years) is available; occasionally with as many as 100 'key-words' per title.

c In a database stored as a textual file (.txt) the fields are usually separated with tabs, while each record starts on a new line.

thor'. If an Edited Book is part of a series with a series' editor, he is mentioned in a field 'Tertiary Author'.

Endnote can distinguish sixteen reference types with their own lay-out requirements: Journal Article, Book, Book Section, Edited Book, Magazine Article, Newspaper Article, Conference Proceedings, Thesis, Personal Communication, Computer Programme, Report, Map, Audiovisual Material, Artwork, Patent and Electronic Source. Also to those who do not use Endnote, it is important to be aware of these differences. Each reference type uses in a different way the available fields. This way, in the case of Conference Proceedings the name of the conference is mentioned in the field 'Secondary Title' and the venue in the field 'Place Published'. Each publisher has his own conventions for making the literature list. A considerable number of these lay-out conventions is digitally available in Endnote and on the Internet.

Article and publication

A published book also mentions an ISBN number: a sequence of 10 digits ordered in 4 groups. The publisher (407 is Delft University Press) and his language (90 is Dutch) may be derived from it. If the ISBN number starts with a 0 or 1, it is an Anglo-American publisher (3, 4 and 9942 are respectively German, French and Surinam publishers, regardless of the language they are publishing). The final digit is a control digit. Remaining digits are provided for the publisher and the numbering given to the publications himself. A programme like Endnote can not mention ISBN numbers in Book Sections. Therefore, it makes sense to enter the Edited Book as a whole on its own separately. One must select then between key-words of all separate articles. If one is referring to different articles separately, it is superfluous to indicate all the time the data of the publication in which they appeared; furthermore, the articles may be found via key-words immediately.

Many key-words

A few key-words per publication is insufficient nowadays. In a library a search for publications can be carried out using author, title, and a few other reference words. This seldom produces the content required. Edited Books, sometimes extremely important for students, are often characterised by a few reference words.

These reference words characterise the whole book, but do not refer to a useful chapter, for anyone especially a lay-person, which summarises the whole field of study. When carrying out a search in a library, one very quickly chances upon extensive standard books for this field of study, which as a first point of contact with the subject for a lay-person is too complex. Architecture does not have an unambiguous nomenclature which in Chemistry, for example, makes searching pleasurable. This problem is intensified when carrying out a search for images (Maps, Artwork) that are of significant importance for Architecture. An image can say more than a thousand words, but which words are these? Very often an image can portray a tremendous number of concepts in mutual relation (see page 36). It is almost impossible to characterise them using singular reference words. A method invented for this is the Faculty of Architecture's Interactive Image Archive (IAAI, see page 49), which, in time, will also enable texts to be retrieved in a more goal-orientated manner. This method is inspired by formal logic (sentence functions) and the mathematical concept of function a simplified manner. (See page 40 and 225).

5.2 REGISTER OF KEY-WORDS

The last chapter of a book or its end is ideally a complete alphabetical list of key-words for its contents (list of key-words, register, index). Although not usual, a register like that would be quite appropriate for an article as well. Since a register per key-word is pointing to consecutive pages where the key-word is occurring, it is a good author's habit to give in the case of a first occurrence of a professional term in the text its most important definition, description or context. This provides the best possible link to the experiential world of the reader, by giving first a description and only then (between brackets) the professional term. This may be done unobtrusively, without cumbersome sentences 'defining in passing', for instance:

'In this series of drawings one sees a process of increasing accumulation of the built environment (concentration).'

'Concentration' is here the key-word to which the index refers. After such a phrasing, this shorter professional term can be used, since the index is referring the reader directly to the first page where the term is used. If all is well, the context (built environment), description or definition (process of increasing accumulation) is given there.

Not sub-dividing list of key-words

By including on a standing basis the index in the final pages of the publication the reader may intuitively find it at once. State-of-the-art word processors are putting together an index like that automatically when one marks the words concerned in the publications an index word and mark the place where the list should be generated. In the present text the marked key-words are printed with a wide spacing, except in the head-lines. An index is an alphabetical gate to the publication, the table of contents is a systematic one. Therefore it is not logical to make in the alphabetical list of key-words a distinction between a 'register of persons' and a 'register of subjects'. This complicates retrieval without necessity. Since the word processor can assist us in this regard, it is worth the effort to mark author's names, as well for the index, even if they have been collected already in the list of references. This allows the reader to readily return to where he or she has been reading about a given author. An author's name can be used as a label for a line of thought. There is a lot to say for including in the index in addition to key-words and (place) names also crucial adjectives and verbs or words in a different language. These words may be integrated in alphabetical sequence in the index. By the same token it is superfluous to make, for instance, a separate register of English or Latin terms. Let it not be forgotten also, to make images retrievable with key-words; so give each illustration a title with crucial key-words to which the index can point. The word processor can also produce a separate list of illustrations; useful if provenance has to be acknowledged in terms of intellectual property and copyright.

Headings

The table of contents with its pagination in the beginning of the book or article gives systematical entrance to the publication and can contain the central key-words in their context (the headings). This table of contents can be generated in a word processor automatically with any desirable number of levels (chapters, paragraphs, sub-paragraphs), if the chapter and paragraph titles are head-marked at the right level (heading 1, 2, 3). Do not exceed 3 numbered levels and use logically decreasing letter sizes (like 16, 14 and 12 point). Headings should assist the reader in navigating through the publication, should arouse curiosity in the text and represent its content in crucial key-words. In the rules already marked for the table of contents as a heading, the key-words can not be marked once again for the index. After the heading one should return to that key-word in the text, in order to be able to mark it for the index. By starting a paragraph by explaining the heading in different words, legibility is enhanced; especially desirable when the rule is followed that a heading may never exceed one line. When the heading is a good rendering of the content, the table of contents is a concise survey of the proceeding of the discourse. When the table of contents is regarded this way, the line of discourse may show up in a reversed way.

Combined key-words

Next to author and year of publication the title is the third important key-word allowing retrieval of a publication. We talk here deliberately of a 'key-word', although the title of a publication is usually composed of more than one word. In this contribution we recommend key-words comprising several words, since the number of professional publications has increased the previous century to such an extent, that just one single word is pointing to too many publications for convenient retrieval. That is quite clear on the Internet. Just type the word 'building' and one is faced by the task of visiting some 30.000.000 sites. Search engines allow connecting words to the logical terms 'AND', 'OR', 'NOT' or 'NEAR'. The disadvantage of single key-words is that they can not transfer relations between concepts even with those tools, while they are the essence of a scientific document. So see to it, that the most important relations addressed by the publication may be recognised in title and headings and possibly in matching illustrations. Two illustrations next to one another may clarify effectively by their differences and similarities what can be hardly expressed in words. For that purpose poetical means and ambiguous evocative use of language or images is also used. Although this might be functional, it is loosing its aim if it does not connect to the pre-suppositions of the potential user.

Choosing key-words

Making a text retrievable begins by marking reference words which touch on the very core of the matter in question and may be chosen, at some point, when carrying out a search. This must not be limited to substantive nouns. Names of places, persons, adjectives, verbs and even dates can often fulfil an excellent rôle when searching for a text or an image. Articles, conjunctions and prepositions must not be marked, unless these change the meaning of adjacently situated words significantly. Imagine that, in the text fragment below[a], the following reference words have been marked with a marker or by the word processor for the index:

'If you ask a constructor what a hybrid bearing construction is, then he will reply with definitions which have nothing to do with the hybrid character of buildings. Because hybrid load bearing constructions are, according to constructors' definitions, just load bearing constructions that include different construction systems or various materials.'

This provides the following register (using the sortfunction in the word processor if required)

- *Construction systems*
- *Load bearing constructions*
- *Hybrid*
- *Materials*

Compiling key-words

The relationships between these concepts can be expressed partially by re-arranging the words and coupling some groups to one reference word. A classical way of doing this is the hyphen (-), as used in 'Zuid-Holland'. The hyphen also keeps the compiled terms together during electronic selection in an index. This is different with the concept of 'hybrid load bearing construction'. These four words must be considered as one concept with its own meaning, but are separated in the case of alphabetical selection and than loose their meaning.

It is standard practice in the world of computers to replace spaces with an underscore (_): hybrid_load_bearing_constructions. Due to this, reference words, which are of no use as searching terms, are not split into three reference words when placed in alphabetical order or when read by a computer:

- *Construction_systems*
- *Hybrid_load_bearing_constructions*
- *Materials*

The question is, will the term hybrid actually be used in order to search the section stated? If it is thought that the passage will more readily be sought using the term 'load bearing' constructions, load_bearing_construction_hybrid can also be used.

a Weeren, K. van (1999) *Hybride gebouwen en hybride draagconstructies*.

Syntactic connection

Most relationships, when attempted to be conveyed using a scientific text or an image, are not relationships within concepts or variables; they actually lie in between. These relationships are seldom symmetrical: there is a primary active variable (independent variable) (x) and resulting from this a passive (dependent variable) (y), an input and an output, a cause and a consequence, but also a condition and a possibility created through this, such as insulation and internal temperature, columns and beams.

Colloquial language almost always establishes such a relationship in the syntax of a sentence with an active subject, (who or what does what?) a predicate, (what is being done?) and a passive direct object (who or what undergoes the action?) In formal logic, such a sentence is abbreviated to a sentence function: y(x). See also page 40 and 225 This can be interpreted as: y as an action or working of x. This abbreviated representation is suitable for use as a reference word, when the bracket is used as a special syntactic coupling symbol and all spaces are omitted: direct object(subject). Van Weeren's text can therefore be represented as follows:

load bearing construction(hybrid construction system and material).

The load bearing construction is determined by the hybrid construction system and material, not the reverse, expressed as:

construction system and material(hybrid loadbearing construction).

This would imply that the construction system and material could have been chosen as a consequence of hybrid uses of the load bearing construction. If both are to be considered (inter-action) then both have to be mentioned as a key-word.

'Nested' summaries

A representation of A as an action of B as an action of C, A(B(C)), is known as 'nesting' in the world of computer programming. Van Weeren continues his text using an example from the municipality of Zoetermeer.

'Hybrid load bearing construction: furniture mall Zoetermeer

The Furniture mall in Zoetermeer can probably be called a hybrid building. The building is used for three different functions: basement parking, large-scale shopping areas above, and above this, residential housing. Co-incidentally, here too, hybrid constructions are present, but they have little to do with the fact that there are different functions in the building. At the entrance, in one singular detail different construction elements come together: a pre-fabricated concrete column, a pre-fabricated concrete beam, a steel beam and a steel column with an special form, covered by a pre-fabricated floor, which in some areas is extended with concrete floor segments which were poured on-site.

The fact that steel, on-site poured concrete and pre-fabricated concrete are inter-mingled with each other has nothing to do with the hybrid character of the building. This is just a consequence of insufficient space below the ceiling. The (cheap!) pre-fabricated concrete construction system did not generate enough space. Therefore, an on-site change to an integrated steel beam in the floor was implemented. It was also impossible to realise the required form of floor finish using (cheap) pre-fabricated concrete; this however was possible using on-site poured concrete.

Construction costs are a major factor for the design, especially with projects such as a furniture mall. This is even more so for the load bearing structure. The floors account for most of the cost of the load bearing construction. An unbeatable alternative in the area of floors in this situation is pre-fabricated concrete hollow core slabs. These elements cost Dfl. 70.— per m^2 for a span of approx. 7m, which was implemented in this case, with total construction costs of around Dfl.2000.— per m^2. If a form cannot be constructed in one go, with this material (rec-

tangular slabs), then the special segments of the form are created using on-site poured concrete. This hybrid is cheaper than opting for a total system which could be manufactured in the form desired.'

This relatively compact text can be summarised using three reference words. The actions within actions are made explicit using 'nesting'.

furniture mall(parking, sales area(furniture), housing, entrance(pre-fabricated versus on site pouring), Zoetermeer)

pre-fabricated(concrete(column, beam, floor(hollow core slabs, costs, steel(girder))

on site poured(floor segment(lack of space(ceiling versus floors), floor finish form), costs)

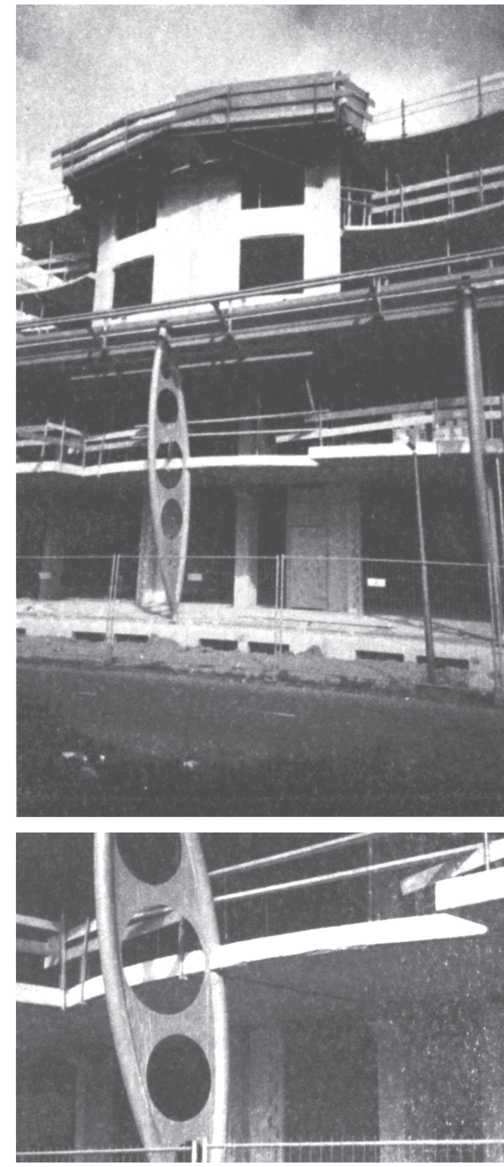
In the index, the content of this book is retrievable this way.

The syntax of a text

Research proposals can be analysed in this way. Using the reference words of such a text could be more efficiently and concisely re-written and contextually assessed. It could then be seen at a glance if too many, too few or too complex (multiple nested) relationships are made and how operational they are for research (computable, measurable). In the interim reports, analysed in the same way, new relationships can be involved in the research and others removed. One can also train oneself in making notes and making summaries of the readings. In the future intelligent linguistic databases will be created, which can comprehend 'summaries' such as these. Besides this, the content of a record could be represented as follows:

Recordname(fieldname1(fieldcontents), fieldname2(fieldcontents)…)

The most important area of application and also the reason to change to syntactically compiled key-words is the problem of the retrievabliltiy of images.



27 Shopping mall in Zoetermeer, under construction; entrance and construction detail

5.3 IMAGE SEARCH ON INTERNET

The Internet is the largest image archive in existence. The images are inexpensive, quickly retrievable from any location, sometimes in motion (animated GIF) and mostly in colour. Animated gifs are excellent for placing transparencies over a drawing in order to show alternating images: all locations remain at the same place, therefore, no-one has to overcome any locational comparability problems. However, internet images are coarse (the screen representation varies from 72 dots per inch (dpi) to extremely rough images (quick loading thumbnails), or they cost too much download time (for high resolution images). The Saariste website,[a] for example, gives numerous photos of historical architectural examples per architect. High quality photos can be ordered via the site. Many architectural offices have a similar website[b] from which simple images of their work can be downloaded directly from the web (refer to source and web site!) and used in a word processor or a drawing programme.

These coarse images are only suitable for printing small images. Line drawings without filled-in colour areas are often not very clear. It is possible to obtain drawings as CAD-files (DXF-format or otherwise) from the web.[c] This is not a raster file, but a vector file with an unlimited zoom focus, which can easily be edited personally.

The Architecture Faculty building[d] in Delft, for example, can be obtained from the web in layers for educational purposes. In order to do this you need a special programme on your computer (a plug-in). The global map of the Netherlands can also be downloaded in many layers and in various file formats without using a plug-in.[e] If you have access to a drawing programme such as CAD, Corel Draw or Adobe Illustrator, this can be used to compile various layers, colour, cut out details and, if necessary, re-convert into a raster file which can then be used in a written report using a word processor.

a http://www.bk.tudelft.nl/d-arch/agram/
b http://www.architectenwerk.nl
http://www.archined.nl, http://www.luna.nl/~xino/
c http://www.greatbuildings.com
d http://www.bk.tudelft.nl/users/barendse/internet/onderwijs/bk_dwgf_2d/bk_dwg_2d_frm.htm
e http://www.ai.bk.tudelft.nl/projects/data/top_data.html

Research shows that Internet users become depressed due to the sheer volume. The main problem of this medium is the search function. The images are poorly documented and therefore difficult to retrieve using scientific image properties. Image recognition using colour and global composition is possible;[a] image recognition by means of architectural structure is still in its infancy.[b] The Interactive Image Archive is dealt with below in order to give insight into which image characteristics are of primary importance as reference words in order to enable image retrieval.

Image and image characteristics

The TU Delft's Faculty of Architecture has developed an Interactive Image Archive (IAAI), the purpose of which is to store images using scientifical characteristics and in doing this making the images retrievable for students, graduates and researchers. It comprises a decentral input programme and a central programme for data processing and output to the Internet.[c] In future development the 100 best documented and the 100 most consulted images will be automatically shown on the Internet site.[d]

A committee then chooses monthly the scientifically or esthically best for a top ten which serves as a homepage. When one of these images is clicked upon, an enlarged image appears with many key-words. These reference words can be clicked on in order to show the images (small images), which comply with that characteristic. These thumbnails are also 'clickable' which shows enlarged images with reference words etc.

Not every image has an equally good provision of reference words. This depends on the individual effort of suppliers (students and researchers) at the time of input. The input programme is for Architecture students (ca. 3000) and staff (ca. 300) and can be downloaded from the stated website using every computer within the faculty. The image, to be entered from the computer, is shown and a series of questions is asked, both scientifically relevant as image characteristics, from construction drawing to regional plan. Not all reference words are required to be filled in. Student number or log-in name, authors name, frame and grain (scale) are compulsory, and location, if possible. The date is automatically recorded. The Faculty of Architecture is considered as the copyright publisher and the place of publication is Delft. At the end, the opportunity is given to enter free, syntactically compiled reference words, possibly using simultaneously provided professors' much used terminology or those of the Faculty library. The input programme sends the data to a personal server space of 50Mb, which is allocated to each student and to the central data processor, which continually compiles the Internet page.

Scale

One of the most powerful search functions for images in the IAAI is scale. Scale indications such as '1:1000' are dependent on the paper format when determining what is readable. This is why for computer images the radius of the 'frame' and the 'grain' (see also page 210) of the image replace these usual indications. The radius of the frame means the smallest circle described (from the series 1,3,10,30…mm, m, or km, see page 37) which the image portrayed can contain in every direction or the largest registered circle within the boundaries of the image. The radius of the grain means the radius of a described circle (in the same series) that could in reality contain the smallest detail readable from the image. The relationship between grain and frame determines whether the image concerns a contract drawing (grain/frame = 0.001), a sketch plan (0.01), or a rough draft (0.1). When choosing grain and/or frame the search assignment can not only be limited to construction drawings, architectural or urban development drawings from the archive, but within this, distinctions can be made between rough drafts, sketch plans, final designs or contract drawings.

a http://disney.ctr.columbia.edu/WebSEEk/
b http://www.bk.tudelft.nl/Informatica/koutamanis/onderwijs/index.html
c http://ai.bk.tudelft.nl/
d http://ai.bk.tudelft.nl/

Location, concept and perspective

If during the input into the IAAI, geographical co-ordinates or postcodes have been entered, the location is automatically mapped on the Internet site. A location on the map of the Netherlands can then be clicked on, in the IAAI website. The output programme then shows every entered project situated at this location. In time this map can be ‘filled’ with three-dimensional CAD drawings, which can be zoomed in upon, into the actual rooms. In this way within a few years the Netherlands will be virtually transformed by the designers of the 21st century into a sort of flight simulator scenery.

Some locations are popular for many projects resulting in an overlap of designs in this landscape. The total image must then be limited to a specific future perspective.[a] For example, one may only wish to view designs which are intended for the context of shrinking European Economy, a steering national government, a traditionally orientated local culture, etc. The input required for this per image, must place the image in one context (everything which falls outside the framework and structure) and in a future perspective (see diagram on page 38).

This is not only important for such selections in futuristic spectacular computer applications; it also has crucial functions for utilisation and supply of an image archive. When nothing is known about the context and the perspective in which an image has been placed, the external effects cannot be assessed, it is taken out of context and is mostly of no other use than inspiration. A design may fit in and function in a particular context, and not in another. The image supplier, usually the designer, is, therefore, requested during the input programme to enter the intended functional period for the image portrayed (plan horizon) and which perspectives per scale level it provides as probable future (see page 7).

This awareness appears to have a high educational value and aids systematic creation of a graduation thesis. If, on the other hand, the user or assessor has totally different perspectives regarding the probable future, this does not automatically mean that this will be judged as a poor assessment, if the designer has explicitly stated his perspectives. In turn, the assessor is challenged, to make future pre-suppositions explicit and to compare this with what the designer or researcher had in mind outside the design. Subsequently it can be assessed as to whether the design in various perspectives of various assessors holds its ground or not, therefore allowing the ‘robustness’ to be determined for various scenarios.

Readability

Various actors in the construction process want to be able to read various effects (environmental, ecological, technical, economical, cultural and administrative) using the design drawing. Images are sought in which these effects are ‘readable’. The majority of effects are only readable within a specific context and in a well-described perspective.

Only when such questions have been answered, can questions be asked regarding the effects, which in that specific context and from that perspective can be read from the drawing or image. In the input programme of the IAAI the diagram on page 38 is used. Which effects are precisely readable is not asked, but of which nature (environmental, ecological, technical, economical, cultural, administrative) and scale (1,3,10,30…. mm, m, km) their action is.

Distinction is made between intended and unintended effects. The intended effects are desired by definition, they contain (if present) the programme. The unintended effects may be desirable and undesirable. The unintended effects cannot all play a rôle in the designing, however the image producer can involve them in the accountability of his design in retrospect. It is only of a scientific interest to specify by scale and nature in advance, even though they do not yet play a rôle in the designing. The awareness of such effects is important when choosing participants in the construction process and for references during research.

a It is requested that within the plan horizon and per scale level the environmental (concentration<>deconcentration), ecological (homogenous<>heteregenous), technical (combination<>specialisation), economic (shrinking<>expanding), cultural (tradition<>experimentally directed) and administrative (directive<>following) perspectives are specified. They are noted as syntactically compiled reference words.

5.4 REFEREES

Texts and images get a scientific status when they are actively exposed to the possibly refuting judgement of experts outside the personal circle (referees). This is pre-supposing in any case that they can be judged; in its turn this is pre-supposing that they can be found again. With images pretending at any moment a possible future (designs) this potential to be judged presents a problem that may be partly solved by making the context, perspective and demonstrable effects on the presented (future) image explicit. The designer should actively start searching critical referees. One who is not interested in criticism and critique is not fit for scholarship. To the student this is the teacher or researcher recognised as a judge for a certain professional area by his appointment; possibly within the Faculty itself. For the university researcher this is someone outside his own university. Up to now editorial boards of highly regarded journal or publishers are catering for such a judgement (peer review). With the rise of the Internet, Internet-'journals' are coming into being, only to be distinguished from normal web-sites by organised peer review.

A publication with scholarly ambitions can be recognised by the circumstance that the referees can be traced. For referees it is vital that all aspects of a study: texts, images, references (which is not the same as referees) can be retrieved.

6 DESCRIPTIVE RESEARCH

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A lot of knowledge is needed for a good design; one that is functional, affordable, with architectonic interest etc. The same applies to a wealth of other activities within the architectural discipline; as there are policy development, spatial planning, formulating programmes of requirement, building and maintenance. Knowledge may contribute to well-considered and well-founded decisions. A methodological way to collect knowledge is the precise description of reality. The subject of description can relate to facts and wishes, to people and material objects, to plans and realised buildings. Examples are charting the housing preferences of potential inhabitants of VINEX-locations[a], a careful description of a building,[b] or plan documentations.[c]

A lot of insight may also be derived from detailed description of processes; as there are the thinking process of a designer or the decision making process concerning large projects in infrastructure. Two questions are of prime importance: 'What is going on?' and 'How is it going?'[d] The results may be presented as texts, drawings, tables, graphs, statistical notions (mean, spread), maps like the one of a city or a function chart, web-sites and databases. The description may be focused on individual variables and on relations between variables. Suppose, that local authorities want to know the opinion of the community on different designs resulting from a prize contest. Then it could be interesting to find out whether the preferences are differing per age category, or that 'laymen' and professionals are differing in preference.

In the present contribution we are describing firstly some characteristics of descriptive research. Next, we present examples of descriptive research and show how results can contribute to development of the architectural discipline. We conclude with recommendations.

6.1 CHARACTERISTICS OF DESCRIPTIVE RESEARCH

It is characteristic for descriptive research that it is restricted to factual registration and that there is no quest for an explanation why reality is showing itself this way. In principle, descriptive research is not aiming at forming hypotheses or development of theory. Another characteristic of descriptive research is objectivity or neutrality. Descriptive research is about describing how reality *is*. In this regard descriptive research differs from prescriptive research that is primarily concerned with the question how the reality *should be*. Descriptive research is making inventories; prescriptive research is normative.

With descriptive research in its purest form explaining and evaluating is left to the reader or to other disciplines. This applies for instance to the statistical surveys of Statistics Netherlands (CBS). Disciplines like geography (description of the earth) and social geography (description of the spatial aspects of social phenomena) are largely based on descriptions of reality. However, in practice there is a gliding scale from pure description to analysis, interpretation and evaluation. The same applies for the dimension objective <> subjective. Analysis and interpretation of the data are seldom completely objective. As a consequence, a biography (description of a life), or a plan documentation, is always partly, or even strongly coloured by the selective perception of the author.

When a study is explicitly focused on looking for explanation or on formulating a hypothesis or theory, we talk about 'exploring study' or 'study(explorative)'. Explorative study starts without clear preliminary ideas, at best with vague suspicions, looking for linkages and concluding with a careful explanation for what is found. In the case of testing study there is already in advance a coherent body of statements on reality (hypotheses). Next, whether the

a See e.g. Wassenberg, F.A.G., H.M. Kruythoff et al. (1994) *Woonwensen en realisatie van VINEX-locaties in de Randstad*. Priemus, H., F.A.G. Wassenberg et al. (1995) *Mozaïek woningmarkt stadsregio Rotterdam*.

b See e.g. Tettero, W. (1991) *Ministerie van Sociale Zaken en Werkgelegenheid*.

c See e.g. the collections of building plans of Risselada et al and Barbieri et al, that are discussed in subsection four of this Chapter.

d Baarda, D.B. and M.P.M. de Goede (2001) *Basisboek methoden en technieken*. See also Bechtel, R., R. Marans et al. (1987) *Methods in environmental and behavioural research*.

theory is supported by observations in reality is checked by study. That type of study is trying to provide more certainty as to the correctness of the hypotheses. When the results of study are providing more and more support for the hypotheses (in the jargon: confirmation of the hypotheses), the confidence in the theory is increasing. The tripod descriptive – explorative – testing is closely related to the empirical cycle as described in the classical monograph '*Methodology*' by A.D. de Groot.[a] Descriptive study and research is predominantly orienting on the observation stage, explorative study on the induction stage, testing study on the stage of deduction and testing.

6.2 METHODOLOGICAL CHOICES

The approach of descriptive research can vary greatly. Usually a choice must be made, given the limited means of study, between research aiming for study in width (a limited number of data on a lot of objects) and study in depth (for instance thorough description of one single case). The advantage of a case study (casuistry) is that it allows deeper penetration into the core of the matter. The corresponding disadvantage is that it is often difficult to generalise on the basis of one single case and to draw general conclusions.[b]

A second methodological choice is related to systematics. A lot of descriptive research is trying to describe reality according to a systematic approach rigorously followed. Usually it is based on theoretical considerations and is dependent on the objective of the study as well. Our own study of the decision making surrounding a pilot project in office innovation made use, for instance, of the study scheme presented here.[c] It was endeavoured to get, per stage, a picture of the agents concerned, their tasks and commissions, (changes in) objectives etc. In contrast, the phenomenological approach is refraining from a systematic approach on purpose. One wants to get into the heart of the matter and is trying to let the data speak for itself as much as is possible. It is only afterwards that an ordering is made on the basis of the findings. The phenomenological approach is particularly suitable for explorative study, when it is of prime importance to develop new ideas and insights. The emphasis is then not so much on generalising, but on generating knowledge and on building hypotheses.

When one does not look with a certain distance ('from outside') at phenomena, but via introspection ('looking within') a significant degree of subjectivity may well result; particularly when the introspection of the student himself is concerned and not the introspection of his respondents. This need not present a difficulty; as long as the material is primarily used for building hypotheses and the student is open to objective checking by other people or objects.

	Initiative	Preparation	Design	Construction	Use and maintenance
Players and responsibilities					
Objectives		The cells include a description of the items per phase			
Activitities					
Aimed result					
Time schedule					
Time actually spent					
Costs					
Information and tools					
Positive and negative experience					

28 Possible framework for a systematic description of a plan process

A third methodological choice is the one between quantitative study and qualitative study. A study of demographic developments or a description of the stock of homes according to certain characteristics is suitable for a quantitative approach. Advantageous in a quantitative approach is the possibility of analysing data statistically with the assistance of advanced software like Excel and SPSS.[d] Vast quantities of data may be summarised succinctly in central magnitudes such as 'mean' and 'spread' (see page 219) and in graphs and tables. Another advantage is the high degree of objectivity. However, not all phenomena can be expressed in numbers ('imponderabilia'). A description and analysis of the oeuvre of an architect is calling for a more qualitative approach. For a practical guidebook for the approach of qualitative study we refer to Baarda et al.[e]

6.3 METHODOLOGICAL POINTS OF ATTENTION

A description of an object or process is realised from a specific context or perspective. By the same token, every description is in a certain sense subjective. This applies to the choice of aspects to be described as well as for operationalisation (the way of 'measuring', see also page 92) and interpretation of the results. By making the context or line of approach explicit

a Groot, A.D. de (1961) *Methodologie: grondslagen van onderzoek en denken in de gedragswetenschappen*. English edition: (1969) *Methodology: foundations of interference and research in the behavioural sciences*.
b Swanborn, P.G. (1996) *Case-study's: wat, wanneer en hoe?*
c Voordt, D.J.M. van der (1999) *Universitair Vastgoed: de leer- en werkomgeving*.
d Ronden, J. den and W. van Nieuwenhuysen (1996) *Handboek SPSS voor windows*.
e Baarda, D.B., M.P.M. de Goede et al. (2001) *Basisboek kwalitatief onderzoek*.

the results of descriptive study can be better judged as to their value. Checking them against the judgement of others increases reliability and objectivity. In this context the term 'inter-subjectivity' is often applied.

In addition, it is important to define concepts used clearly; this precludes interpretation problems. A topic of attention is the change in meaning of a concept in the due course of time. This may cause that results from study from different historical periods are difficult to compare. Striking examples are the standard company classification with which CBS is describing industrial development, the legends of maps and borders between municipalities. When these are changing over the years a calculation factor is needed in order to make them comparable. A related point of attention is the size of the grain of the measurements and the units used for measuring. Is utilisation of space described per postal code, per municipality, or per sub-municipality? Are the project costs of a plan description referring to the costs of investment or to the costs of construction? Is the scale of the graph a multiple of ten, or of hundred? Which operations on the data (adding, calculating a mean or ratios) are permitted? Are we dealing with data on individual people or objects, like year of construction or its state, or with aggregated data, like the average year of construction for a range of buildings? These are important questions to ask, not only while defining and measuring variables, but also while being informed on results of study by other parties. Subconsciously – or maybe even consciously – the presentation of data may give a distorted picture of reality. A booklet such as '*How to lie with statistics*' speaks in this regard for itself.[a]

6.4 EXAMPLES OF DESCRIPTIVE RESEARCH

Descriptive research is often used in the Faculty of Architecture as well as outside it. It partly concerns study linked to individual projects and direct application, with the aim of being able to solve the design task: think of a description of urban characteristics of a building location or an inventory of the number of parking lots in the direct environment. However, in these cases rather finding out and registration than study proper is called for. The examples we will be discussing have been chosen on the basis of sufficient depth, methodological approach and the intention of contributing to the body of knowledge of the architectural discipline. Two examples relate to a project description; in the present case objects from the built environment. The other two examples concern descriptive study of an individual thought process and a collective decision making process.

a. Phenomenological studies

An example of a phenomenological approach is the introspective study of Van Lennep of the hotel room.[b] In it, the author is in search of the essence of inhabiting a room. For that purpose he analyses what it is that makes a room a 'room of one's own'; and why it is possible to feel at home – after a while – even in a hotel room. On the hotel room:

> *I have paid for it. In that sense it is 'my' room, but in no other respect. Just hours before, it was someone else's room. His traces have been wiped out with care. The hotel room is for everyone, so it belongs to no one. Even if I do not approve of the engravings on the wall that does not disturb me, for it is not my room after all. While unpacking, the room is already belonging more to me. If I have slept in it and return in the evening, the feeling increases. The hotel room does not only give me the experience of inhabiting in an original form, it is teaching me a form of existence that I hardly know at home; or not at all. I do not have any obligation. My activities are having a freedom, a being loose from everything that I do not know in this form at home. The hotel room is still indicating something of the adventure, a new task, after which one goes home contentedly. Dirty hotel rooms or with shoddy furniture do not evoke the sense of feeling at home. If a hotel room is too expensive, the same is true.*

A second example is the PhD. thesis of Pennartz.[c] The subject of the study is the significance of space and spaciousness for the social conduct of people. The author describes three em-

a Huff, D (1954) *How to lie with statistics*.
b Lennep, D.J. van (1956) *De hotelkamer*.
c Pennartz, P.J.J. (1979) *Mensen en ruimte, een studie naar de sociale betekenis van de gebouwde omgeving*.

pirical studies, one quantitative and two qualitative. The study is aiming at building a theory on the influence and experiencing of the built environment with regard to habitation. Theories and concepts from the social sciences are those predominantly used. Space and time are seen as framework for human activity. By way of an analysis of the relation between spatial characteristics of the home, characteristics of its inhabitants and the interest they are taking in privacy (studied via a written questionnaire) the aspects have been formulated influencing most strongly the wishes and appreciation with regard to privacy in the home. It is shown that the importance people associate with privacy is hardly dependent on spatial characteristics of the situation in the home; if at all. However, as a part of human behaviour, privacy is influenced by it, especially in the case of children. In addition, privacy proves to be an important aspect of valuing the home.

For the qualitative part of the study 25 families were interviewed on feeling at home, the functions of the different rooms in it and cosiness at home. The talks have been recorded and typed out. On the basis of a content analysis items have been selected for further working out; like 'knowing one's way around everywhere', 'having control over your own time', or 'the meaning of the place of the space'. Per item, texts were collected from the interviews and summarised. In this the original data has been maintained as long as possible in its context intact, receiving minimal interpretation. Finally 'constant structures' have been distilled from this. For situations within which people are feeling at home this is, for instance, "being free from social control, not needing to respond to certain expectations of others and being able to withdraw from observation by others", and also "being significant to others, getting assistance from them and giving it to them, belonging to them". The structures have been largely formulated in terms of relationships with other persons. Spatial characteristics have been made hardly explicit, while these are in fact the conditions determining to what extent certain human activity can take place. For the theme 'cosiness' spatial characteristics were more explicitly taken into account.

By inquiry in time and place, or when and where the home is at its cosiest, data was collected on the significance of the place of activity, the structure and size of the space. All this is illustrated on the basis of parts of the interviews. Closure of spaces, the possibility to partake in collective activity and to observe one another determine largely whether a space is experienced as being cosy. In this, size and shape are important factors. Work and great emphasis on efficient facilities are lowering cosiness. Next to spatial characteristics, the characteristics of the activities are influencing the experience of cosiness as well. Taking pleasure in activity, beyond obligation and absence of boredom are enlarging the feeling of cosiness. Pennartz relates his findings to future developments in the area of work and leisure time and the significance the home is going to have in the future.

Comment

Both studies are providing a deeper insight in – at first sight – very common phenomena. However the conclusions are very global and have been translated hardly in spatial implications: that is largely left to the policy makers and the designers themselves. Often the thread is picked up by different studies, like the one by Marja van der Werf focussing on inhabitant preferences and usage quality.[a] On the basis of studies by others – Pennartz among them – she is providing realistic guidelines for a usage-orientated home. Another example is given by Franceline de Jong.[b] She ordered the results from a large number of habitation preference studies per part of the home; on this basis she put forward a theory on the relation between inhabitant characteristics and habitation preferences.

One disadvantage of the phenomenological approach is its labour-intensity and the risk of a lack of balance between a lot of material and few conclusions ready for application. Perhaps this is the reason that the phenomenological approach is not often applied in the environ-

a Werf, F. van der (1993) *Open ontwerpen*.
b Jong, F. de (1997) *Woonvoorkeurenonderzoek: theorie, empirie en relevantie voor de praktijk*.

ment of the designer's discipline. Usually the wishes and preferences for habitation are enquired into as directly and concretely as possible.[a] A descriptive study by Wassenberg *et al.*, for instance, is addressing the question *what* should be built on VINEX locations and *for whom*. Attention is also given to policy and boundary conditions. Use has been made of study of the literature, discussions with parties in the market and a poll among those who are considering to move to a VINEX home. The pre-suppositions of the market parties prove to differ from the results of the poll in several respects. This underlines the usefulness of empirical study. Building in high densities will not be accepted by many consumers. For most of the candidates high-rise apartment buildings are not a good solution. Particularly people who intend to move to a suburb want a garden. Its absence can only be compensated for by an extra high quality of the immediate surroundings (water, exceptional quality of greenery). Parking garages are not appreciated. The most important requirement is a lot of space within the home. Consequently, less surface space is not a good solution for building in high densities.

b. Architectonic studies

Between 1985 and 1991 the Faculty of Architecture TUD produced seven '*Architectonic Studies*', edited by Leen van Duin *et al.*[b] It was tried, on the basis of plan analyses and interviews with designers, to get better insight into the objectives and design methods of architects. The series is a next step following four notebooks in the education module '*Architectonic Designing*' (1981–1984). Around the change of the millennium a book was published on hundred years of Dutch architecture 1901-2000'.[c] In it, a large number of plan discussions was collected once again. In the plan analyses, intensive use is made of a systematic thematic fourfold structure: 1) effectiveness, 2) intention (programmatic analysis, focused on functionality), 3) material form and, 4) image. This ordering is derived from an article by P. Frankl dating from 1914.[d] The interviews with the designers are following the design process between the commission and the final design.

In contrast to architectonic studies, the collections of building plans of large and industrialised housing projects, libraries, homes and theatres restrict themselves largely to description of the plans.[e] In the preface to the '*Collections of building plans: libraries*' Barbieri states that this collection intends to offer students the wherewithal needed for formulating and then solving the problem of the 'construction' of the architectonic design of a specific building type. The book is meant to be an educational instrument for architectonic designing. It is presupposing a methodology and apparatus of epistemological means and techniques. Point of departure is that a design, following selection and combination of a sequence of parts and elements, can be constructed into an architectonic whole. The collections of building plans is providing the ingredients for this, by describing for an array of libraries a number of functional, constructive and formal aspects. Criteria for the selection of the plans are lacking. In the '*Collections of building plans for the basis*' however – with photographs, blue-prints, cross-sections and details of forty homes – it is indicated which aspects are the basis for selecting the plans; for instance type of home, floor plan, type of articulation. By making this visible the plans become better legible and comparable. In addition the introduction is providing a number of questions, clustered in themes like technique, process, environment, type, situation and programme. These questions establish a handy utensil to study the plans systematically.

Comment

The plan documentation in architectonic study can be seen partly as a descriptive study. However, they are going a step further by putting the plans in a social context, by tracing underlying arguments and comparing plans to other plans. There is a lot to be learned from this. An evaluation in the form of a valuing judgement, drawing lessons from plusses and minuses and distilling designing principles and representative variants of solution is neverthe-

a See Kempen, R., H. Floor et al. (1994) *Wonen op maat*. Wassenberg, F.A.G., H.M. Kruythoff et al. (1994) *Woonwensen en realisatie van VINEX-locaties in de Randstad*.
b Duin, L. van (1985-1991) *Architectonische studies 1-7*.
c Barbieri, S.U. and L. van Duin (1999) *Honderd jaar architectuur in Nederland, 1901-2000*.
d Frankl, P. (1914) *Die Entwicklungsphasen der neueren Baukunst*.
e Risselada, M. (1993) *Plannenmap: het ontwerp van het grote woonhuis;* Risselada, M. (1996) *Plannenmap: het ontwerp van het geïndustrialiseerde woonhuis;* Barbieri, S.U., L. van Duin et al. (1997) *Plannenmap: bibliotheken;* Haaksma, S.H.H. (1999) *Plannenmap voor de basis;* Barbieri, S.U., L. van Duin et al. (2000) *Plandocumentatie theaters*.

less largely absent. This is applying even more for collections of building plans. Apart from modest inroads into plan analysis, it largely concerns a description of the plans. This can be defended as an educational means for students. But for the development of the profession it is a missed opportunity. Studies like this would increase in value by adding a comparative analysis of the plans and by Post-Occupancy Evaluation (see page 151) of realised buildings. This is giving better insight into alternative approaches of design, relations between means and objectives of designing and advantages and disadvantages of variants of solution.

c. Architectural thought

An example of a clear and systematic description of a process is Hamel's' study of designing processes from a cognitive-psychological point of view.[a] Based on a review of literature on design methodology, Hamel developed a descriptive model that represents experienced architects reasoning during the design process. The next step was an empirical test of this model using verbal protocols of architects thinking aloud while working on a design. The author concludes that a design process consists of repeated cyclic processes with three principal steps: analysis, synthesis, and choosing of forms.

- Analysis includes a review of the task, collecting additional information and dividing the total problem into sub-problems. This decomposition is based on different dimensions, like functional aspects, aesthetics, construction aspects and town planning.
- The synthesis focuses on solving sub-problems, an integration of sub-solutions for each dimension and subsequently integrating these sub-solutions into one overall solution.
- Choosing forms is described as giving shape to the solution in such a way that the design can be considered as 'architecture'.

According to Hamel each step includes three stages: orientation, execution, and evaluation. The designer's task consists mainly of transformation (from text to drawings, from user's activities to square metres), switching (from concept to detail and vice versa, from one sub-problem or dimension to other sub-problems and dimensions) and feedback (from solutions to objectives).

Hamel's descriptive model fits in with other design methodology models that are partly descriptive, partly prescriptive. Lawson[b] discerns five tasks: preparation, analysis, synthesis, evaluation and communication, which continually inter-change. However, some differences appear between Hamel's (a psychologist) the models and the other authors (mostly architects or engineers):

- In prescriptive models, 'analysis' consists of compiling and structuring the problem, investigating data and identifying objectives, whereas Hamel's descriptive model highlights gathering information, decomposing the problem and solving sub-problems.
- In most prescriptive models, synthesis is conceived as generating solutions, whereas in the descriptive model the search for solutions is divided into two separate steps. Step one is searching for a solution for each sub-problem separately (analysis), step two is finding a combined solution for the design problem as a whole (synthesis).
- In prescriptive models, shaping is primarily directed towards aesthetic experiences, whereas according to Hamel, the designer is also looking for 'elegant' solutions, using no more means than necessary.
- In the prescriptive models evaluation is interpreted as overall activity, as a means of weighing up solutions against objectives. According to Hamel evaluation is a part of every step in the process: each sub-solution is evaluated with reference to relevant criteria. As such, design processes explicitly show characteristics of problem solving processes and are related to the TOTE cycle of systems analysis: Test → Operate → Test → Exit (see page 254).

a Hamel, R (1990) *Over het denken van de architect: een cognitief psychologische beschrijving van het ontwerpproces bij architecten*.

b Lawson, B.R. (1997) *How designers think: the design process demystified*.

According to Boekholt[a] the sequence is not fixed. Processes are drifting from formulation of objectives to generation of solutions and (in between) evaluation of solutions. It may also happen that a solution is generating new objectives, or that an evaluation necessitates new analyses, before new (partial) solutions may be thought out.

Comment

Descriptive models of the designing process can be used for testing prescriptive models and founding them empirically. Furthermore, designers can mirror their own activities in them. Hamel also analysed for all steps in the designing process what a designer should know and what he should be able to do. This is making his study not only theoretically interesting, but also socially relevant, particularly for education in designing. The difference in problem formulation, use of language and framework of concepts of scholarly students and architectonic designers is posing a problem. Hamel's suggestion for shared authorship would perhaps alleviate this problem.

d. *History of the emergence of the Bijlmermeer*

Amazement about the radical break in the Dutch building of cities caused Maarten Mentzel[b] to start a search for the backgrounds and motives for designing the Bijlmermeer. That settlement in Amsterdam was designed in the late sixties. The aim was an exceptional example of modern town planning, inspired by Le Corbusier's ideas. Soon after completion, the quarter became problematic. His thesis contains a systematic description of the process of realisation and the habitation history, demonstrating a cleavage between the expectations of the planners and architects and reality. His most important sources are existing documents and articles in newspapers and the professional media. In contrast to Pennartz, postponing the selection of data as long as possible, Mentzel is orientating his study primarily on continuity and on changing designing ideas, as well as on factors influencing them. He is paying attention to the (habitation) buildings as well as to the environment, motives and ideologies and the planning process. The results have been placed in a theoretical framework with three dimensions: knowledge, group and organisation, and planning. For this dimension of knowledge a study is made of what the importance and influence of knowledge and ideology has been and how insights from the sciences and the arts have been dealt with. The dimension 'group and organisation' is high-lighted from social-psychological mechanisms, with special attention to the functioning of the small group that was charged with the formulation of a plan. The study of the planning dimension is focused on the initial stage during which the objectives were formulated.

With regard to the knowledge dimension Mentzel concludes that a small group of people dominated the planning process. The choice for high-rise building is purely based on the ideas of (urban) architects and planners. Second thoughts generated by urban studies and results of studies in habitation preferences have not played a rôle of any importance. The same is valid for socio-economic developments like an increase in spending income, leisure time and mobility. Ideas from outside were only admitted if they fitted into the shared striving for a 'daring' design, leading to distinction. The planning group felt itself supported by pleas for systematic building and labour-saving building devices – among others from the national Minister at the time, Bogaers – and by a report from the High-rise / Low-rise Committee stating that high-rise is requiring for broad segments of the population 'just' an adaptation of style of living and its civilisation.

The dimension 'group and organisation' is analysed according to the theory of Janis and Mann. They formulated seven criteria for an ideal process of decision making. It is essential that decision shapers should study with the information from experts objectives, and the values associated with them, and audit alternative solutions in terms of costs and risks. According

a Boekholt, J.T. (1984) *Bouwkundig ontwerpen: een beschrijving van de structuur van bouwkundige ontwerpprocessen*.
b Mentzel, M. (1989) *Bijlmermeer als grensverleggend ideaal*.

to Janis and Mann, reality often differs strongly from a rational decision process and the shaping of decision is characterised by thinking as a group. This applies in particular when there is a strong coherence within the group, isolation, no procedures for methodical searching and little willingness to look for different solutions, see also page 389. Conditions like these can readily lead to decisions with great disadvantageous consequences. Mentzel is showing that the conditions mentioned were emphatically present in the planning process of the Bijlmermeer.

With regard to the planning dimension Mentzel demonstrates that insufficient attention has been devoted to the strategic stage: the global determining of objectives and means. During the stages of an increasingly more specific determining of objectives and means alternative plans have hardly been discussed; if at all. Lack of time certainly played a rôle.

Comment

Careful description of a planning process can shed light on what makes a project more, or less, successful; certainly when the description is related to the comments of planners, designers and users, as well as placed in a theoretical framework. This creates a better understanding of the case, while the study is contributing to the furthering of theory, building on the processes shaping decision. In spite of the social-historical approach, Mentzel's study offers a thorough reflection on planning principles and designing strategies. In studies by urban architects the intention is often more strongly focused on understanding spatial forms. An example is the study by Han Meyer[a], for an important part a set of descriptions of the relation between city and harbour in London, Barcelona, New York and Rotterdam and the differences in cultural appreciation of the spatial form of this relation. On this basis Meyer formulates a number of agenda points for the design of intermediary open spaces. Among other topics, Meyer is pleading for designing a new typology of public spaces enabling a symbiosis between large-scale networks and the small-scale of urban fragments.

6.5 CONCLUSION

Descriptive research and study can assist designing in several ways. In the first place as a basis for the programme of requirements. On the basis of demographic and socio-economic data, for instance, it can be decided to reserve a supply of homes for elderly people, to transform a neighbourhood school into a community centre, or to build a new hospital with x beds. Data from descriptive study are used then to make predictions on a situation that is in the future desirable or probable. In the second place, descriptions of plans and of realised buildings may be an important source of inspiration for the development of a plan. Architects and city-builders often get their inspiration from references in the past; i.e. precedents, see also page 401. Implicitly a designer is trying to distil from the descriptions hypotheses and predictions on the functioning of the partial solutions selected by him or her as they relate to wishes formulated by the commissioners or by him/herself. In the third place the results from descriptive research can be used as a means to test designs. By comparing a design to other designs and realised buildings it may be considered on which points this design matches or is standing out. Maybe, on this basis predictions can be made on the functioning of the building to be realised. Linked to an evaluative moment, this may, or may not, necessitate adaptations. Descriptions of processes can also teach a lot. They can give insight in factors for success and failure and in the significance of study for decision making. Descriptive research is increasing in value when it does not limit itself to mere description, but also contains initiations to interpretation and evaluation of its findings. A more intensive co-operation between those who study and those who design could enlarge the application potential in the design process. This seems to apply particularly for the start of the study – the formulation of the problem and of the objective – and for the finalisation of the study: the formulation of conclusion and recommendations, together with making the results accessible.

a Meyer, H. (1996) *De stad en de haven*. English translation: (1999) *City and port*.

7 HISTORICAL RESEARCH

OTAKAR MÁČEL

The methodology of study in the history of architecture is permeated by fundamental presuppositions with regard to the arts and architecture itself. Since the history of art – with the history of architecture as one of its constituent parts – does not feature its own universal-historical systemisation, but is one of its parts, the methodological problem is permeated by the concept of history as a branch of learning. This sees to it that a systematic rendering of the method of the history of architecture is complex; and, in a historical perspective, by no means conclusive.[a] The present text is a first attempt to formulate the methodological starting points of the study of the history of architecture based on its practice and the literature: a systematic formalisation along the lines of a model. This entails that the practice is more 'synthetic' and demonstrates more methodical cross connections.

I depart from the object, the building. On that basis I try to explain the different steps of the study of architectural history: heuristics, analysis and interpretation. Firstly the use of sources (heuristics) is dealt with, next the methodology of analysis and interpretation and finally the 'usefulness' of the methodology for designing.

In accordance with my education as an art historian, I regard the history of architecture as one of the parts of the history of art. This means that my methodological discourse is presented before the background of the methodology of the history of art. It also implies that architecture is regarded here as a member of the 'family' of the visual arts. This may be restrictive. Wherever possible I will draw attention to this restriction of the methodology when it comes to architecture. On the other hand, I would like to make clear from the start that the way to proceed as described should be applicable for an object dating from the fourth century B.C. as well as for an object of the fifties of the twentieth century.

7.1 USE OF SOURCES – HEURISTICS

a. Sources and Literature

The use of sources is an essential point of departure for the study of the history of architecture. With this a distinction may be made between the sources themselves and the literature on them. 'Literature' means here the architecture-historical studies on the subject of the study which have already been written. The documenting material, printed or not, from the era of the subject of the study falls under the category 'sources'.

In an Architecture Faculty the study of architectural history is usually restricted to study of the literature, particularly when it concerns the work of students. This may be sufficient, seen within an educational perspective, but it certainly is not seen fundamentally, while only the sources are witnesses of the past; not the interpretations of the present.[b] Also, where the study of the literature is concerned the source material is called for: not by way of personal experience – autopsy – but, 'second-hand', pre-processed by others. Study of literature is a pre-requisite, but can not replace in any way the study of the sources. However, it may point the way towards the sources.

Clear separation between sources and literature as described has a demonstrative purpose. In practice things may be more vague. The borderline between a documentary source and the literature does not always resemble a honed razorblade. Furthermore, it is not always possible to consult all kinds of sources personally.

b. Kinds of sources

The sources themselves may be differentiated as primary and secondary. Primary sources include the building itself, design drawings and models: the building of course, since only by its materiality it embodies architecture. The blue-print and the model are admittedly no buildings, but represent in a visual form the concept of the building. Texts on architecture, regard-

a As far as is known Dutch historians of architecture have written seldom methodological treatises. An attempt to it was made in the inaugural address of Grinten, E. F. van der (1963) *Bouwkunst-geschiedenis of bouw-kunstgeschiedenis: grenzen en mogelijkheden in de geschiedschrijving der bouwkunst;* or: Mekking, A.J.J. (1986) *De Sint-Servaaskerk te Maastricht.*

b See for instance the different descriptions en floor plan illustrations of the same building (San Carlo alle Quatro Fontane), Grinten, E. F. van der (1963) p.8-9, 22-23.

Examples of ordering are the following:

Topographical ordering
Published descriptive lists of monuments, topographical inventories like:

- Maiocchi, R. (1937-1949) *Codice diplomatico-artistico di Pavia dell anno 1330 ad 1550 I+II*.

Also, under this heading are collection catalogues of museums and other collections, particularly important for architectural drawings and models, e. g.:

- Egger, H. (1903) *Kritisches Verzeichnis der Sammlung architectonischer Handzeichnungen der K.K. Hof-Bibliothek;*
- Drexler, A. (1986) *An illustrated catalogue of the Mies van der Rohe drawings in the Museum of Modern Art;*
- Blau, E. and E. Kaufman (1989) *Architecture and its image. Four centuries of architectural representation, works from the collection of the Canadian Centre for Architecture*.

The last one mentioned is an example of a combined topographical-monograph ordering.

Chronological ordering
Editions of sources, with or without commentary, relating to a specific era, like:

- Schloßer, J. von (1924) *Die Kunstliteratur. Ein Handbuch zur Quellenkunde der neueren Kunstgeschichte;*
- Lefaivre, L. and A. Tzonis (1984) *Theorieën van het architektonies ontwerpen* or
- Ockman, J. (1993) *Architectural culture 1943 - 1968*.

Bibliographic ordering
Lists of documentary sources, e. g.:

- Senkevitch Jr., A. (1974) *Soviet architecture 1917 - 1962: a bibliographical guide to source material*.

Monographic ordering
Catalogues of collected works, e. g.

- Boesiger, W. (1946-1970) *Le Corbusier et Pierre Jeanneret: oeuvre complete*;

to one project, e.g.:

- Neutelings Riedijk Architecten (1998) *Minnaert-gebouw Universiteit Utrecht*.

Reprints of tracts and theoretical observation also belong under this heading.

less of their importance, belong to the category of secondary sources. They are words, not buildings. They lack the significance of visual information. This applies in a general sense. When texts on architecture are an object of study themselves they should be viewed as a primary source.[a] Secondary sources are then 'addenda'; e.g. the texts of the designer himself, illustrations, letters, testimonies and opinions of contemporaries, business documents like bills, licences, legal papers, correspondence on the commission, etc.[b] Finding source material often requires special effort, particularly in archives, since many archives follow their own systematic approach and are usually not focused on architecture.

A different systemisation of sources is also possible. In that case the works of art – by the same token works of architecture – are seen as objects of the study as an independent category and positioned outside of the sources. The distinction between primary and secondary sources then looks different.[c]

c. *Critique of sources*

This entails the assessment of sources in terms of their value to yield information; at the same time the factual data of the literature already existing may be checked. Questioning the usefulness of the sources relates to the following problems: the correctness (possible 'falsum', the partiality of the source *vis-à-vis* the subject, etc.), the provenance (may seem obvious, but sometimes it is not)[d], the time (dating), the author or origin and the originality of the information. In that last case the question must be answered whether the source is a primary one in terms of content and chronology, or that it reproduces data already known. Some data will probably never be found. In that case an answer must be reconstructed from contextual data. In the case of an anonymous building inquiries concerning the author or time of construction may only be answered approximately by a comparison of style criticism.

d. *Ordering the source material*

Systemising the data obtained depends on the subject of the study. Usually ordering the source material first in terms of elementary information, like time, place, subject and author or a combination thereof, is the thing to do obvious. Thematic ordering of primary sources as to type, based on its functional use or on form (form typology) or on material and construction is specific to architecture. This stage is occasionally the final objective of the study. Arranging the source material may already encompass an element of analysis and interpretation, especially in the case of editions of sources containing comments. However, the emphasis of editions like that rests on representing the sources. Examples of ordering are listed alongside.

e. *Adjacent disciplines*

In addition to general history, here considered as an obvious background, processing and ordering source material often needs support by other disciplines of learning. In part specialised branches within the historical discipline are concerned, the traditional disciplines enabling it being, among others:

- Paleography (the learning associated with the development of lettering and writing) enabling reading old sources.
- Diplomacy, devoting itself to the origination, kinds and dating of legal sources and writs
- Chronology, that might assist in re-calculating old types of time keeping to our current one, dating. This is particularly important for the history of architecture of previous ages up to and including the eighteenth century.

In the case of material sources help from chemical and physical technologies is sometimes needed. Computer technology may also be helpful in ordering and comparing sources. Critique of sources may also call upon other areas of learning like legal studies, philology, economics, mathematics (statistics) etc.

a E.g. Kruft, H.W. (1991) *Geschichte der Architekturtheorie. Von der Antike bis zur Gegenwart*. English translation: (1994) *A history of architectural theory: from Vitruvius to the present*.

b For a very extensive and systematic treatise on source material and criticism see Tietze, H. (1913) *Die Methode der Kunstgeschichte*. p.184-278.

c Compare e.g. Bauer, H. (1976) *Kunsthistorik: eine kritische Einführung in das Studium der Kunstgeschichte*. p.108, 120 en Badt, K. (1971) *Eine Wissenschaftslehre der Kunstgeschichte*. p.64-65.

d See, for instance, the cumbersome and time-consuming search for the provenance of the ideal monastery schema from Sankt Gallen.

7.2 ANALYSIS

The first conceptual recording of the image and structure of a building (the drawing) is morphological and technical analysis. This should result in the description of the building with its specific characteristics.

a. *Morphological analysis*

A morphological analysis is an approach bound by an object. Its purpose is determining the specific characteristics of the architectonic work (what and how), in order to interpret them later in a criticism and comparison of style and to put them in a broader perspective (why). A morphological analysis analyses the architectonic (visual) properties of a building or of a design drawing, the conceptual version of a building. Whether a drawing is the only rendering of the design, or when it has a complementing function might make a difference; in the second case it documents the existing building and eventually the stages of the design.

From the vantage point of systemisation one might make a distinction between formal and structural aspects of the style-critical analysis in spite of the fact that in reality all aspects of a building always relate to one another as a unity. The concept (disposition) of the blue-print, the articulations of the elevation (the building mass rising from the blue-print) and the ensuing spatial concept may be seen as structural aspects. The problems of the ordering of the whole (composition, rhythm) and the visualisation of the constructive aspects (tectonics) also belong under this heading. Formal aspects are, for instance, the ordering of the outer walls, detailing and the architectural decoration (also of the interior) and the 'use' of visual artworks within the building.

A morphological analysis of a building displays its specific, individual architectonic characteristics: the materialisation of the design idea is charted.

b. *Technical analysis*

Since a building is bound to a concrete place and subject to physical laws as a material object it also has technical and physical properties. Style critique can not determine them; at least in an artistic, sublimated form (construction tectonics). Following Robert Hedicke[a] one might call the analysis of these properties the technical methodology. This type of analysis is directed towards the properties characterising the building in terms of site, building materials, and construction. Style-critical and technical analysis complement one another.

One may view the site as something outside of the work of piece of architecture proper. On the other hand the site is physically insolubly connected with a building. Considering that the site by its size, positioning (geomorphic disposition, adjacent buildings) and structure of the soil is one of the determinants of the design and its actual execution these aspects always require attention. Possibly references in terms of cultural history of the site might be important.[b]

The significance of the building material for the manifestation of architecture speaks for itself, since the material chosen also determines the construction of the building and the structure of the building surface. Information on the kind and provenance of the building material may also provide insight into the building process and its history.

The building construction is a literal embodiment of the physical *raison d'être* of a building. Vitruvius already mentions 'stabilitas' as one of the three necessary conditions for architecture. That is the reason that the identification of the construction of a building is a necessary step in the architectural-historical study while giving the background information for the analysis in terms of style critique. Not only the building itself, but also its drawings and blue-prints are an important source for this analysis. Usually building constructions distinguish materials used and the construction proper.

7.3 INTERPRETATION

The interpretation of a building aims at determining and understanding the original architectonic intention of the work and its significance and place in the development of architecture.

Typological ordering
Usually surveys of kinds of building, like:
- Dimier, A. (1949-1967) *Recueil de plans d'eglises cisterciennes;*
- Sherwood, R. (1978) *Modern housing prototypes*;
- Barbieri, S.U., L. van Duin et al. (2000) *Plandocumentatie theaters*.

Material and construction
Description and survey, e.g.:
- Leonhardt, A. (1964-65) *Vom Caementum zum Zement I-III;*
- Quarmby, A. (1974) *The plastics architect;*
- Oosterhoff, J. (1978) *Constructies, momenten uit de geschiedenis van het overspannen en ondersteunen*.

a Hedicke, R. (1924) *Methodenlehre der Kunstgeschichte: ein Handbuch für Studierende*, p.100-132. Although the book is rather dated, among the historians of art Hedicke is from a methodological perspective an exception because of his attention to the technical aspects of the visual arts (including architecture). Remarkable is his still topical observation: *"Außer den Kreisen der Architekten-Kunsthistoriker und der Künstler ist heute das Technische in der Kunstgeschichte verachtet, und äußert sich auch darin, daß die Studenten der Kunstgeschichte für das technische in der bildenden Kunst heute gar kein Interesse und Verständnis mehr besitzen."* l.c. p.102.

b For a widely ranging meaning of the building site see Norberg-Schulz, Chr. (1981) *Genius loci: towards a phenomenology of architecture*.

Any historical study – and, perforce, architectural-historical ones – always focuses on the intentions and context at the time of the work itself. It is the only way to understand the work: it is a *conditio sine qua non*. This way we may now experience a gothic church as impressive by the materiality of its daring construction and the clear spaciousness, while in the middle ages it was just surpassing materiality and the mutual symbolic functions of the parts establishing the 'experiencing' of this architecture. The 'delight in art' at that time carried much more the stamp of theology than present-day appreciation; it was of a different order. However, this approach is only tentative: it is not only seldom that all data can be found, but a complete experiential transition to the past is impossible; the work of a historian of architecture is done by necessity in the present. The past is over. Although understanding sources in their original significance results in some access to the history, historiography is an activity of the present. Already in 1868 the historian Johann Gustav Droysen put it this way: *"Unsere ganze Wissenschaft beruht darauf, daß wir aus solchen noch gegenwärtigen Materialien nicht die Vergangenheit herstellen, sondern unsere Vorstellungen von ihnen begründen, berichtigen, erweitern wollen, und zwar durch ein methodisch verfahren, das sich aus diesem ersten Lehrsatz entwickelt."* [a] Even when 'our imaginings' of the past are determined by today's position of the historian, the importance of the transient 'social relevance' is not always relevant for analysis and interpretation of the sources. In the study the sources can only be understood within the original context. In contrast, actuality can determine what is going to happen with the result of the study. This may affect the selection of the theme of the study. It becomes clear then where the historical approach and current social interests ('relevance') cross one another. With problems of monument in the national trust, for instance, the knowledge of the original significance of a building plays a leading rôle since it is a factual testimony of the past. At the same time its value as a remembrance, decisive for putting it on the list of monuments, rests on an interpretation in the here and now. The rôle of 'social relevance' (present context of the building) comes much more strongly to the fore during renovation and renewed usage.

a. *Context as a frame of reference*

Where the stage of analysis addresses the question 'what' the characteristics are of the work of architecture, the stage of interpretation addresses the question of the 'how' of these characteristics and their original significance. Although the building embodies its characteristics and, therefore, also its significance itself, it can not be understood by itself. The answers to these questions can only be found in the inter-connection of the work with its contemporary context: a building does not come into being in a timeless vacuum, but in a specific historical situation. This entails that the pure object-driven approach of the architectural work must yield to a broader approach, related to the historical context of its origins. This may call for study of the relationship of the architectural work with the contemporary aesthetic norm(s), technical know-how, the conventions and backgrounds of its use and study of (original) significance of the architectural work transcending these categories. It may also be undertaken on a more general level (school, area, era). Not only determining and interpreting the characteristics and significance of the architectural work is important for study in architectural history, but also their changes. In this way interpretation might have several aspects and levels. Since these aspects and levels always relate to one another, rendering them systematically is a difficult and schematic exercise by necessity. It also depends on the theme of the study. I have opted for arranging the interpretation according to the context of the architectural work, in this case the context of factual originating, the context of the functional use, the context of the style and the context of the iconographic and transcendental significance of the work. It is admittedly a heterogeneous systemisation, but it attempts to encompass and conclude the problem of interpretation. Allocating the architectural work within the history of architecture would then require weighing all four contexts as they inter-relate.

a Droysen, J.G. (1960) *Grundriß der Historik: eine Enzyklopädie und Methodologie der Geschichte (1868)*, p.20.

b. Context of the originating

The most immediate context applicable to the architectural work is the one of the commissioner, the author (designer) and the constructor (building company). Together they embody the conditions for the building to get into being, so that their rôles in that process should always be studied. The factual data on the commission, the author and execution should already have been determined by the critique of the sources. Here their specific rôles *vis-à-vis* the characteristics and intentions of the individual architectural work stand central. Studying the commission, the author and the building company can be an independent objective of a study – separately or not – focused on the individual building or on a general theme.

The commission

A commission, given by a principal, starts the designing and building. Compared to the art of painting, for instance, this is specific for architecture and for arts and crafts. Historically speaking, this difference is of relatively recent origin, since the nineteenth century. This commission includes the destination, so the kind of use (type) of the building and the specific wishes and conditions of the commissioner. These wishes are inter-related with his social position and with his possible political ambitions. The study of the commission and the commissioner may choose several directions, but this aspect always marks the specific history of the originating of the building. The kind of commission and the position of the commissioner also point to typological considerations.

See e.g.:
- Panofsky, E. (1946) *Abbot Suger on the Abbey Church of St. Denis and its art treassures;*
- Boorsch, S. (1982-83) *The Building of the Vatican. The Papacy and Architecture;*
- Ellis, R. and D. Cuff (1989) *Architects' people;*
- Dijkstra, Tj. (1991) *De kunst van het opdrachtgeven*.

The author(s)

If the commission starts the originating of a building, then the commissioner is its cause. The author (designer, architect, master builder) is the one who outlines with his knowledge, purpose and, perhaps, talent the building. At first sight the author seems as a person less important where it comes to the history of art and architecture, since the object of this discipline is primarily the work of the author and not this person. In addition his alienation with the building commences with the completion of the work with regard to the intentions of the maker. From this moment on the work may be understood by others in a different way than the author had in mind. Although the author is the cause of the building, he himself is not always the most important source of information. Many buildings are anonymous or only associated with just a name with a background. Nevertheless, the author is a crucial link in the chain of the interpretation of an architectural work. Author related considerations with regard to the building include his training, professional experience and expertise, the relationship to the commissioner and the intentions and ambitions inherent in the commission.

An intermediary problem between the categories 'author' and 'execution' is the operation for its own profession (from construction hut to the architects' office). Knowledge of this may contribute to the insights into the social status of the author, the task distribution during designing and the relationship with the executor.

The literary genres on authors most common are the monograph, the biography and the texts of the authors themselves. In addition historical studies on the profession and the education of architects are relevant, e. g.:
- Briggs, M.S. (1927) *The architect in history* (Pevsner, N. (1930-31) *Zur Geschichte des Architektenberufs*.);
- Harvey, J.H. (1972) *The mediaeval architect;*
- Müller, W. (1989) *Architekten in der Welt der Antike;*
- Severin, I. (1992) *Baumeister und Architekten. Studien zur Darstellung eines Berufstandes in Porträt und Bildnis;*
- Saunders, W.S. (1996) *Reflections on architectural practices in the nineties;*
- Pfammatter, U. (1997) *Die Erfindung des modernen Architekten. Ursprung und Entwicklung seiner wissenschaftlich-industriellen Ausbildung*.

The execution

Without builders there is no building. In spite of that the building company plays a less important rôle in the history of architecture, while it plays only an intermediate rôle, in a certain sense a hidden one, however indispensable it may be. Nevertheless, a minimum of knowledge of this problem is needed from a factographic viewpoint. And what is more, the possibilities of execution of the design may influence the resulting Gestalt of the building. The organisational structure of a building enterprise may be of importance for conserving and passing the knowledge of building to future generations like in the Middle Ages – where the author and the enterprise worked together – in studying the building. If in the problem of the execution the question of technical know-how is taken into account also, the significance of this contextual aspect increases. The building enterprise may be seen as the carrier of con-

Examples in the literature on the execution include:
- Grote, A. (1959) *Der vollkommen Architectus. Baumeister und Baubetrieb bis zum Angang der Neuzeit;*
- Colombier, P. du (1973) *Les chantiers des cathédrales: ouvriers, architectes, sculpteurs;*
- Binding, G. and N. Nußbaum (1978) *Mittelalterlicher Baubetrieb;*
- Vroom, W.H. (1981) *De financiering van de kathedraalbouw*.

temporary technical knowledge. This knowledge determines, together with that of the author, the possibilities of materialisation of the design.

A general typological survey is the one of

- Pevsner, N. (1976) *A history of the building types*.

Examples of monographical-typological literature include:

- D'Amico, S. and F. Savio (1954-1966) *Enciclopedia dello spettacolo (10 vol.);*
- Braunfels, W. (1969) *Abendländische Klosterbaukunst;*
- Thompson, J.D. and G. Goldin (1975) *The hospital, a social and architectural history;*
- Petersen, M.A. (1978) *Gedetineerden onder dak; geschiedenis van het gevangeniswezen in Nederland vanaf 1795, bezien van zijn behuizing;*
- Geist, J.F. (1979) *Passagen, ein Bautyp des 19. Jahrhunderts;*
- Wesemael, P.J.W. van (2001) *Architecture of instruction and design : a socio-historical analysis of world exhibitions as a didactic phenomenon (1798-1851-1970)*. (Formerly published in Dutch: (1997) *Architectuur van instructie en vermaak. Een maatschappijhistorische analyse van de wereldtentoonstellingen als didactisch verschijnsel (1798-1851-1970)*.)

c. Context of use – Typology

Utilisation function is a characteristic difference between the visual arts and architecture. Admittedly paintings and pieces of sculpture are always used as well – their museum function is relatively recent – but, the work of architecture is, in its assembled state, structurally determined by its intended use. Already Vitruvius names 'utilitas' as one out of three fundamental characteristics of architecture. The functional use is an essential property of architecture, but a building may loose that function temporarily – the Pantheon as a stable for horses – or forever, or get a new one. Nothing new under the sun; witness the re-construction of monasteries into hospitals, military barracks or industrial plants.

With the originating of the building the functional use is inherent in the commission. In order to consider the commission within its own 'kind' requires comparison with different building serving the same purpose: a typological comparison.[a] The answer to the question why a building has a certain appearance may be determined by historical experience already existing (tradition) with the structure of buildings of the same kind. Next to this the ascertainment of the possible provenance of a typological solution such a comparison may also bring to light the specific contemporary expression of the function and change in the customary typology. The typological problem has dis-enfranchised itself within the history of architecture to a distinct type of study, addressing the development of the different kinds of buildings. This needs knowledge of the specific functional usage; that is one outside the discipline of architecture. In this vein the development of the theatre-type can not be understood without knowledge of the development of acting, nor the development of hospitals without the history of the medical sciences, nor the development of prisons without the history of penal law, etc. It is obvious that this type of study calls for different fields than history. Typological problems can be quite complex. Next to type-driven history the socio-economic and political aspects play a specific rôle.

Typological literature is rather many-sided. Some publications have the documentary nature of an edition of sources. Others concentrate especially on systemising the development of the blue-print of the type concerned. The more synthetic publications regard the development of the type as a whole and relate it to the historical backgrounds causing it. Typological literature may also deal with the subject within a certain territory or time-period.

The literature based on style-critical interpretation may vary from monographic treatment to the history of a style period. The subject of the literature might also be some elements of the interpretation, like tectonics, e.g.:

- Frampton, K. and J. Cava (1995) *Studies in tectonic culture : the poetics of construction in nineteenth and twentieth century architecture*.

The interpretation of the concept of style is part of every systematic historical study of art. See e.g.:

- Bauer, H. (1976) *Kunsthistorik: eine kritische Einführung in das Studium der Kunstgeschichte*, p. 74-80, 87-89;
- Dittmann, L. (1967) *Stil, Symbol, Struktur: Studien zu Kategorien der Kunstgeschichte*.

d. Context of Style – Style-critical interpretation

Morphological analysis addresses the recording of the formal and structural attributes of the individual architectural work. The style-critical interpretation consists of a comparison of these individual attributes to other works; in the first instance with contemporary works, but they may be earlier or later buildings as well, depending on the aspirations of the study. 'Reflective' sources, theoretical writings and criticism, are important for such a comparison. In this way the historian of architecture may get insight into the prevailing or usual aesthetic norm(s) at that time and in the design toolbox. Then he can judge which position the building occupies there – he can place the building in its context. This might mean that the work conforms to that norm; which means that it is an example of a standard solution or an imitation, or copy.[b] It may be that the work does not co-incide with the usual norm, while the author was looking in his work for new solutions of the design problem. It also may be that the author rejected the norm and continued to base himself on an older point of departure, or did not understand the new norm, like, for example, in some buildings of the Renaissance north of the Alps.

This enables the positioning of the work of architecture with regard to the contemporary time. It should become clear which problems and challenges characterised the profession at that time and how the architectonic ambitions and the talent of the author as embodied in the building (drawing) relate to that. The concepts 'contemporary' and aesthetic norm are

a Here, the concept 'type' is for the time being not identified with the function of use; however it should be linked to this function exclusively.

b In the practice of the study the deliberations should be more subtle. On the related problems see, amongst others, Bakos (1991) *Peripherie und die kunsthistorische Entwicklung*.

not intended here as a static moment, but as co-eval development with temporal limits determined by the theme of study. This positioning of the work within the development of architecture may be realised on different levels. It may relate to the collected works of the author himself (along the lines of a monograph), to the significance within certain territorial boundaries (the cathedral of Chartres and Gothic building in Northern France, or the 'Zonnestraal' sanatorium and the 'Nieuwe Bouwen' in the Netherlands), or to a generalist tendency along the lines of a general development (the significance of Borromini's oeuvre for European Baroque). The last example indicates that a contemporary comparison alone is not always sufficient. Borromini's oeuvre became very significant in Central Europe only a century after his death.[a]

A generalist approach is the style-critical interpretation of groups of buildings in the broader context of time and place. This may lead to determining the aesthetic norm and design tool box used to realise it (periodising) within a period, style or stream of development.

With a style-critical interpretation the concept 'style' has a historically normative character. It is an abstraction of characteristics of the individual works of architecture. That is what is linking these works. The concept of style is necessary in the study of the history of architecture for identifying the collective qualities. Further explanation of the concept of style would require a separate, historically founded, exposé.[b]

e. *Context of the significance – iconography, iconology*

Formulating the significance is here related to what is admittedly depicted by the work of art, but what surpasses the style-critically formulated visual meaning of a work of art. In the general history of art that is the field of iconography and iconology. Originally, iconography was only occupied with identification and analysis of the depiction. The concept of iconology, formulated later, implies explanation of its symbolic meaning. From the time that iconography was considered more contextual-interpretative[c], the difference between the two levels of interpretation started to become vague. Both approaches were developed by studies of medieval art and the mythology of antiquity surviving in it. Since both approaches consider the work of art, more often than not, as a carrier of meaning and content, without paying attention to its appearance, they are sometimes regarded in the history of art as one-sided.[d] In the history of architecture these terms are in a similar interpretation of significance infrequently used, while they can be hardly distinguished from one another.[e]

Iconography

Since architecture can hardly be reckoned to depict (mimetic) arts, iconographic study can orient itself especially on formulation and interpretation of the 'pictures' present in the building within the architectural genre. They may be architectural motives; that is to say, the shapes and details of other buildings having become independent, used as an element of composition outside of their original context (the triumphal arch, the Palladio motive, columns, the dome etc) for architectonic and / or symbolic reasons. They may also be elements originating outside of architecture, like the round windows in ships, or elements of utility structures, with an allusion to attributes.

The interpretation of the 'pictures' of other buildings concerned as a total might also fall within the iconographic frame-work. An example is the visualisation of a ruin: the ruin of an aquaduct as a folly, or a neo-medieval ruin of a castle as a hunting lodge. Other 'depicting' buildings may fit under this heading: e.g. a Chinese pagoda as a garden pavilion, or the church in Oudenbosch, The Netherlands: a replica of Saint Peter's in Rome. The shapes appropriated from outside architecture, as there are the shape of a ship or anthropomorphic ones (the follies in Bomarzo, Italy) and zoomorphic shapes (a fried chips joint shaped like a duck, see Robert Venturi) fall in this category.

Determining and interpreting the iconographic characteristics of one building is the task set to morphological analysis and style-critical interpretation. However, beyond the level of

The iconographic literature is heterogeneous and partly overlaps style-critical considerations.

- André, G. (1939) *Architektur als Gegenstand der Ikonographie;*
- Reinle, A. (1976) *Zeichensprache der Architektur*.;

specific:

- Duby, G. (1978) *Les trois ordres ou l'imaginaire de féodalisme*. (English translation: Duby, G. and A. Goldhammer (1982) *The three orders: feudal society imagined*);
- Moos, St. von (1974) *Turm und Bollwerk: Beiträge zu einer politischen Ikonographie der Italienischen Renaissancearchitektur;*
- Vogt, A.M. (1974) *Russische und Französiche Revolutionsarchitektur 1717-1789;*
- Kähler, G. (1981) *Architektur als Symbolverfall. Das Dampfermotiv in der Baukunst;*
- Kern, H. (1982) *Labyrinthe, Erscheinungsformen und Deutungen 5000 Jahre Gegenwart eines Urbilds* (English translation: (2000) *Through the labyrinth: designs and meanings over 5000 years*);
- Onians, J. (1988) *Bearers of meaning: the Classical orders in antiquity, the Middle Ages, and the Renaissance;*
- Schulte, A.G. and M.J. Kuipers-Verbuijs (1997) *Ruïnes in Nederland*.

a From the end of the 17th century onward, architects from the Middle of Europe travelled to Rome in order to study the architecture of Borromini there, by that time 'old hat' to Romans, rather than contemporary buildings.

b For the general definition of the concept of 'style' see Gadamer, H.G. (1970) *Wahrheit und Methode*, p. 466-469.

c See e.g. Biaostocki, J. (1973) *Iconography*.

d See e.g. H. Bauer, l.c., p. 93-99. Recently see the discussion by Eddy de Jongh of the re-edition of Panovsky's Meaning in Visual Arts (E. de Jongh: 'To me, this book was not less than a revelation', *De Academische Boekengids* (2000) Vol. 21, p.20).

e See e.g. Sauer, J. (1924) *Symbolik des Kirchengebäudes und seiner Aussattung in der Auffassung des Mittelalters;* and: Krautheimer, R. (1942) *Introduction to an iconography of medieval architecture*.

the individual building it is an independent iconographic theme, that in its turn may serve as frame of reference for style-critical interpretation.

Examples of the literature on iconology include:
General:
- Bandmann, G. (1951) *Ikonologie der Architektur*. p.67-109 (reprint 1969);
- Sedlmayr, H. (1960) *Architektur als abbildende Kunst;*
- Hartog, E. den (1994) *Bouwen en duiden. Studies over architectuur en iconologie*.

Middle Ages: next to the mentioned Sauer, J. (1924) and Krautheimer, R. (1942):
- Sedlmayr, H. (1950) *Die Entstehung der Kathedrale;*
- Panofsky, E. (1951) *Gothic architecture and scholasticism;*
- Simson, O. von (1956) *The Gothic cathedral: origins of Gothic architecture and the medieval concept of order;*
- Mekking, A.J.J. (1986) *De Sint-Servaaskerk te Maastricht*.

Baroque:
- Sedlmayr, H. (1956) *Johann Bernhard Fischer von Erlach*.

Modern age:
- Neumeyer, Fr. (1991) *The artless word; Mies van der Rohe on the building art*.

Iconology

The formal and structural characteristics of a work of architecture may also have allegorical, metaphorical or symbolic meaning, not to be ascertained by style-critical interpretation. They can also refer to contents and meanings outside the building and architecture itself. In that case knowledge on the horizon of the contemporary world-view, on general opinions on the arts and learning, of social norms and values may provide a frame of reference for interpretation. Architectural iconology can in its interpretation also relate to symbolic meaning; and transcend the architectural genre. This is the reason why a precise delimitation between both approaches is difficult.[a] However, architectural iconology emphasises the metaphorical meaning of the work of architecture (the church building as a manifestation of the 'ecclesia' and of the Heavenly Jerusalem, the triomphal columns of the Karlskirche in Vienna as a manifestation of the Habsburg claim to Vienna as the New Rome, etc). The traditional iconological methodology – whether it carries that name or not – is especially mature in the field of medieval and baroque architecture. Although the layered structure of allegory and symbolism has changed in the meantime this does not entail that the alluding 'power' of a work of architecture should have vanished. Actually, the iconological approach is continued in the interpretation of more recent buildings. Usually an interpretation like that is part of the study. The interpretation of Mies van der Rohe's Barcelona pavilion by Fritz Neumeyer as a 'Platonic temple' is an example of architectural iconology of modern architecture.

7.4 LITERATURE

The literature of the history of architecture is as wide as the collected knowledge of the professional field up to now. That is the reason why a study of the literature is almost always the first step in a study of architectural history. This supposes an inventory of knowledge on the subject: it is hardly worthwhile to 'discover' personally what is already known. In a scientific sense this is a *conditio sine qua non*. Further study checks the literature in terms of facts and interpretation. During presentation (publication) of the study the chapter on the study of the literature, the literature criticism, should be positioned at the beginning, seen from the editorial viewpoint. The historian of architecture positions his own study in the 'field'of existing knowledge of the subject, while taking responsibility in terms of content and method for his study. The study of architectural history pre-supposes knowledge of genres of literature of the subject. This is a task for education or self-study.[b]

7.5 REMARKS

By necessity, the preceding description of a methodology of study is succinct and schematic. There are more problems than could be mentioned explicitly. The following remarks intend to highlight some problems.

From the viewpoint of scientific systemisation, my contribution could have started in a different way. For example: "Together with the history of art the history of architecture is part of historical learning. Its object is architecture..." and next the object is described and a methodology of study derived from its properties. But, what is architecture? The historian of architecture Nicolaus Pevsner, at the Faculty of Architecture of Delft in the seventies despised, but in the world outside quite respected, once wrote: *"A shed for bikes is a building. Lincoln cathedral is a piece of architecture. Almost anything wherein there is sufficient space for a man to move is a building; the term 'architecture' is only applicable to buildings also meant to be aesthetically attractive by the designer."*[c] His dictum exemplifies the tendency of the current history of architecture: following the changes of aesthetic norms during the ages; from the viewpoint that not everything that is built carries equal importance, but mainly what characterises this development. This is certainly true in a book on the general development of Euro-

a The *Dizionario Enciclopedico di Architettura*, for instance, devotes just 11 lines to iconography, but to iconology one whole page. Portoghesi, P. (1969) *Dizionario Enciclopedico di Architettura*, p. 134-5.

b Published course-books may be helpful, like Wilk, B. (1987) *Wie finde ich kunstwissenschaftliche Literatur*.

c Pevsner, N. (1970) *Europese architectuur, middeleeuwen en renaissance*, p.13. Originally published as: Pevsner, N. (1990) *An outline of European architecture (1942)*.

pean architecture, where Pevsner expressed his opinion. From a documentary standpoint (National Trust) or the one of typology this might be different. The proposition that architecture starts where the manifestation of a building transcends its utilitarian function by its 'aesthetic attractiveness' is in daily life a handy criterion. For the practice of the history of architecture it should only be accepted under conditions.

Theoretic as well as pragmatic objections could be formulated against Pevsner's dictum. The theoretic objection mainly rests on the absolute contrast between a building as an ultimate piece of art (cathedral) and a mere contraption serving utility (bike shed). The Gestalt of a building is always completely inter-woven with the fulfilment of its usage, even in the case of a monument. 'Aesthetic attractiveness', the aesthetic function and norm have a historical character; and is therefore, subject to change. That is the reason why it is not possible in the study of architectural history to fix a nomenclatura of the buildings in terms of 'aesthetic attractiveness' as a normative a priori. The field of inquiry of the history of architecture should be open. The differences in intentions and significance of the buildings should result from the study itself. The pragmatic objections to Pevsner's dictum rest on the fact that during the most recent century and a half the production of buildings has increased considerably and that a range of new types of building on a utilitarian basis has emerged, putting into jeopardy the pre-supposed border between 'cathedrals' and 'sheds'. For the history of architecture this is associated with a widening of its domain of study.

From the problem 'cathedrals versus sheds' it is but a small step to the question 'Is architectural history a social science?'[a] While architecture – buildings – caters for one fundamental basic human need: to provide shelter, the use of the 'shelter' and all problems pertaining thereto are also part of the study. Studies like that fall under the umbrella of architectural history, but even more under that of social sciences. How the result of the study contributes to the knowledge of the professional field concerned is more important. The preceding sketch of the methodology of architectural history may make clear that the social aspects of the commission, the author, the user and the construction company are needed for grasping the meaning of the work of architecture. Where an individual building is concerned, or when a typological study is involved, the history of exploitation is also of importance. The history of architecture makes good use of these data. That does not make it a social science; housing is not a house. In this regard a possible theme for study was already hinted at in 'Context of the originating', but it might as well be much broader.

General literature:

- Hauser, A. (1951) *The social history of art;*
- Stekl, H. (1980) *Architektur und Gesellschaft von der Antike bis zur Gegenwart*.

Special subjects: e.g.:

- Lützeler, H. (1931) *Zur Religionssoziologie Deutscher Barockarchitektur;*
- Rosenau, H. (1958) *Zum Sozialproblem in der Architekturtheorie des 15. bis 19. Jahrhunderts;*
- Müller, M. and R. Bentmann (1970) *Die Villa als Herrschaftsarchitektur: Versuch einer kunst- und sozialgeschichtlichen Analyse* (English translation: (1992) *The villa as hegemonic architecture*);
- Bollerey, F. (1977) *Architekturkonzeption der utopischen Sozialisten, alternatieve Planung und Architektur für den gesellschaftlichen Prozess;*
- Frommel, Chr.L. (1986) *Raffaels Paläste: Wohnen und Leben im Rom der Hochrenaissance*.

It is obvious that the history of architecture has as its object of study the past of architecture. However, where does the past cease and where do actual conditions start? This is the problem of the relationship between the history of architecture and the critique of architecture. Both analyse and interpret the work of architecture and judge its quality. Added to that, the practice of architectural critique pre-supposes some knowledge of the history of architecture. The essential difference between both disciplines rests in the temporal distance with regard to the object of study. By reacting to contemporary buildings and architectural concepts the critique of architecture is part of the discussion of architecture today. Playing this rôle, the critique can not only reflect existing notions on architecture, but can also influence them. This involvement is its essential property. However, this involvement with a design of today is not the primary aim of the study of architectural history; at best a possible side-effect.[b] In order to shun this type of involvement *vis-à-vis* the object of study a certain historical distancing is required. It also has a methodological advantage, since contemporary opinions are put in a context not yet visible to co-eval observers. An example of mixing both disciples might be Siegfried Giedion, who as an historian of art was also actively involved with the present as secretary of the CIAM. His history of modernity (Time, Space and Architecture. The Growth of a New Tradition, 1941) gives, for that reason, too one-sided a view of that development.[c] Each historian should draw the border-line of historical distancing for himself; as a rough estimate it could be fixed at one human generation. This does not prohibit that the

a The title of a meeting on the *'Kunsthistorisch Instituut'* in Utrecht in the beginning of the seventies. This meeting seemed to be a politically engaged protest against the established history of architecture.

b See for instance the influence of the publications by Kaufmann, E. (1933) *Von Ledoux bis Le Corbusier: Ursprung und Entwicklung der Autonomen Architektur*; and of Wittkower, R. (1949) *Architectural principles in the age of humanism*.

c *"We need, I think, to recognise the fact that a historian should try to escape from prejudices of his own period. If he merely sees past architecture in the terms of current aesthetics or fashion he is likely to be a propagandist rather a historian."* Allsop, Br. (1970) *The study of architectural history*, p.68.

person of a historian of architecture can also be active in the field of critique of architecture and voice an opinion on today's architecture. The relationship between the history of architecture and the critique of architecture presented here is not without controversy, also because of the underlying similarities.[a]

For the study of the history of architecture the critique of architecture and art offers important and stimulating source material for the history of reception, development of theory and changes of the aesthetic norm. An example of such a study is Woud, A. van der (1997) *Waarheid en Karakter. Het debat over de bouwkunst 1840-1900*.

7.6 SIGNIFICANCE FOR DESIGNING TODAY

Between the two no direct link exists. The one keeps itself busy with what has already been created, while the other creates something new. The methodology described can not be used for designing a building, but possibly for understanding an existing building better. The potential significance of the history of architecture rests in this. Since designing never has a '*tabula rasa*' for a point of departure, and never happens by the same token without some previous knowledge – also in negative sense – familiarity with what was written here influences a new design. And what is more: a new design is placed in an existing context. Consequently, a certain knowledge of that context might be useful; sometimes it is required.

To put it concretely, this means that the result of the study of the history of architecture can provide background information on design decisions; as there is knowledge on the typology of architecture and usage and the information on provenance and significance of architectural shapes and motifs. Since the use of typologies, and particularly, the one of architectural motifs is always culturally biased, knowledge of the past is important at the time of a design decision. Of course the designer is at liberty in his selection of utilising this knowledge; it should not have to agree with the mind-set of the study. In the case of restoration and renovation the study of architectural history plays a more direct rôle in solving the problem.

Generally, one may state that knowledge of the past of one's own personal field of professional experience contributes to the 'Bildung' of the designer. It is useful in a way that can not be made clear in advance. In contrast to a medical doctor or an electronic engineer, working in the profession of an architect entails a specific view of the past. Culturally, architecture is not getting better and better, but more and more different. That is the reason why her past can return, time after time, and influence designs of today.

a Compare Dresdner, A. (1915) *Die Kunstkritik: ihre Geschichte und Theorie*, p.9-10 and Venturi, L. (1972) *Geschichte der Kunstkritik*, p.31-33. Originally published as (1936) *History of art criticism*.

8 MAP STUDY

RIET MOENS

A study concerning the making of maps and a study of how to use a map are two different subjects. Study addressing the making of maps comprises not only collecting data and recording them in a map, but also studying the production of maps (reproduction techniques, usage of colour, legend, readability). A study facilitated by maps often generates additional, new maps.

Recording study data by means of symbols in a map may be compared to descriptive study. Actually, a shape is recorded by means of a token. The meaning of all tokens used is described in a list linking each separate token with a description: the legend. Determining the content of the legend, particularly the variety of data to be recorded and the size, is a problem in conceptual terms as well as in terms of technical production. Studying maps by analysis, comparison and deduction exceeds the recording of shapes by means of well-known tokens or those agreed upon. A study like that comprises a historical study (development) as well as a categorising study (recognition). A design study by means of maps is also a possibility.

In this Chapter, making maps as such is not taken into account. How study data may be recorded in a map and how knowledge from a comparison and deduction of maps may contribute to urban designing are central issues.

8.1 MAPPING THE EARTH'S SURFACE

A territory may be documented spatially (without words) by way of a map, aerial photograph, satellite image[a], or a model. We restrict ourselves to images on a flat surface. A map or a remote sensing image is a distortion of reality, since a projection of a spherical surface, in this case a three-dimensional space is recorded. In addition, a map is an abstracted representation of reality. The content of the map is determined by the object of study, like topography, infrastructure, morphology, etc. The data result from measurements in the territory.

The conjunction of study and maps has been extended since the start of the twentieth century with the study associated with remote sensing images. A remote sensing image is a mapping of an environment obtained from a distance, without touching the object physically. A technique often employed is the vertical aerial photography of a territory. These images offer a detailed registration of all shapes present on earth in realistic proportion. A correction of distortions resulting from the projection – from sphere to flat surface – and from the lens technique employed belong to the scientific field of geodesy.

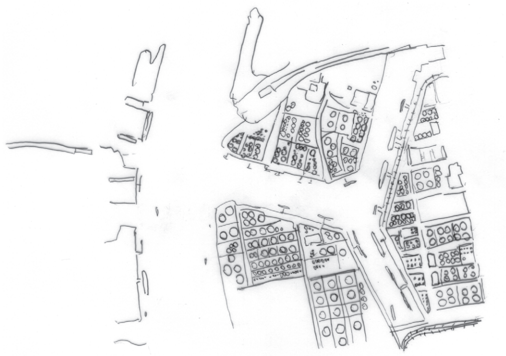
Shapes of the earth's surface may be recognised by the shape itself – like a building or a road – or by a combination of shapes. The images also document the date of the recording; it is automatically included on the image (a photograph) itself. The present generation of topographical maps has all been derived from remote sensing images.

8.2 REMOTE SENSING IMAGES

As a matter of fact, remote sensing images are unstructured material without legends, while maps feature legends, a descriptive list of tokens. The study of remote sensing images demonstrates two different options: production of a (topographical) map, and facilitating study of maps. In both cases recognition and interpretation of shapes is the objective, followed by recording in a document. Differences concern primarily the extent of depth, systematic approach and method of recording. The expertise of the researcher determines the recognition of the shapes. Other capabilities of the researcher, like the power to visualise a shape from above and an extraordinary patience, also play an important rôle. Because a trained researcher recognises and identifies more easily, he will get results more quickly. Knowledge of the territory covered by the satellite images is a great advantage.[b]

a The aerial photograph and the satellite image have been combined in the concept 'remote sensing image'. These images are being produced with the help of various recording techniques, such as photography, infra red recordings, radar, e.t.q.

b American Society for Photogrammetry and Ryerson R.A. (1999) *Manual of remote sensing*.



29 Oil port Pernis, Rotterdam. Author's interpretation based on an aerial photograph dating from 1970

1 BUILT-UP AREA		
	1.1 housing	
		1.1.1 detached house 1.1.2 semi-detached house 1.1.3 row of houses 1.1.4 urban villa 1.1.5 appartment buildings low 1.1.6 appartment buildings middle high 1.1.7 appartment buildings high rising 1.1.8 …
	1.2 commercial services	
		1.2.1 shop 1.2.2 shopping centre 1.2.3 shopping mall 1.2.4 hotels, restaurants, pubs 1.2.5 pleasure area 1.2.6 schools 1.2.7 medical provisions 1.2.7 cemeteria 1.2.8 …
	1.3 industry	
		1.3.1 … 1.3.2 …
	1.4 mixed housing and commerce	
		1.4.1 … 1.4.2 …
	1.5 mixed housing and industry	
		1.5.1 … 1.5.2 …
	1.6 mixed commerce and industry	
		1.6.1 … 1.6.2 …
	1.7 traffic and transport	
		1.7.1 … 1.7.2 …

30 Example of a simple determination table

By and large, a study of remote sensing images in order to produce a map is effected as follows. The researcher orders the material and tries, by looking and reading, to distinguish, recognise and identify shapes and structures. Shapes may be recognised and determined by certain characteristics as there are shading or colour, texture, pattern, shape, size, height, shadow, situation or environment. The result is a list of shapes, a preliminary legend. The method of representing the shapes by tokens, or possibly colours, is also recorded. A remote sensing image becomes more than a picture at random from the moment a (preliminary) legend has been drawn up. An ordering typology has been formulated. This typology is strongly determined by the field of expertise of the researcher. The preliminary legend is the basis for subsequent study, the interpretation. Combining shapes, the positioning of shapes with regard to one another and knowledge of a situation add to the content of the remote sensing image at the time of interpretation. The facility of the researcher to imagine a situation plays an important rôle. An example to illustrate: in a harbour area different types of buildings are located; like terminals, shipyards, docks, storage structures. On the waterfront cranes are installed and areas for containers. How would these activities look on an aerial photograph? Is it possible to recognise elements and activities as such?

The result of the operations is a map: a personal interpretation of a remote sensing image. In principle, this map is not objective. By recording the interpretation in a code, the legends, a higher level of objectivity is realised. The same interpretation may then be repeated for another area. In addition the legends heighten the uniformity and precision of the repetitions of the interpretation for other areas. When it becomes clear that no adequate tokens are available to render new shapes whilst interpreting a new area, the legends will be extended with new items. At least all tokens of the map should be present in the legend.

As a result inherent in production of a map – difference in scale with reality, thickness of lines, reproduction of a surface – and the impossibility to reproduce the smallest shapes and elements, they are conjugated, abstracted, omitted and, given their importance, depicted in an exaggerated way. An example of this method of making maps is the topographical map.[a] The topographical map is used as a basic map for the production of thematic maps.[b]

Utilising remote sensing images in the study of an area as a tool or an addition to the maps available is based on recognition and interpretation as well. In fact the same procedure as described is followed. With the help of these images the researcher may determine a further precision and content of the abstracted form, or, if necessary, update the maps with the most recently obtained remote sensing images.

8.3 IDENTIFICATION OF SHAPES

Keys of interpretation and determination tables are used particularly when interpreting remote sensing images. A table helps to identify the shape in an organised and consistent manner. This table may be a written one or pictures with or without description; it can be constructed in different ways. Most frequently employed are a selection table and a table based on elimination. In the case of a selection table the shape is determined by comparing the shape of the reproduction to a standard form from the table. In the case of elimination a selection from different possibilities is made step by step. Proceeding with what is chosen another choice from different possibilities is made by increasing precision. Ultimately, the result should be an unequivocal answer to the question: what shape is this? This method is very suitable for recognition of cultural products like buildings and results of civil engineering. It is also used for the determination of plants.

8.4 THE LEGEND

A distinction should be made between the content of a map and its reproduction or rendering. It is recommended to keep the content of a map as straightforward and unambiguous as possible. Do not combine two totally different studies in one map; make separate maps of the

a A map is a maximally faithful rendering of a part of the earth's surface.

b A thematic map indicates a specific theme, like infrastructure or soil.

different subjects of study. These maps may be compared to one another by sieve analysis.[a] Do restrict the number of categories in a legend for the sake of readability. Scientifically well-considered choices must be made where magnitude and importance of the different elements and shapes are concerned. How typical or characteristic these elements and shapes are is also of importance in the study? The choice determines scale and legend of the map. Put differently: the subject of the map determines the 'content' of the legend. The scale of the map chosen determines its level of detail and therefore the number of items in the legend. The content of the study determines the elements that must at least be represented. That is the reason that the content also determines the scale of the map.

Next to the conceptual aspect of the map, technical knowledge on the human capacity to discern is needed. This involves depiction of elements and shapes on a map, use of colouring, grey-tones, and so forth. Knowledge is required on the number of elements that may be distinguished on a map and on the smallest possible element still standing out at the scale chosen. To what extent may elements, for instance, be simplified in shape (straightened) or omitted? What is the importance of an element on a reproduction? What are the limits set to abstraction from reality of a map? Next to this knowledge on human perception there should be cognisance of reproduction techniques, both analogue and digital.

8.5 SCALE OF A MAP

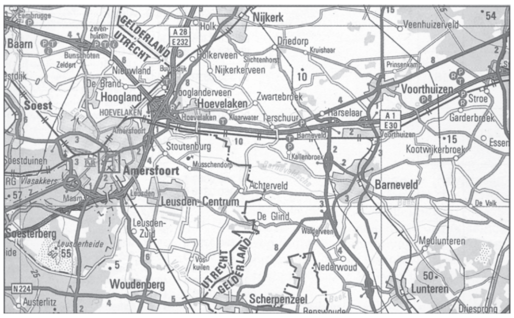
As mentioned, the scale of a map is determined generally by the object of study. The precision of the map is inter-connected with its scale. On a map with a scale 1: 1.000 a road 10 m wide is proportionally represented by a line 1 cm thick. On a scale 1: 10.000 the same road is represented by a line 1 mm thick. At an even smaller scale (1: 100.000) the same road can not be rendered proportionally. However, if we deem this road to be very important, it may be indicated by a token. In that case the legends should mention the width of the road. A deliberately chosen falsification of scale then applies. Measurements on this last map mentioned in order to determine the width of the road, do not yield the correct width of it and are, therefore, not valid. In addition the correct positioning of this road is in jeopardy; within certain margins.

Obviously, maps with a small scale (1: 100.000) can contain less information than maps with a large scale (1: 1.000). On maps with a small scale the shapes have been abstracted and similar or associated shapes are placed in one category. Enlarging maps with a small scale does not yield more information and greater precision. Changing a map with a large scale into one with a smaller scale – the opposite procedure – gives a map with the same information and accuracy, as long as the new map may be reproduced technically. If the reproduction is not feasible the accuracy is at least equal to the one inherent in the new scale.

31 Topographical map of the city of Rhenen on scales 1:100.000, 50.000, 25.000 and 10.000, based on the same aerial photograph[b]

a Sieve analysis is a method super-imposing maps with the same scale in order to be able to inspect and analyse differences and similarities in mixing, spreading and accumulating spatial components. The method may be extended and refined in various ways by introducing the factor time or potential.

b Source: Topografische Dienst Nederland



32 Thematical map: the roadmap of The Netherlands[a]

8.6 DIFFERENT TYPES OF MAPS

Cartography distinguishes between basic maps – usually topographical maps – and thematic maps. A basic map is a two-dimensional representation of the shapes and elements occurring on the earth's surface. Generally, the basic map comprises the following elements: elevation, water, infrastructure, buildings, land utilisation: forests, meadows, farmland, and so forth. A researcher may use a basic map as a basis or reference for his study. A basic map usually serves as a background for thematic maps. They may be derived directly from the basic map, like a roadmap for motor vehicles, maps for tourists, maps of the distribution of dwelling clusters, maps of waterways, and so on.

One distinct category of thematic maps are maps where the distribution of characteristic non-topographical elements is depicted. Examples are geological maps and maps indicating soil compositions (figure 33 shows different kinds of clay, sand, peat and water), vegetation, population (figure 34 shows units of e.g. 100.000, 50.000, 20.000 people) and statistical deviations. The data for these maps have been obtained by study. They are based on data obtained in the field, or on study of sources in literature.

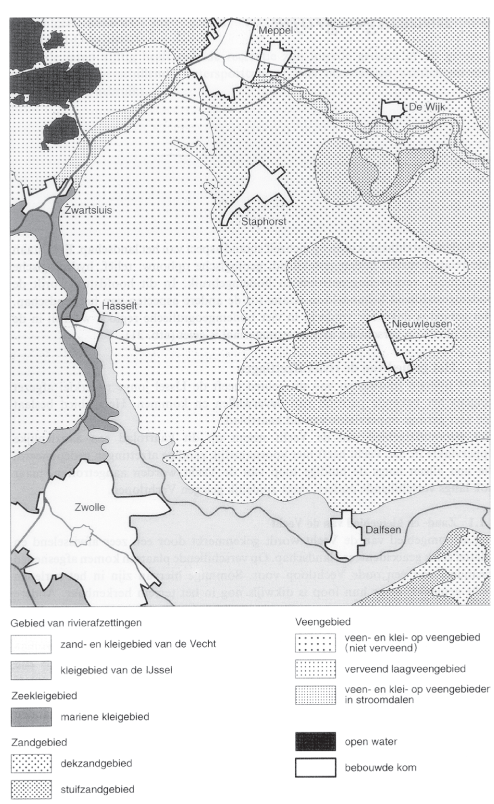
8.7 STUDY AIDED BY MAPS

Research with the use of maps comprises examination of inventories and source material as well as conventional research methods like describing, comparing, evaluating and recognising problems. Instead of maps, remote sensing images like aerial photos and satellite images can be used for research.

a. *Inventory*

This research comprises the following actions, depending on the choice of the subject to be inventoried:

- compilation of material in the form of maps and remote sensing images,
- scaling the maps by enlarging and reducing
- studying the maps and
- processing the research conclusions whether or not in map form.



33 Thematic map: soil composition based in data obtained 'in situ'.

34 Thematic map: dispersion of the population

a Source: Topografische Dienst Nederland

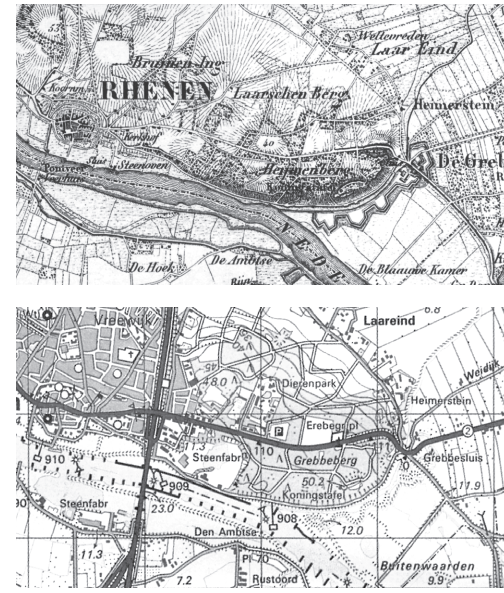
The subject of the inventory determines the contents and the legend of the newly generated map. The inventory is in fact a recording of forms in signs. A description of a form is recorded by means of signs. Normally a topographical map is used as a basic map, because this map is an objective representation of the reality. In fact, these maps could be denominated as second-generation maps.

b. Historical study

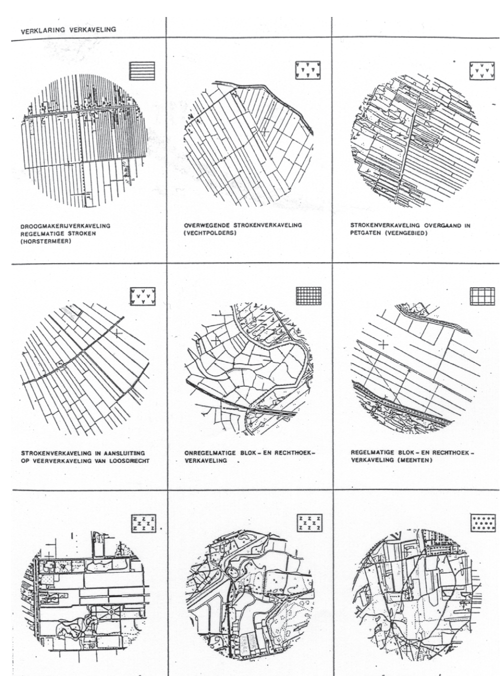
When carrying out a historical study of maps, besides an inventory, a comparative research is carried out. The transformation of a form in the course of time is subject of study. The research is normally carried out using topographical maps of varying ages. The map material can be supplemented using aerial photos if required. For clarification purposes maps other than topographical maps are studied, like watercourse maps, property maps etc, using the topographical map as background. Besides the comparison of various historical maps the maps also undergo other processes. Data from various maps are placed under one denominator where possible and recorded in one map. The maps are supplemented with details from written sources where required. For example in the case of research into soil contamination, details from chemical soil research and municipal permits of the companies established in that area are used.

c. Comparative study

Historical comparative study can be supplemented with an interpretation of the maps. Anomalies and similarly formed elements are recognised and established during this study. This way striking topographical elements like parcelling, watercourses, classification and forms of settlements are more closely examined. An attempt is made to find explanations for the characteristics found during the interpretation. These explanations can be based on the comparison of a thematic map like geological and soil maps, groundwater level maps and contour maps. Written sources like taxes, purchase reports of grounds, etc. can also clarify characteristics. The explanation of characteristic elements can result in research of the tolerated deviations within the form. In this manner the archetype of the form can be established. Using this archetype comparative study can subsequently be carried out regarding existence and distribution of this type using other maps. A good example of this is the landscape arrangement, which here in Holland was made using parcelling and settlement structure as a basis.[a]



35 Comparison of Rhenen between 1850-1865 and Rhenen around 1987[b]



36 Parcelling of The Netherlands according to Hofstee and Vlam (1952)

37 Legenda by image[c]

a Hofstee, E.W. and A.W. Vlam (1952) *Opmerkingen over de ontwikkeling van de perceelsvorming in Nederland;* Visscher, H.A. (1975) *Nederlandse landschappen;* Maas, Buro (1981) *Een beeld van het Zuidhollandse landschap, deel 1, 2 en 3.*

b Source: Topografische Dienst Nederland. See also: Topografische Dienst Emmen (2001) *Topografische dubbelatlas;* – (1996) *Grote provincie atlas 1:25.000.*

c Maas, Buro (1981) *Een beeld van het Zuidhollandse landschap, deel 1, 2 en 3.*

Sieve analyses can also be used for comparing maps of different types. The analysis can produce a suitability, which may or may not be coupled to a weighing. For example, the result of sieve analysis can be a potential map for agriculture. In Ian McHarg's *Design with nature* (1969) this method is described based upon the applications in the area of town and country planning.[a]

The latest development in the area of sieve analysis is analyses carried out using the GIS (geographical information systems) by computer. Maps are stored in the computer in layers of information. The information per layer is recorded in a grid. Combining or sieving various layers creates potential maps for a chosen function. Using this computer application the size of the grid plays an important rôle in the accuracy of the product. In this way the amount of information stored in the different layers is also crucial for the foundations of the result.

d. Morphologic study

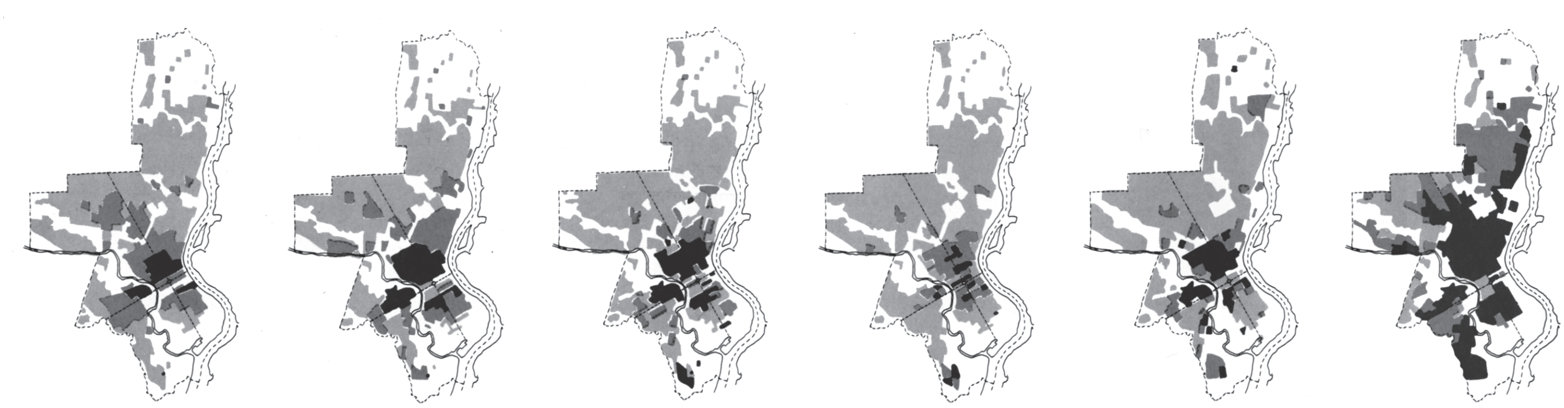
Carrying out a town planning survey, frequently use is made of images of the area in the form of topographical maps and remote sensing images. This way information about the position and structure of buildings, land utilisation, infrastructure, parcelling, water, etc. is collected. With morphological study the emphasis lies on space in every case. In fact it is not about space itself, but about the elements that form and determine space. The distribution, form and direction of space and space forming elements like walls play an important rôle during analysis. Morphologic research is often augmented with an explanation of the elements through the influence of the physical and socio-economic circumstances and history (origination history).

Key questions in morphologic research are:
- Is the form of space sheer co-incidence or are there circumstances which obviously have had an influence on the form and position of the space and the space forming elements?
- To what extent has history made its mark on the current form of town, village or landscape?

Besides studying and analysing historical maps, explanations are sought regarding form and distribution of the space and the elements which are part of this. A number of forms can be explained from geomorphology and sub-soil, however, the building technique and legislation also play a rôle. Palmboom's study into landscape and urbanisation between The Hague and Rotterdam is an example.[b] The intention of the analysis was not only to clarify in words the character of the area, but especially to illustrate the area using map images. Using a large number of map images it is made clear which form the area has, how it is made up and what it looks like. Aspects involved in the study are (small) height differences, parcelling forms, sub-soil, landscape forms (like dunes with shoreline complexes, rivers with riverbanks, tributaries). How insignificant these aspects may be, they had an effect on the area. The time el-

a McHarg, I (1969) *Design with nature*.
b Palmboom, F. (1990) *Landschap en verstedelijking tussen Den Haag en Rotterdam*.

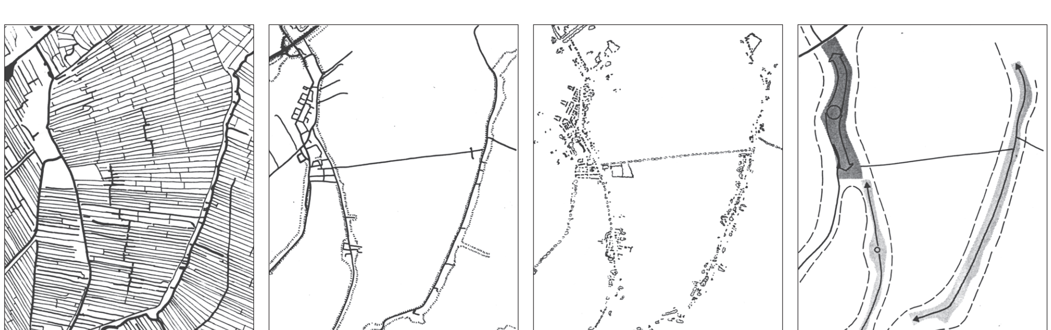
38 Sieve analysis according to McHarg (1969)



ement arises in an endless series of interventions in the Dutch landscape. Besides the comparison of historical images (time element) with the current situation, attention is also paid to the possible prospective changes. The aim of this analysis is not to freeze current structural images, but is actually for the benefit of the design. According to Palmboom the aim of the analysis is *"to find possible starting points for design proposals in the current situation, which can assist in directing a gradual, lengthy, and partially unpredictable process of change"*.

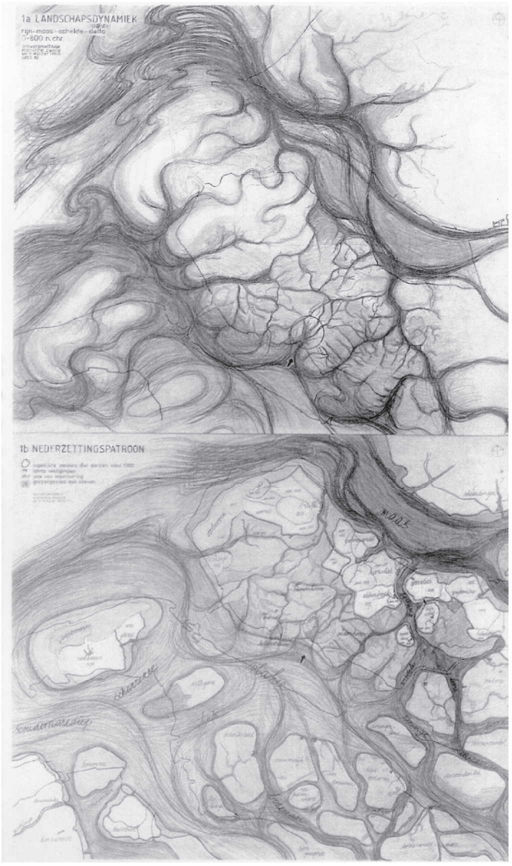
A similar study was carried out earlier by Buro Maas for parts of South-Holland Province: *An image of the Landscape of South-Holland*.[a] The emphasis in this study is on making the manner of origin and development of the landscape and the accompanying landscape forms, present in South Holland comprehensible. The study serves as a reference frame for municipal and provincial administrations to recognise and evaluate the consequences of intervention within the area - like town expansion or choice of area for a new industrial establishment. Designers can also make use of the landscape details assimilated in this study.

39 Parcelling analysis of Palmboom (1990)



40 Image of the South-Holland Landscape (Buro Maas, 1981)

a Maas, Buro (1981) *Een beeld van het Zuidhollandse landschap, deel 1, 2 en 3*.



41 Morphological study of the landscape (Reh, 1980)

e. morphologic research in aid of design

One special application of making a plan based upon morphological data is the book *How to do it differently* from South-Holland Province.[a] It illustrates how a study into the history of the development of the area surrounding Hellevoetsluis creates motives for designing a rich ecological and greenery structure and an interesting living environment. The planning preparation takes on the course of a creative process, whereby landscape forms are dramatised and transformed. Knowledge of various fields of specialisms comes together in the implementation of the plan. The study shows how a broad development plan takes shape in successive plan phases. A new process is systemising the ‘image formation” and making the creative steps of the design process visible. Each step of the design process is explained using an image (map or sketch) and a description.

8.8 CONCLUDING REMARKS

The future of the map lies in digitalisation. The increase of knowledge associated with rendering representations in digital form will contribute to the study of maps and by maps. Due to the increased accuracy of digital representations of the maps expected, a generation of more information by special*ised* techniques will become easier. Aided by geographical information systems (GIS) sieve techniques can be employed more quickly and thoroughly. Digitising the existing body of maps is an awesome task. What should be digitised, and how, involves important decisions.

a Reh, W. (1980) *Hoe het ook anders kan*.

9 CASUISTRY RESULTING IN LAWS
JUDICIAL ASPECTS OF DESIGN RESEARCH

FRED HOBMA
LOES SCHUTTE-POSTMA

How to arrive at general statements/rules using individual situations (cases) is an important question in many fields of science and in the field of law it is the same.

In this contribution a number of judicial aspects of design research will be discussed: the issue regarding the generation of general rules based upon cases is part of this. We will firstly distinguish between scientific and practical judicial study with respect to building. Furthermore, we will address the unique rôle cases play in law. Some cases can be denoted as 'standard rulings'. In this way a court decision regarding one case is defined as a general ruling regarding a specific area of law. We illustrate this with an example. Finally, we discuss the various levels of scale to be recognised in the ruling on building.

9.1 SCIENTIFIC JUDICIAL RESEARCH

In society many things are not going well, there are problems and also in the extensive area of building: the subsoil appears to be contaminated in many areas in the land, there is a scarcity of locations for new construction, not enough inexpensive living accommodation, 'durable' construction is lacking and complaints are made about newly built houses, etc, etc.

Proposals can be made in order to create new legislation for these problem areas or to amend existing legislation, from different sides (politicians and/or lawyers). A large part of the scientific judicial study lies here. Furthermore, following an inventory of the existing legislation (including the respective legal precedents[a]) and the problems that are not adequately resolved by it, proposals are drawn up for new legislation that should be able to resolve problems. In this way, judicial study, deviating from study in many other scientific fields, is highly prescriptive.

Adriaansens and Fortgens phrase the judicial scientific practice as follows. *"The judicial scientific work, according to many, differs significantly from the scientific work in the remaining fields of social science and natural sciences. It is mainly composed of classification of information, document processing, establishing the scope of legal rules and harmonising the conflicting regulations. In order to do this, considerable amounts of literature, case law, legislation and other regulations must be read and processed. At a higher abstraction level, the aim of judicial scientific practice is the establishment, development and systemising of general legal rule, using general legal principles, legislation, legal precedents and doctrine"*.[b]

With judicial science the emphasis is 'how things should happen', more specifically: directing behaviour using regulations. Our statute, in this respect, is the most important documentation; the way things should happen is laid down by legislation, which is what 'by law' means.

The purpose of laws is to promote positive behaviour, to prevent or punish negative behaviour, to find resolutions for conflicting interests etc. This directing of behaviour by means of legislation is linked to the principle of legality that prevails in our legal system. This principle states that no other restrictions can be imposed on the civil liberties other than those which are equally valid for all, laid down in law by the parliament.

It is legitimate to talk about the 'designing of ruling', since the process has the characteristics of a design process. The term 'designing' often immediately evokes technical associations, but it should not be restricted to them, since designing is not only 'methodical thinking out', but according to its nature, a process of persuading and convincing as well.[c] The process giving rules and the one giving laws are comprising both elements: a set of coherent rules is being 'thought out', but those rules are also legitimised in a political process.

a With legal precendents we mean: verdicts of judges.
b Adriaansens, C.A. and A.Ch. Fortgens (1990) *Volkshuisvestingsrecht*, p. 3.
c Schokker, J.T. (1996) *Wet en informatiesysteem in de maak: een onderzoek naar processen van wetgeving en systeemontwikkeling vanuit een taalspel-perspectief*, p.12,46.

9.2 EXAMPLE OF SCIENTIFIC JUDICIAL RESEARCH

The rather abstract circumscription of scientific judicial research from the preceding paragraph we clarify by way of an example. In the law-giving policy of the last years we are witnessing increasingly and more often that private parties (enterprises, lobbies, branch-organisations) are participating in the process of making rules. As an example one may think of the vast amount of technical norms or normalisation norms to which the Building Decree refers. These norms have been determined for the larger part by the Netherlands Normalisation Institute (NNI). What is actually happening in this respect is legally conditioned self-regulation: the phenomenon is termed 'normalisation'.

The motivation for the government to use normalisation law giving is found in enhancing support and effectiveness of these rules. In addition, because of it the law giving process can be simplified and accelerated. From a judicial point of view, however, the question remains whether it is permitted, on the level of state law, to refer to norms drawn up by private parties in public rule giving, with the aim to make these in this way into rules binding to all and everyone.[a] Another question concerns the intellectual property aspects of normalisation norms. Who owns it in the case of normalisation norms? What is the relation between the rights of the author and the requirement of the potential cognisance of law giving referring to norms, now that in practice the norms are available at the NNI only by way of purchase against commercial tariffs?

Both these questions have been studied by M.H. Elferink in her thesis.[b] She comes to the conclusion that normalisation norms are generally binding prescripts and that they have not come into being in a judicially valid way; since the state law requirement of public cognisance, that rules binding everyone should be published formally and officially in the *Staatsblad* or *Staatscourant* or one of its supplements.[c] The *Staatscourant* does publish the announcements of new NEN-norms, but not their text. This makes the potential to become aware of these rules, a legal requirement of our democratic law-abiding state, too vague.[d]

She also studied what the consequences of this could be for the building sector. Her conclusion is that suing claims of constructors and private persons who had to adapt or demolish buildings on the basis of the rule giving as recorded in normalisation norms might be successful.[e]

In addition she concludes that the normalisation norms of the NNI are not protected by authors' rights, since generally binding prescripts are at stake. By the same token everybody may make them public and copy them (as intended in the Authors' Law). On top of that, these norms should be provided to the users free of charge and should preferably be financed by public means.[f]

The first conclusion is one that must be put before the judge: is the judge also of the opinion – if the question should come on the agenda – that in the case of normalisation norms (like the NEN-norms) rule giving is concerned which has not come into existence legally. The other conclusion regarding authors' rights and the costs can also lead to new policy, if the Law (Minister and Parliament) would endorse this conclusion.

9.3 PRACTICAL JUDICIAL STUDY

Next to the scientific judicial study with respect to building, there is also the practical judicial study with respect to building. In our contribution we assume that the architect under the terms of the assignment carries out the practical judicial study.

For the architect the practical judicial research will take on a form in accordance with the obligations which the Dutch SR (Standard Conditions for the legal relationship between the architect and the client) formulates in this matter: "With the realisation of the assignment the architect must consider the public law regulations, the existence of which is considered to be common knowledge among architects."

a If this would be juridically illegal, these norms could imply only a recommendation.
b Elferink, M.H. (1998) *Verwijzingen in wetgeving: over de publiekrechtelijke en auteursrechteljke status van normalisatienormen*.
c Bekendmakingswet.
d Elferink, o.c. p. 265.
e In connection with this questions were asked in Parliament to the Ministers of Justice and the Environment on the juridical status of normalisation norms.
f Elferink, o.c. p. 273 a.f.

As part of the framework of the application for building permission the architect must carry out the required practical judicial research. Is a building permit actually required or is the work a structure for which an official notification is required? Do the zoning plans allow the intended construction to be built on site? If this is not the case, is it the intention of municipal administration to co-operate with the exemption of the zoning plans? Which on-site demolition regulations apply? Is a clear ground certificate for the construction a requirement? Are specific urban aesthetics regulations applicable? Which regulations incorporate the Building Decree for the intended construction?

Practical judicial research can cover many other judicial aspects. In this way neighbours rights and obligations issues can be presented, for example: can windows be placed on the sidewall of the building, overlooking the neighbour's property? How can an existing easement (for example a right of way) that obstructs the building plan be cancelled? Questions regarding compensation claims can also arise, for example if the municipality only wishes to co-operate to the exemption of the zoning plans under the stipulation that any loss resulting from government planning decisions incurred by the neighbours will be paid for by the builder. Can this be done just like that?

Pursuant to the SR, it is not a 'standard' obligation for the architect to resolve these practical judicial questions, stated in this paragraph, for the customer. However, he can accept an (extra) assignment for this purpose.

Various 'tools' exist, which are architecturally beneficial when carrying out practical judicial research. Besides survey work[a] the tools mainly consist of: checklists, models, guidelines, form letters and business forms, example solutions, standard contracts etc, satisfying judicial requirements. Without trying to attain completeness, examples are listed beside.

- Stichting Bouwresearch, ed. (without year) *Praktijkboek Bouwbesluit grotere bouwwerken; leidraad bouwaanvraag*
- Koning, B.M.G. de, ed. (1999) *Arbobesluit voor de bouw; Inclusief diskette met de modellen van het Kennisgevingsformulier, het Veiligheids- en Gezondheidsplan, het V&G-dossier en checklists*.
- Stichting Bouwresearch (1998), *Hoe te handelen bij schade*
- Stichting Bouwresearch en TNO Bouw (from 1992) *BSC Bouwregelgeving Consultatie Systeem*. (CD-rom).
- VROM (1989) *Bestemmen met beleid; nieuwe mogelijkheden voor het bestemmingsplan*
- Vereniging van Nederlandse Gemeenten (1999) *Bedrijven en milieuzonering* (inclusief diskette met afstandentabellen naar categorie)
- Schenke, H.A., W.D. Susanna *et.al.* (1996) *Contractvorming in de bouw; juridisch praktijkboek*
- Meijer Drees, F.J. (without year) *Handleiding Milieuwetgeving; deel 3, 3a Inrichtingen en procedures* (losbladig)
- Infomil (1999) *Informatiebladen regelgeving (Kantoorgebouwen, School- en opleidingsgebouwen enz.)*

9.4 FROM CASE TO GENERAL RULING

The Dutch legal system can be found in 'sources of law'. The sources of law are: the statute, international conventions, common law and legal precedents. In this paragraph one source of law will be specifically examined: legal precedents. Based upon the legal precedent phenomenon, we will deal with the question: how can we (in the law) generate public knowledge based upon cases?

As in many other sciences, law makes use of cases. With the term 'cases' we are referring to, in law: rulings by judges concerning disputes. There are various types of disputes: between individuals(private)/private organisations among themselves (example: not fulfilling a contract), between local authorities and private individuals (example: not granting a building permit) and between the authorities themselves (example: the municipality which does not want to co-operate regarding the construction of a motorway through a nature reserve). Each judicial decision regarding disputes contains besides facts, an imposition of a rule of law.

In Holland thousands of rulings are made annually. For our considerations it is useful to divide the total of rulings into three parts: (a) un-published rulings, (b) published rulings and (c) standard rulings.

(a) Un-published rulings

Most rulings are un-published. This means that a written ruling from a judicial authority was produced regarding the submitted dispute, but this ruling was not published in legal precedent magazines; the reason being that the ruling was not interesting enough for judicial sciences and practices.

(b) Published rulings

A smaller number of rulings are published in legal precedent magazines; rulings of interest to judicial sciences and practices. There are different reasons as to why a ruling is interesting enough to be published. One reason may be that the ruling provides clarity regarding an issue

a For example: Recht en Techniek, Sectie (2001) *Recht voor ingenieurs*. Also: Berg, M.A.M.C. van den (2000) *Bouwrecht in kort bestek*.

upon which no ruling was in existence up until that point. Broad announcement by means of publication is then useful. Another reason for publication may be that the court of justice has made a ruling that deviates from the traditional course of previously published ruling in the field of law concerned. Published rulings are sometimes 'annotated', which means: provided with juridical comments. The annotator discusses the judicial aspects of the ruling that are of interest for the judicial sciences or practices, in his note.

(c) Standard rulings

A subset of the published rulings propels it to standard ruling. These are rulings from the 'supreme judge' in a specific judicial area. In civil law the Supreme Court, in administrative law the Department of Administrative Jurisdiction from the Council of State and in (one category) building arbitration cases, the Arbitration Board for the Construction Companies in Holland. In a standard ruling a Court of Justice makes a ruling considered to be of significant importance for judicial sciences and practices. There are various reasons why a ruling receives the status of standard ruling. One reason may be that the highest court of justice clarifies conflicting rulings from a lower court of justice (district courts, courts of appeal), with its ruling. Another reason may be that the Court of Justice 'fills' a lack of clarity or a deficiency in the law. Another reason may be that the Court of Justice returns to other rulings from the same Court of Justice. It is then said that the Supreme Court (or another Court of Justice) 'switches round'.

Standard rulings are not only published and annotated; they are also collected in special ruling volumes used in practice and education. Standard rulings are also used in judicial handbooks and loose-leaf judicial commentaries.

An interesting aspect of them is that they are strong determining factors for rulings in comparable situations brought before the lower courts: these District Courts and Courts of Appeal will not deviate from the regulations as formulated in standard ruling. Also in practice the parties will not be able to get around them. We see here the interesting phenomenon that public knowledge is generated using an n=1 situation. The legal rule as formulated in one case which was ruled upon by the Court of Justice, becomes a general ruling. We have gone from case to general ruling. More importantly, standard ruling can lead to amendments of the existing law in agreement with the standard ruling. In these cases, this is casuistry resulting in laws.[a]

A standard ruling has a wider purport than an individual case wherein a ruling is made, the condition being that the new cases are comparable with the original situation. Or vice versa, unless there are special circumstances at issue, the lower Courts of Justice (just as the courts of justice which made the standard ruling) will not deviate from the regulations of the standard ruling. This is an important area of work for the legal profession. If the regulations of the standard ruling do not satisfy his client, an attorney will argue, (a) that in this case the circumstances are not comparable with the standard ruling and, therefore, (b) the regulations of the standard ruling are not applicable in this case.

An interesting parallel can be seen for standard ruling with the art of building. Designs and/or buildings can also offer a 'solution' that extends further than the individual building concerned. Likewise, deviations of these solutions can be argued.

The rôle of cases is in Anglo-Saxon countries (United States, Great Britain) even larger than in countries with a continental judicial system like The Netherlands, Germany and France. This is due to the fact that, in the countries stated, a comprehensive system of legislation is in place (Civil Code, administrative laws, criminal legislation, etc.), whereas Anglo-Saxon countries do not actually have a code of law. Their laws are almost fully based upon judicial precedents (cases). In addition, they work with, for example, extremely comprehensive con-

a Also a special variant of this situation occurs in practice: the standard verdict is (politically) undesirable and the Minister responsible tries to neutralise the standard verdict by a change in the law. An example of this is the ruling of the 'Hoge Raad', the highest legal authority in the country of September 1994. The verdict was that Shell was not responsible for damage in the soil of the Zellingwijk neighbourhood in Gouderak by pollution during the fifties. The Minister of Ecological Affairs, being very disappointed by this ruling, next made an effort to adjust the jurisprudence on soil sanitation in terms of responsibility to the old pollution. This proposal proved to meet with serious opposition in the Senate; and, in the end, the Minister did not get his way as intended.

tracts, for which regulations have been laid down in legislation in Holland. These regulations are applicable in Holland, unless the parties agree otherwise. Therefore Dutch contracts are much more concise than in the United States, for example. In Great Britain the rulings of the supreme courts of justice are used as precedents: the lower courts of justice are formally bound to the Supreme Courts rulings. In Holland, on the other hand, there is no formal (however, there is a practical) commitment.

9.5 EXAMPLE OF STANDARD RULING

In this paragraph we clarify the phenomenon 'standard ruling' on the basis of an example in the field of construction and building. The case concerns the '*Graafstroom* question'.

The Monument Law of 1988 gives to the Municipal Executive the right to give permission for intervention in state monuments by way of monument permits. However in order to be able to use this right, the Municipal Executive must obey a condition: the municipality needs to comply with a Monument Ordinance, in which co-operation with a committee for the care for monuments is organised advising the Municipal Executive on the monument permission that is applied for (article 15 of the Monument Law). The Monument Law does not state specific requirements with regard to the number of committee members or to expertise!

What happened in the case of the *Graafstroom* municipality? It had appointed the existing committee of the council of the municipality for Public Works, Housing and Environment as the committee for monuments as well. According to the municipality the members of this existing committee were in their expertise sufficiently equipped to function as members of the monument committee, while they all lived in the community and by the same token aware of the situation surrounding the state monument in jeopardy.

The Council of State ('*Raad van State*'), highest judge in the field of policy law, had to rule in the final and highest instance in a conflict between the municipality and an interested lobby association, 'Bond Heemschut'. The lobby had appealed against a monument permission given by the municipality; it implied demolition of the monument. The Council of State was of the opinion that the composition of the municipal monument committee (members of the Public Works committee) was well under par and ruled that a monument committee may comprise admittedly some members without specific expertise, "provided that the expertise on the field of the care for monuments has been warranted sufficiently by the appointment of other members."[a] In other words: the committee may include members without expertise, but then the expertise should be guaranteed by the presence of other members who can be considered experts.

Although the Law has formulated no requirements with regard to the composition or expertise of a municipal monuments committee, the judge does formulate them. So the judge is complementing the law. The complementing requirement demonstrated by this ruling does not only apply for the monuments committee of the Graafstroom municipality, but for *all* monument committees in The Netherlands. The ruling in this single case has a general effect.

The ruling in the Graafstroom question established new jurisprudence: before this the Council of State had made no statements on the composition of municipal monuments committees. Given its national importance, the ruling quickly got publicity.[b] The ruling was also published in a journal on jurisprudence.[c] In a loose-leaf comment on the Monument Law the ruling is discussed.[d] Finally the ruling is dealt with in educational material.[e] All taken together, we may call it a 'standard ruling' in monument legislation.

An interesting comparison may be made, here as well, between judicial science and architecture. Also in architecture, buildings that may establish a new 'standard' are getting publicity, are being commented on and treated in education. However, it is our impression, that the documentation infrastructure in judicial science has been institutionalised and professionalised

a Ruling Chairman Legislation Department Council of State, November 27th 1991. Published in Administratiefrechtelijke Beslissingen 1993, 133.
b Cate, F. ten (1992) *Monumentencommissie met alleen gewone raadsleden is niet deskundig genoeg.*
c See footnote a.
d Zundert, J.W. van (1994) *Artikelsgewijs commentaar Monumentenwet 1988; Artikel 15, aantekening 3.*
e Hobma, F.A.M. (1997) *Monumentenrecht.*

better than in architecture. In this respect architecture has something to learn from judicial science.

9.6 SCALE LEVELS IN RULING FOR BUILDING

Just as in architecture, we may discern in ruling for building scale levels; the 'spatial interface' of rules for building may differ on different scale levels.

- As an example the Physical Planning Act recognises (among others) The Netherlands as a whole as interface: structural outline plans may be made going through the Physical Planning Key-Decision[a] procedure. These structural outline plans are making spatial statements in national level.
- The same law is encompassing also the regional level as an interface: regional plans may be formulated with spatial statements on regional level.
- For the level of agglomerations rules exist as well: the Frame-work Law Policy in Change obliges seven specifically named agglomerations to formulate a structure plan. In such a plan the locations of projects important to the individual agglomeration have been recorded.
- For (parts of) the municipal scale level land-use plans can be formulated, pursuant to the Physical Planning Act.
- Urban Renewal Act enables that for certain neighbourhoods an environmental ordering is formulated in terms of well-being.
- On the level of the separate building the rulings of the Building Decree apply, pursuant to the Housing Act. On the basis of the Environmental Control Act an extensive system of general rules for 'facilities' applies there as well.

Although it is possible, therefore, to order rulings for building according to scale level, the ruling for building has not been designed generally with spatial scale levels for point of departure. This does not make consulting rulings for building by architects any easier. Ruling for building is by its very being, quite extensive and thereby hard to consult. Technical and constructional rules exist, rules for materials, rules for urban planning, environmental rules, rules for working conditions of the workers themselves, rules for historic buildings, rules for bidding, rules for professional conduct, rules for judicial relationships between parties in the building process: and so on, and so forth. In spite of many efforts to attain deregulation[b], the rule giving for building remains a vast complex. For judicial scientific study of the building profession this entails, - see also paragraph 1 – that, amongst others, study will continue to be done with respect to the length of the arm of the law-rules and to harmonising conflicting rules. For the practical judicial study on the field of building itself – compare paragraph 3 – this entails that architects and those who build do well to use the tools available to lead the commission in suitable channels.

a Planological Core-decision. Examples of structural schemes are the Structural schema Traffic and Transportation and the Structural Schema Green Space (with the Ecological Main Structure).

b 'De-regulation' is understood to be here alleviating the pressure of rulings on industry and citizens, particularly as materialised in lessening the number of rules.

DESIGN RESEARCH AND TYPOLOGY

B DESIGN RESEARCH AND TYPOLOGY

In empirical study the hypothesis functions as an object of verification in an existing reality. Establishing a hypothesis itself scarcely figures as an object of methodological thought. Usually the hypothesis of a study is considered to be 'free'. With the design as a hypothesis this would also be the case, if that would not result most of the time from the designers study.

The architectural design is nevertheless in all its stages a fact ('factum', 'artefact') in so far as it has been made with considerable effort; before it even functioned realistically enough to be checked. In its several stages of development an architectural design is not a real and working object. That enrichment is achieved 'ex post', when it is executed and put into a context of use; or when, 'ex ante', a mathematical or material model of it has been made for evaluative assessment. At that time the design has produced two things:

- the hypothesis "This design will work", and:
- a reality or model to test this hypothesis.

Only if a design can be realised is it a model. The type entails the comparison of models. There are types of models, not models of types. Following the criterion of Quatremère de Quincy, quoted by Leupen (page 113), the type is not yet a model. It can not be copied in reality. Like an intuition it can not act as a model for that reality. By the same token a processing by design is needed. That applies also, although less, for the architectural notion 'concept' in the sense of 'conception', e.g. aiming at communication and consensus between designers and members of the construction team before a design or model exists.

Therefore not every content of experience is a model. If the notion of a model would be that encompassing, it would lose its meaning and crucial applicability in sciences. What is a model then? In the present section different definitions are used. Not only spatial relations (form, composition) and connections (structure) may be read from a model. A model allows for effect analyses and critical evaluations before execution. If a hypothesis on existing reality – or a design for a possible one – is to be tested inter-subjectively, it is a model.

Design research

Van Duin and De Jong give a classification of possible studies when a context is determined.

Designerly enquiry

Breen explores what kind of study is needed before the design is ready for design research. How could we study design before it is a model to be realised and tested?

Typological research

A type is a tool, not yet a model. To elaborate a type into a design we still need a concept as Leupen will explain. Engel and De Jong give a classification of types. The design with a certain function satisfactory on this spot may be a failure elsewhere. How could we extract more context-independent types out of design research?

Concept and type

A concept summarises crucial elements of context and the object to be designed. Leupen explains the relation of concept and type in making designs. This making requires a 'technique' in the connotation of Ancient Greece (*teknè*, art, capability; *poèsis*, making). People who never designed will not be able to conceive of it while it is hard to transfer it verbally, in terms of mathematics, or even as straight pictures. This technique is increasingly supported by sketching and tutoring during designing, by specific computers programs, individually.

Analysis of buildings and plan analysis

Molema and Meyer give examples of analysing existing architectural and urban designs. There are more design methods than designers. The emphasis on design methods in the study of design of the sixties has shifted from process diagrams with stages and arrows to more spatial components: the toolbox of the designer, his means of design and the classification of design interventions.

Design driven research

Breen examines the potential for design driven research in academic environments. Making a design as such is part of the academic education in design; by the same token partial to design research. If the making of a design would not be the object of scientific study, a design education at the academic level would lack justification.

Conclusion

What may be studied in a design before a model of it exists? It is the model itself that should be made. Predecessors of the model do require attention here: the types, concepts, and other means of design. They are the main subject of this section; the next one will deal with the forming of the model following design.

10 DESIGN RESEARCH

TAEKE DE JONG
LEEN VAN DUIN

Design research - when it comes down to it, is the comparison of designs even though they are often implicit. Even if only one design (n = 1) is researched (casuistic-study), then this is carried out at the background of the design profession, its concept formation and terminology and, therefore, carried out on the basis of experience with other designs. One must be conscious of these implicit-references when describing a design and give notification of these or even present images if necessary. At least one design object and its context are explicitly described during design research. The analysis begins once the description has taken place.

For example, Lefaivre and Tzonis[a] compared in the floor plan of Van Eyck's Burgerweeshuis, its classic architectural canons with those from 'De Stijl'. They describe how Van Eyck combines these with new design means wherein both can be recognised. They enumerate a number of compositional means, not only the well-known classical and modern ones, but also their new synthesis in Van Eyck's work.

Can one selectively search for similarities using earlier experiences when carrying out design research using a definition of a problem with pre-determined-concepts and stated hypotheses therein? Can these new characteristics be discovered (which cannot be named) by means of design research (exploratory-research, heuristic-research), or does one come to a dead-end in the concept-constriction, which is imposed upon us by the convention of the use of words?

Can everything be said using words or does the drawing have to assist with this? How scientific then is the conclusion?

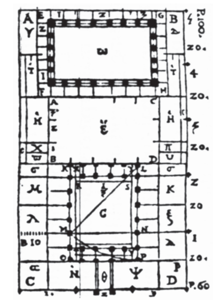
Are words and drawings sufficient to make the experience (and up to a point not verbally expressible, intuition) of the designer, his or her 'design-means (choice of materials, providing structure, providing form, providing function, providing intention, the integration of their conflicts or incomparability) communicable using examples? If the attempt continually gets bogged down in mysticism and only succeeds in demonstrating, then the ambition of the university design research can no longer be defended. All that remains is the traditional practice of the 'master-pupil apprentice' relationship.

10.1 OBJECTS AND CONTEXTS

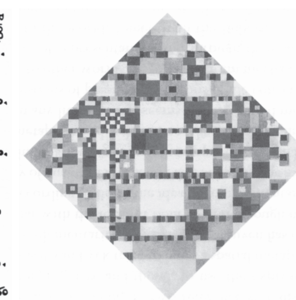
Architectural context entails everything that falls outside the frame (or within the grain) that could have bearing upon the spatial object being considered (such as the form of the location and the layout preceding the design) or vice versa (see page 38). The situation, the site and the programme of requirements belong to the context.

Therefore, strictly speaking, context is not situated *beside* or *opposite* to form.[b] After all, the (historical or prospective) context also has form, which is different at every scale level. In the table below, an overview, as a variant of Frielings' schema[c] is shown of research forms wherein the design plays a rôle.

Design study (upper right in the diagram) is a daily practice in each and every architect's office that does not exclusively work in an instinctively untraceable manner. An object must be designed for a specific context (spatial, ecological, technical, economic, cultural, and administrative). New possibilities are sought for this determined context usually using a programme of demands (part of the context). This form of research will be discussed on page 387.



Cesariano, 1521



Mondriaan, *Victory Boogie Woogie*, 1942-1944

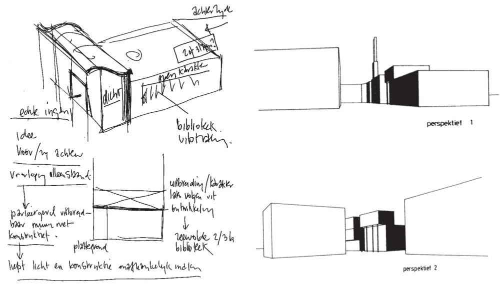
Aldo van Eyck, *Burgerweeshuis*, 1960

42 See similarities in design means, Lefaivre and Tzonis (1999)

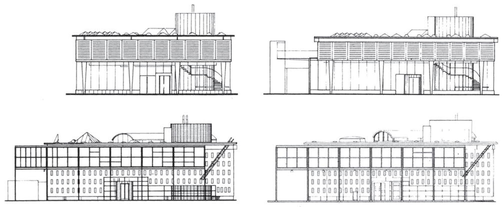
	OBJECT *Determined*	*Variable*
CONTEXT *Determined*	Design research	Design study
Variable	Typological research	Study by design

43 Types of design-related study

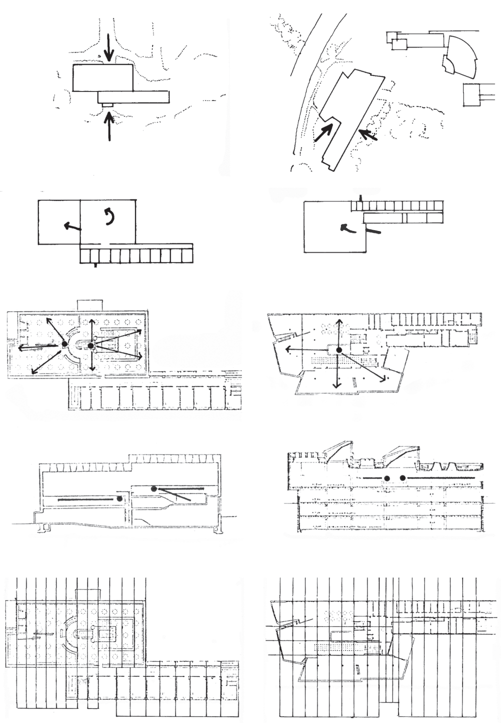
a Lefaivre, L. and A. Tzonis (1999) *Aldo van Eyck: humanist rebel*.
b Alexander, C. (1964) *Notes on the synthesis of form*.
c Frieling, D.H. (1999) *Deltametropool: vorm krijgen en vorm geven*.



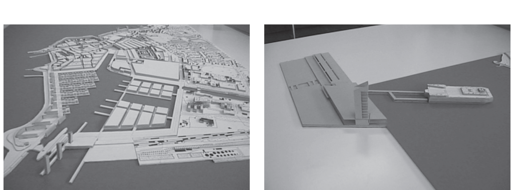
44 K. van Velsen, 1988, design study for the library of Zeewolde



45 Design study of the design process of the library in Zeewolde



46 Typological research of libraries



47 Study by design graduation Van der Voort

a Duin, L. van (1985-1991) *Architectonische studies 1-7*.
b Clark, R.H. and M. Pause (1985) *Precedents in architecture*.
c Duin, L. van and H. van Wegen (1999) *Hybrides*.

In the figure alongside K. van Velsen studies, for instance, the possibilities of a programme and a site for his library.[a] Study of that type comprises a formal analysis and a functional analysis of the existing material and the social (programmatical) context. Apart from this, a limited number of relevant precedents[b] is studied in search of possible means of design; either implicitly, from memory, or explicitly, with the support of documentation. Strictly speaking, this is design research as discussed in the present Chapter.

Design research hones the insight into possible directions of solutions of a design problem; by the same token it contributes to development of a reasoned concept of the designing.[c] As soon as a design has been completed (and consequently, the object determined), it may be studied empirically as to its external (contextual) effects; but also as to the means of design applied within the design, together with their inter-change during the emergence of a design.

After a number of design researches in varying contexts have been carried out, one discovers a complex of characteristic properties, typical for a class of buildings, independent of context; the parlance is then of typological similarities. A type may be rendered schematically. It is possible to verify whether form or structure return under different conditions (architecturally, or in terms of urban planning) and whether it maintains the same effectiveness, such as functional properties (typology).

The type is then context independent. This does not mean that the context is of *no importance* for the typology. The context is *variable,* and this variability is, therefore, the object of typological research: object(context). For each (relative) context independent type, variants of this type are subsequently described, from which the appearance may well be context dependent. The point of discussion is the level at which the spatial-functional constellation of the design is dependent on the context and, therefore, the generalisability. This research is highly concept defining for the design practice and the communication between designers, as much in the naming of the type as the context. This form of research will be discussed on page 103.

An inter-action exists between object and context. If this can be perceived during the design process, due to the fact that alternatively the object and the context are subject to scale changing design, then this is known as study by design. This form of research will be discussed on page 453.

10.2 CONTEXT DEPENDENCY

If a design features a location, it has a material (spatial, ecological, technical) and a social (economical, cultural, political) context. That context will change. The designer anticipates on future contexts (perspective) in so far as they are probable during the period of the designing process. Each design differing from any other design in space and/ or time, differs in context and perspective. This evokes questions concerning the possibilities of comparison, although these are often neglected during the study (*ceteris paribus*). However, the same design has in each material and social context a different effect on the various levels of scale. In a strict sense, one can not identify effects on the base of effects identified previously, if the context differs. As an example the spatial environment can be a built one; or un-built. In a more general sense, one may call this concentration and de-concentration of building within a radius of circa 30, 100, 300 metres; etc. Along these lines the Schröder House of Rietveld has been perceived, once upon a time, as the outer built-up area of Utrecht city.

Nowadays it is faced by a main traffic road; with new buildings at the other side. Within a radius of 300 metres the building concentration has increased. The usage of the house has changed, as have costs of maintenance, ownership, utilisation. Is the effect still the same? Does the building still have the same characteristics in this context? To what extent is the concept, the type, the model (that means three different things!) still applicable in different contexts? This is already a subject of typological study. The design study itself is restricted to detailed description of the object, its context and the analysis of effects therein.

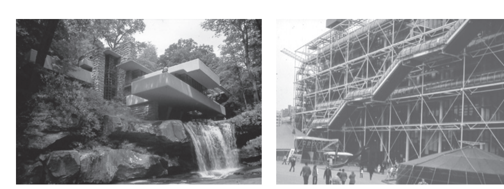
48 Rietveld Schröder House[j]

There are more contexts and perspectives than the spatial one. As an example, the ecological context may vary between small and considerable diversity in terms of soil, plants, growth and use: homogeneous/ heterogeneous characteristics within a radius of 30, 100, 300 metres; etc.(see page 38) On its turn the same applies to each scale level around the architectural design *vis-à-vis* technical, economical, cultural and political contexts. In the case of the technical context one should think of function segregation versus function integration within constructions[a], between constructions, but within buildings[b], between buildings, but within the ensemble[c], within neighbourhoods[d], within areas[e], within cities[f], within landscapes[g]. The economical context is determined by shrinkage versus expansion for the user, care-taker, municipality, province, national government. Culturally there may be huge difference in orientation on the traditional versus the experimental with consumers, producers, third parties and passers-by. Politically, one should ask oneself the question which agency acts in a leading versus a following rôle: user, entrepreneur, municipal, provincial or national authorities?

10.3 GROUNDS FOR COMPARISON

Red and round can not be compared. Something can not be redder than round; a particular design can not be redder than the degree to which the other design is round. Only in a poetical sense is it possible to say that a design is more useful than firm, or more firm than beautiful (alluding to Vitruvius'[h] categories). The comparison has only a scholarly character if an underlying common ground of comparison has been made explicitly.

While comparing designs or their parts, known and identified from other designs, the question whether they can be compared and, if so, in what sense, can not be avoided. In other words: which ground of comparison is chosen? In the case of red and round the two properties each have a set examples of red and round objects (extension). In order to compare them, a third set that may be counted is needed; for instance the set of recognisable objects that might be arranged as to colour and/ or shape more or less conclusively, so that one could say: "this object is more readily recognised by its colour than by its shape."[i] In that case recognisability is the ground of comparison for red and round, colour and shape.



49 Which ground of comparison?[k]

a For instance composite materials, stretch < > pressure.
b For instance carry < > separate
c For instance separate or shared walls, roofs, ducts, heating, parking facilities.
d For instance specialisation or integration of living, working, facilities.
e For instance combination or separation of types of traffic
f For instance compartmentalised or rather connected dehydration.
g For instance combination of agriculture, environment protection and recreation or rather separation.
h Vitruvius and M. Morgan (1960) *Vitruvius: The ten books on Architecture*.
i Key-word: recognisibility: colour and shape as cause for this.
j Source: media-centre, Fac. of Arch. DUT.
k Source: media-centre, Fac. of Arch. DUT.

Independent variable	(Legend)	(Form)	(Structure)	(Function)	(Intention)
Dependent variable					
Intention				Intention (function)	Ideology
Function	Semantics	Function (form)	Function (structure)	Human sciences	
Structure	Syntax	Structure (form)	Construction	Structure (function)	Structure (aim)
Form	Naming	Formalism	Functionalism	Structuralism	Symbolism
Legend	Logic				

50 Actions between legend, form, structure, function and intention

When comparing designs or design phases the inevitable question arises: are they comparable or not, and, if so, in which respect? In other words: which basis for comparability is to be chosen? Is it useful to compare designs with a specific magnitude, material application or colour, with specified form principles, technical, functional or intentional purposes? Can these principles be formulated beforehand or must one be surprised by the design, in order to discover essentially new, not yet formulated principles? Legend (material)[a], form[b], structure[c], function[d] and intention are, in this order, pre-supposing bases for comparison.[e]

One of these aspects, (for example, function), can be altered, within stated boundaries, (the independent variable) in order to enable the effect of the variation (the dependent variable) upon itself or upon other aspects to be reported. The function can, within a stated boundary, (for example railway stations) be varied with different design examples. Subsequently, different buildings with more or less the same function are compared in order to see which effect this has on their structure (the implemented separations and connections).

This is one of the 25 theoretically possible forms of design research differentiated upon here: structure(function).[f] In this way the structure is regarded as an action of the function (functional analysis) or more specifically as an action of the aim(intention). Structure is a design means and this form of research is known as aim-orientated research because the function of the aim as an independent variable is achieved with specific design means as the result being: means(aim). This sort of research can be carried out in the form of evaluative research (see page 149). Also methods stated in the following Chapters (predictive, evaluative, optimising research) can be utilised.

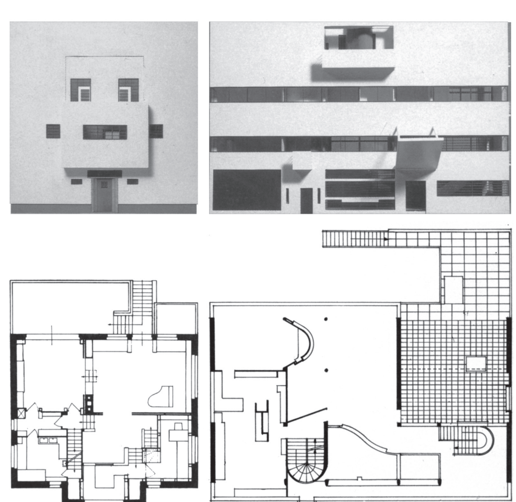
10.4 OPERATIONALISATION

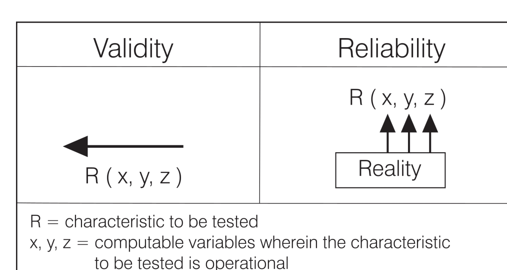
Risselada placed two characteristics of architectural design opposite to one another: Raumplan <> Plan libre.[g] He presents a significant number of convincing examples of Loos and Le Corbusiers' work without being able to conclusively define the characteristics of both.

Supposing that the level wherein space boundaries and bearing constructions come together is a computable indicator 'x' from which the 'Raumplan character' R could then be measurable from a design. When x is high, the design is of type 'Raumplan', when x is low, the design is of type 'Plan libre'.

The search for such computable variables is called 'operationalising'. The level at which the characteristic to be researched is represented is called 'validity', the level at which the ranking or measuring approaches reality is called the 'reliability'

The aim of 'operationalising' is to make characteristic R that alone is an immeasurable characteristic, accessible for more quantitative research. The value of the named variable x is





51 Raumplan and Plan libre

52 Validity and reliability

a The use of legend here refers not only to the explanatory drawing code of a drawing but also the 'that which takes on form' in the drawing or in the proposed reality, for example 'concrete', 'brick', 'steel' or 'parking areas', 'roads', 'green areas', 'buildings'. A similar legend is normally a pre-condition in order to compare drawings, unless different legends are to be put to the test as design means, then something else has to remain constant. What would this brick building look like made of concrete?
b The meaning of form here is the joining distribution layout of the material or of the space in or around the material. This bare concept of form has no sensation, as sensation is a function, an action of the form (distribution layout).
c Structure, the manner in which composing parts remain as a whole is defined here as the compilation of separations and connections in a joined whole.
d Function here is regarded as 'external action'
e See also: Frankl, P. (1914) *Die Entwicklungsphasen der neueren Baukunst*.
f This must be regarded as 'structure as an action of function'.
g Risselada, M. (1988) *Raumplan versus Plan Libre: Adolf Loos and Le Corbusier 1919-1930*.

high for the Raumplan, low for the Plan libre, therefore both previously named extremes are an action of x: Raumplan<>Plan libre(x). However, does characteristic x cover the whole range of the difference, or is that only a ‘half truth’? Should additional indicators be found, for example y and z: Raumplan<>Plan libre(x,y,z.)? What is the connection between x, y, and z? If they overlap, these aspects are measured twice; if there are missing factors, then shortcomings in the validity exist. Are they of the same significance or should each factor be weighed up?

10.5 AIMS OR MEANS ORIENTATED APPROACH

If the design, contexts and perspectives wherein the design has been made are sufficiently described, various aspects can be analysed. The methodical, most developed analysis confirms if the design has achieved its goal within the given context: (aim-orientated research): means(aim). The method of the aim-orientated research is discussed in more detail in the section regarding evaluation (see page 149). There are, in fact, numerous architectural solutions in order to achieve the same aim, from which the variation cannot be explained measuring efficiency. The potential to accommodate *numerous* or unexpected (non-programmed) functions (multi-functionality, robustness) is a researchable quality as well.

The question can also be inverted: if these means are utilised in the design, which aims do these serve: aim(means)? This is means-orientated research, because the design means like form and structure can be independently varied, in the relationship function(form) or function(structure), in order to determine their action on the function. Could a round building be used as a railway station?

Can a hall with a span of 50m function as a railway station? A design can have numerous functions that are verbally indescribable like specific forms of image qualities or non-described ‘functional potentials‘, which have never been included in a programme. Is it possible to feel at home in a round building, be able to orientate oneself? More comprehensive actions occur at this point, which are more difficult to operationalise empirically, such as ‘hospitality’ or ‘transparency’.

The effect to be reported upon can also concern the structure or form of the design, such as the relation between structure(form) or form(form) (composition). In this case the total focus is on the formal design means, the designer’s toolbox. Can a round shape combine itself with a rectangular form? Once these questions have been asked the structural action of such combinations can be looked at on a higher level: structure(form(form)). What are the technical consequences of a combination of rectangular and round forms?

10.6 LEGEND, FORM, STRUCTURE, FUNCTION, PROCESS

The study into the means of design is a study into the instruments that could bring us beyond the probability of empirical reality in the field of what is possible. In this the relation between form and function in the design and in the designing process is crucial. Form has perceptible (visual, tactile, motor) and conceptual functions, but does not equal it, in spite of the suggestion of the dictionary (“form is outward shape”). People do experience form, but form is not the same as that experiencing value. It determines, for instance, also functional and constructional possibilities. Form (and format!), seen separated from a possible causation, is the situation of spreading of adjacent material, so that it, for instance, may be recorded, recollected and represented in co-ordinates.

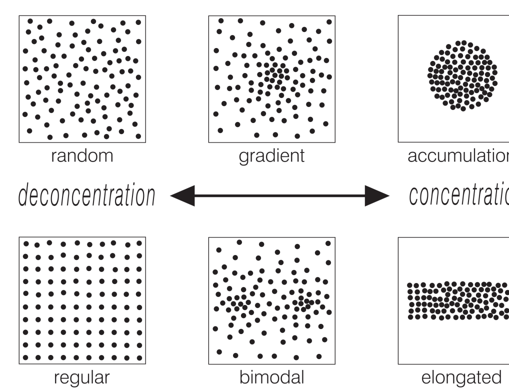
Concentrated situation of spreading can be described with an outline. If a regularity is found within a spreading situation a pattern results. A pattern with an increasing density is a gradient. This gradient may be a central, bi-modal, or tri-modal one.

Form pre-supposes that something takes on form (material, space), expressible in a legend. The units of the legend emerge in the drawing as a situation of spreading, proportional to those of the material or space in reality. This form is perceived by different people from different standpoints and is associated with meaning. By the same token form does not

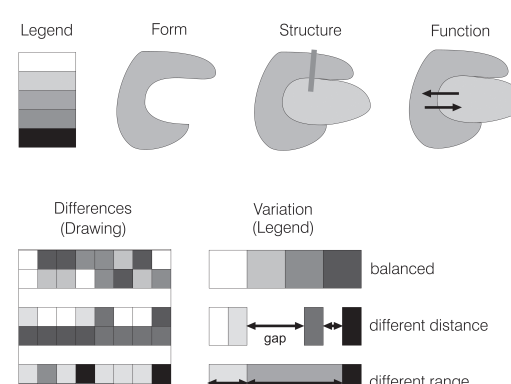
53 Difference not to be explained by the purpose [a]

$$M=f(A) \qquad A=f(M)$$

54 Means resulting from Aim or vice versa?



55 Situations of spreading

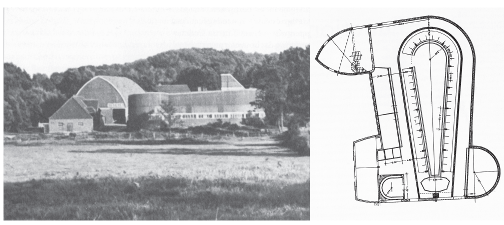


56 Legend (material or space)

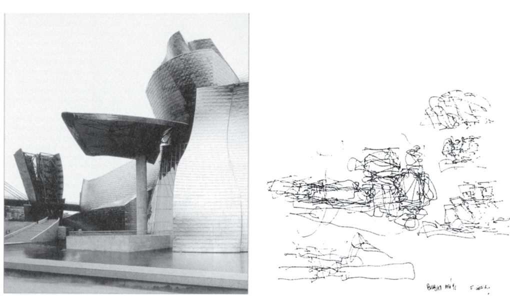
a Photograph: Theo Uytenhaak, Amsterdam

	matter	*space*	*image*
form (state of dispersion)	mass	divison	appearance
structure (separations and connections)	construction	articulation	composition
function (external action)	physics	use	meaning

57 Domains of terminology



58 Functionalism (Häring, *Cow Stable Holstein*, 1922)



59 Formalism (Gehry, *Museum Bilbao,* 1998)

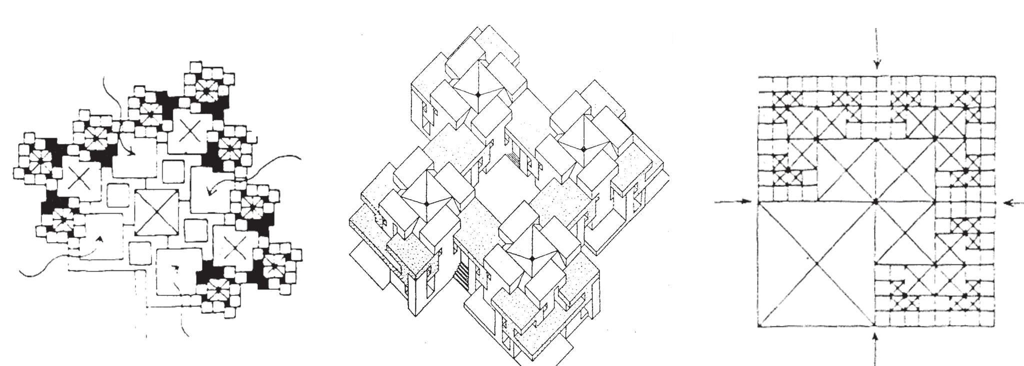
equal experiencing. Experiencing is an external working (function) of the form. However, the image of the form is, in its turn, something else than the experiencing of a form: for an image may precede the form; something experiencing cannot do. Each architectural drawing features legend units in material and spatial terms which might be getting, or aiming at, structure and function. This also applies for the image or the visualisation of both.[a]

It is possible to compare individual stages of the same location or of the same design. In that case the design study concerns a design process in which the supplement or change of the drawing is evaluated.

When should the designer translate the usage function desired to form (functionalism[b]), and when is it allowed to give a form concept pride of first place (formalism[c])? 'Programme' (literally 'pre-writing') is seen in this Chapter as the working of a (prescribed) function. In the end it results in prescribed formats and separations or connections in between, with a view on the function. The question is then: should one always design from a programme, or is it possible to generate functions from a design study, for instance of the potential of the location?

Between function and form the concept 'structure' may be placed; many regard it as one that is too ambiguous. Structure is the set connections and separations with which the constituent parts form a more than incidental whole. This is implying more than the way in which com-ponents have been put together (com-position) or a regularity therein (pattern). Is it possible to determine form and function also from the structure (structuralism)?

If the designing process is selected as foundation for comparison, a first classification may be made in terms of the multi-functionality of the product (the function aimed at). Mono-functional products, as there are an tea-pot, a road, an air-plane, feature a designing process, fundamentally differing from those applying to a building or a city. It is a much more optimising designing process than the other one, in which the large number of aims intended makes for a rather more means-orientated approach. Within the urban architectural design process a distinction may be made as to function: the Board of a School is a different kind of commissioner than a building co-operation, or a rail-road executive board. In its turn, within each function the degree of the multi-functionality aimed at is determining the degree to which the designing process is taking function as a point of departure (functional analysis as a van-guard, functionalism), or form (morphological analysis heading, formalism), or structure (structuralism), as its intention. Here study by design is catching its connecting flight to the methodology of designing itself; and so to the design study.



60 Structuralism (Blom, *Prix de Rome*, 1962)

a Duin, L. van (1995) *Vorm en functie*; Durand, J.N.L. (1975) *Precis des lecons d'architecture (1819)*.
b Key-word: form(function), i.e. form as a working of function.
c Key-word: function(form), i.e. function as a working of form.

11 DESIGNERLY ENQUIRY

JACK BREEN

This contribution explores the opportunities for *design driven* approaches to architectural research. Starting with an investigation into the broad domain of architectural design and its working methods, the relationships between design and scientific methods of research are explored. The discourse focuses on instruments and procedures that are suitable in order to approach design products and design thinking within a research context. It is argued that *designerly* modes of *enquiry* can offer opportunities for the benefit of innovative design driven research.

11.1 DESIGN

How should architectural design be considered in a (scientific) research perspective? What are the aims of design activity? Can characteristic methods of design be identified?

The primary aim of architectural design (in the broadest sense) is the creation of shelters and surroundings which should be functionally and structurally sound and create a sense of 'place'. The result should ideally be visually pleasing and contribute to a sense of emotional well-being, creating room for human activity and experience. The classic pre-requisites formulated by Vitruvius: *firmitas, utilitas, venustas* (durability, utility and beauty), are generally still considered pertinent today.[a]

The act of designing is a form of creative *organisation*, which takes place on different 'levels' within an overall design *concept* (often simultaneously). A design is 'work in progress' which is gradually developed and refined from an initial idea to a built environment. In the course of the design process a designer will generate design propositions which are judged on functional, structural, material and aesthetic levels, to name but a few.

During a design trajectory intermediate (sub-)solutions are constantly being generated and evaluated in relation to the composition *as a whole*. This interactive approach - focusing on the overall composition as well as on its constituting components and details (and vice versa) - is characteristic of architectural design activity.

Designers work towards proposals which offer a fitting 'answer' to a specific context, a given programme and sets of economic constraints. At the same time they endeavour to create *authentic*, even *novel* solutions: end products which are experienced as more than a sum of separate solutions: as a *synthesis* of form, material and space (Kurokawa even suggests that design elements may be considered to co-exist in a state of *symbiosis*).[b]

In their work, designers address a variety of formal themes, such as: order and contrast; size and proportion; rhythm and (inter)space; symmetry and asymmetry; symbol and ornamentation; exploiting the expressive qualities of materials and the effects of light and colour, in order to shape new architectural objects and environments. On a compositional level this may involve creating visual *tension* between different, constituting parts, but the design ought not to be perceived as 'falling apart'. In a kind of 'balancing act' between order and chaos, the designer tries to achieve a form of *harmony* throughout the composition as a whole.

Alberti, paraphrasing Vitruvius: *"Beauty consists of a rational integration of proportion of all the parts of a building, in such a way that every part has its fixed size and shape, and nothing could be added or taken away without destroying the harmony of the whole."*[c]

P.F. Smith: *"The most successful buildings are those which clearly express their elements, but which, at the same time, come across as wholes which are much greater than the sum of their parts. This is the primary aesthetic 'dialectic' in architecture. Aesthetic success demands that orderliness wins, but not too easily. There has to be sufficient complexity to make the perception of unity a worthwhile mental achievement."*[d]

a Vitruvius *De architectura libri decem*. (from the English translation: Vitruvius and M. Morgan (1960) *Vitruvius: The ten books on Architecture*.

b Kurokawa, K. (1991) *Intercultural architecture, the philosophy of symbiosis*.

c Wittkower, R. (1952) *Architectural principles in the age of humanism*. p. 6.

d P.F. Smith in: Canter, D., M. Krampen et al. (1988) *Environmental perspectives*: *"The most successful buildings are those which clearly express their elements but which, at the same time, come across as wholes which are much greater than the sum of their parts. This is the primary aesthetic "dialectic" in architecture. Aesthetic success demands that orderliness wins, but not too easily. There has to be sufficient complexity to make the perception of unity a worthwhile mental achievement"*.

Fundamental to creative composition is *knowledge* and *understanding*. One needs to acquire cultural and technical knowledge and acquire *insights* into relevant design options and the effects of design *decisions*. Designing is a process of *searching* for a 'correct' result. This quest can be considered 'empirical' only in so far as that it tends to follow a path of *trial and error*. In a design process there is not one 'correct' outcome. The designer can come up with a *variety* of potential solutions, each of which would lead to considerably different environmental qualities and spatial experiences, if built.

Although the design process itself is clearly not 'scientific' in nature, the designer does make use of many sources of knowledge and information, which contribute to shaping the end product. In education, a proven method of acquiring knowledge and insight is the study of *precedents*, to be analysed systematically. Recurring formal themes and characteristic forms of variety make it possible to identify specific *types* of design artefacts. These can be organised systematically in design *typologies* which may in turn contribute to understanding and appreciation of *specific* design artefacts.

One of the most effective compositional structuring devices was traditionally the architectural *style*. In the Renaissance, the renewed orientation on 'classical' architecture of Romans and Greeks led to a set of stylistic rules which would not necessarily lead to the same result, but could be applied with a certain amount of freedom and inventiveness by different designers. After the emergence of the modern movement in the early twentieth century, the classical rules were declared obsolete. No generally accepted stylistic framework has taken their place. Although designers frequently refer to their knowledge of historical examples, and may at times *re-interpret* previous themes or even borrow directly from design examples, designers frequently attempt to cross - or at least to 'stretch' – existing boundaries. Design practitioners are constantly 're-inventing' what was conceived before, within the shifting cultural (and technological) climate of the moment.

The cultural climate of the twentieth century *fin-de-siècle* seems to have given rise to a tendency amongst leading designers to keep surprising their audience with 'original' solutions in order to stay in the limelight. In contemporary architecture there is a tendency not to adhere to any pre-determined, binding themes – or indeed *methods* - of design, but rather to make choices within a framework of plan-specific design rules developed *per project*. The contemporary architectural 'landscape' offers both the familiar and the innovative. We bear witness to a constantly shifting 'parade' of architectural forms and themes. There is no generally accepted architectural style, no standard set of *rules*.

Architectural and urban plans are not created directly 'in situ', but are conceived, notated and communicated via specialised design *media*. Drawings and *models* are generated to explore and create insights into the 'workings' of the design. By learning to 'read' visual information design students develop the ability to translate ideas into form. Images are used to lay down ideas, this information can then be shared and communicated to others.

Design processes tend to be *iterative*, following a series of successive 'loops'. At any given point, the 'state' of the design is evaluated in relation to previous steps and successively developed further. It is essentially a process of creative *imaging*, as Zeisel indicated.[a] Imaging is a form of communication with oneself (or with other partners in a design team), a way of questioning or verifying the merits of intermediate design ideas and developing new options and strategies. As such, the imaging process is a way of 'channelling' inspiration; the designer thinking while *doing* and reacting directly to ideas as they are being visualised, reflecting, eliminating and refining, subsequently making decisions and documenting the results. By determining *criteria* (frequently on the basis of 'taste') judgements are made concerning the *qualities* and *potentials* of different ideas.

a Zeisel, J. (1985) *Inquiry by design: tools for environment-behavior research*.

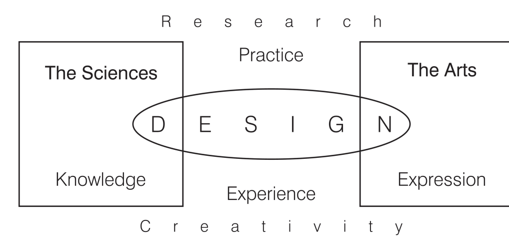
The working *methods* of designers may have been changed to a certain extent by the recent influx of computer aided techniques, but design *composition* remains a way of getting to the *heart* of the matter: a process of simultaneous development and testing of ideas, involving reflection, selection, reduction and perfection. There is no such thing as a 'standard' approach to designing. Although all sorts of themes are constantly (re)surfacing within design processes, design itineraries and working styles vary considerably, from one designer to another and frequently even *per* designer, depending on the kind of project at hand.[a] Viewed in this light, the *imaging* process, involving the active use of various design media, should perhaps be regarded as the most enduring *method* of design.[b]

11.2 DESIGN AND RESEARCH

What is the relationship between design and research? To what extent might design products be considered as research output? What are the characteristic aims and methods of design orientated research?

It may be clear that design is a broad field of enterprise that cannot easily be 'tied down'. Working methods and formal composition tend to be determined by personal preferences and dynamic – cultural, technological, economic and ecological – developments (including fashions). The design process is not orderly and linear, but unpredictable and may – to an outsider – seem haphazard and erratic, even chaotic. Projecting scientific models of thought onto such a complex, varied and layered domain can easily lead to gross reductionism or simplification, in which case the – so called – 'research' findings will not be taken seriously by design practitioners or academics.

It is important to realise that *design practice* and *design research* are activities which, as it were, move in *different directions*, back and forth between (historical and contemporary) *culture* and (technical and applied) *science.* Architectural design is a development process which is both *creative* and *rational*, drawing from a wide range of knowledge and experience, concerning technical, practical and cultural aspects. An 'in-between' realm: broad and multi disciplinary; traditional as well as innovative; stretching into the domains of the Technical Sciences on the one hand and those of the Arts on the other.



61 Scheme 1:The in-between realm of design

De Jong: *"Some futures can be predicted, others must be designed"*[c]

Designing is essentially an activity of conceiving futures. Instead of looking back, designers are inclined to look towards 'what might be', they seldom look back in order to understand what has come to be and why. They apply their knowledge in a pragmatic way, but they are also inclined to 'bend the rules' for aesthetic effect whenever they consider it necessary. Such 'poetic licence' may be at the root of persistent objections to architectural design and research activity by conventionally inclined academics. However, it is precisely this tension between logical and aesthetic considerations that makes architectural compositions so *complex* - and therefore so challenging.

A design remains a mental 'construction' up to the moment it is actually built and begins to function within surroundings that have been altered by its introduction. In the unpredictable and iterative design process, various options are developed and 'tested'; a process which is rational as well as intuitive. Designers base their conceptions on experience and knowledge but are often able to take 'shortcuts' and 'bypasses', using *intuition* fed by knowledge and experience. As such a design product is clearly not the same as research output. A designer is primarily involved in a creative process aimed at reaching a solution which is – in principle – 'buildable', whereas a researcher is involved with the evolvement of *knowledge* .

To put it another way: the ambition of *archi*-tects (the traditional 'masters' of the combined building disciplines - in present-day conditions often 'creative directors' of complex planning

a Bakel, A.P.M. van (1995) *Styles of architectural designing: empirical research on working styles and personality dispositions*.
b Breen, J.L.H. (2000) *The medium is the method: media approaches to the designerly enquiry of architectural compositions*.
c Jong, T.M. de (1992) *When is designing also research?*

processes) is to create *architecture*; to achieve the 'highest' form of building production. Architectural *researchers* attempt to *understand* architectural thought and expression. Their ambition is to uncover the 'origins' and the 'workings' of architectural artefacts and as such they might be considered as '*arche*-tects'.

Architectural researchers have to ask 'how and why' questions. This involves fact-finding, systematic analysis and documentation in an orderly manner. However, it might also require thinking - and possibly even *acting* - along the lines of designers.

Inventive, innovative design research may call for the *re-searcher* to get 'behind' the architectural *search* and its results. A kind of 'detective' approach involving logical thought and systematic (comparative) analysis as well as less 'stable' forms of (designerly) enquiry, in an attempt to get behind the 'event'.

Press: *"Research is the systematic investigation towards increasing the sum of knowledge which is reported in a form which renders both methods and outcomes accessible to others."*[a]

De Jong and van der Voordt: *"Study is a collective term to denote the furthering of knowledge through profound thought, by carrying out experiments and by identifying and collecting subject matter which is processed and analysed systematically."*[b]

Design research might aim at quite different areas of design efforts, like *product development* (devising new or better building components and technical solutions) or *practical applications* (aiming at the development of methods and new design tools), but a great deal of design driven research is aimed at *understanding* the workings and backgrounds of designs and design thinking. This is essentially *fundamental* research, even if the subject of study is by definition not 'pure', but *applied*.

Scholars find themselves confronted with an enormous *quantity* and *variety* of architectural artefacts - each with its own specific *context* and characteristic *synthesis* of space, form, material and detail. How should researchers set about exploring this extensive field of enquiry?

Architectural compositions are not necessarily 'technically' complicated. What really makes designs complex is the *inter-play* of different *sorts* of aspects within a relatively coherent 'whole'. Whereas common scientific principles usually require the researcher to focus on specific, narrowly defined issues - which may be studied *intensively* – it often proves to be difficult for researchers to 'unravel' designs to such an extent that an unambiguous field of study, with clear boundaries, can be determined. For this reason, design research output is often viewed with scepticism by professionals from other disciplines, who may consider the outcomes too broad, longwinded and 'fuzzy'.

For the sake of clarity, architectural researchers need to 'narrow down' their subject matter considerably. On the other hand, this should not lead to disproportionate *simplification* or abstraction. Without sufficient 'context', design research can easily become totally irrelevant in the eyes of design experts.

Henket: *"Designing is working across the width of a broad domain, science should attempt to investigate the connections within this realm of design."*[c]

Jansen: *"Intensive study of a tiny bit of some item with a thousand facets, that leads to output!"*[d]

Duffy: *"Architectural knowledge does not 'sit well' in academic structures."*[e]

It is not terribly difficult to paint a negativistic picture of the opportunities for design research in an academic environment[f], but the challenge should be to *develop* forms of research which do justice to the kinds of mental activities and procedures that are fundamental to design.

a Press, M. (1995) *It's Research Jim*.
b Jong, T.M. de and D.J.M. van der Voordt (2000) *Criteria for scientific research and design*.
c Architect Prof. ir. H.A.J. Henket, speaking at the Architecture faculty, TU Delft, April 2000.
d Information Technologist Professor dr.ir. F.W. Jansen, speaking at the faculty of Architecture, TU Delft, May 2000.
e Francis Duffy: "The kind of architectural research I value most fits uncomfortably with academic models of what research ought to be." Duffy, F. (1996) *The Value of a Doctorate in Architectural Practice*.
f Architect Professor Carel Weeber: "... at this university of technology people are mainly taken with empirical-technical research and the diffuse situation of architectural culture ensures that each research proposal is immediately branded as wrong by other architects. Thus, there seems to be no room at Dutch universities for design studies, and we may be relinquishing control of the development of the profession to journalism and the theorising of the art-historical sciences." In: Weeber, C. (1992) *Dutch architecture today*.

Designers make use of their own arsenal of knowledge, insights and skills. These should not be ignored, but made operational in relevant, innovative forms of study. Designing – as an activity - can potentially be made instrumental in research, as long as the aim of such an application is the furthering of knowledge and understanding.

Matthews: *"There is a need to reclaim design research for designers. Too much design research has been conducted by technologists, systems practitioners, historians, psychologists, sociologists, anthropologists, organisation and management theorists. Too much design research has been research into design. Too little design research has been research conducted by designers doing what they do best - designing."*[a]

An important requirement of an architectural *research* project - as opposed to a design process - is that it must be methodically *transparent*, as well as *systematic* in the way insights are gathered and subsequently communicated. The characteristically wide range of design endeavours should not be denied, but should somehow be 'tamed' for the benefit of research.

Most contemporary architectural research tends to be *descriptive*, often focusing on the oeuvres of individual architects or groups and their underlying ideological motivations. However, design research might involve *applying* design knowledge and experience in order to get behind the kinds of *considerations* and *choices* which determine the end product and to understand how such an object or environment is *conceived* and *perceived*. This has to include the characteristic *interplay* of compositional aspects. At the same time it means introducing certain *constraints*, which may narrow down the field of study, without this leading to reductionism or simplification. This must involve an attempt at identifying themes, defining meanings, establishing relationships and unravelling the complex patterns on the level of design composition.

Matthews: *"Design is not only a great orchestrator of knowledge, it constructs its own peculiarly polyvalent knowledge which makes visible and realisable the possibility of change."*[b]

Duffy: *"It is absolutely necessary for architects to re-define architectural knowledge in a way which commands public respect. ... We architects need to invent our own models, our own future, in our own way"*[c]

Design clearly does not fit comfortably the kinds of empirical conceptions characteristic for scientific research. Design activity is not the same as research activity, but it can certainly *lead* to research. This implies that something must be *done* with the design product or process in an orderly way.

In this respect researchers should not simply try to *imitate* the working methods of other research disciplines. Design driven research projects require methods - or combinations of methods - which *do justice* to the nature of design, while at the same time learning from proven scientific methods, by adapting these or by finding suitable models and methods for design driven research. This means *designing* and *initiating* new forms of research.

11.3 DESIGNERLY ENQUIRY

What sorts of enquiry might be considered to be characteristic of design? What are the potentials for approaches involving controlled design activity in design education and design driven research?

Architects have a reputation of being far more interested in design(ing) than in research.Architectural practitioners are primarily concerned with the conception and realisation of built environments, inclined to move on swiftly to the next project, generally spending little time evaluating precise effects of their creations after they have been built.

However, the designer's search for the right solution(s) is a venture driven by an *inquisitive* nature and a *creative* approach. To a certain extent the kinds of study carried out by a designer in the course of such a process might be considered a form of research, but the designer's way of working and thinking is also quite different from familiar scientific research.

a Matthews, G. (1996) *Doctorates in Design? Why we need a research culture in design.*
b Idem.
c Duffy, F. (1996) *The Value of a Doctorate in Architectural Practice.*

The designer is involved in *problem solving*, using his or her imagination to develop - and indeed to predict - a *successful* final solution. However, design solutions are expressed not so much as conceptions, but as (proposed) *form*. The designer's thinking process is essentially a process of *transformation.*This 'search' involves a specific kind of active *exploration*, for which Bruce Archer has introduced the term *designerly enquiry*.

Archer: *"The idea of Design as a broad area of man's concerns, comparable with Science and Humanities, seems to be defensible in pedagogic terms. The idea that there exists a designerly mode of enquiry, comparable with but distinct from, the scientific and scholarly modes of enquiry seems to be defensible by the design methods literature"*.[a]

Such a *designerly* way of thinking is typical of design. It is a kind of problem solving which transforms a relatively complex problem into a workable solution, which may be tested, judged and effectuated afterwards. Other activities requiring such *foresight*, like setting up a workable planning, developing an educational curriculum or organising a sound research experiment, could also be considered as forms of designerly enquiry…

The intellectual aptitude – usually denoted with *talent* – required for such *visionary* reasoning is not universal. Some people can be said to 'have' more designerly abilities than others. Design students are expected to have such talents, although it is not easy to recognise whether first-year students have the necessary capabilities. Designerly modes of enquiry deserve to be recognised as *intelligent* forms of enquiry, that it works and can be used in projects requiring problem solving directed towards creating a workable product.

What is of interest is if the *direction* of such enquiry can, as it were, be 'turned around': if designerly enquiry can be directed towards a better *understanding* of a product and the *sort* of 'solving' that went into it…

If so, it can be argued that this aptitude is not only necessary for designers in order to make designs, but also important for researchers involved in design driven research. If – as might be conceivable – this is not the researcher's 'greatest talent', it would be worthwhile to get others – more expert in designerly working methods – involved in research projects. In this context, term designer*ly* enquiry seems appropriate, precisely because it has a certain, elegant *ambiguity*. It is a concept which can denote practical designing activities, but also suggests an *'as if'* designing approach, which may be particularly relevant in design education as well as in research *experiments*.

Design work needs to be carried out rigorously and conscientiously, if one is not to be confronted with 'unpleasant' surprises at the end. In this respect there is not that much difference between design and research. Designerly enquiry calls for (and to a certain extent is even *dependent* upon) *imaginative* insights. At the same it should be recognised that the working processes of design are relatively methodical and transparent, even predictable. On a 'creative' level, a design process requires both artistic and logical consideration, involving what David Bohm would regard as *imaginative* and *rational* insight and fancy.[b]

Hertzberger: *"Designing is a complex thinking process with its own possibilities and limitations, within which ideas are developed fairly systematically."*[c]

Which characteristics of designerly enquiry might be considered pertinent for other forms of study, like education and research? In the following overview four significant attributes of designerly enquiry are identified and discussed briefly.

11.4 DESIGNERLY CATEGORIES OF ENQUIRY:

a. Designerly decomposition

As it is impossible for a designer to constantly address a design project as a whole, regarding all its facets with equal attention, there is a tendency to 'decompose' the design. The project

a Archer, B. (1981) *A view of the nature of design research*.
b Bohm, D. and L. Nichol (1998) *On creativity*.
c Hertzberger, H. (1999) *De ruimte van de architect: lessen in architectuur 2*, p. 28. English translation: (2000) *Space and the architect: lessons in architecture 2*.

is as it where 'taken apart' (and subsequently re-assembled), so that items of importance can be isolated and developed further in detail. The designer should be able to focus on specific *parts* of the composition and on *combinations* of parts in relation to the concept as a *whole*. In this way it becomes possible to recognise levels of priority and room for variation. By organising such information, decisions can be made relatively objectively. Essentially this attitude involves loops of successive decomposing – and *re-composing* – the project at hand.

b. Designerly variation

An important part of designing a project is developing forms of systematic organisation. Such project specific *structuring* devices set the tone for the types of compositional *variation* which are opportune on different levels. Finding the right dimensions, rhythms, proportions, subdivisions, connections, materials and colours (to name but a few) requires relatively systematic study. For this reason different variations (often on the basis of some identifiable theme or *motif*) are worked out, compared and evaluated. One of these 'solutions' may consequently be chosen, to form the basis for further designerly developments.

c. Designerly visualisation

Possible design solutions need to be *made visible*, not only for the benefit of the designer or the development team, but also for other 'actors' involved. Such visualisation, using design media is essential for design *communication*. Drawings and models can in a way be considered the primary 'language' of the designer. At the same time they form a kind of 'laboratory' involving (de)composition, selection and variation. The designer uses this visualisation ability to create impressions of the *effects* of potential design decisions, which makes choices *accessible*.

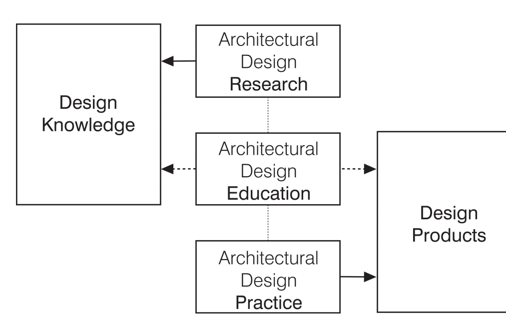
d. Designerly reference study

If an architect receives a commission for a particular kind of building - a museum, hospital, bank or housing complex - this usually involves extra 'homework', in order to get acquainted with specific demands, regulations and considerations. Designers often refer to *precedents* - usually more or less comparable, previously realised projects - which may be arranged in a kind of temporary 'project library'. Such references allow for comparison with similar *types* of projects and solutions. Findings are not translated literally into the design at hand, but primarily allow for *reflection* concerning the merits of intermediate design solutions.

In a design process, activities such as those mentioned above help to keep the 'thought experiments' constantly carried out relatively orderly and transparent not only to the designer, but also to others. By determining *criteria* and *values* of certain design attributes, an objective judgement might be made concerning the relative *qualities* of different ideas. The *data* generated in such designerly study activities and evaluations can offer valuable insights into the underlying design process and benefit the *interpretation* of design results in education and research.

Whereas traditional design activities are primarily involved with development of design *products* and design studies with *knowledge*, in design driven education the processes are characterised by *reciprocity*. In the academic environment an '*as if*' design setting is the norm, whereby design and research activities are primarily targeted at the generation of *knowledge, insights and skills*. Thus, the aim of designerly exercises, integrated into educational curricula, is one of *learning by doing.*

A traditional approach to teaching design involves requiring students - as 'apprentices' - to repeatedly carry out *integral* design tasks under the critical supervision of a 'master'. With such an organisation, there is the risk of a 'black box' situation, with relatively little transparency on the level of the objective exchange of ideas or evaluation of results. A pedagogical alternative is to set up clearly structured courses which incorporate designerly activity, aimed at the *discovery* of architectural design themes. An effective way of 'channelling' student



62 Scheme 2: A comparison of aims in research, education and practice

activities towards research is by creating a kind of 'game' situation. Such a method has, amongst others, been promoted by Donald Schön and colleagues, who carried out explorative design exercises with considerable success at MIT.[a] The more clearly such tasks and objectives are defined, the more profoundly the students may be made aware of the constraints on one hand and the creative freedom on the other. An advantage of such a structured approach is that, in principle, results can be compared and the qualities of specific design solutions recognised and discussed. Examples of such a thematic, designerly approach in an educational setting can be found in the Delft Form Studies programme.[b]

The four designerly categories of enquiry mentioned earlier, common in design practice, can be used as - integral - parts of the didactic set-up of *educational* exercises (either with a design or a research emphasis), but potentially also in experimental design research:

a. Designerly decomposition:

The kind of decomposition which designers practice can be used most effectively in education by making such decomposition a part of the set *task*. This can come down to consciously not setting a complex, integral design task, but instead offering a more compact, clearly defined 'problem', to be studied in depth. An alternative is to make students aware of this approach as part of the *tutoring* method, or of a research approach and protocol.

b. Designerly variation

Designerly variation can be used in education as a part of the design *counselling* method. Such an approach can involve pointing out relevant themes or options, without necessarily suggesting an outcome. Such "could (also) be" scenarios can purposefully be developed as design variants, to be tested and discussed. Apart from using such an approach in design tutoring, designerly variation may be introduced as part of a research *task* and the accompanying procedures.

c. Designerly visualisation:

Active application of design visualisation techniques does not only constitute an important part of design activity, it is an essential component of education – and consequently can be made operational in design driven research. Essentially this approach involves creating *models* of (aspects of) the project which is being scrutinised. These may vary from physical models (from conceptual to detailed scale models), digital models (computer visualisations and simulations) to two dimensional representations (sketches, drawings, schemes, collages).

d. Designerly reference study:

In education and research, reference study can be introduced to shed new light on the project at hand. A process involving targeted *juxtaposition* of the subject of study and one or more projects or specific design aspects, allowing for insightful *comparison* and evaluation. This approach may include the use of precedents, but also of metaphors and even conscious development and systematic comparison with designerly variations.

Well organised – designerly - projects can help to create a kind of 'laboratory' atmosphere, in which procedures and results can be considered more or less empirically. Of course, the disadvantage of projects involving groups of students is their relative lack of *experience.* However, this is often compensated generously by their *candour* and lack of 'hang-ups', which can lead to refreshing viewpoints and surprising insights. Such educational projects may be considered promising in the context of design driven research.

a Schön, D. (1992) *The theory of inquiry, Dewey's legacy to education*. Habraken, N. and M. Gross (1988) *Concept Design Games*.

b Breen, J.L.H. (2001) *Designerly Approaches to Architectural Research*.

12 TYPOLOGICAL RESEARCH

TAEKE DE JONG
HENK ENGEL

		OBJECT Determined	Variable
CONTEXT	Determined	Design research	Design study
	Variable	Typological research	Study by design

Architectural typology pre-supposes design research, but not all design research pre-supposes typology. What appears to be a legend unit in a specific structure, (for example 'split-level houses') can be a type in a smaller structure. Typological research searches for object constancy in a variable context.

An architectural type is a summary (concept) of architectural designs with common characteristics, conveyed in a 'schema'.[a] It may possibly be a forerunner of a model, a design. A type is, therefore, not yet a model which can be imitated actually in reality (Argan, 1991) in order to interpret the effects in a specific context. For example, a design, a realisable proposal with a scale factor, is actually a model whereas a type is not. Conversely, a model is more concrete with regard to specific selected components, more clear-cut than a type, and, therefore, not a type.

An ideal-type[b] for example, may have more characteristics than all the examples. The ideal type complements its examples in specific aspects, whereby they become more conceivable. A model or representation may be made of such an ideal type, which can serve as an ideal model in education for example, but it will always lack characteristics because they can never be simultaneously realised. The other (realised, therefore, incomplete) representations of the ideal type have characteristics (for example details which are neglected in the type) that in a specific context can make it usable and possibly unique.

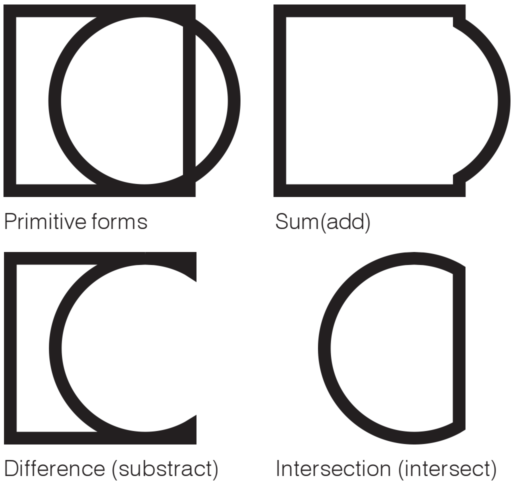
If one historical original example, (possibly irrevocable) is available from one type, then a model can be made based on this. Such a model has, in order to be able to reproduce it in other aspects, also more (practical) characteristics than the type (for example a material specification and a form). Even if it can be made using this, it does not necessarily have to be useable[c] in a specific context.

A system also pre-supposes analysing components (elements) and well-defined system boundaries in which system and context are clearly independent. The boundaries remain intentionally vague regarding type and sometimes with the model (if parts of the context herein have, or have not, been suggestively incorporated). For example a study can make use of types and models, but they do not necessarily have to form a system with removable elements. An archetype[d], for example the Trinity is a type that precedes the form and is filled with old connotations and form associations. The labyrinth for example is an archetype based upon the myth of Theseus and Ariadne's thread, which originates from King Minos of Knossos' palace in Crete.

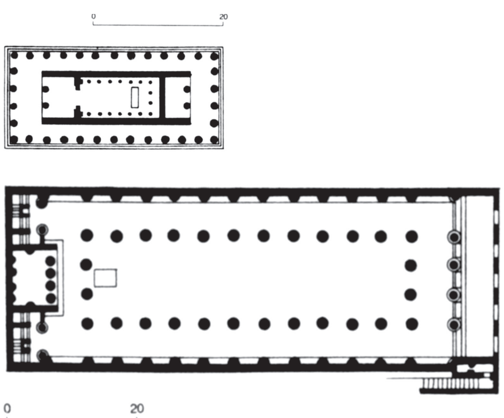
Every example of a type is a variant with other incidental characteristics (for example the location), as in music; the variations are categorised according to theme. A type can be a stereotype if it can secure itself in an unquestioning repetitious application without variants. Typological criticism (Argan, Tafuri) is the removal and addition of characteristics in well-known types. According to Levaivre and Tzonis, Van Eyck used classic types, (see page 89) in this way and exchanged a few characteristics with those from De Stijl.

Some design students consider it an honour to create a design, which complies with no individual type and therefore represents a 'new type', to be used by others. Types like these are prototypes. Very often such a type turns out to be a variant of an already existing type. Sometimes a variant is so diverse, that it is regarded as an individual type and remembered this way. The number of types is so immense, that nobody can imagine each and every plausible type. Typological research compares and classifies types and determines their variants in various contexts. When the classification adopts a structure of inter-related types in the form of a genealogical tree, it is known as 'taxonomy'.

a The word *'schema'* is Ancient Greek for posture, gesture, external appearance, as well as condition, viewpoint, place relating to something. This can be summed up with the word 'pose'. With 'schema' the English word 'shape' is also related to the suffix '-scape' in landscape.
b The German term Idealtype was introduced by the sociologist Weber. The platonic notion of idea is the foundation for a reality conception in which every true object looks upon this as a reflection of an idea from a supreme reality.
c When considering the word 'use' the term 'experience' is also included.
d The term 'archetype' was introduced by the psychiatrist Jung, who claimed to recognise inherited images from dreams, which were inexplicable from the individual's experience.



63 Primitive forms and their combinations



64 Hephaiston-tempel 440 BC Athene agora (above) and Basilica, ca. 80 BC Pompeï [c]

12.1 FORM, STRUCTURE AND FUNCTION TYPES

If the characteristics of a type are only related to the form (the layout distribution or the contour of this), it is known as a 'form type'. There are organic types (tree, stem, flower, umbel) and geometric types. A pyramid for example is a geometric form type. Round (spherical, dome shaped), square (cubic) or triangular (tetrahedral or pyramidal) construction elements, constructions, urban ensembles, neighbourhoods etc. are therefore form types. Geometric differences like these can be elaborated upon using their sum, difference or intersection. Computer drawing programs provide such primary form processes (add, subtract, intersect). Such combinatoric transformations can yield taxonomy.

If one includes a collection of separations and connections (structure) such as typified openings, dividing and bearing constructions in the characteristics of the type then this is known as a structure type. The peripteros and the basilica are structure types because the columns and dividing wall structures are indispensable in their constellation. The function does not need to be considered at this stage.

If the external working (function) is included in the characteristics of the type, then this is known as a function type. In this way a railway station is a function type. The function concept always pre-supposes, albeit mostly implicitly, an elaborate external structure wherein the function concerned is a specialism. In this way a railway station is inconceivable without railway tracks and usually directly next to it an entrance and an exit (unless this is the 'terminus' type for commuters with an origin (a home for example) and a destination (work for example).

This material or social structure, pre-supposed with the function type, is, not as yet, a well-defined context. This type of context must be discussed when carrying out design research and design study. An external structure is variable in typological research, however it is decisive for a structural distinction such as 'front', 'back', and 'side' in the constellation of the type. Since a type is less restrictive than a system, external structure characteristics can also form part of a structure type. The entrance in particular is an important characteristic of the structure type. The direct surroundings of the entrance or the other openings leading outside can be involved in the structure type. For example, the archetype, the Villa Rotonda (Palladio) is inconceivable without the lines this type draws in the surrounding landscape, whichever landscape this may be. This elementary context-sensitivity takes you to the brink of the concept of type.

12.2 A FUNCTIONAL TAXONOMY

The function concept is most suitable in typological research for the classification in taxa, families and types. The function of the developed or undeveloped surroundings consists of different values like short-term sensation value, medium-term utilisation value, long-term prospective value and extremely long-term sustainability value. The 'form' is sufficient for the sensation value; structure other than the sensory connection with the observer is not necessary.

For other values a notion of structure is a pre-condition in increasing measures. Utility values can be sub-divided into economy, culture and management.[a] Values less directly related to human utilisation or human sensation, like technical, ecological and environmental functions are not taken into consideration here. In the medieval town (see the market square in Delft) this trias is recognisable as a type.

Pierre George's categorisation could be denoted as trias urbanica. Further sub-division as a result of social differentiation and function divisions is known as a *trias politica*[b], a *trias cultura* and a *trias economica*, using the systematics of Jakubowski and Parsons.

Of course, function entails more than the above stated taxonomy based upon social differentiation at an urban level. Besides this top-down approach, the bottom-up approach is also possible, whereby pre-suppositions regarding individual activities (wherein the individual sensation is understood) play a rôle. This leads to another function typology more difficult to capture in a taxonomy.

a This line of reasoning is derived from the French geographer George, P. (1964) *Précis de géographie urbaine* (Dutch translation: (1966) *Geografie van de grootstad, het probleem van de moderne urbanisatie*). This can be found in the theoretical form with the American sociologist Parsons, T. (1966) *Societies: evolutionary and comparative perspectives*; Parsons, T. and J. Toby (1977) *The evolution of societies,* and by the Marxist orientated, with the Frankfurter Schule associated Jakubowski, F. (1936, 1974) *Der ideologische Ueberbau in der materialistischen Geschichtsauffassung* (English translation: (1990) *Ideology and superstructure in historical materialism*, Dutch translation: (1975) *Basis en bovenbouw*).

b Montesquieu, C. de (1748) *De l'esprit des lois*. English translation: Montesquieu, C. de, Anne M. Cohler et al. (1989) *The spirit of the laws*.

c Source: Koch (1988) *De Europese bouwstijlen*.

12.3 FORM AND STRUCTURE PRE-SUPPOSED IN FUNCTIONS

Urban functions can be spatially concentrated or de-concentrated. This leads to various types. In this way institutions of higher, secondary and primary schools can be concentrated in one building or scattered over many buildings of different types. Deconcentration normally means implicit inter-weaving with other forms of land utilisation. Dispersed living often means inter-weaving with agrarian functions in a radius of one kilometre. Concentration means segregation.

Relatively unrelated to this, functions can also be centralised or de-centralised in a hierarchic organisational classification. Spatial concentration must not, therefore, be confused with the *organisational* notion of centralisation. In this way local shops can be an organisational element of a national chain, of which the distribution points are spatially spread. Implicit pre-suppositions regarding the layout form of one social function may have bearing upon the typology at varying scale levels (in a different frame).

Inter-weaving, for example, leaves intact the fact that juxtapositioned functions can have no connection due to local physical factors, economic, cultural or governmental barriers, (segregation**)**. Examples of divisions like these are watercourses, unaffordable factors or due to unfamiliarity for specific population groups in the area or differing management responsibilities. For example, an office of a specific size in the vicinity of a restaurant, may have its own canteen. This in turn gives rise to a different type of office or restaurant.

On the other hand, segregation leaves the fact intact that functions are, in spite of distance, connected with each other by means of infrastructure, (function binding). This is the reason why long-term parking provisions, situated at a reasonable distance from the airport, are often linked to the airport using a system of shuttle bus services. Such possibilities have bearing upon the type of airport. Taxonomy therefore does not only have implicit form pre-suppositions but also implicit structure pre-suppositions, related to the analogy and divisions between functions.

12.4 SCALE SENSITIVITY OF TYPE CHARACTERISTICS

The type characteristics, distinguished in the schedule below, are scale sensitive. Something considered segregation in one specified framework can be considered inter-weaving within a larger framework (scale paradox**,** compare the apparently contradictory concept of ‘heterogeneous mixture’ from materials science).

These concepts, therefore, cannot be used during a scale switch in an argument. Similarities at different scale levels between drawings, which are in themselves fixed-scale drawings, or arguments which can contain these scale sensitive concepts without a change in interpretation, can be compared once more at a higher level of abstraction than comparing the argument itself once again.

Based upon these comparisons a type may be chosen which is recognisable at different scale levels. For example Lefaivre and Tzonis (see page 89) recognised the same type of form in a building, a painting and an urban construction design. When designing with a scale-free type, one again comes across the scale dependency of its characteristics. An office building situated adjacent to a restaurant, able to have its own canteen, is within the framework of the urban ensemble an example of segregation$_{100m}$, however within the building it is a form of integration$_{30m}$.[a]

This reversal of conclusions due to scale change also takes place at other scale levels and can be typified at higher abstraction levels. Function separation is used in the trade jargon in the case of both separation and segregation. The well-known CIAM-doctrine argues separation at urban level of housing, working, recreation and traffic on functional and environmental protection grounds. The question is, however, whether this must also lead to segregation. Structural means like sound barriers for example, separate the traffic from the housing, in order that they can continue to co-exist spatially (function segregation$_{30m}$). If segregation should be required in that framework, (for example by zoning surrounding hazardous companies), the question is: on what scale: within the area (between neighbourhoods) or within the town (between the areas). These are different types of function separations: function separation$_{1km}$ is a different principle than function separation$_{3km}$.

SOCIAL - DIFFERENTIATION	URBAN - DIFFERENTIATION
Ruling body (nobility)	castle, palace
Culture (clergy)	church, monastery
Economic basis (townspeople, serfs)	market, shops, housing, traditional businesses

65 Spacial expressions of social differentation

TRIAS POLITICA	
Legislative power	City hall
Judicial / administrative	Court house Civil services
Executive power	Police station, prison barracks
TRIAS CULTURA	
Religion / ideology	Churches, monuments, memorials
Art & sciences	Muse, institutes, libraries
Upbringing / education	Social-cultural provisions, schools
TRIAS ECONOMICA	
Production	Companies, banks, offices
Trade	Distribution points infra-structure
Consumption	Homes, health-care, recreation

66 Spacial forms of political, cultural and economical differentation

	Form characteristics	
Structure characteristics	*Isolation*	*Inter-weaving*
Separation	Function separation	Segregation
Connection	Function binding	Integration, function combination

67 Implicit function characteristics

a The dimension index must be seen as ‘within 100m’ and ‘within 30m’ Function segregation within 100m (ensembles) can therefore go hand in hand with function integration within 30m (buildings). As soon as this is externally considered, the same situation must be named at one scale lower: Function segregation between buildings (30m), related to function integration between building segments. In order to avoid systematically concept confusion, an internal consideration is used.

b CIAM, 1933, earlier formulated by Hercher, 1904.

The distinction between function separation and function combination (integration) is, severed from the function itself, on each scale level a structural design dilemma allowing solution by structural types. The Swiss Army pocket-knife is by way of an example a type with a function integration$_{10cm}$. However, if one is accompanied on a holiday by a knife, cork-screw, bottle opener, screw-driver etc., then a function segregation$_{10cm}$[a] applies. At the same level of functionality this yields very different types of tools. Who wants to develop photographic film in a living-room is working at a function integration$_{3m}$; when working in a separate dark-room it implies a function-segragation$_{3m}$. Kinds of traffic (pedestrians, cyclists and motor-cars) may be combined and segregated as well. It is striking, in all examples, that function integration costs time, but saves space. Function segregation, on the contrary, often has time saving as a motive, but costs space. However, this applies only if it is possible to continue reasoning in the same order of magnitude. For, if in the case of function segregation the partial functions resulting are spread out to such an extent that, for instance, finding, walking or travelling time start to play a rôle, one should allow in a wider context for loss of time. In principle characteristics like that do not depend on function. They are related to usage of time and space; but there is no need to be specific about which kind of use is applying. Structural types restrict themselves to characteristics like that.

12.5 IMAGE TYPES

In architecture an image type – like a gate, mountain or grotto – is a scale-less image of the archetype (nature, God's ordination) preceding the form. The image knows no scale. However, in landscape architecture the term is also used as a function type recognising just one function: the visual and / or tactile, moving impression that an artefact leaves in many people collectively.[b] A Dutch *'polder'* – together with its agricultural and recreational function throughout the ages – is a function or an image type.

This impression is a condition for effective use of the artefact. An impression is containing more and less than the spread of material (technical, operational, real 'form'), of which only the outer appearance (*'vorm'* in the leading Dutch dictionary) is landing through the senses in the remembrance of people. If the collective impression would cover a spread like that, it would be a form type. In this vein the characteristic pattern of Dutch waterways, dikes, sluices, ditches and many other things just passing translation into English establishes within a polder is a form type. When their technical (water) separating and connecting operation is also taken into account, a structure type is discussed. An impression seldom contains the actual three-dimensional form below and above the topsoil as it may be reconstructed from blue-prints and cross-sections, or from constructional surveys, with the co-ordinates recorded in the computers of design agencies. In this sense an image type is a more restricted notion than a form type. However, to this restricted impression collective historical (cultural) connotations are added that have found access to collective memory through different media than the individual's perceptual senses. Through this, the objects of that type are getting collective meaning and value (imagination).

Visual types correspond in a more direct way to active imagination of designing than the analytical types described earlier. This imagination is comprising more than what is termed imagination in development psychology. It also comprises imagination techniques to be learned as a creative capability (see page 389 and 399). This includes analysis of the image (for instance in the historical, partially overlapping 'layers'), their supplement and restriction in a renewed synthesis (transformation), mounting the images in a different context (transfer) and analysing the effects on that context.

Because of the lack of words indicating concepts in images often images from a very different context – such as 'paper-clip' or 'satellite' are used in designing. Such metaphors can be regarded as types of transference.

a In order to avoid change in significance and scale, the order of magnitude of the function-combination is adhered to while comparing functional separation and combination. Even if the same function-separation is presented on a much greater distance, such as a knife in the picnic basket and a screwdriver in the luggage boot, keeping together within one container is already function-separation, in order of magnitude comparable to the integration in a pocket-knife.

b Aben, R., P. van der Ree et al. (1994) *Metamorfosen, beeldtypen van architectuur en landschap;* Conijn, E. (1999) *Wonen op een buiten, spanning tussen het oneindige en de geborgenheid;* Kooij, E. van der (2000) *Het buiten voorbij*.

13 CONCEPT AND TYPE

BERNARD LEUPEN

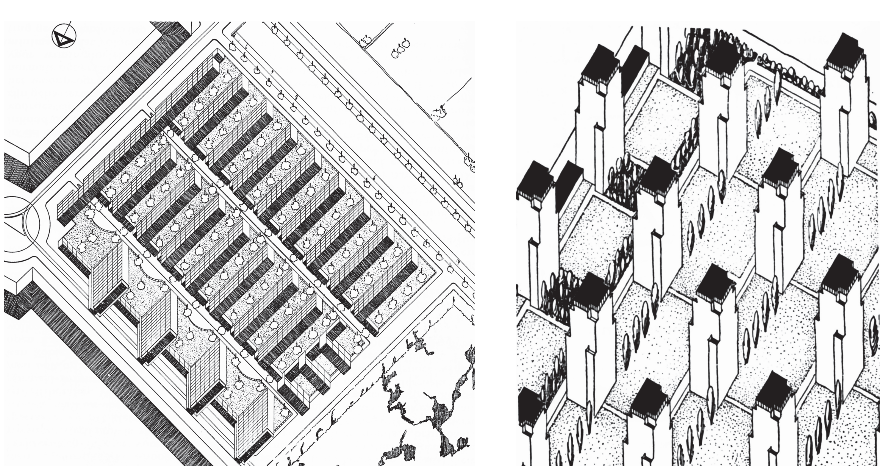
13.1 HOW TO GIVE FORM TO A DESIGN

We have been told for a long time that form follows function. Functionalists, in particular, held this view. But, if function directly generates the form, why, then, are there often many different solutions for one assignment?[a] Even when functionalism was in its heyday, one single assignment would result in a series of multiform designs, as demonstrated, for instance, by the results of the competition for low-cost working class housing in 1936.[b] These differences may be partly due to difference in insight, or interpretation of the assignment. If the differences between the designs were solely due to a different interpretation of the assignment, then, with the same interpretation of the same programme, the resulting designs would have the same form. The question remains: how does the programme generate form or, more specifically, how does the form of a bedroom follow from the function sleeping?

A functionalist will explain that this form is the result of careful analysis of all the activities that are part of the function sleeping. The dimensions and areas that follow from this analysis should lead to the ideal form of the bedroom; this also applies to kitchen, living room, etc. The result is a number of rectangular boxes that, together, fit overall dimensions. A sort of minimal envelop, not yet an architectural solution. For instance, what is wrong with the bedroom that Goff, the architect, designed for a house in Aurora (Illinois)? Why would this bedroom, placed in a quarter segment of a sphere, not follow the function?

The reasoning that form automatically follows function disregards two phases in the design process.[c] First, there is the phase of interpreting the assignment, as was mentioned. Then, there is the phase in which form and spatial arrangements are determined. In both these phases the architect makes active choices.

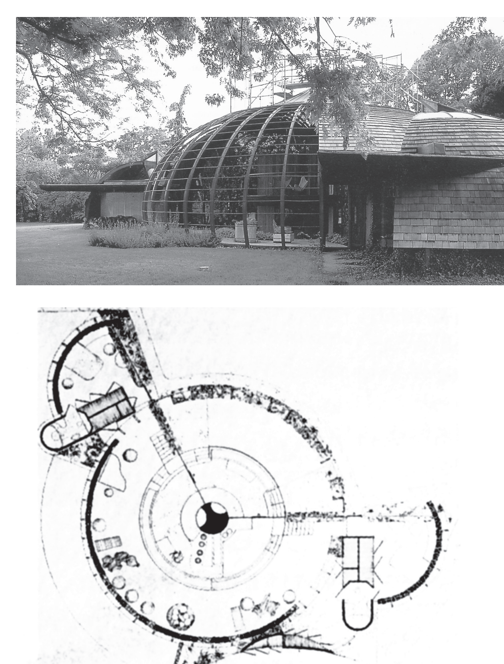
The first essential choices are made at the interpretation stage of the assignment and when developing a view of the project requirements in relation to the location. In many cases, certainly in the past, interpretation of the assignment was self-evident. The approach was mainly conventional: a certain project at a certain location should be handled the established way. That is how it was taught at the academy, or the way it had been done for years in a certain region. However, increasing complexity of assignments and current construction methods require a personal interpretation, based on an underlying principle, vision or concept. The notion 'concept' is further discussed below.

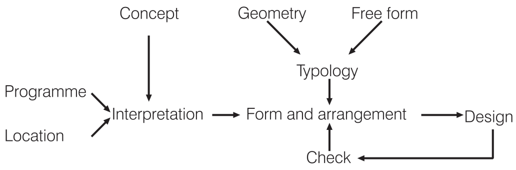


a The idea that the assignment generates the form has also kept a whole generation of CAAD specialists busy.
b Ottenhof, F. (1981) *Goedkope arbeiderswoningen (1936)*.
c Please note that Sullivan with his tenet that form follows function did not mean that the form automatically follows from the function. In his view, one should choose the form which best fits the function. Sullivan, L. (1956) *The autobiography of an idea (1924)*.
d Photograph: Jan Molema. Source: Archis (1996) nr.6 p.21.

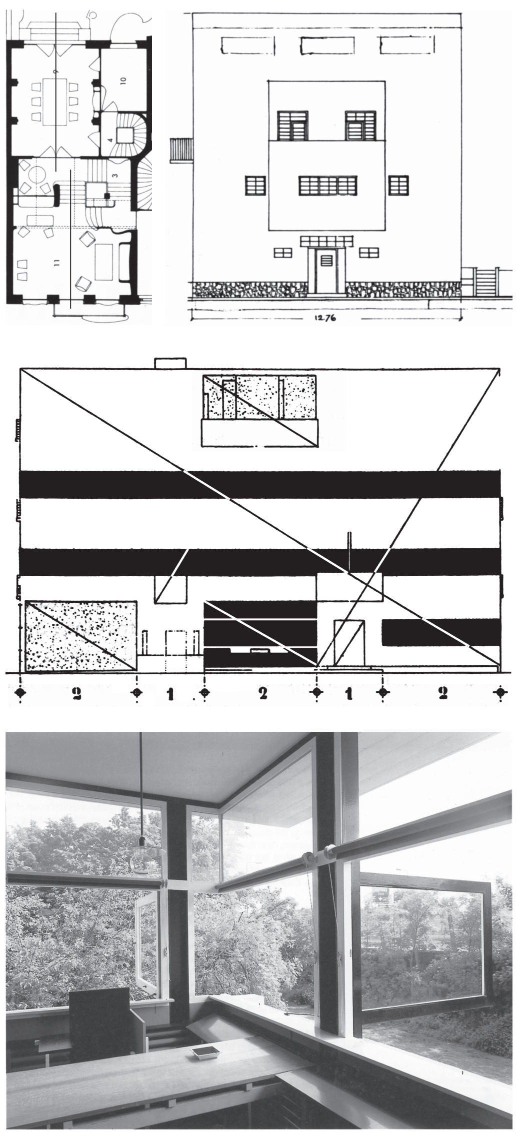
68 Contest submissions for cheap labour housing Van den Broek (left) en Van Lochem (right)[b]

69 House in Aurora, designed by Goff. The bedroom is situated in the top half segment of the sphere[d]





70 Schematic representation of the phases and influences in the design process



71 Horta, floorplan with shifted axes, private house.
Loos, front façade *Haus Möller*,
Le Corbusier, front façade *Villa Stein,*
Rietveld, *Schröderhuis*, open corner.[e]

13.2 RECURRING PRINCIPLES OF SPATIAL ARRANGEMENTS CAN LEAD TO THE USE OF 'TYPE' SOLUTIONS

Once the interpretation has been made, the spatial arrangement and the decision on the form will, in broad outlines, be developed by a process of searching for solutions, making assumptions and testing results. Searching for a main principle for the spatial arrangements and for a form where it is assumed that there will be a fit to the assignment, and then testing the results as to how these work in practice. For centuries, the same criteria guided this process. Vitruvius spoke about 'durability, convenience and beauty'.[a]

The form can, in principle, be derived from geometry or from nature, in the last instance reduced again to geometrical form. If principles of spatial arrangements or form structures keep recurring, this may indicate use of a 'type' solution. From experience, we know that certain forms, schedules or models are more useful than others. In particular, when there is repetition, or when project requirements are very strictly defined (housing, theaters, prisons, etc.), the same principles recur regularly.

13.3 THE CONCEPT HAS NO FORM

In recent decades, the notion 'concept' came to achieve a prominent position in architectural theory. What does 'concept' mean in relation to architecture? Before addressing this question, I will first indicate why a concept plays such an important rôle in present-day architecture.
In an interview Rem Koolhaas said this:

> *"I find the notion of 'concept' very difficult. When I, myself, was teaching, I found it difficult to explain what a concept is, and whether it is necessary. Today, I find it an absolute necessity. The concept is the theme on which the design is based. One can sum it up in one sentence. It can be very primitive, but it is still a test of your design"*[b]

Nouvel states on the subject:

> *"I am always able to describe with enormous precision any of my projects in five written pages. It simply happens like that, and it is essential. But, at the same time, there is a moment in the process where the argument is there and I have no longer the need to keep talking about it, because the essential point is to fix the concept. This is the moment when, through a sort of miracle, other things will be produced. The work becomes more plastic; memory and attention take over."*[c]

From Renaissance to the end of the nineteenth century, concepts, as we view them now, had no significant rôle. The discussion concerned primarily correct style. When discussing style, one usually thinks in the first place of appearance, the form of elements used and differences in decoration. However, a second, underlying system with regard to style can be discerned. The art historian Emil Kaufmann calls this system the 'architectural system'.[d] It delineates the structure of the designs attributed to a particular style, the way in which the elements are assembled and spatially arranged, and indicates which set of instruments has been applied. Spatial arrangement and composition of buildings were to a large extent determined by the prevailing architectural system. Until the beginning of the nineteenth century, the underlying system was hardly ever discussed.

13.4 THE CLASSIC SYSTEM PUT TO THE TEST

Around the 1900s, several architects began to work on fundamentals of the system. Horta queries symmetry, Loos attacks ornamentation, Le Corbusier redefines the classical rules for composition, Rietveld and Mies van der Rohe open up spatial arrangement.

Thus, slowly, but surely, a new form of architecture was developed, typified by absence of a coherent architectural system. Le Corbusier also, using the 'five points' and the 'Modulor', did not manage to create a new and generally accepted architectural system. Although elements of the classical architectural system can be found in many creations of modern

a Vitruvius and M. Morgan (1960) *Vitruvius: The ten books on Architecture*, p.17.
b Leupen, B.A.J. and N. Bisscheroux (1984) *Interview met Rem Koolhaas*, p.51.
c Zaera, A. (1994) *Incorporating: Interview with Jean Nouvel*, p.17.
d Kaufmann, E. (1955) *Architecture in the age of reason*, p.75 a.f.
e Sources respectively: Catalogue with the Horta Museum, Risselada, M. (1988), Rowe, C. (1982), Overy, P. *et. al.* (1992).

architects, the programme is now the basic issue. While transparency, apparent weightlessness and machine aesthetics form the basic idiom of the Modern Movement, each new design seems to be seeking its own identity, its own concept.

13.5 THE CONCEPT ORGANISES DESIGN CHOICES

When one common view still dominated the architectural system, the architect had a clear set of rules while making the numerous architectural choices with which a designer is confronted, choices about dimensions, proportions, rhythm, spatial arrangement, composition, structure, use of materials, etc.

That each design needs its own legitimacy or concept, is not only the result of the urge for innovation amongst architects, but also of the growing complexity of building specifications and materials and building techniques now available.

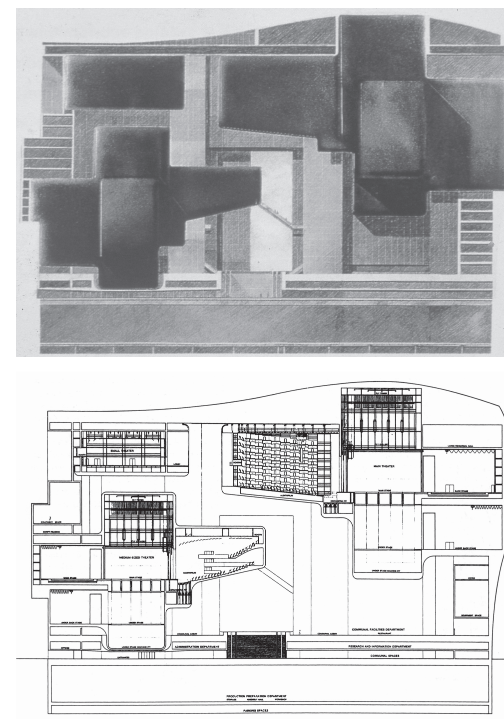
A concept does not have to be decisive about the form of the definitive design. It expresses in first instance the overall idea, the character and direction in which the solution is to be found. The concept expresses the basic thought behind the design, it gives direction to design choices and, at the same time, excludes alternatives: in a way, it organises the design choices.[a]

13.6 A CONCEPT MAY BE PRESENTED IN DIFFERENT WAYS

A concept may be presented in various ways: in a scheme, by visual images, in words. The procedure at the office of the French architect Jean Nouvel can serve as an example and illustration. Before the first line is drawn on paper, extensive discussions are organised between designers and specialists on sub-areas. Drawing is only allowed to commence when a description of the project – a concept – is clear to the mind's eye. This procedure pre-supposes wide knowledge of possibilities and great power of imagination.[b]

An example of such a verbal concept is the concept of the design of the Prize for an opera house in Tokyo (1988) designed by Nouvel. As the result of a series of discussions within the office a leading metaphor was chosen: a vast travel case of a musical instrument. On the outside the building should have a smooth black skin; on the location of the great hall it should have a slightly bulging surface. On the inside golden-hued auditoriums were placed in space, like instruments in a case.

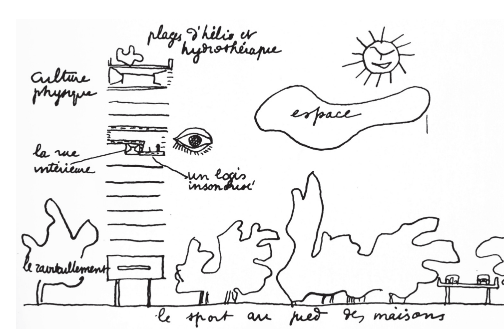
The risk of a metaphoric concept lies in taking the metaphor too literally; for instance a hamburger joint in the shape of a hamburger. That may be funny briefly, but does not generate interesting buildings. While designing on the basis of metaphor the difficulty is to maintain a sufficient level of distance from the literal interpretation.



72 Nouvel in co-operation with Starck, design for an opera house in Tokyo, model and cross-section.[c]

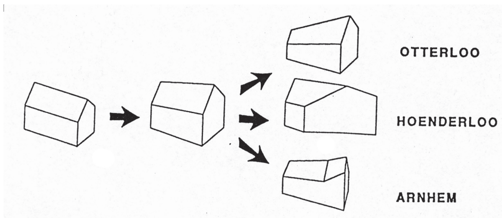
Le Corbusier condensed the *'Unité'* concepts – several concepts form the basis of the work – to two sketches, where points of departure like light, air and space, view, the pilotis and the roof-garden may be found back.

Along the same lines functionalism may be conceived of essentially as a concept: 'form follows function' is a discourse guiding the subsequent design decisions. Although an analysis of the programme of requirements does not result automatically in selection of a shape and certainly does not generate a shape – like functionalists pretend – functionalism obtained for itself via the metaphor of the machine-aesthetics a language of shapes.



73 Le Corbusier, sketch of the concept of his 'Unité'.[d]

a Leupen, B.A.J. and C. Grafe (1997) *Design and Analysis*. p. 13. Originally published in Dutch: Leupen, B.A.J., C. Grafe et al. (1993) *Ontwerp en Analyse*.
b Leupen, B.A.J. (1989) *Een nouvel concept*, p. 85.
c Source: Leupen, B.A.J. and C. Grafe (1997)
d Source: Samonà, A. *et.al.* (1976)



74 MVRDV, scheme of the concept for admission lodges on the ‘Hoge Veluwe’.

13.7 A HOUSE OF STEEL, WOOD, OR STONE

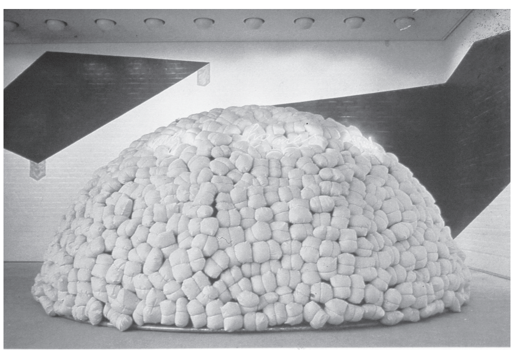
An example may clarify how a concept guides design decisions. The Foundation *‘Nationaal Park De Hoge Veluwe’* published in spring 1994 a controlled prize for the design of admission lodges. The existing ones were constructively but in sad shape and longing for successors; added to that, for safety and comfort of personnel, new requirements applied to the lodges.

The MVRDV office developed a concept for the admission lodges as simple as it is efficient. The shape of each small building may be reduced to the archetypal shape of a house with a pointed roof. By morfing, attenuating, and folding this main shape each lodge can boast its own shape. This way a playing with perspective emerges to the person observing the lodges.

13.8 A ‘POWERFUL’ CONCEPT PERVADES A DESIGN INTO THE DETAILS

The concept used by MVDRV is strongly similar to the concept used by the Italian visual artist Mario Merz for the igloos he created. Merz made a series of installations with a basic shape that may be carried back to the igloo archetype. However, in contrast to this frozen Eskimo abode Merz does not use ice, but a range of different materials like slate, glass, wax or asphalt. By realising the igloos in an unfamiliar material Merz obtains an alienating effect.

Inasmuch as MVDRV executes the main shape of the archetypal house each time in a different material, this office follows the same line of thought as Mario Merz. However, the MVDRV objective is not to create alienation, but distinction and contrast.



75 Mario Merz, two installations of an igloo (photograps by author).

The selection of the material may be understood from the immediate context at first sight. The house made of brick may be regarded as an answer to the present brick home at the entrance Otterloo; while the wooden house is undoubtedly an answer to the forest and particularly the tree, almost the Siamese twin of the entrance pavilion at the Arnhem side. The selection of corten steel at the Hoenderloo entrance may be thought of as an allusion to the military training area that side of the Veluwe region.[a]

In a wider sense the context also influenced the selection of the material by the designers. In this vein the concurrence, or maybe on the contrary the conflict between conserving a bit of nature and culture, in a wider and more restricted sense influenced the concept. Culture in a wider sense relates to manipulating nature at the beck and call of hordes of visitors: the ‘Hoge Veluwe’ as a soft park of fun, culture. In a more narrow sense culture comprises the works of high arts stored in and around the Kröller Müller Museum. Likewise the corten steel may be regarded as a direct reference to visual artist Richard Serra, while the brick at the admission lodge near Otterloo evokes images of the work of Per Kirkeby.

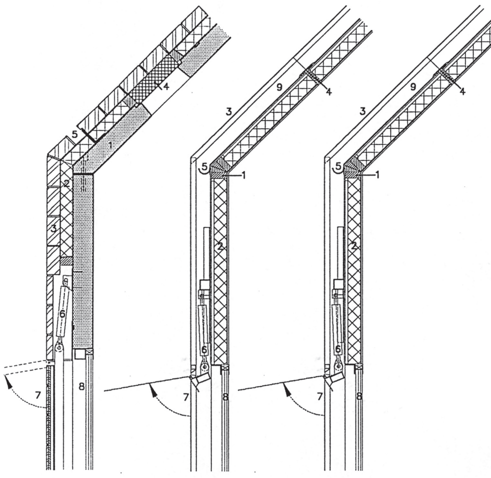
a In a discussion with Winy Maas he mentioned that the choice of the corten steel was suggested by colour. The rusty colour is functioning in Autumn as a camouflage colour between the red beeches.

76 MVRDV, three admission lodges, in brick (left), steel (middle) and wood (right) (photographs by author).

The concept used by MVRDV is so powerful, that it determines the design decisions not excluding detailing. The selection of one material per lodge caused the designers a lot of trouble, particularly in the case of brick. The skin of brick has been stretched accordingly over the door and the shutters. This was realised by gluing brick strips on the structure.

In order to emphasise the idea that the outer material is just a skin, the designers have kept it loose of the soil. Particular attention went into the transition from roof to wall. Rainwater is disposed of by means of a hidden gutter. This reinforces the concept of the archetypal basic shape. In the case of the lodges of wood and brick a slit in the roof was made on that spot, while at the one executed in 'corten' steel circular holes were cut there in the steel sheets. These 'bullet holes' further strengthen the reference to the military training areas.

At night the shutters in front of the panes of glass of the admission lodges are closed. Then the continuity of the material is complete. The humble dwellings are thereby transfigured into rough crystal-like shapes of steel, brick and wood. The shutters of steel and brick are raised during daytime so that they may function as an eves. At the house of wood the shutters, built in a string of loose vertical slats, fold outward in elegantly pleated prisms.

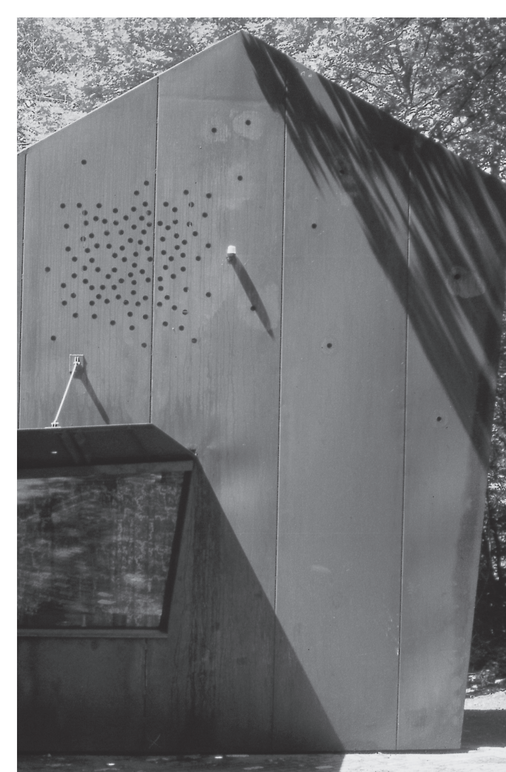


77 MVRDV, detailing of the admission lodges thrice: brick (left), steel (middle), and wood (right).

78 Richard Serra, composition of corten steel

79 Per Kirkeby, object in brick

80 MVRDV, detail admission lodge in 'corten' steel with holes for disposing of rainwater and ventilation (photographs 78-80 by author)



13.9 THE TYPE, THREE THEATRES AS EXAMPLE

As mentioned, we know from experience that certain forms, diagrams or models are more useful than others. In particular, in the case of repetition or precisely defined programmes (housing, theaters, prisons, etc.), one frequently sees that the same principles recur. With this sort of experience in mind, we now enter the domain of the typology. To illustrate the point, we show three theaters: the theatre in Genua by Aldo Rossi (19..), the *Stadtstheater* Essen by Alvar Aalto (1983-1988) and the *Danstheater* in The Hague by Rem Koolhaas / OMA (1980-1987). What do they have in common? The three architectures are so different that it can not be on the basis of the similarity. Closer study of the spatial arrangement of the three designs shows similarity in composition on two points. Firstly, in all three designs, there is a relationship between stage and auditorium via a 'proscenium'. From the auditorium one looks at the stage through a frame. A curtain can close the frame. In contrast to the classical Greek theatre, the spectator looks at the stage as at a show-box. A second similarity is the shape of the auditorium. Although the final form is different in each case, the three auditoriums have in common that the public is seated on a floor sloping upwards. The auditorium has a shell-shaped floor, allowing each spectator a good view of the stage.

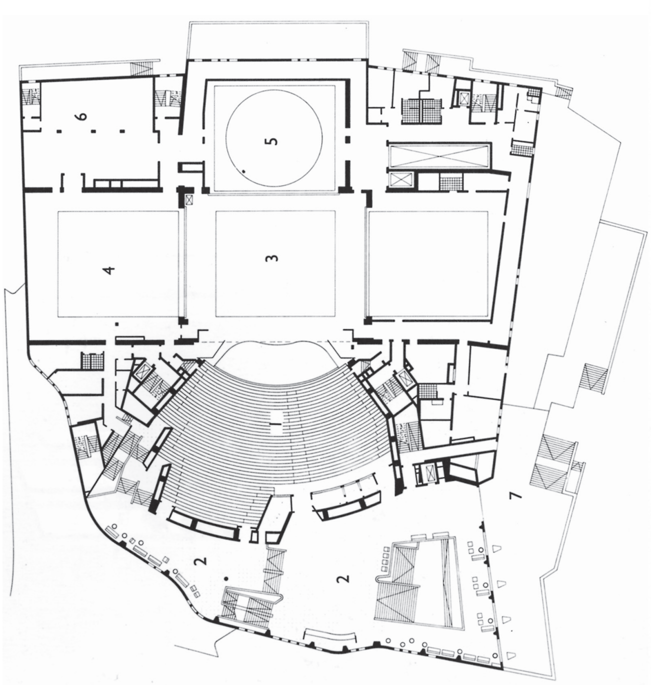
13.10 THE IDEA OF TYPE SHIFTS BETWEEN WORD AND DIAGRAM

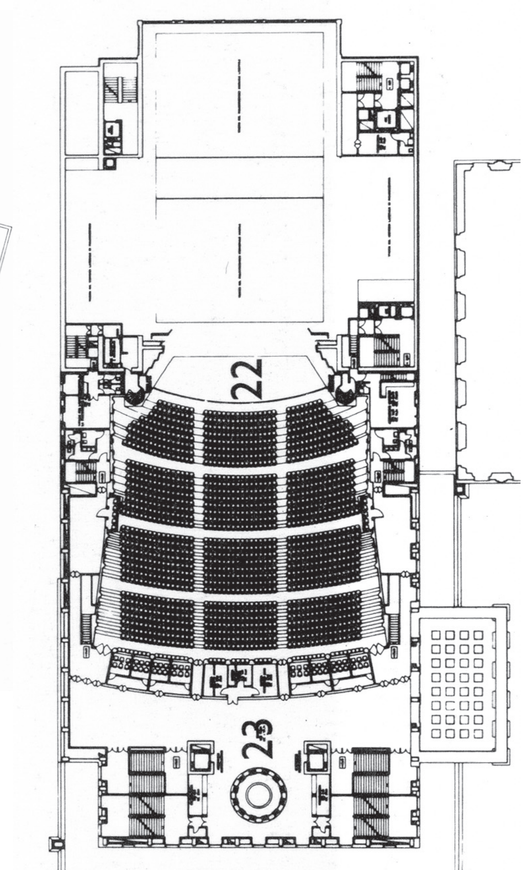
It might seem to be self-evident, but until Semper designed the *Festspielhaus*, Bayreuth, it went without saying that a large part of the public, and, in particular, those from the upper classes, were seated in the loges, boxes situated on horseshoe-shaped balconies around an auditorium with a flat floor. A number of these boxes were situated in such a way that occupants could more easily see each other than the actors on stage. Being seen was the primary reason for going to the theatre In the eighteenth and nineteenth centuries. What happened on stage was less important.

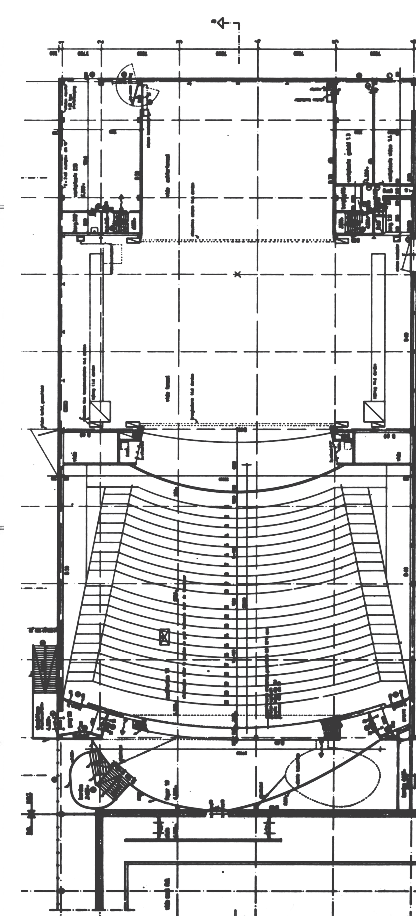
81 Aalto, Floorplan theatre in Essen.[a]

82 Rossi, Floorplan theatre in Genua.[b]

83 OMA, floor plan Danstheater, The Hague.[c]

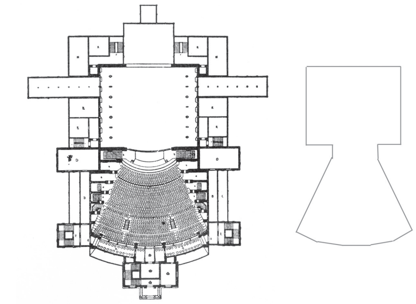






a Source: Archis (1989) nr.1, p.24.
b Source: Archis
c Source: AMC (1987) nr. Décembre, p.9.

Wagner finished off this principle once and for all when he commissioned Semper to build a theatre that would focus attention on the performance on stage. Since then, the shell-shaped auditorium has become a idea used many times, as in the theatres designed by Aalto, Rossi and Koolhaas. The similar spatial arrangements – the formal basic structure – we can also designate as examples of the concept of type. There are actually two types shared by the three theatres: the framed proscenium and the shell-shaped, or Bayreuthian auditorium. The similarities between these three theatres can be summarised in a diagram that represents the formal basic structure of the corresponding principles. Such a diagram we call a typological scheme. This scheme is a representation of the type; however, note that it is not the type itself. The concept type shifts between the schedule and the words - the language - in this case *the shell-shaped theatre and the framed stage*.



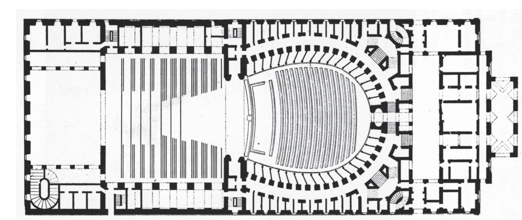
84 Semper, floor plan Festspielhaus Bayreuth and typological scheme applying to all of the four theatres.[c]

13.11 TYPE ACCORDING TO QUATREMÈRE DE QUINCY

At the end of the eighteenth century, the French architectural theorist and encyclopaedist Quatremère de Quincy gave a clear definition of the idea of type. He defined this idea by placing it in juxtaposition with the concept of 'model'.

"The word type is also used synonymously with 'model,' although there is between the two a difference that is easy enough to understand. The word 'type' presents less the image of a thing to copy or imitate completely than the idea of an element which ought itself to serve as a rule for the model... The model, as understood in the practical execution of the art, is an object that should be repeated as it is; the type, on the contrary, is an object after which each (artist) can conceive works of art that may have no resemblance. All is precise and given in the model; all is more or less vague in the type. At the same time, we see that the imitation of types is nothing that feeling and intellect cannot recognise, and nothing that cannot be opposed by prejudice and ignorance.

This is what has occurred, for example, in architecture. In every country, the art of regular building is born of a pre-existing source. Everything must have an antecedent. Nothing, in any genre, comes from nothing, and this must apply to all of the inventions of man. Also we see that all things, in spite of subsequent changes, have conserved, always visibly, always in a way that is evident to feeling and reason, this elementary principle, which is like a sort of nucleus about which are collected, and to which are co-ordinated in time, the developments and variations of forms to which the object is susceptible."[a]



85 Floor plan of the Scala in Milan, an example of a nineteenth century theatre.[d]

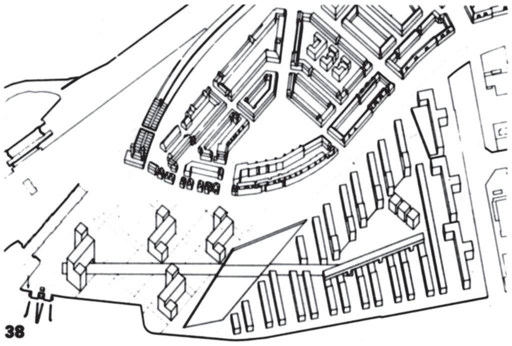
The Italian art historian G. C. Argan further elaborated upon Quatremère de Quincy's definition:

"The second important aspect when designing from typologies is the relationship between design decisions. This brings us to the question of typological levels. A typological level can be regarded as a scale of planning in which the design decisions present a unified system of choices. The number of typological levels (or layers) in a design is not dictated beforehand, but can be specified according to the complexity of the object and the modus operandi of the designer."

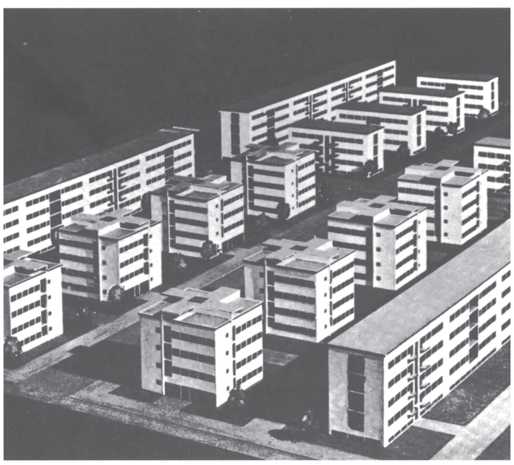
Argan distinguishes three such levels in a building:

- the configuration of the whole building,
- the major elements of construction
- the decorative elements (façade, separating walls, stairs,..)[b]

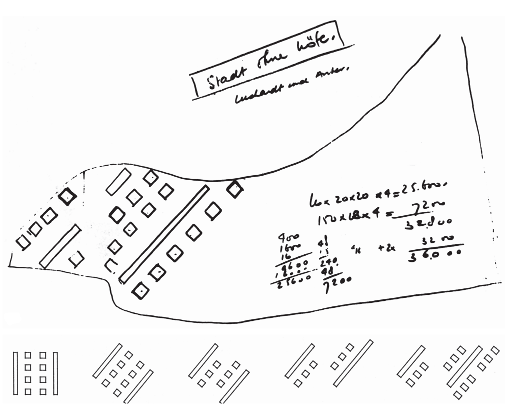
a Leupen, B.A.J. (1989) *Een nouvel concept*, p. 85.
b Argan, G.C. (1965) *Sul concetto di tipologia architettonica*.
c Source; unknown.
d Source: Pevsner, N. (1976).



86 OMA, axonometry of the IJ square.[b]



87 Luckhardt brothers, model 'Stadt ohne Höfe'.[b]



88 OMA, sketch for the IJ square, with adjustment to 'Stadt ohne Höfe'. Scheme of the transformations.[b]

13.12 THE TYPOLOGICAL TRANSFORMATION OF THE ARTICULATION OF THE SITE

The urban design of the Western part of the IJ square in Amsterdam-North of the OMA office (Koolhaas) is an example of deliberate manipulation and transformation from an existing type to a new type. A transformation on the level of the articulation of the site is crucial here. When during the first stage of the designing process high-rise building was banned, the designers were looking for a different form of site articulation, so that their initial point of departure – a view of the IJ expanse of water for everyone – might be realised. Selection was made of a type based on a design of the Luckhardt brothers for a residential neighbourhood in Berlin. This 1927 design – not realised – *'Stadt ohne Höfe'*, is constructed out of two units of surface articulation: each time consisting of a long slab, flanked by a row of urban villas. This transparent type of articulation features a common green inner area, while access is positioned at the edge of the unit of articulation.[a]

Guided by an analysis of the OMA design sketches one may explore how the transformation of the Berlin type lead to the rise of the western part of the IJ square. Transformations both on the level of configuration of the blocks and on the one of surface and access manifest themselves.

On the level of the configuration of blocks the Berlin design may be reduced to two rows of cubical blocks with two slabs at both sides. The internal shape-structure may be rendered by the typological scheme 'eight cubes and two beams'. The first transformation to which this scheme is put, is a rotation in order to adjust to the situation. In this rotation two cubic blocks are omitted. Next, an important step: the two halves of the configuration of blocks are shifted *vis-à-vis* one another. By shifting the two halves, the urban villas become free in space. At that moment a transformation of the type occurs and a new type is born, constructed from a row of urban villas positioned before a slab, functioning in it as a backdrop against which the urban villas show out as loose objects.

The next imaginary step concerns lengthening the long block at the right and adding two rows of three separate blocks at the free side of this lengthened block. By locating the urban villas as much as is possible opposite of the large spaces the spatial effect of the urban villas before the slab is exploited to the maximum.

On the level of surface and access a complex process prevails. What it boils down to, is essentially that the original typology of access – as an open building block opened cluster of a beam and four urban villas – has been given up by OMA and is replaced by an access that has been made subservient to the architectonic furthering of the western part of the plan. Whereas with the Berlin plan a systematic change of street – block (open) inner area – blocks – street reigned, OMA deals with these parts as autonomous elements in a composition organised in bands. This positioning of the elements is much more determined by the will to create a montage of zones with distinct atmospheres on the surface than by the need to make public (street) and semi-public (inner areas) spaces. In this new positioning the street ends up between the long block and a row of urban villas. With this, the original access typology is turned inside-out, resulting in a new relation between public and private on the ground level.

a Leupen, B.A.J. (1989) *Een nouvel concept*, p. 27.
b Source: Leupen, B.A.J., C. Grafe et al. (1993) *Ontwerp en Analyse*.

13.13 TWISKE-WEST, THE TRANSFORMATION OF A RESIDENCE TYPE

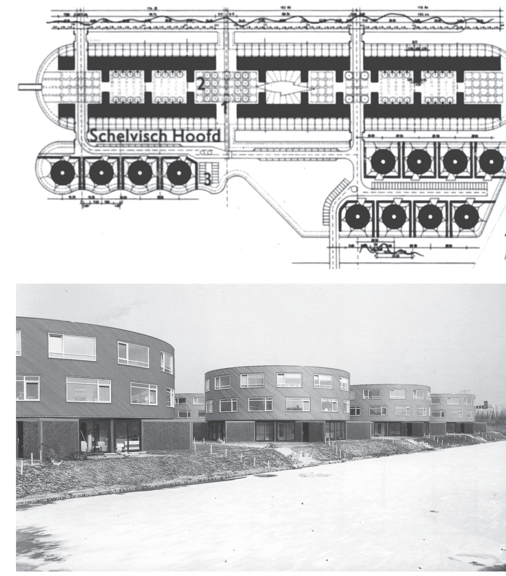
Liesbeth van der Pol designed a residential neighbourhood with round urban villas for the area Twiske-West (Northern Amsterdam). It has two parts. One comprises a double ribbon with residences positioned around some ten courts. At the court-side these residences are three stories high. At the backside they slope down with a parabolic roof to one story. At this side, the one of the garden with water, the living-rooms have been situated. They have a special spatial signature since Van der Pol continues these spaces to the parabolic roof.

The other half of the plan is the zone where the round urban villas have been situated. Each of them contains seven apartments. The small buildings have been positioned like an autonomous sequence of objects between the street and the water. The square building-lot on which the round buildings have been placed is divided into seven gardens. The separation between the gardens is emphasised by the arched storage units on ground-level hugging the round drums.

All apartments have their entrance at ground-level. Six out of seven front-doors are situated on the small central open space in the middle of the drum.

Typologically these residences are very interesting. Each apartment uses the three tiers of the drum, divided in seven segments. By stapling the apartments spiral-fashion each time, each of them always occupies three of the seven segments. This way Van der Pol ensures that those at the north-eastern side also catch a sufficient amount of morning or evening sun.

The structure of the drums may be regarded as a typological transformation of two peculiar buildings. The way in which the circle has been sub-divided recalls the servants' home on the site of the former sanatorium *'Zonnestraal'* in Hilversum. Where it comes to the stapling of the appartments a similarity suggests itself with the small dwelling of the partial plan East III on the IJ square in Northern Amsterdam designed by OMA.



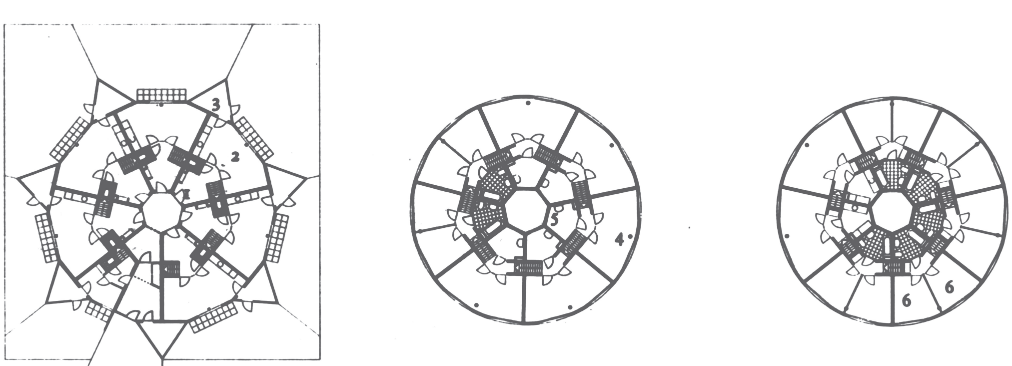
89 Liesbeth van der Pol, Twiske-West, urban plan and drum residences.[a]

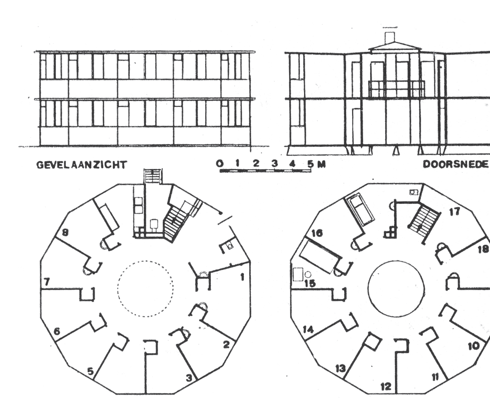
13.14 THE COMBINATION OF TWO RESIDENTIAL TYPES

Just like the drum residences of Van der Pol the floor plan of the servants' home at *'Zonnestraal'* may be understood from the division of the circle. In the case of the servants' home the circle is divided into twelve segments; geometrically a plausible number. By off-setting the radius of the circle against the circumference it is divided into six equal parts. Halving them results in a dozen. The division into fourteen segments of the drum residences (each dwelling segment being constructively split into two by means of a wall or a column) is not aligned to any geometrical operation and may be realised only arithmetically: which means that one must calculate the measures of all sides of the triangles determining the floor plan before the design can be drawn up on the drawing-board or on the site.

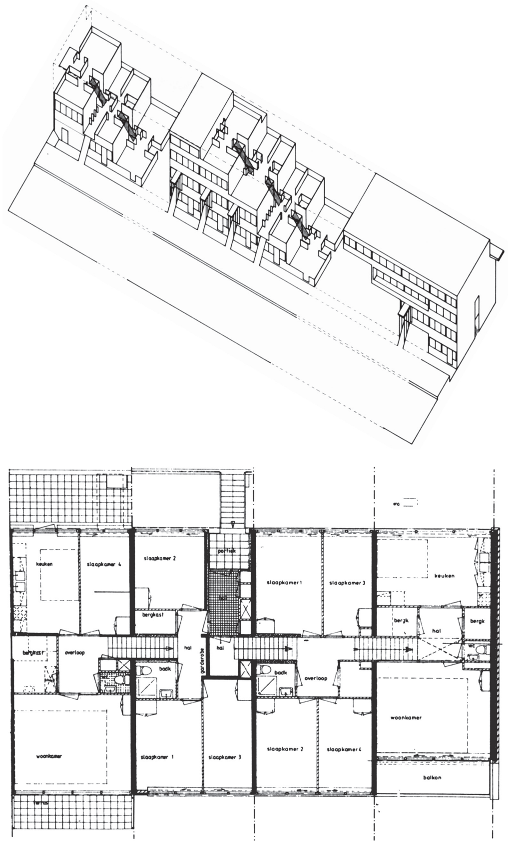
90 Liesbeth van der Pol, blueprints of the drum residences.[b]

91 Duiker en Bijvoet, servants' home of the 'Zonnestraal' sanatorium.[c]





a Source: Brouwers, R. (1996)
b Source: Archis (1994) nr. 6, p.23
c Source: Forum (1962) nr.1, p.40



92 OMA, block on the IJ square. Opened out axonometry en floor plan.[a]

In the case of the servants' home the façade consists out of a number of flat surfaces determining like twelve facets of a diamond the angular shape of the modest building. The ground-level of the drum residences has been shaped similarly, as long as the arched storage units are not taken into account. With a rising on this kind of floor plan the designer has in principle the option to place the walls rectangular to the front or on the corner point of the fronts. The first one has the merit that the angles of the space stay orthogonal – often to be preferred when it comes to putting pieces of furniture where they may serve - ; particularly when small spaces are involved. With the servants' home this solution gets an additional dimension because of the angle between the fronts in the middle of the outer expanse of the room. While standing on this spot behind the transparent front one has the feeling of standing in a bow outside the surface of the façade. Because of the positioning of the storage units this effect does not apply in Van der Pol's work. On the higher levels Van der Pol has opted for a circular façade. The diagonal trimming in wood, an echo from the craft of ship-building, strengthens the effect of a drum.

The spiral elevation of the apartments has been derived undoubtedly from the small block of the partial plan East III on the IJ square. The essence of the stapling of this block is that the living of one residence is situated above the bedroom floor of the neighbours: a stapling enabled by straight flights of stairs perpendicular to the wall; and passing it. This stapling results in a very compact internal circulation within the apartment. By this step-wise rising the designer is obliged to invent at the beginning and at the end of the block special solutions. On the IJ square this was realised by situating there HAT units. The other side of the block is finalised by means of a large dwelling unit for mentally handicapped living independently.

With the drum residences Liesbeth van der Pol manages to have the snake bite its own tail, so to speak. This way the step-wise ascending end is shifted over the step-wise descending beginning of the stapling. In her work the only particularisation in the system is the entrance. On this spot she can not realise an apartment with a kitchen on ground-floor level. There she situates a different type with a kitchen on the third floor; another illustration of the flexibility of the stapling she has chosen

13.15 RELATION BETWEEN TYPE AND CONCEPT

Finally, there is the question as to the relationship between type and concept. As stated in the introduction to this Chapter, the notions of concept and type are linked to different phases of the design process. Looking at it like this, the two notions do not seem to be related at all. However, it is certainly possible that the choice of a particular type is actually part of the concept. This is, among others, the case with the concept that MVRDV use in their design of the three porter's lodges. The archetype house is, in this design, a basic part of the concept they used. It is also possible that the choice of the type is a direct consequence of the concept. In some cases, the borders between type and concept cannot be sharply defined. In this context, the Unité as a building is an object situated somewhere on the border between concept (a housing estate placed on its side on pilotis) and a type (a slab shaped building on pilotis). The first description is more abstract and does not yet indicate a formal spatial arrangement, in contrast to the second description. For the slab shaped building on pilotis, the formal spatial arrangement can be defined and, if so wished, can be schematised.

a Leupen, B.A.J. (1989) IJ-plein, Amsterdam een speurtocht naar nieuwe compositorische middelen: Rem Koolhaas / Office for Metropolitan Architecture

14 ANALYSIS OF BUILDINGS

PROPORTION AND MEASUREMENT IN EARLY TWENTIETH CENTURY DUTCH BUILDING PRACTICE

JAN MOLEMA

14.1 ANALYSIS OF BUILDINGS AS AN EDUCATIONAL TOOL

I cannot exclude history from my investigations, since I am dealing with existing buildings, but I am certainly not a historian. I treat buildings as actualities, not as historical data. I also cannot, should not and do not want, extract the chosen buildings from their cultural environment, yet 'the building of the building' as such is my subject. It is important to relate historical facts to the technical possibilities at the time of building and today by finding and researching the tools used for the design and the way it was realised with the building methods at the time. My hope is that the architectural student will, by analysing, learn from the building for his own future practice. Buildings and their elements of yesteryear are viewed as possible tools for the design-process of tomorrow.

Analysis of Buildings does not wish to select the subject-to-be-investigated *a priori* on the basis of Style or Movement. In fact, we studied works of a great variety of architects from different places and times: from Hendrik P. Berlage and Antonio Gaudí y Cornet to Johannes Duiker and Bruce L. Goff. Gaudí has become a topic without comparison, as may be concluded from the success of our books and our exhibition, shown again and again. But, on the other hand there are the productions that treat the Dutch Modern Movement. These products have come from a profusion of material collected by students in their research projects and elaborated by a small group of faculty members.

As the school was mostly unable to provide the money needed for the publication of the results, so the *Stichting Analyse van Gebouwen* (Foundation Analysis of Buildings) was formed, through which necessary funds are obtained from ministries and private funds. Books appeared about Gaudí, Duiker, Wiebenga, the Dutch New Movement 1924-1936 and exhibitions about the same, but also about Johannes Bernardus van Loghem.[a] A result of the investigation of Van Loghem's work in Siberia is the Uralski constructivist restoration and conservation project, in which faculty members take part as well as external professionals, Russians and Dutch alike.[b]

It will be clear, that there has also been a great variety in the choice of building types as we studied faculty buildings, sport complexes, schools and housing projects, Piet Blom's cubicles in Helmond and mobile homes. In Siberia (Kemerovo Oblast) the research programme even included environmental and urban problems to be solved.

Some time ago the chair for Building Integration and Co-ordination (BIC decided to extend certain studies of *Analysis of Buildings* done in the past and execute an overall research of Dutch building practice in the twentieth Century. The idea of describing this period is not original, but as our research method and viewpoint are different from the historical it can have different outcomes. The central topic is specific: the building as the result of a process of design and building. The reader must acknowledge here, that we do not speak of architecture, but of building.

14.2 THE METHOD

The method of analysis of buildings is simple. It is advisable to investigate the general structure of the building first, be it spatial or material, and draw a general layout. One needs furthermore good tools for measuring the chosen building, a bit of intelligence to understand its structure and good tools to draw and describe it correctly. It is important to know that archives contain a lot of documents, like construction drawings and contracts. This material can help to understand the building better and eventually the intentions of designer and builder. One needs a lot of training to make a good analysis and a satisfactory description, be it in

a The exhibitions produced by Analysis of Buildings:
Antonio Gaudí, rationalist met perfecte materiaalbeheersing, 1978;
Jan Duiker, constructeur in stuc en staal, 1982;
Jan Gerko Wiebenga, apostel van het Nieuwe Bouwen, 1987;
Gaudí in de Beurs van Berlage, 1988;
Het Nieuwe Bouwen en Wonen in Nederland 1924-1936, 1990;
The New Movement in the Netherlands 1924-1936, 1992;
Johannes Bernardus van Loghem, architect van een optimistische generatie, 1996.

b Rudolphine Eggink did the Van Loghem study. Her dissertation formed the basis for the exhibition and the starting point for the Uralski project of the Foundation Analyse van Gebouwen.

drawing or in text. Above all, the researching designer must have the capability of imagining a building spatially and make it spatially imaginable.

When starting to work with the students we first of all visit and investigate with them the chosen building in situ. Then we gather as many specific publications as possible about the object, a building or an ensemble of buildings. It is important to read the existing interpretations, before developing a new vision or drawing conclusions. We especially want to find information about the structural reality of the building and whether it has been build as it was designed. If this was not the case, we want to find out what the reasons have been to deviate. We also want to know which tools were used in the designing process and in the building process.

The second step is inspection of the sources at the NAi, the nation's most important architectural archive, at municipalities, architects offices and in private collections. We look chronologically at the original sketches, drawings, correspondence, commands of consultants, about rules for building permits, articles in newspapers, photographs, etc. We also do interviews, when possible, with the architect or with people who were connected with the architect('s office), the owner of the building, the contractor, consultants, and technical people. It is important in that stage to relate research results to the actual condition of the building.

The third step is to organise the material according to themes. We use essentially the same themes for every building, to be able to make comparisons. Examples of these themes are: assignment, architect, client, situation at location, history of the location, mass and volume, proportion and measure systems (design / build), structure of functions (design / build), structure of space (design / build), structure of materials (designed / build).

The last step is a complete description of the building, if possible into detail, including the conclusions of our investigation.

Specialised articles and lectures about a building or about a theme belong to the results. But, also complete investigations of one building in a monographic study. It is furthermore of interest to combine the results of investigations of several buildings under one of the investigated themes, for instance the proportion and measure studies of The Beurs, Hotel American and The Nederlandsche Handel-Maatschappij, all three in Amsterdam. It shows new ways of interpreting the proportional system, related to the dimensions of bricks.

14.3 IN SEARCH FOR PROPORTION AND MEASURE

The architect must study many aspects. One of these is, although applied by important architects from early times on, many times forgotten or at least underestimated: proportionality. *Proportion and measure* belong to the means to define a building in relation to its site and its functions. Already Vitruvius wrote about it; but also Fibonacci, Alberti, Palladio, Viollet-le-Duc. Le Corbusier wrote about it in his famous Modulor (see page 212).[a] Throughout history it seems to be forgotten every now and then, or devaluated, especially in daily design practice. It was recognised once more by the end of the 19th Century by architectural historians, like the German August Thiersch, but also by practicing architects, as in the Netherlands, specifically in Amsterdam.

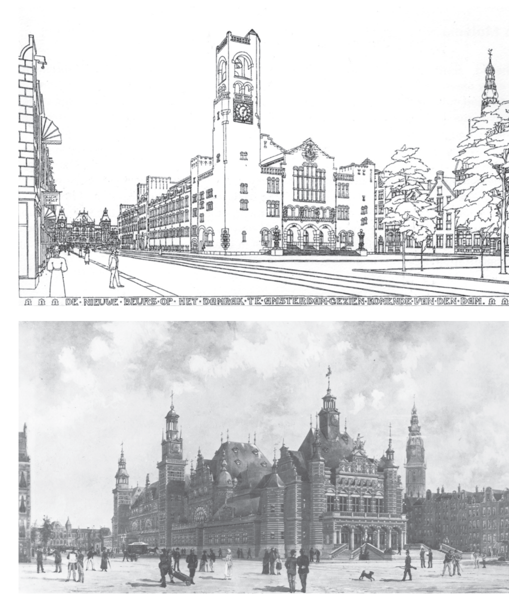
While in the 18th Century Dutch architecture still flourished, it had gone into deep decline in the early 19th Century. In the second half of that century, Pierre Cuypers (1827-1921), architect of the Amsterdam Central Station, the National (Rijks) museum and dozens of Roman Catholic churches, gave Dutch architecture a new impulse. Influenced by Eugène Viollet-le-Duc, Cuypers predicated French Gothic as the right manner for the new architecture.[b] This was not so much out of stylistic considerations as out of rational thinking about the process of designing and building. The availability of new techniques, of newly discovered materials like tropical timber and of newly developed materials, like artificial stone and steel, inspired Cuypers to find a new way in architecture as it did other architects, who found theír ways through Eclecticism and Art Nouveau (*Nieuwe Kunst*).[c]

a Le Corbusier (1948) *Modulor 1;* (1955) *Modulor 2*. English edition: (2000) *The modulor : a harmonious measure to the human scale, universally applicable to architecture and mechanics*. Vitruvius (1960) *Book 3*; Alberti, L.B. (1986) *Book 6* a.o; Palladio, A. (1997) *Book 1*.

b The analysis by Viollet-le-Duc was only partly right. The 'gothic' did not exist as one style, one system or one structure. The common nominator, the essence of "the" gothic is the search and find of a different way of building, one that demands rather less material for larger envelopes of spaces. As such the gothic still exists in our days. It furthermore must have been of influence that the greater demand for permanent structures made it necessary to import materials along longer transport lines or to develop new materials. At the same time there is the wish for exclusiveness in a society of abundance. These are factors that played a rôle in the project for the Beurs.

c Auke van der Woud's extensive study The Art of Building sheds a new light on the rôle of the different movements in the modernisation of Dutch architecture. Woud, A. van der (2001) *The art of building: from classicism to modernity*.

But, it was in fact with the generation of Hendrik Petrus Berlage (1856-1934) and his somewhat younger colleagues, like Willem Ceeszoon Kromhout (1864-1940) and Karel Petrus Cornelis de Bazel (1869-1923) that truly new architecture began. With their buildings architecture in The Netherlands reached international repute within two decades, equalling the worldwide known Dutch 17th Century standards in city planning and architecture alike. The Amsterdam Stock Exchange building, now named *'De Beurs van Berlage'*, became the Dutch hallmark for progressive architecture in the 20th Century. The development of its design shows in plans, sections and perspectives how, step by step, the definition of a new architecture developed. The sequence of proposals for the Beurs, starting with the competition project in 1885, presents the purification of form that became fundamental in Dutch architecture. It is this striving towards purification, the wish to go back to essentials as expressed in the Beurs that impressed later generations particularly.[a]



93 Different designs for *'De Beurs'*.[e]

14.4 THE BEURS, BUILT BETWEEN 1898 AND 1903

The examination of this building with the eyes of a builder provides insight into constructional and measurable physical aspects and reveals intriguing characteristics of it. One of these is the question of the basic measures related to the dimensions of the brick and the proportional system in plan, section and elevation. In his famous lecture in Zürich (1907) Berlage defines precisely how one should look at a building before criticising it.[b] He starts with a quote:

"Time alters fashions (…) but that which is founded on geometry and real science will remain unalterable". He continues: "I have come to (…) the conviction that geometry, the mathematical science, for the making of artistic forms is not only the most profitable, but even absolutely necessary."

Evidently Berlage's lecture was also influenced by theories concerning the coherence of the universe, which had been developed at the same time. He writes, "these shaping / creative / formative laws (*Gestaltung*) are of the same mathematical nature in the whole universe, that is where it concerns the bodily stereometric and where planes are concerned geometric". Berlage identifies the process of slow genesis in nature with quick production in building, the growing of the crystal with artificial imitation or interpretation of the same.

Essential to an understanding of Berlage's work is what he said next in the same lecture:

"...you should at once investigate how it was made, that is: with what consequence the forms have been applied. You have to make yourself clear with what talent the volumes concerned are brought in concordance with it. But, not only that, you even have to admit that the proportions have been applied with excellence and the decoration with great understanding and taste. All in all, you have to admit that the whole work shows an absolute entity in all its parts".

Here Berlage shows himself a classicist, following the old principles of harmony.

Choice of the proportional system

There has been quite some discussion about the basic figure that Berlage introduced in the façades of the Beurs, the so-called Egyptian Triangle with oblique side √ 41, base 8 and height 5 (proportion 1:1,6).[c] Half of this triangle is the square-angled one with base 4 and vertical 5. In this triangle the inclination of the oblique side is important. We know that in the traditional *'grachtenhuis'* (canal house) the windowpanes have a diagonal under ~50° with the horizontal, which corresponds more or less with the angle of the Golden Section (see page 212). In Berlage's Beurs this angle is 52°, very near to the ideal one of 51,82..° of the Golden Section, with a proportion of 1:1,618... The advantage of Berlage's system of proportion is, of course, that it works with full numbers, 8 and 5, in the horizontal and the vertical directions.[d]

On the other hand, Berlage worked with bricks and calculated heights and widths of the building in courses and headers. The measures of the applied 'Waal' brick format are 11.2 cm. and 6.25 cm (9:5=1,8) including joints, which means that only a certain multiple of the element corresponds with the Egyptian Triangle. Thus the question remains how did Berlage solve it?

a Curiously enough it also became in a way the cradle of such opposing movements as De Stijl and the expressionistic brick architecture of the Amsterdam School.

b The text was published as: Berlage, H.P. (1908) *Grundlagen & Entwicklung der Architektur: vier Vorträge gehalten im Kunstgewerbe Museum zu Zürich*.

c Here Egyptian Triangle must be understood as it was defined by Viollet-le-Duc, E. (1977) *Entretiens sur l'architecture* (English translation: (1987) *Lectures on architecture*) and not as the Pythagorian triangle with sides 3:4:5.

d There is no doubt about the introduction of the 'Egyptian triangle' as such in the Beurs design. For instance do we find the figure with its proportions on one of the drawings for the bidding and has Berlage's mentioned its use in several occasions.

e Sources respectively: *Architectura* (1998) nr. 12 and *Topografische Atlas gemeente Amsterdam*.

Berlage was indeed quite clear in his Zürich lectures about his choice of the Egyptian Triangle.[a] Far less clear was his reasoning for the basic module measure concerning which he only declared that it resulted after a long search as the right module.[b] Neither did Berlage attempt to explain the application of the Double Square in his Beurs ground plan, although the use of it there is easy to deduct.

As Berlage would have it, there exists in a well-detailed building coherence between the dimensions and proportions applied and the choice of materials. In main points Berlage applied three materials in the Beurs that co-determined the dimensions of the building: iron, stone and brick, the latter being the only one with standard production measures. Although the immense amount of brick in the Beurs would have made possible a specific standard, Berlage applied an existing one, the so-called Waal format, the most robust format that the Dutch brick industry was able to produce. It is not by chance, that the Waal brick has a basic proportion of 1:2, being 5,25 cm x 10,5 cm x 21,5 cm. Therefore, it did not co-ordinate with the Egyptian proportion Berlage wanted to apply.[c]

The simplest bond would be the running bond, but Berlage used a less dull cross bond in which at terminations (corners etc.) he could use the so-called *'drieklezoor'* (three-quarters of a stretcher) to improve cohesion of the wall. But also the bond that Berlage choose to apply has its restrictions. Parts of walls, as between windows, of odd numbers of brick heads result in a different (symmetrical) termination pattern from those of even numbers: a-symmetrical and therefore not quiet. As Berlage aimed at quietness we may suppose that he prefered the first solution and, therefore, made wall parts between windows with odd numbers of brick heads. The general module of 17 brick heads is thus correct, but the above mentioned wall part is 34 heads with 20 heads for the window openings and 14 between windows at the main floor, both even numbers.

14.5 HOTEL AMERICAN, BUILT IN 1900-1902

From the start, the Hotel American on Amsterdam's Leidseplein - close to the Stadsschouwburg, the new Rijksmuseum, Vondelpark and Concertgebouw - owed its fame to its café, the meeting place of choice for well-known public figures. The building itself, designed by W. Kromhout and H. G. Jansen, was an architectural masterpiece even today greatly admired for its exceptional design.[d] The first Hotel American (1880) was built at the same time as the Rijksmuseum. When, in the nineties, the decision was taken to renovate and expand the hotel, the site was already fixed: adjacent to and under the existing building. What was not yet settled, however, was the ultimate size of that site. The possibilities for expansion increased over time. Although little of the original building has survived, one is struck by the degree to which the new structure has been determined by the preceding structure. The extent of the formerly existing buildings and of the renovation is clearly visible in the archival drawing of the foundations, in which the architects have indicated both the old and the new structure. The structure of the new Hotel American was indeed determined to a considerable degree by the old, both in material and spatial sense.[e]

The desire of the architects to base their design on a simple basic floor plan becomes evident when one looks at the ground floor, especially the café. It is also immediately clear that they did not confine themselves to the basic plan, but were striving for a sound structure with a high degree of complexity, with meticulous detailing, and judiciously chosen proportions. The fact that Kromhout and Jansen made use of a measuring method to recreate the Hotel American on the basis of the existing construction becomes clear from the drawings and from the building itself.[f]

The dynamics of the new hotel are rooted in the buildings, already existing on the site. The old, both in material and spatial sense, determined to a considerable degree the structure of the new Hotel American. Kromhout and his fellow architect Jansen encountered a complicated situation. To conquer this they laid a simple basic figure on it and elaborated upon this until they reached the highest degree of complexity possible.

a For example p. 60 of Grundlagen

b P. 14 of Grundlagen

c The 1:2 proportion would make it suitable for one of the other triangles that Viollet-le-Duc indicated as proportionally correct: the equilateral, right-angled, were it not that there must be space between the bricks for the mortar and tolerance of size deviation. Also would it be difficult to set a brick with the 'Egyptian' proportion in a bond, this in contrast with the applied Waal brick.

d Jansen had already been working for the owner of the hotel; Kromhout was invited to help only when the second or third plan was prepared. His position was probably comparable to the position of 'aesthetic advisor' that Van der Mey took in the *Scheepvaarthuis* case and De Bazel in the *Nederlandsche Handel-Maatschappij*, as will be mentioned later.

e Source material found in archives can be rich in information about the building as such and the building process. Here, by a happy co-incidence, the highly informative diary of the overseer of the project has survived. The diary entries are terse, sometimes even cryptic. For example, why is no mention made of the drawings of the window frames on the second and the third floors, even though the overseer never failed to mention that he had received such drawings? The answer is very simple: they were never made! The frames from the old buildings were saved and re-used. No architectural historian ever discovered this, which led to quite intriguing misinterpretations about the formal intentions of the architects.

f Had the architects been at liberty to build on an empty site, the result would undoubtedly have been quite different from the building that we know as the Hotel American. The unity, which they were clearly aiming for in the façade, would have been greater, and the building would probably have been less dynamic. Looking at the floor plan, one suspects that they would have preferred to execute it in reverse. This would have given the café a more favourable exposure: towards the sun and away from the less attractive Marnixstraat, which even then was a busy thoroughfare. That would have been an appropriate spot for the entrance to the hotel; indeed, this is where it was planned in the preliminary drawings.

Footnotes next page:

a About Le Modulor and other proportional systems inspired by the 'golden section', see: http://www.tu-harburg.de/b/kuehn/lec4.html (also in Dutch)

b Here we find in fact the 'proof of the pudding': if I had been able to precisely follow the rules of Analysis of Buildings I would first have measured the building, with the help of students, and as a result would have had measured drawings to work with. My conclusions would have been more precise.

c It even is evident, that De Bazel has had a big influence on Berlage's evolution as an architect with the published, but not executed, design for the library.

d After a design by Hendrick Jzn. Staets and Lucas Jszn. Sinck and on the initiative of the Mayor Frans Hzn. Oetgens.

e Compare with the Scheepvaarthuis.

Choice of the proportional system

Although we do not find any sign of a proportional system in the Hotel American documents as such, we find evidence in some drawings for a non-executed hotel by Kromhout in 1911. The system there applies exactly to the final solution for the Hotel American. The fact that the architects Kromhout and Jansen made use of a measuring-method to recreate the Hotel American on top of the existing construction furthermore becomes clear from studying the drawings and the building itself.

Kromhout must have quickly become aware of the fact that the L-formed lot for the new hotel comprised about three squares; one of these covered the lot of the existing hotel, being exactly 18.80 x 18.80 m. The architects' need to base their design on a simple basic figure we read at a glance from the ground floor plan. We also see that they did not just stick to that, but as good composers pursued complexity. This is, for instance, reflected in the variety of spans over the main room. We find here the proportions 1:1, 1:2, 2:3 and 3:4, incorporating the numbers 1,2,3,4. These proportions gave the floor plans sufficient variety to fit in any of the desired spaces in the whole building. We can easily trace the applied method of measure and proportion from the drawings for the design, in which 3 existing buildings had to be incorporated. The rectangularity in the plans is pointedly present, as we see in the way the façades divert from the existing alignments at both sides of the building. The square and its diagonals determine the whole building in all three directions.

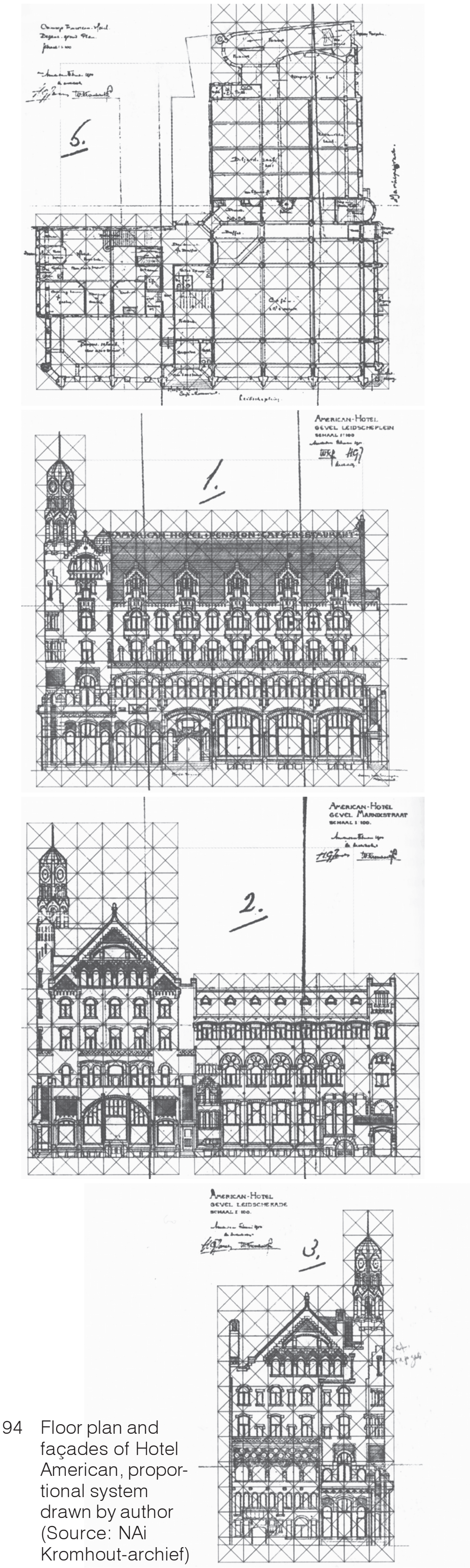
The height of the tower is remarkable. We find that it maintains the basic proportion of the building, 1:1, in the sense that the height equals the total width of the front façade of the hotel. In the preliminary design, made before the client acquired the lot of the neighbouring police station, we find the same principle, be it that the height of the building at that stage was more than the available width. Consequently, this led Kromhout at that moment to the choice of the equilateral triangle as basic regulating figure. All in all, he used the same principle as found in the Berlage Beurs, though with a different triangle in height.

I must add, that the remaining drawings do not show measures of height, length nor width. After carefully measuring I have come to the conclusion that the basic dimensions are those found in the café: height 592 cm and horizontally 592 x 888 cm (rectangle between the four central columns of the café). 592 Co-incides with what Le Corbusier defined much later in his Le Modulor, as well half of it, 296.[a] The latter should be seen as the module on which the building was designed. Also 148 is used for the smaller additions that Kromhout adapted the building to the building lot, which had several oblique sides.[b]

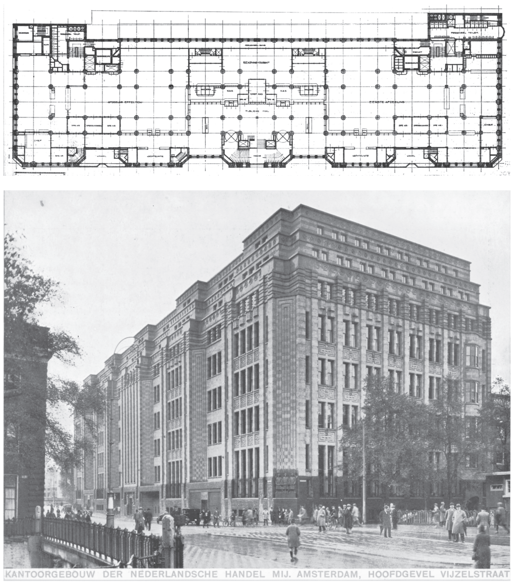
14.6 THE NEDERLANDSCHE HANDEL-MAATSCHAPPIJ, BUILT IN 1919-1926

In spite of the expressionistic exuberance of the Amsterdam School, restricted form was still, around 1920, an expression of modernity. Karel P.C. de Bazel, as aesthetic advisor responsible for the exterior of the building concerned, had already in 1895 acted in accordance with it, with his solution for a library, preceeding Berlage's final design for the Amsterdam Stock Exchange (1898-1903).[c] We may want to ask ourselves, whether De Bazel still belonged in the early twenties to the architectural vanguard with his most important building, finished only after his death in 1923.

The history of the site for the *Nederlandsche Handel-Maatschappij* (NHM, Netherlands Trading-Society) goes back to the year 1612, when the decision was taken for the construction of the famous city-extension, known as the *Grachtengordel*.[d] The southernmost part of this historical plan was built from 1658 on and received as main tangent the Nieuwe Vijzelstraat, at which the NHM building stands today. The parcels along this tangent, which runs from what is now the Muntplein southward, were sold in 1665 and immediately filled. The sixteen parcels of the later NHM grounds, between Heeregracht and Keizersgracht were each slightly more than 20 feet wide and 70 feet deep. The parcels along the two canals were wider (24 feet) and much deeper (180 feet each).[e]



94 Floor plan and façades of Hotel American, proportional system drawn by author (Source: NAi Kromhout-archief)



95 Floor plan and façade of the *'Nederlandse Handel Maatschappij'* [f]

CHOICE OF THE PROPORTIONAL SYSTEM

In his book 'K.P.C. de Bazel-Architect', Wessel Reinink examined extensively De Bazel's use of measure and proportion. Briefly, his explanation is as follows: Already in his competition-design for a library the use of a regulating system of measure and proportion is evident. In the design process for the NHM De Bazel was working from the beginning till the very end on the basis of a square-angled grid for the ground plans and a system of horizontal lines for the façades.[a] The grid was applied as a system of squares, subsequently rectangles, with only one basic figure. In the first case this is a square of 360 x 360 cm; in the other, mostly researched and also finally applied, system the basic figure is a rectangle of 320 x 360 cm. In the vertical sense De Bazel used a line pattern of 30 cm. The most common measures are 90 and its multiples 270, 360 and 450 cm (while 320 cm is not found).

De Bazel's architecture looks very austere, to my mind a direct consequence of the rather rigid use of grids. The singularity of the ground plan grid gave him little compositional material for a high complexity, which becomes obvious in his sketches for the street façade, in which several parts clearly deviate from the grid. On the other hand we can read De Bazel's struggling in the many drafts he made on the basis of a pre-drawn grid. This grid was obviously too rigid indeed to give all different functions the right place, form and dimensions. The preconceived grid is too simple, a common mistake in architectural practice, which in the case of De Bazel is rather amazing. Why did he stick, in spite of his struggling, till the end to the same grid of 320 x 360 cm?[b]

The following explains the choice and his insistence. One of the letters to the architects, in which the municipality comments their plan, says that they must take into account the maximally permitted depth of the buildings on the adjacent lots at the canals at both ends of the NHM building, being 28.3 metres.[c] The measure of 28.3 m. may seem deliberate, but becomes understandable once we know that we find ourselves in the part of town built in the 17th Century. The original parcel division plan shows the dimensions of the parcels in Amsterdam feet. The depth of the parcels along the canals is, as already mentioned, 180 feet, which brings the total depth to 360 feet. The Amsterdam foot equals 28.3 cm.! The maximum building depth is therefore 100 feet. But, the most interesting is, that 360 are the measure of De Bazel's grid module in centimetre, from which follows, that he q. q. could place 28.3 modules on 360 feet!

On the other hand, the fact that De Bazel and Van Gendt applied a different module in the other direction may be explained from the total amount of modules on the depth of the parcel, which varied from 29.89 to 31.82 m. This depth would be sufficient for 8 modules of 3.60 m + 1.09 m to 3.02 m. Dividing the measure of 8 modules of 3.60 m in 9 modules of 3.20 m (both 28.80 m) and leaving the last module free admitted a greater height at the back of the building. Building as many cubic metres as possible was, before and after all, more important than anything else. Even more than representativeness.[d]

14.7 PUTTING THE THREE TOGETHER

As I tried to show, proportion played a major rôle in Dutch architecture at the beginning of the Twentieth Century. It must still be researched, though, how it influenced the move towards modernity. It is known from documents that around 1900 proportional systems were subject to many discussions between architects; especially in architectural circles of Amsterdam, where Berlage, Kromhout, De Bazel and others held talks and gave courses.[e]

The Golden Section was probably the most discussed proportion. Yet, it was certainly propagated more by theorists than practitioners. The definition of it in words sounds simple enough: the proportion between the smaller and the bigger of two elements equals the proportion between the bigger and the sum of both. But, it gives dimensions which are difficult to handle, be it in metre or in feet. The practical architect, like Berlage in his Beurs design, prefers 8:5 (1,6), very néar to the Golden Section (1:1,618..). For human eyes the difference is not perceptible, in building practice, therefore, the simpler method is prefered.

a Here I must remark, that the 'aesthetic adviser' De Bazel was invited to collaborate with the house architect of the NHM, the well-known Amsterdam based Van Gendt firm. The reasons to involve De Bazel were purely political as he was to be the supervisor for the re-construction of the Vijzelstraat, the street at which the building would arise.

b In the descriptions of the building I could not find a reason for it, neither did I find it in the correspondence between De Bazel and his companion A. van Gendt and the representative of the client.

c This in relationship with sufficient daylight at the backside of the building; even in case the neighbours would fully use their right of building.

d Though the building height in Amsterdam was restricted to 22m, the NHM building became in the end more than 30m high, thanks to political intrigue. NB All information about the NHM comes from the related archives at NAi, Rotterdam and the GAA, Amsterdam.

e Molema, J. (1999) *Berlage's Beurs-concept and method*. Furthermore: Molema, J. (2000) *Hotel American aan het Leidseplein te Amsterdam*. and Molema, J. (2000) *Het Scheepvaarthuis, een droomschip met hekgolf*.

f Sources respectively: *Bouwkundig weekblad en Architectura* (1927) no.2 p.11; Publication of *N.V. Nederlandse Aanneming Maatschappij v/h Fa. H.F. Boersma Hoofdkantoor 's Gravenhage* (1934).

Here and now we can conclude that Berlage, De Bazel and Kromhout made use of a regulating triangular figure in their designs.[a] They also had a few other, common, denominators:

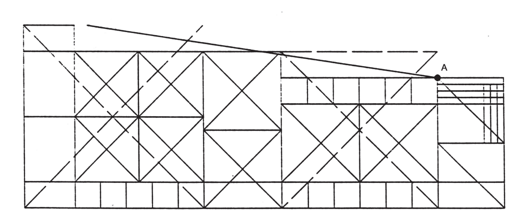
- the regulating proportional system always starts at ground floor level; anything in the façade below this level is not taken in account,
- the basic proportion defines the whole building, including height of the tower if there is one.
- the vertical side of the 'grand figure' (half of the regulating triangle) co-incides with the axis of the tower, the basis of it with the ground floor,
- the grid lines co-incide with the boundaries, although not necessarily with the axis of the wall present and most important:
- the grid does not have in the first place an aesthetic function, but is meant to organise design and building process. It helps to clarify the presumably vague ideas at the conceptual stage of the design process and it helps the architect to make decisions.

14.8 BACK TO BERLAGE

From his presentation drawings for the final project we can deduce how precisely Berlage was working in the end. The inserted module lines indicate exactly how the different parts of the building are related to each other and to the whole, and also where the material is going to be placed, for instance with the centre line co-inciding with the modular grid. In Berlage's own words: 'The art of building is the art of composing precisely, such that from there on a building which is not composed precisely, can not be described as a piece of art'. (*Seven lectures on the Art of Building*) As mentioned before, Berlage discussed the importance of proportions in a building most extensively in his Zürich lectures, in which he rhetorically asked: "Would designing on a certain geometrical system not be a great step forward? A method, with which several of the modern Dutch architects already are working?" Evidently, he had learned a lot during the design process.

The rectangle 1:2 – the double or super square

In relevant literature the rectangle 1:2 with a diagonal v5 has been identified frequently as ideal for ground plans.[b] Although the Beurs ground plan, because of the given site, has a proportion of nearly 1:3, and thus is not a double square, it becomes obvious that Berlage used this basic figure of 1:2 repeatedly for the division of his ground plan. The three main halls all have the proportion 1:2, not including the side-aisles; also the two groups of small rooms at each end of the main hall are set in a double square. Remarkable is that Berlage secured the wholeness of the main hall and its aisles by moving his ground plan over the given situation along the Damrak building line. He had this possibility as the lot was longer than Berlage needed for building.



96 Proportional system of the ground plan of *'De Beurs'*.

Finally, the northern group of small rooms is an exception, although it forms a square together with the two small exchange halls and their side aisles. Berlage made his choice for the double square between 1896 and 1898, as a comparative analysis of the first design phase, and the plans for the building specification, confirm.[c]

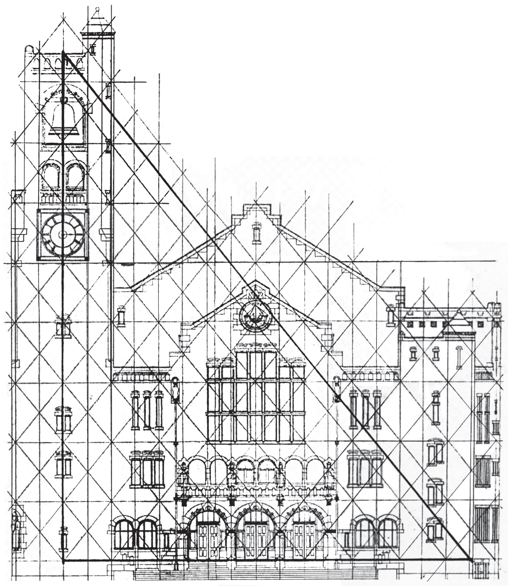
The brick

As observed, the brick applied in Waal format does not fit an Egyptian triangle. The smallest quantity of bricks necessary is 17 headers and 19 courses - each prime numbers. The conclusion is simple: Berlage took the smallest unit possible of whole headers and courses, starting from a header measurement of 11,2 cm and course dimension of 6,25 cm. both including the joint, using normal brick-laying methods, the standard of the Waal format and the practical proportion of 5:8. The course includes a 1 cm joint, the vertical joint being 0,7 cm. 17 headers and 19 courses give 190 and 118,75 cm. The last measure appears rather awkward,

a And the Amsterdam School architects Van der Mey and De Klerk at some moment

b August Thiersch, for example, proved that many Greek temples have a ground plan with this ideal proportion. Thiersch, A. (1893) *Die Proportionen in der Architektur*. Antonio Gaudí y Cornet also repeatedly used this figure as a basis for his design, in plan as well as in elevation.

c It is, therefore, quite certain that Berlage learned about it during the meetings at A. et A. in 1896, where several lectures were held about proportional systems. From my research on Gaudí's work I concluded that the Catalan investigated it in his much earlier work around 1880. Read Molema, J. (1987) *Antoni Gaudí, een weg tot oorspronkelijkheid*.



97 Façade and proportional system of *'De Beurs'*. Fat triangle drawn by author.

but results in exactly 16 courses per 1.00 metre rise, normal bricklaying practice in the Netherlands. The 190 cm is, furthermore, not too difficult to use. In the Golden Section 118,75 cm would mean 192 cm length, while on the other hand 190 cm would give a height of 117,5 cm. Berlage's choice was a rational one.

Façade at Beursplein

From measuring drawings and reasoning it appears that Berlage used the centre of the (main) tower as the measuring line for its height, a precedent established in other architect's work, such as the Hotel American. The tower occupies 4 modules in width; the axis of the tower splits the Beursplein façade into 2 and 17 modules, from these 17 modules resulted the height of the tower: 17 x (190 x 5/4) = 17 x 237.5 = 4037.5 cm (17 vertical modules), which is indeed what the drawings show.[a] It is notable that Berlage choose to use the prime numbers 17 and 19 on a grand scale. At the Damrak, the height of the tower does not have an obvious, clear proportion with the façade, which may indicate the importance and the character Berlage gave to each of the façades. Furthermore, we find the Egyptian triangle starting from the axes of the two towers of the middle section at floor level and their apex: 10 modules of 190 cm correspond with 10 x 237.5 cm = 23.75 metres in height. The gutter level at Damrak, 6 x 237.5 cm, corresponds with 6 modules, which is a 1.5 'canal house' of which 6 fit in the major hall and 5 in the small ones. It follows that the large hall plays the most important rôle in defining the height of the Damrak façade, although the building regulations may also have had a significant influence.

14.9 THE LESSON

Taking everything together we are witnessing a growing interest in, and domination of, the proportional system as a form giving principle in the development of the Beurs and other early-modern buildings in the Netherlands. Under the influence of discussions in those years between architects about proportional systems in the past and which ones could be used in actual practice, Berlage followed the recommendations closely in an analysis of his own, existing, designs for the Beurs. The introduction of the 'Egyptian triangle' led to the building being realised. Without exaggerating: the full proportioning of the design was instrumental in the development of the new architecture. Berlage probably could have gone further if he had been freer in the concept of the ground plan in the given situation.

It has been mentioned that Berlage was not a *Prinzipienreiter*, but it would not have brought him any further if he had been one. Where given conditions and principles do not cope with each other, a way-out must be found, which in most cases means one must leave principles aside. These confrontations of conditions and design principles give the buildings their specific character. There, as always, the architect has to decide what is the best solution in the given circumstances. A proportional system facilitates the decision process during design and is highly adequate in the building process. Such a system is not an aim, but a tool, one of a whole set. As I have shown, designers who use such tools are not the worst.

Analyses of Buildings is there to help students to discover these tools, investigate them, and learn to work with them and add them to their toolbox. Its impact can be much greater as the students also learn to write and publish their findings through articles, books, expositions and in conferences. A much larger public will be reached than just the single student at the faculty. Above all we want the architect(ural student) to do what the architects introduced have done: analyse existing buildings and literature, find out essentials and apply the findings where possible in their own practice. Only simple minds will deny the necessity of it. Originality is to be found in the origins. As Antonio Gaudí said, again and again, to be original one has to return to the origin: *Para ser original hay que volver al origen.* It is our task as a technological scientific institute to go and show that way through analyses of buildings.

a The following heights may be found in the specification drawings:

4037,50	top of main tower	8,5	x	4,75 m.
2850	top of façade of main hall	6	x	4,75 m.
2375	top of towers at Damrak	5	x	4,75 m.
2018,75	top of gutter of main hall (= ½ height of main tower)	4,25	x	4,75 m.
1425,00	top of gutter Damrak (= ½ height of façade main hall)	3	x	4,75 m.

15 PLAN ANALYSIS

HAN MEYER

15.1 MORPHOLOGICAL REDUCTION

Morphology literally means 'form-lore', or knowledge of form. In the present case the knowledge of the form of the city is concerned: what is the essence of that form; does a certain logic in spatial composition apply, certain structuring principles? During the seventies, the interest taken in analysis of the form of the city and the wish to try and understand which compositional principles and spatial conditions and restrictions were underlying an existing part of the city or an urban architectural design witnessed new impulses. This was strongly related to growing criticism of functionalistic design philosophies that dominated urban architecture in the decades following WW II. The discovery that historic cities and parts of them often feature certain spatial characteristics relatively insensitive to changes in usage and significance through the years caused growing interest in the principles of composition underlying the spatial form of a part of the city – independent of functional, legal, social or economic considerations. The development of morphological analyses in the sixties and seventies that flourished in Southern European countries (Italy, France, Spain)[a] and in Northern America[b] was in the seventies and eighties to 'Delft' a source of inspiration to build a new foundation for urban design.

Several kinds of morphological analysis may be discerned; each of them with its own purpose and its own (drawing) technique. Especially the figure-ground analysis and formal plan analysis developed in Delft are mentioned here. These methods of analysis play an important rôle in the search for new urban compositional principles and in the debate on them. There are two important considerations; first, that morphological analysis is indispensable to the designer in order to be able to make statements on the position and significance of a building in a given spatial context. The second is that a morphological analysis usually does not lead to a clear conclusion that can be transformed directly to a design.

A common property of various kinds of morphological analyses is that they endeavour to provide an unambiguous explanation and/ or interpretation of the spatial structure of the city; the purpose or the aim of the analysis however may vary, resulting in differences in the 'usefulness' of the analysis for the design. Here, we make a distinction between:

- morphological analysis as a method for plan criticism,
- morphological analysis as a method for knowledge development and explanation of the origination of the form of the city,
- morphological analysis as an exploring preliminary study for formulation of the commission for the design.

Finally, a fourth category of analysis, important to urban architectural design:
- typological analysis as an exploration of the design toolbox.

15.2 PLAN CRITICISM

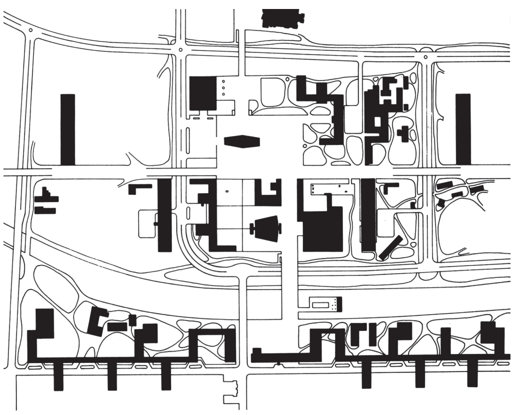
Figure-ground analyses

An important motivation for development of morphological analysis consisted in mounting dissatisfaction and criticism connected with the methods and products as they are employed in the modern building of cities. They were dominated by the intention to replace the morphology of the existing city by an entirely new one. However, the debate on the intentions and effects of modern urban architecture were still dominated, for the time being, by ideological motivation. The first generation morphological studies can be characterised as a quest for development of a 'language' enabling a way to discuss the effects of modern urban concepts and the significance of old, traditional city forms without deteriorating directly in ideological positioning.

a Intended here is the work of Muratori, Saverio (1959) *Studi per una operante storia urbana di Venezia;* Aymonino, C., M. Brusatin et al. (1966) *La Città di Padova, saggio di analisi urbana;* Rossi, A. (1982) *The architecture of the city* (Dutch translation: (2001) *De architectuur van de stad*) a.o. in Italy; Fortier, B. (1989) *La metropole imaginaire: un atlas de Paris;* Panerai, Ph.;, J.-Ch. Depaule et al. (1999) *Analyse Urbane (1980)* a.o. in France; Sola-Morales, M. de (1993) *Les Formes de Creixement Urbà* a.o. in Spain.

b Rowe, C. and F. Koetter (1978) *Collage City;* Moudon, A.V. (1986) *Built for change, neighbourhood architecture in San Francisco*.

98 Parma according to Rowe (1978)



99 Saint Die (Le Corbusier) according to Rowe (1978)

As a method of plan-criticism morphological analysis has as its objective to ask, by means of a drawing, the question whether any spatial structure in an urban project is there at all. The most explicit type of drawing developed for that purpose is the figure-ground analysis, introducing an essential aspect of the urban composition: the ratio between (built) mass and open space. The central question is which of the two components plays a figurative or form determining rôle in utilisation of the area. This method of analysis was developed by the American professor Colin Rowe; in first instance with the aim to differentiate fundamentally between the urban architecture of the 'Moderns' and traditional city forms preceding the twentieth century.[a] With this goal in mind Rowe compares the city maps on the same scale of two different cities: the inner city of Parma, result of a process of development during centuries; and the design of Le Corbusier for Saint Die. Rowe explains:

"Thus, the one is almost all white, the other almost all black; the one is an accumulation of solids in largely unmanipulated void, the other an accumulation of voids in largely unmanipulated solid; and, in both cases, the fundamental ground promotes an entirely different category of figure - in the one OBJECT, in the other SPACE."

Saint Die is primarily a composition of objects, while Parma is primarily a composition of spaces. Rowe claims that actually two different models are concerned, both with their roots in classical antiquity: the model of the acropolis (the object in space) and the model of the forum (space surrounded by mass, the urban interior).

The figure-ground analysis is important in order to address the relation between building and open space. When an analysis demonstrates that open space is the category determining form, giving form to buildings is largely subservient to the logic of the structure of the open spaces. The design of the structure and form of the open spaces primarily puts conditions to giving form to the buildings.

By means of his figure-ground drawings Rowe wants to show that this space concept has left modern urban architecture completely. Emphasis on the autonomous qualities of the building stands central. Position and shaping of the building will relate particularly to composition of the whole of object-like buildings. Rowe wrote with a purpose: as a polemics against modernistic urban architectural concepts propagating them as the only obvious ones.

15.3 KNOWLEDGE DEVELOPMENT AND EXPLANATION

Studying the development of the form of the city and of the factors responsible for origination of that form is not necessarily directly linked to the ambition to make a design. Central is the wish to understand the form of the city, to give a theoretical explanation of its growth, independent of notions like 'right' or 'bad', 'beautiful' or 'ugly', 'valuable' or 'uninteresting'.

However, the usefulness of these morphological analyses is that they offer a framework that ultimately enables value-judgements, that can trace conflicts between different kinds of spatial systems, and that provides to the designer the wherewithal for forming an opinion on spatial qualities and bottle-necks of the city. Important studies in this field have been conducted by Muratori, Panerai, Moudun and others.

Amsterdam Urban Building

The most complete example in The Netherlands of such a morphological analysis is the book by Casper van der Hoeven and Jos Louwe, *'Amsterdam Stedelijk Bouwwerk'*.[b] By now it has the status of a classical study. Conclusions concerning changes in the form of the city deemed desirable have not been drawn in the book at all, nor is there stimuli to a design. Nevertheless, the book should be regarded as obligatory literature for any designer who wants to do something in Amsterdam.

It is an example of a theoretical discourse where reduction drawings play the leading rôle. The original designs of most of the plans analysed were not available; and certainly not

a Rowe, C. and F. Koetter (1978) *Collage City*. See also: Trancik, R. (1986) *Finding lost space: theories of urban design*, p. 98 a.f.

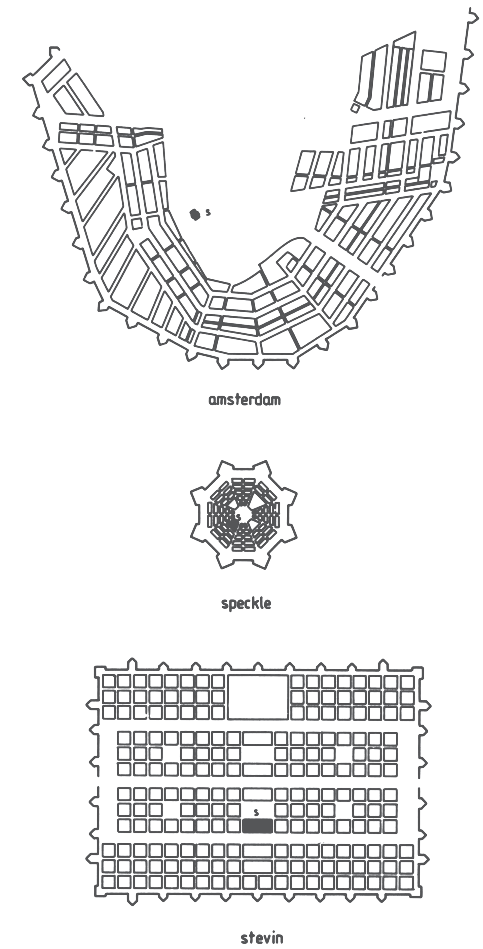
b See Hoeven, C. van der and J. Louwe (1985) *Amsterdam als stedelijk bouwwerk: een morfologische analyse*. Other important studies in this respect: Cusveller, S., R. Geurtsen et al. (1987) *Tilburg, wolstad in ombouw;* Geurtsen, R. (1988) *Locatie Delft Zuidpoort, stadsmorfologische atlas;* Hoog, M. de (1988) *De Pijp. Een morfologische studie met een accent op het stadsontwerp.*

the precise considerations that played a rôle in the originating of the historical designs. In the analyses it is tried to reconstruct those considerations.

An example is the analysis of Amsterdam's girdle of canals. In this analysis it is explained as a combination and adaptation of the ideal plans of the fortress building engineers Stevin and Speckle, spread out into a linear ribbon, in which several variants are possible leading to varying sizes of building blocks.

Another fine example of van der Hoeven and Louwe is their analysis of the Dapper neighbourhood. In six drawings they show what the principles were leading to the final spatial structure of this area. In the first drawing they show the basic principle: two rows of building blocks, mirrored at both sides of a central street. The second drawing demonstrates that is was necessary to introduce a torsion because of the shape of the plot available. According to the third drawing, a grouping of building blocks took place, causing two large ensembles of six building blocks and two smaller ensembles of four, respectively two building blocks. This grouping also leads to differentiation in the pattern of wider and more narrow streets. The fourth drawing shows that by narrowing the ground surface locally, and also by railways, triangular endings emerge. The fifth drawing shows introduction of some special elements, like a church and an oval square. Finally, the sixth drawing gives an idea of the basic structure of the neighbourhood.

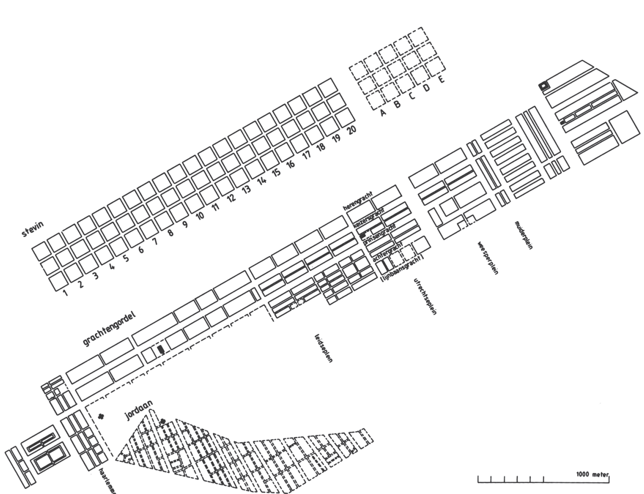
How could the authors make these drawings? Probably the analysis itself moved in the opposite direction: the beginning is to put a transparent sheet over the map and to make a drawing like number 6. Next, all special elements have been removed step by step, until the first drawing remained as the drawing of the basic principle: a double repetition of a series small building blocks. By the same token, the presentation of this series of drawings is a theory, that is to say a plausible sequence of steps leading to the final form.

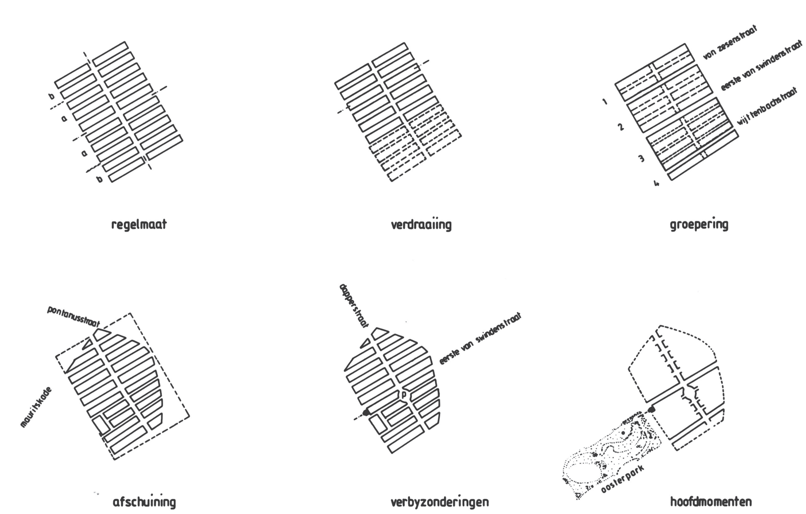


100 Amsterdam versus the ideal plans of Speckle and Stevin. Fig. 100-104 from van der Hoeven and J. Louwe (1985).

101 The girdle of canals as a variant on Stevin

102 Dapper neighbourhood





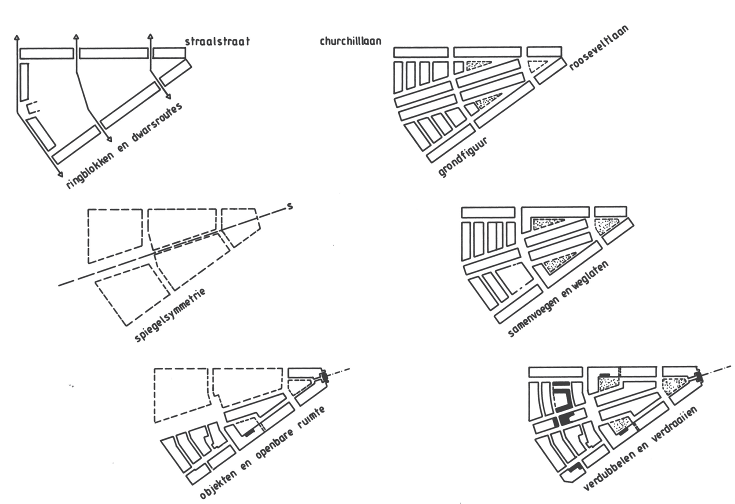
The method leading to such a drawn theoretical discourse is further described by van der Hoeven and Louwe in three separate processes; the informative, deductive and abstracting stages.

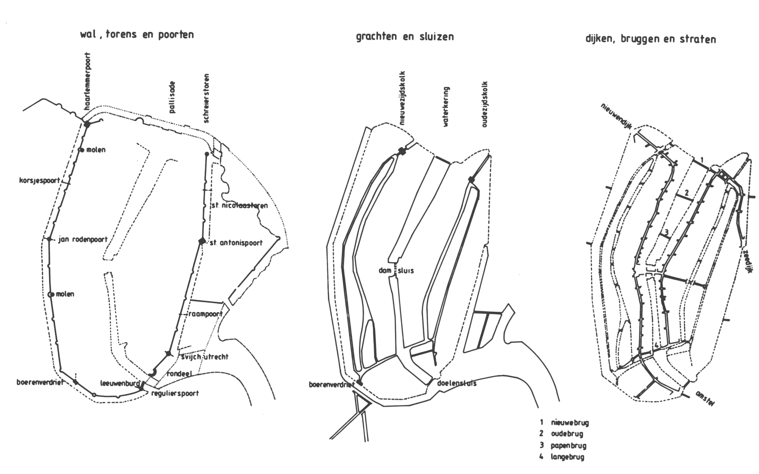
1. The informative stage concerns dating (collecting map material in chronological order), rubricating (putting the map material into the same scale and the same position), standardising (uniform rendering) and normalisation (omitting irrelevant co-incidences and exceptions). Although in this stage already various choices have to be made (which historical maps are relevant or not, which aspects are regarded as exceptions, etc.), the aim is to visualise as objectively and clearly as possible the developmental process of an area.
2. In the deductive stage studying and interpreting the factors that lead to the spatial composition are central. This stage concerns reconstructing (drawing the possible variants of a basic design and their transformations), deprogramming (cleansing the material from data pointing to legal or functional use), addition (of relevant parts outside of specific part of the plan in order to explain the position or orientation of certain parts), fragmentising (subdividing the drawing in parts and re-arranging them in a different inter-connection) and sequencing development (making a number of drawings of a subject with an increasing level of abstraction).
3. Finally, the abstracting stage. This comprises formulation of themes (a series of drawings with one theme per drawing), formalising (visualising which aspects of the spatial form are important: symmetries, orientations, lines of view, scale systems, etc.) and making diagrams (abstracting in such a way from the spatial plan that a schematic drawing with symbols results).

Together these three stages establish a method for analysing a plan area with precision as far as its formal characteristics are concerned. This does not entail that all drawings produced according to this method should also be displayed during presentation of a discourse. In that case it is important that one can restrict oneself to those drawings that support the discourse and render it. The sequence of drawings from the Dapper neighbourhood given here, for instance, is an example of a series of drawings from the deductive stage. In order to be able to make these drawings, the authors had first to make a number of drawings of the informative stage, that could not be displayed in order to make the discourse not too time-consuming. In the following series of drawings of a part of 'Plan Zuid' (between the Churchill and Roosevelt lanes and Staal's '*Wolkenkrabber*') the authors have limited themselves to presentation of drawings from the abstracting stage, with mentioning themes – per drawing one theme – as well as formalising (indicating form aspects, lines of view, scale systems, etc.) and diagrams (high abstraction level of the drawing).

103 'Plan Zuid'

104 Medieval Amsterdam





Form, use and structure

The methods of analysis described in the above give insight into factors and considerations which caused a specific form of a city. Van der Hoeven and Louwe's book analyses the various urban parts of Amsterdam from the medieval dam city up to and including the twentieth century city expansion *Algemeen UitbreidingsPlan* (AUP). During the historical stages different legends units play the leading rôle. The analyses of the medieval town relate to changing relationships between water and land: 'wallen', dikes, bridges, canals, sluices: establishing the most important elements determining form. The positioning of the buildings accommodates itself to these elements of the wet infrastructure.

From the seventeenth century onward a more rational form of city expansion emerges. Consciousness of the possibility to steer a form of building by allotting sites in a certain way is increasing continuously. In the drawings relating to the parts of the city originating from the seventeenth century more attention is also given to the relation between the structure of the system of public works, the urban 'islands'(that is to say the areas appropriate for allotting surfaces and building) and articulation of these islands. The direct relation between these three aspects (the system of public spaces, islands, and lots) manifests itself clearly as a factor determining form in the drawings. Separate drawings of the form and structure of the buildings are as yet hardly made in these sequences. There is also no need to: the structure and form of building in the city is from the 17th up to and including the 19th century a self-evident derivation from the structure and form of the lots.

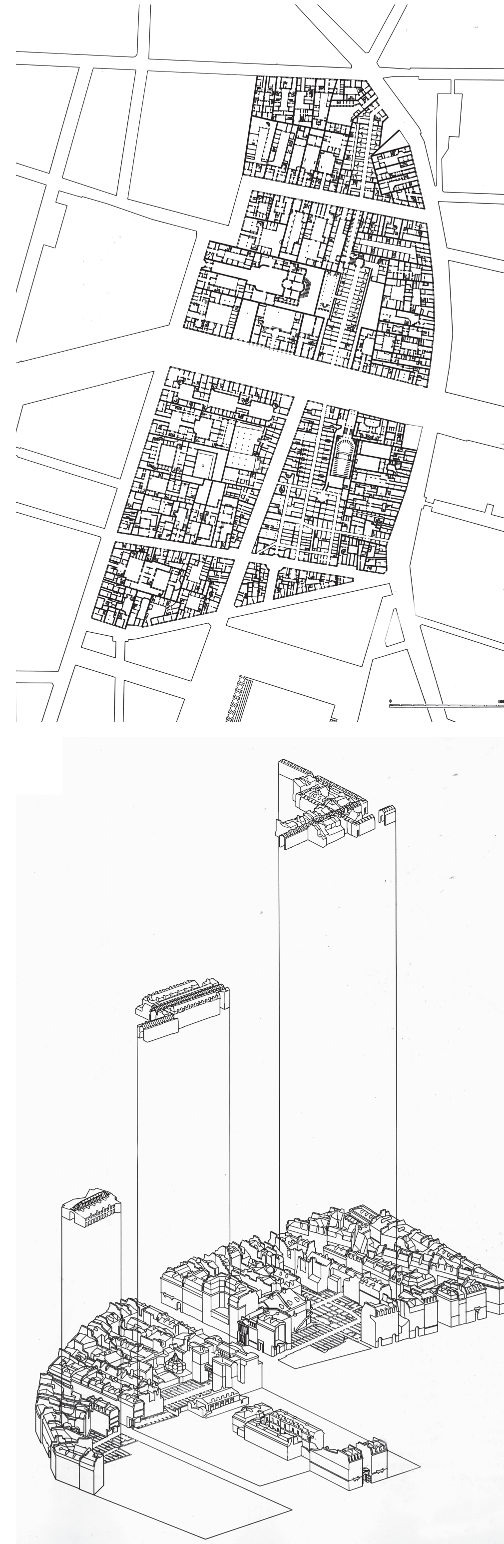
The spatial form of this city was determined in principle by an unambiguous form of use of space, characterised by a direct and unambiguous relation between the system of public spaces and lots made available. Exceptions that cannot be directly explained from this logic are usually caused by infrastructural elements of a higher scale level (dikes, water courses) or specific geomorphic conditions (e. g. differences in soil composition).

In short: the contrast between public and private largely co-incided with the one between space and mass. . The analytical drawings of the 17th and 19th centuries predominantly give information concerning organisation of the public and of the private domain. The buildings were drawn as a distinct category only if they served as specific accents in the urban landscape.

Also in South-European 'sources' of the analysis of the form of the city it is striking how strong the emphasis is on the almost hermetic relation between the structure of the articulation in lots and the structure of building. The brilliant analyses, for instance, by Bruno Fortier of various transformations of Paris during the 18th and 19th centuries[a] show again and again – regardless of the complexity of specific transformations – that the essence of each transformation can be explained from re-organisation of the articulation of an urban island (like in the case of many passages), of the structure of the public domain, or of both. The individual plot is the basic unity in each drawing.

This way of drawing can not be used anymore in the analyses of the 20th century plans, since in the new urban architectural concepts the unambiguous relation between a piece of land and a building has ceased to be accepted. In the analyses of 'Plan Zuid' drawings of patterns of articulation fail to emerge for the simple reason that an articulation on the scale of the individual household does not exist anymore in 'Plan Zuid'. The individual building masses have undergone an increase of scale and co-incide with complete islands.

In the further expansion of the city of the AUP a relation between islands and building disappears as well. The unambiguous relation between public and private domain as cornerstone for the relation between space and mass that still existed in the city of the 19th century has vanished completely in the AUP.



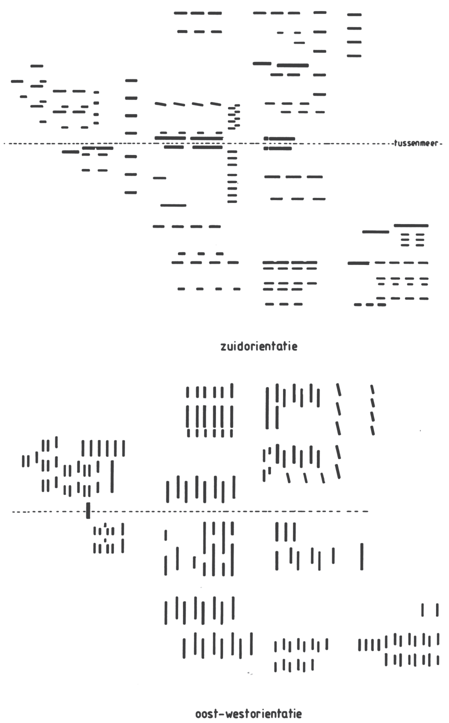
105 Paris: system of three passages (Panoramas, Jouffroy, Verdeau) according to Fortier (1989), city map (above) and decomposition (below).

a Fortier, B. (1989) *La metropole imaginaire: un atlas de Paris*.

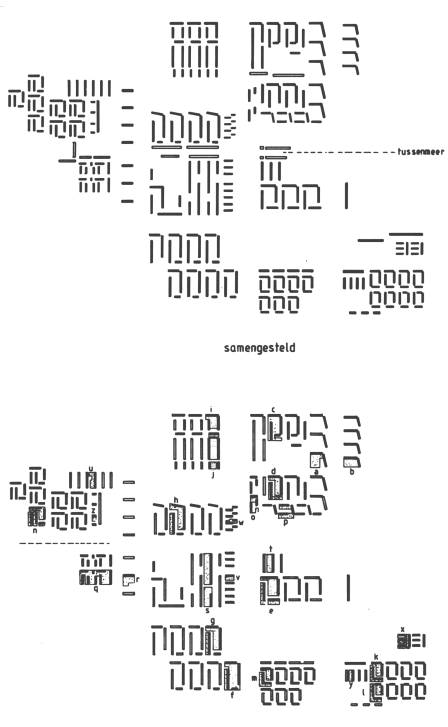
The spatial composition of the Western Garden Towns has become a complex layered structure where different elements of the public domain (traffic structure, structure of vegetation, water structure) and the buildings represent different 'layers' in the design, which cannot be regarded anymore as directly derived from one another. For that reason one is forced to indicate these different layers in the analytical drawings. . The categories public and private domain, playing a leading rôle in the analyses of older parts of the city, are absent. With 20th century policy (the city administration as owner of all the land, land can only be leased) a condition came into existence allowing separation of the urban form and distinction between public and private. For the first time the building as a whole is being drawn, since the structure of the building can be explained from nothing else but by the building structure itself.

Formal plan analyses are a (deliberate) re-construction of a number of steps in the design and realisation process; with the purpose to provide a (theoretical) explanation for the final form of the city. However, explaining the design process does not automatically entail sanctification. On the contrary, this inventory of the original planning process makes it possible to put into debate the finally realised form and structure of the pattern built and the system of public spaces, or parts thereof.

Figure 107 shows the arrangements resulting from the putting together of the residences with an orientation towards the south and the east-west orientation from figure 106. Per type of arrangement one has been rendered with the adjacent green facilities in the form of fields and strokes. This 'demonstration card' is printed on the right half of the drawing. 'While sliding the arrangements together it is striking, that the arrangements with single repetitions are always bounded at one side by a special element. That might be a road, or a green ribbon, but also a residence. These buildings, not belonging to other arrangements, are this way put into a formal relation *vis-à-vis* the arrangements. Free-standing residences occur in Osdorp only on very special places. Examples are the two centres and the high-rise apartment buildings at the Sloterplas.'



106 Osdorp, south orientation (above) and east-west orientation (below).[a]



107 Osdorp, result (above), repeated components (below)

108 Osdorp

a Figure 106-108: Hoeven, C. van der and J. Louwe (1985) *Amsterdam als stedelijk bouwwerk: een morfologische analyse.*

Van der Hoeven and Louwe stop with their analysis where Rowe starts with his figure-ground analysis. Rowe is emphasising and criticising the ever increasing autonomy of the differentiation of building masses mutually as a foundation for modern urban architecture.

Rowe suggests that several principles of composition merely rest on various ideological and aesthetic norms (space central, or mass central, while the book of van der Hoeven and Louwe provides material showing that the changing aesthetics of the form of the city are related to a changing relationship between geo-morphological conditions, allotting sites and buildings structure.

109 The process of damming up, according to Palmboom (1987).

15.4 COMMISSION FORMULATION

Urban designers are often confronted by a situation frowned at by the authority giving the commission: something is amiss, a fundamental improvement of the spatial quality should be realised; but what should be done exactly, and how, is not clear. In short: it is up to the urban designer to formulate clearly what the commission precisely is, and in which way work could be done connected with it. With this the analysis gets a goal-directed character *vis-à-vis* the design. Morphological analyses are possible on each scale level. Three examples clarify this

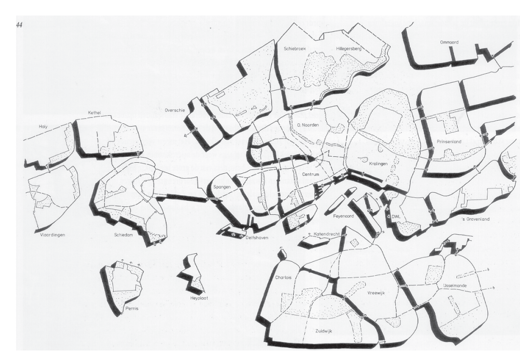
110 Articulation of polder land.

Rotterdam Urbanised Landscape

In this analysis of Frits Palmboom emphasis is on the making of an inventory of the historic development of the urban landscape of Rotterdam.[a] The purely informative stage (editing different historic maps according to the same method of drawing and scale) is almost completely omitted in the final presentation; the drawings presented are almost all strongly interpretative. The book has a clearly different structure and purpose than van der Hoeven en Louwe's '*Amsterdam Stedelijk Bouwwerk*': the purpose is not to survey as objectively as possible the spatial form and its explanation, but much more eliciting a debate on spatial form and on putting on the agenda what the important urban architectural challenges are in the city.[b]

Palmboom makes a distinction between three types of developmental processes. Each of them has produced its own 'layer' and determined this way structure and form of the city:

- the dynamics of the delta that formed the geo-morphological stratum;
- the process of building dikes, gaining land from water, cultivation and urbanisation, resulting in a cultural landscape;
- the economics of transportation that produced in the transporting city of Rotterdam a rather autonomous 'traffic machine', right through and over existing structures.



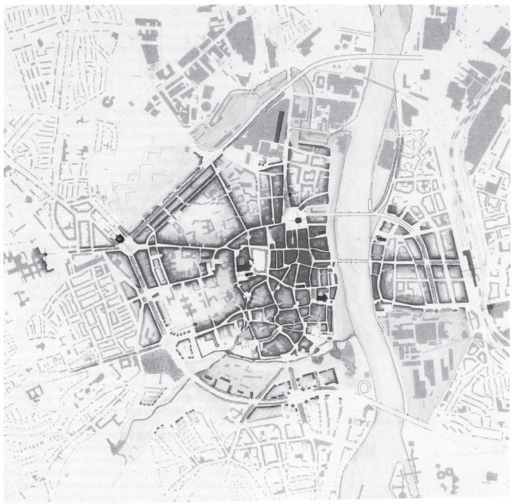
111 Rotterdam as an agglomeration of islands.

This layered structure resulted in a city featuring according to Palmboom two kinds of spatial characteristics:

- parts or long lines characterised by a rather unambiguous connection and continuity in the spatial structure, and
- knots where different layers or areas come into conflict.

The drawings rendering this interpretation of the spatial characteristics of the city are considerably more 'expressionistic' than the severely geometric drawings of van der Hoeven en Louwe. They not only show certain spatial structures, but in particular the dynamics resulting from those spatial structures: the 'polder' structure of the clay area of the South of Rotterdam results especially in a structure of irregularly shaped sheets with an orientation and dynamics orientated towards the centre, while the 'long lines' on the right of the borders of the Maas river produce large, linear structures, meeting with borders of opposition on certain places. The result is an 'agglomeration of islands'.

a Palmboom, F. (1987) *Rotterdam, verstedelijkt landschap.*
b Hoeven, C. van der and J. Louwe (1985) *Amsterdam als stedelijk bouwwerk: een morfologische analyse.*



112 Maastricht according to Geurtsen: the elements decisive for the spatial image of the city

On the basis of these interpretations and observations several design commissions are formulated: the connected parts, lines and structures demand a consistent approach that might strengthen the (potentially present) coherence, while the zones of rupture and knots call for specific solutions, to be formulated one by one.

Structural Vision Maastricht

The structural vision Rein Geurtsen prepared in 1990 for Maastricht uses a method comparable to that of Palmboom, but gives a more detailed description of the areas where urban architectural intervention is needed; and of the type of intervention required in those areas; that is to say the commission.

An example is the drawing below. The important open spaces in this map are not automatically the most important traffic roads. Depicted are just those streets, squares, etc. that, according to the description, *“are decisive for the national and international esteem for the city, to which lovers of Maastricht are particularly attached, and which determine the way in which a visitor will orient himself.”*

The network of streets thus surveyed demonstrates a strong orientation towards the river, while its borders have been indicated as ‘problematic areas’ and are termed an important design commission. The borders have been made subservient increasingly to the throughput of car traffic in the decades following WW II. This caused loss of connection of the river border to the street pattern of the inner city. The drawing states that the design commission consists in restoring the traditional connection.

Renewal The Hague – South West

This graduation project of Paul Broekhuizen studies the morphology of The Hague. The spatial structure of the Hague has been determined historically by the structure of the ridges of the dunes, almost parallel to the line of the beach. Perpendicular to it several attempts were made to realise cross-connections and thoroughfares.

The cross-connections clash at various places with the structure of the ridges of the dunes; occasionally they have been completed only partially, or not at all. The morphological study focuses on tracing the most important problems and hiatuses in this double structure. The hiatuses are depicted in figure 115; particularly The Hague South West has a ‘blind spot’ when it comes to crossing structure.

Together with the observation that this part of the city has become marginal in socio-economic terms, the conclusion is that realising a cross-connection in the urban area is of importance for freeing it from isolation.

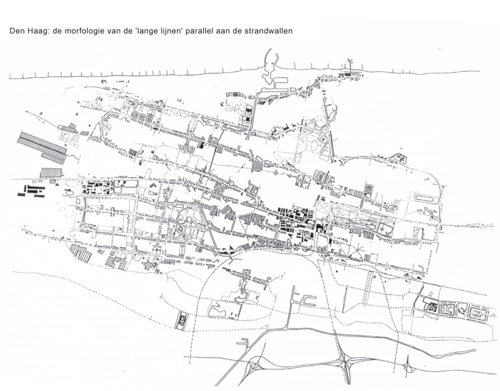
113 The Hague: the morphology of the ‘long lines’ parallel to the ridges of the dunes (fig. 113-117: P. Broekhuizen).

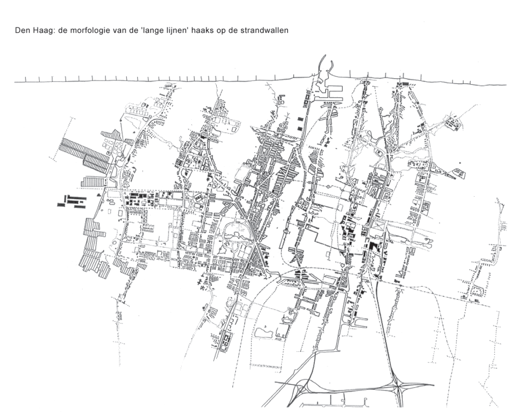
114 The morphology of the ‘long lines’ perpendicular to the ridges of the dunes

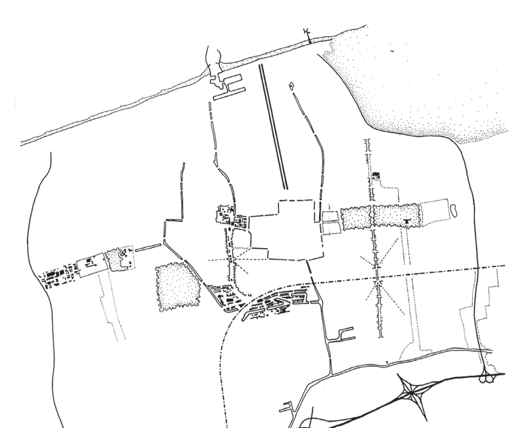
115 System of cross-connections in the infrastructure

116 Decomposition-analysis

117 Plan configurations







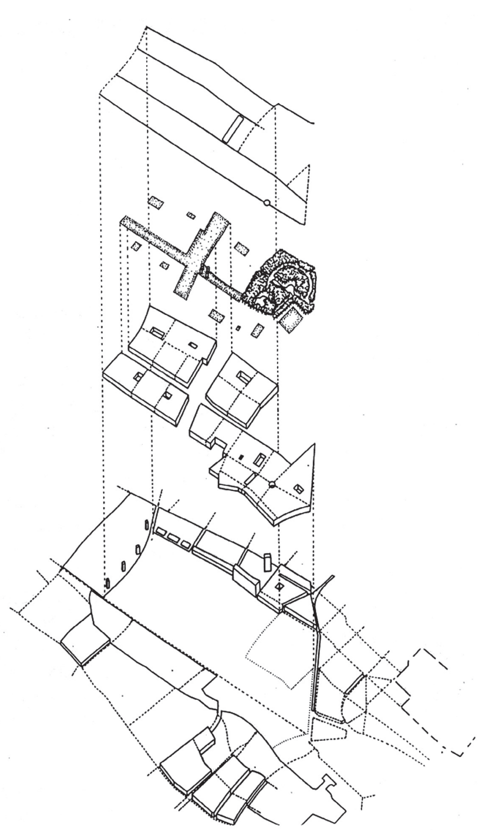
In principle an occasion for situating this cross-connection is already present: the 'Cartesian cross' of the Melis Stokelaan and the Dedemsvaartweg. This cross is characterised by a complex structure, sub-divided in its constituting parts in the drawing below. The last drawing demonstrates how starting from the axial cross a new cross-connection between the Melis Stokelaan and the coast could come into existence.

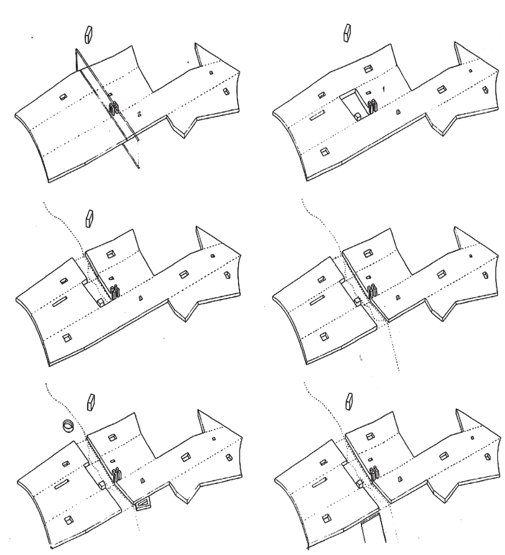
Characteristic for these analyses is that they arrive at a statement indicating what the challenge of the design in a certain place should be. The analyses themselves provide scant material for answering the questions how that design should be made, in terms of methods and tools. The next category of analysis is more fertile in that respect.

15.5 DESIGN TOOLBOX

As soon as the location and the commission have been decided upon, an investigation of the 'repertory' available is a logical first step. If the commission entails to realise somewhere a new cross-connection, traffic inter-change, an ensemble of buildings, or a new quay along the river connecting to the network of streets, a study of other comparable cases might be useful. What is intended is not so much collecting so-called 'reference images' that have become fashionable since the end of the eighties. These reference images rather serve the purpose to create consensus among the various parties during the planning process with regard to architectonic imaging.

In the case of the design repertory, typological analysis is intended here. This concerns the analysis of various variants of designs sharing a comparable intention who lead essentially to comparable spatial configurations. The aim is to reduce differences between the various configurations as much as possible to the most important essences. Maybe there are at first sight some twenty different variants of a type, but when we try to reduce each instance to the most important aspects of the spatial organisation, it may become clear ultimately that only two or three essentially differing variants of a specific type are concerned.





Such an analysis, leading to knowledge about a certain type, is called typological analysis. With such an analysis it can be decided whether it makes sense to use an existing variant of a type as a point of departure for the design, or to develop a wholly new variant. Let us present two examples.

Border of the river Rotterdam South

In this graduation project of Eveline van de Broek[a] the same type of morphological analysis is conducted as that of Palmboom and Geurtsen. She even arrives at the same kind of commission as Palmboom in 'Rotterdam Urbanised Landscape': the spot where the trajectory of the Dordtste Straatweg has been 'cut' by the building of the Maas harbour in the 19th century. Subsequently, this rupture has even been strengthened by the building of a high barrier against the water along the Maas harbour (Brielselaan).

Also because of the disappearance of harbour activities there, it is concluded that a new design for this spot is desirable and possible. The challenge exists in establishing a combination between:

- a new inter-connection with the route from the 'hinterland' (the Dordtse Straatweg) on the waterfront,
- a strengthening of the recreative quality of the waterfront,
- maintaining the defence against the water in the body of the dike, and
- maintaining the function of the Brielselaan as a thoroughfare.

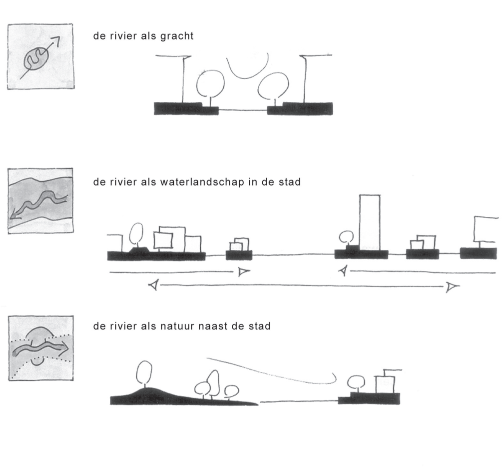
For this design commission a study was made of spatial situations with a comparable combination of aspects. Firstly, she studied to what extent the river landscape of Rotterdam has general characteristics also found frequently elsewhere, or a number of typical characteristics. A first comparative analysis resulted in a distinction between three fundamentally different urban river landscapes: next to the river as an inner waterway in the city ("the river as canal", with Haarlem and the river Spaarne for example) and the river as nature along the city (e. g. Deventer with the IJssel) Rotterdam emerged as a separate type, with "the river as a water landscape in the city".

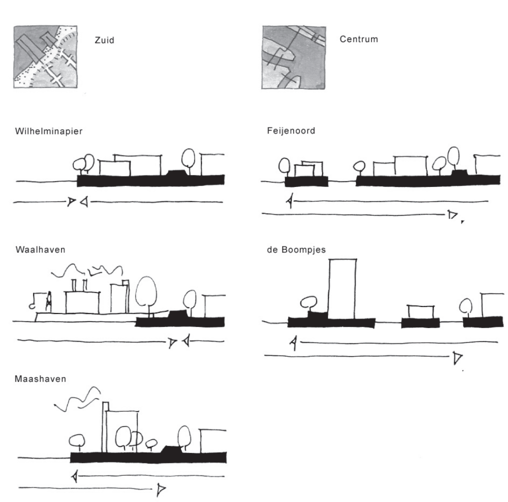
a Broek, E. van den (1998) *Rotterdam aan de Maas, de rivier als centrale plek in de stad.*

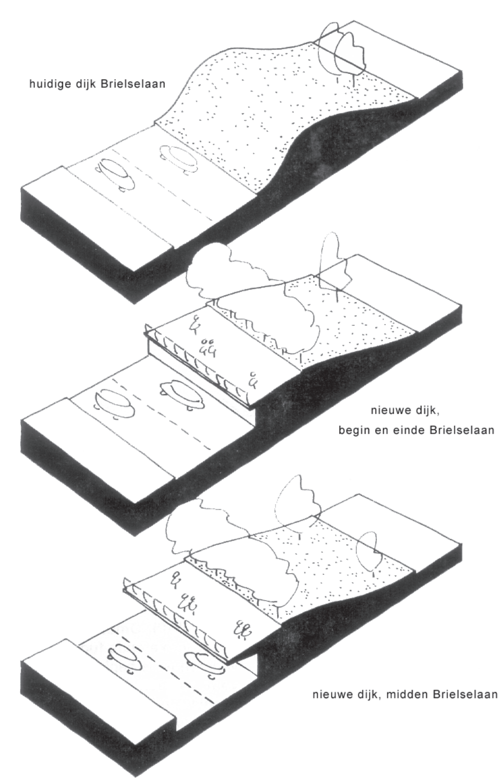
118 Three types of relation between river and city according to van den Broek (1998)

119 Different variants of the type 'the river as a water landscape in the city'

120 Operation on the dike trajectory Brielselaan







This distinction is significant for the spatial furnishing of the zones along the water, where urban morphology and river landscape enter into ever changing relations.

Within the context of the Rotterdam variant of “the river as a water landscape in the city” next various partial variants are discerned; with the Brielselaan for one of them.

However, the situation of the Brielselaan – with the autonomous body of the dike – proves to be so specific, that all existing situations in the Rotterdam river landscape do not provide a solution. By the same token, a new variant of the Rotterdam type waterfront must be designed. The conclusion is that the design challenge exists in acknowledging the typical properties of the Rotterdam water landscape in the City, as well as in finding a solution for the specific position occupied by the zone at the Brielselaan in this water landscape.

Finally, the design provides a new profiling of the body of the dike, with a terrace extending over the motorway, resulting in new possibilities of usage for the zone as a whole.

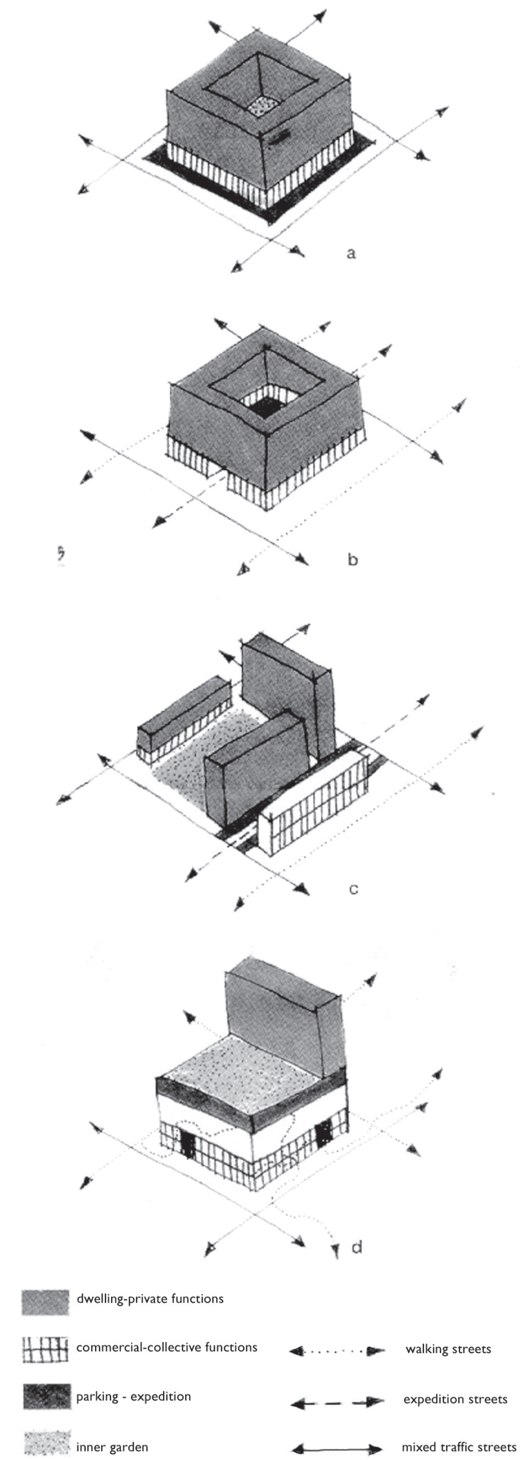
Urban Building Block Rotterdam

In this graduation project of Lyke Bijlsma a typological analysis is made of the development of the building block in the central area of Rotterdam. This analysis is centred around the question in which way commercial facilities (shops, etc.), private space (residences), collective space (shared gardens) and public space can be organised *vis-à-vis* one another in a new building block to be designed. The analysis is addressing the question which variants may be found in connection with the ratio between these units of legends. The analysis concludes that the whole repertory of building blocks in the inner city of Rotterdam may be simplified to three variants:

- the closed building block with gardens at the inside and shops on street level getting their products delivered from the public street;
- the urban inner court, where the inside of the building block is used as a space for expedition; the public street being freed from loading and unloading, but at the loss of collective green;
- the modern ensemble, with a differentiation of various kinds of open space with different functions.

In the fifties it was attempted with this variant to overcome the disadvantages of the closed building block (loading and unloading on the public street) and of the urban inner court (disappearance of the shared garden). Forty years later quite a lot of difficulties are linked to this variant, like the vulnerability of the collective garden because of its direct access from the public street, and the countless expedition streets, devouring a large part of public space and experienced as unpleasant and unsafe.

With these analyses the necessity of searching for a new configuration of commercial, private, collective and public space is put on the agenda: in the design a solution is ultimately only achieved by expanding from a flat surface into the third dimension.



transformation of the building block

a. traditional building block

b. Rotterdam building block, urban inner court

c. opened-up Rotterdam building block (Lijnbaan model)

d. layered city (proposed solution)

121 Typological analysis of building blocks according to Bijlsma

16 DESIGN DRIVEN RESEARCH

JACK BREEN

The potential for design driven research in academic environments is examined. In this context lessons might be learned from educational exercises with a designerly approach and presentations stimulating discovery through systematic comparison.

On the basis of previous experiences with design and workshops, *eight types of design driven composition composition research* are identified, divided into two main clusters. The approaches vary, from more or less familiar forms of design research to more speculative approaches, involving design(erly) activity as integral part of the research method.

16.1 DESIGN DRIVEN RESEARCH APPROACHES

What might be the opportunities for design driven research? Can active designerly enquiry be made instrumental in design education and research? In which ways might activities, integrated in an academic educational environment, lead to convincing research products?

It has been argued that in architectural research there is a need for researchers to operate in a systematic and methodically sound way: standard procedure in traditional forms of analytical or comparative research, but perhaps of even greater importance in projects wishing to incorporate *explorative* forms of designerly enquiry as part of the working method.

The same can be said for education, whereby a clearly constructed *pedagogic* framework is essential. Theme-based teaching forms can stimulate experimentation and discovery and lead in turn to valuable - identifiable - insights for the students, but can also produce *results* contributing to insights on a higher level.

In design *practice* the working *methods* as such are generally considered of less importance than the design *product* and its qualities. However, in *research* a sound, transparent method is essential in order to judge the result and thereby ascertain *validity* of the research outcome. Although differences between design and research might suggest that the two domains of intellectual endeavour are intrinsically different and that these differences cannot be resolved (as is regularly suggested), it should be recognised that there is a need for more methodical *inter-action* between the two fields, particularly within academic environments. Although in design the *evolvement* of new ideas and insights is often unpredictable and decision-making relatively intuitive, working methods are generally far more systematic and methodical than they are often made to appear. Similarly, inquisitive research does not blindly follow pre-conceived paths. The researcher – like the designer - is also dependent on ideas and hunches, conceptual shifts and *shortcuts* which may lead to useful surprises. An undertaking involving the taking of risks and of recognising valuable - intermediate - insights.

Designerly enquiry – both as subject of study and as a potential research activity – deserves to be recognised as one fundamental constituent of intelligent design driven research.

How should design driven research projects be organised? The most ‘scientific’ approach would be one whereby targets and course of action are clearly specified beforehand, allowing for systematic evaluation of outcomes and the drawing up of unambiguous conclusions.

One possibility is to study results *afterwards*. This means that relevant themes need to be identified on the basis of design results and relationships and effects of these are examined and explained. Such a *result based* research can be structured methodically by introducing an underlying ‘*order*’ beforehand, for example by placing binding themes or groups of related constraints, facilitating systematic description, comparison and evaluation of results afterwards.

As with a design task, in design research it is important to specify clearly what it is the study is trying to *solve*, *discover* or *clarify* beforehand. However, it is not always possible to narrow down and define from the outset precisely what is investigated and what the best approach ought to be. More often than not, design researchers are confronted with a complex 'knot' of different factors, simultaneously at play and not easily 'disentangled'. In many cases actually *unravelling* underlying, inter-related themes and their relative *meaning* within the overall composition (including potential dominance of specific 'actors') proves to be the primary aspiration of a design research undertaking. In order to acquire a clear understanding concerning the *questions* a research is attempting to answer or to make more transparent, it is, therefore, often worthwhile carrying out *preliminary* investigations, before determining targets, status and methods of a project as a whole. On the basis of such *explorative* studies the issues and course of action can be clearly defined; *hypotheses* determined, and a *methodological* approach to empirical study specified.

16.2 ELEMENTARY RESEARCH CATEGORIES

By determining the methodological *design* for a project it should be made clear what the goals of a research itinerary are and what type of research is carried out. In this respect the *empirical cycle* of research remains the essential point of reference to determine the *status* of a research project. In the following scheme an overview is given of the three principal forms of research (after Baarda and De Goede).[a]

a. *Descriptive research*

Descriptive research is a commonly used form of design research: an effective approach when it is the intention of the researcher to give a systematic explanation of one or more artefacts, or to give an in-depth account of underlying developments and backgrounds. This method generally involves study and analysis of source material and analysis and documentation of design products and process data. This usually does not involve the conception or empirical testing of hypotheses.

b. *Explorative research:*

If the 'what, how and why' questions are central to a research, we may speak of explorative research. This type can be considered an intermediate form, between descriptive research and empirical research, with links in both directions. The point of departure is usually a set of notions or assumptions. The aim is to create insights: to identify, define and illustrate relevant phenomena, to explain specific characteristics and effects and (inter)relationships. The aim of such an approach is generally to formulate hypotheses, leading to more focused, empirical research.

c. *Empirical research:*

In empirical research the task is essentially to see if certain, previously determined, hypotheses are correct. This usually involves creating more or less experimental conditions, with a clear methodological 'design' and systematic evaluation and interpretation of data. Even if there is no coherent theoretical framework there still might be empirical research, for instance if the intention is primarily to show a predicted effect. In such a case Baarda and de Goede suggest it might be better to speak of 'evaluation research'.

In design driven research projects – as in all research undertaking – it is necessary to specify *what* it is that is the subject of scrutiny and to determine along what lines the research will be carried out. Is the object of study a particular design or a collection of designs, possibly belonging to an individual oeuvre or movement? Are different designs or design *aspects* to be compared systematically in a case study? A research project may focus on existing design *results* – as a given situation which may be described and analysed - or on data from a design process – which may be interpreted in relation to what a design has become or *might have* become, possibly involving a more active, *designerly* approach. On the other hand, design initiatives – like competitions or group workshops – may be taken as a point of departure for explorative, or empirical research.

a Baarda, D.B. and M.P.M. de Goede (2001) *Basisboek methoden en technieken*.

16.3 DESIGN DRIVEN COMPOSITION RESEARCH

There are numerous ways in which designs or design processes occasion academic research projects. In the following section a typological framework for design driven research ventures is constructed.

On one side of the spectrum, design activity may be incorporated into the development of technical applications or product innovation. Such an approach is similar to the practice of *research and development* (R&D) common in industry. Such development research plays a meaningful rôle within – technical – university environments and might be expected to be stimulated and promoted in education.[a]

On the other side, we find the kind of research whose primary aim is to explain *implications* of design interventions. The focus may be for instance functional, ergonomic, psychological, societal or philosophical. Such research generally views design results and processes from a certain 'distance' and makes use of proven methods linked to acknowledged empirical cycles of research. The results may often lead to valuable insights, but are not always held in high esteem by design practitioners and teaching staff.

Between these poles the endeavour of design *composition* may be considered the issue of research. Composition research can involve *conception* and *perception* of the overall design and its constituting parts. It may be concerned with the *workings* of design results, but also with the *methods* of design, including utilisation and effectivity of design media in the development process.

The following typological overview is divided into two main clusters of - design driven - research approaches. In the first the design *process* is made instrumental, in the second cluster it is the design *results* (artefacts and design data) which form the hub of research. Each cluster is sub-divided into two sub clusters (A and B), each consisting of two approaches, whereby A indicates more or less familiar research types, with specific merits but also shortcomings, and B denotes somewhat less proven, but potentially innovative research procedures, with relatively more emphasis on *designerly* methods of enquiry.

DESIGN DRIVEN RESEARCH

Cluster 1: Design activity driven research

Sub cluster 1A: Design process driven research

I:	Individual process based research	- *descriptive / explorative*
II:	Thematic process based research	- *descriptive / explorative*

Sub cluster 1B: Design(erly) workshop driven research

III:	Design workshop based research	- *descriptive / explorative*
IV	Designerly workshop based research	- *explorative / empirical*

Cluster 2: Design artefact driven research

Sub cluster 2A: Design result driven research

V:	Individual result based research	- *descriptive / explorative*
VI:	Comparative result based research	- *descriptive / explorative*

Sub cluster 2B: Design(erly) enquiry driven research

VII:	Design data comparison based research	- *descriptive / explorative*
VIII:	Designerly interpretation based research	- *explorative / empirical*

122 Typological overview of design driven composition research approaches

a An interesting example of recent Development Research at the TU Delft Faculty of Architecture concerns the development of new forms of structural glazing and façade systems for twisted building volumes. Vollers, K. (2001) *Twist & Build, creating non-orthogonal architecture*.

b A previous attempt by the author to identify relevant research trajectories came to six types, divided into three clusters: Breen, J.L.H. (2000) *Towards Designerly Research Methods, an exploration of design-oriented research approaches*.

The examples put forward as indicative of these *eight* approaches[a] are mostly taken from research initiatives at the TU Delft Architecture Faculty.

16.4 DESIGN ACTIVITY DRIVEN RESEARCH

In the first category the design *process* is dominant and forms a continuous line from the beginning to the end of the research, which is, as it were, constructed around the design's development. Generally speaking there is a notion of the research ambitions from the outset. To a large extent the development process can be monitored. As such, projects of this nature can be said to be *process driven* and the design results – at least to some extent – constitute a part of the research output.

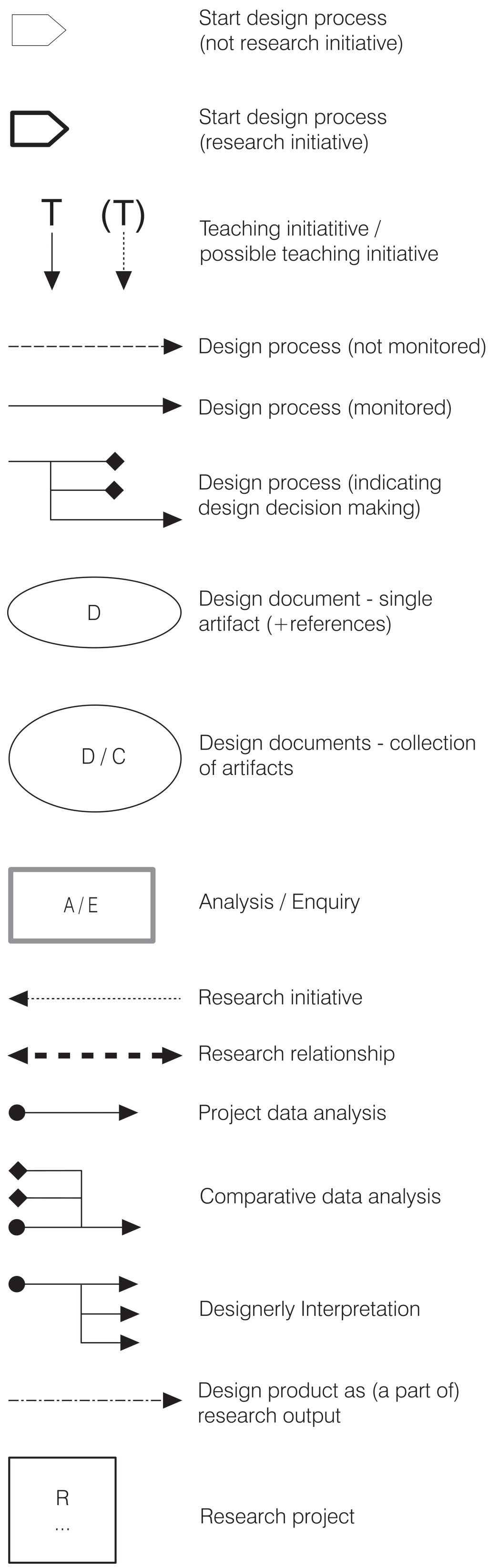
The content of the research activity is largely determined – one might say 'initiated' – by the designerly 'search' of individuals or groups of designers. The extent to which the designs reflected upon are 'let through' into the research project's outcome can vary from integral, broad representation of designs generated in the process (A) to projects with a more rigorous form of scrutiny, filtering and selection of items which are at play (B). The design projects which are the subject of study may come from practice (for instance from competitions) or from education. Apart from following design processes and their results from a relatively safe distance, it is possible to create game-like situations with pre-set specific tasks and constraints, creating a 'design laboratory' situation.

16.5 SUB CLUSTER 1A: DESIGN PROCESS DRIVEN RESEARCH

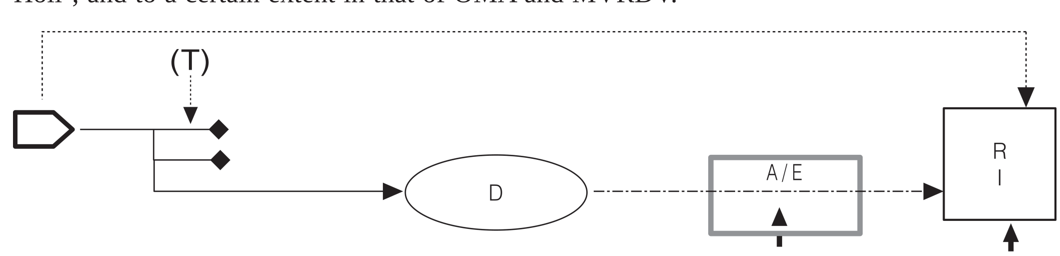
Type I: *Individual design based research*

In principle, the initiative lies with a designer or design team. The design process is documented conscientiously for the benefit of study, whereby design sketches and development models, interim options and results, may be used to illustrate and motivate the final product and place it in a broader perspective. The process may be situated in practice – with the intention of the plans being realised – but simultaneously being developed in view of its research potential. Such an approach runs the serious risk of a lack of objectivity. If the designer - at the same time playing the rôle of researcher (sometimes supported by a 'ghost-writer') - is not able to keep a certain 'distance', there is a danger that 'theory' is confused with design doctrine , leading to indiscriminate promotion of personal convictions and fascinations. Without sufficient critical consideration, the result may soon resemble an office documentation than a serious research product. Nonetheless, such approaches can be valuable, because they offer insights into the domain of design decision-making and often play a meaningful rôle in design education.

Examples of such design based research in which design activity is used as a vehicle and reference point for broader design reflections may be found in the work of Hertzberger[a] and Holl[b], and to a certain extent in that of OMA and MVRDV.



123 Legend, symbols used in schemes of design driven research types



124 *Type I:* Individual design based research

a Hertzberger, H. (1991) *Lessons for students in architecture;* Hertzberger, H. (2000) *Space and the architect: lessons in architecture 2*.

b Holl, S. (1996) *Intertwining;* Holl, S. (2000) *Parallax*.

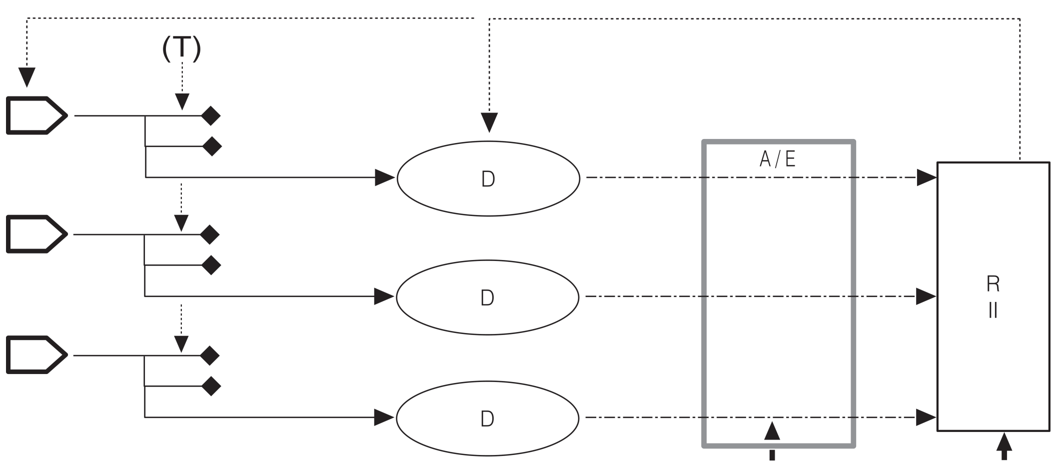
Type II: *Design project based research*

Design projects involving a number of designers can form the basis for design research. Such collective activities, with a set of pre-determined guidelines concerning context, programme and task can lead to a variety of results. These can, nonetheless, be compared relatively systematically, if there are pre-determined, binding themes. Examples of such initiatives can come from design competitions amongst professionals, but also from design projects in an educational setting, like thematic diploma projects.

Frequently, the design results from such projects are presented as an integral part of the research output. In some cases all projects are included in publications with a research ambition, regardless of their qualities. On the other hand, a selection may have been made by a professional jury, rather than by the researchers. Such research often tends to focus on the undertaking as a whole and to highlight particular themes and cultural developments, rather than offering systematic analysis of the outcomes. The clearer the 'format' of the exercise, the more methodical such an evaluation can become.

In many cases the research outcome remains primarily descriptive. However, if ambitions and expectations concerning what it is that he project is intended to address are specified clearly beforehand, such an approach can lead to explorative research, and potentially even to – hypothesis based – empirical research.

Examples of this approach are the research outcomes of the Architectonic Intervention programme – based on thematic diploma projects – at the TU Delft Architecture Faculty.[a]



125 Type II: Design project based research

16.6 SUB CLUSTER 1B: DESIGN(ERLY) WORKSHOP DRIVEN RESEARCH

Type III: *Design workshop based research*

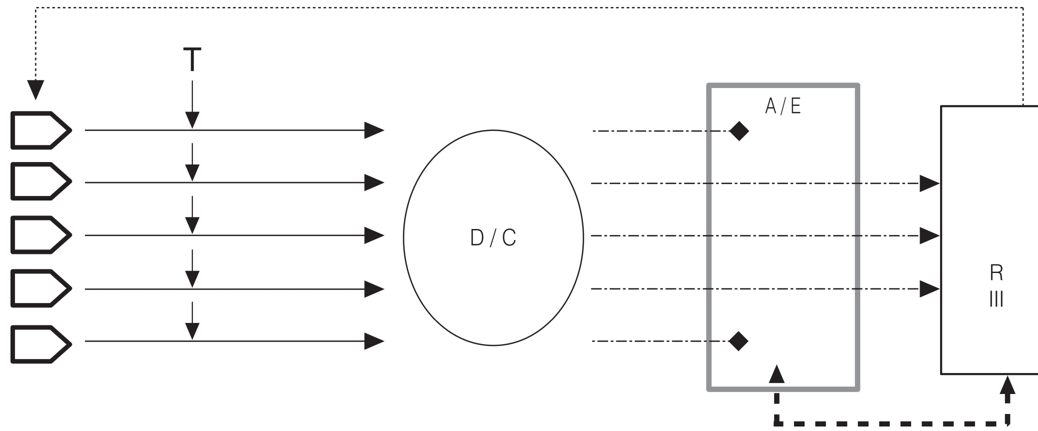
There are similarities between design *workshop* based research and type II. However, in this case the design process plays a different rôle and evaluation and selection has more prominence. In this context 'workshop' indicates a collective project whereby there is more than a loose binding theme; it means that all participants are facing precisely the same task. The workshop project sets certain rules, there is a clear programme (indicating what and even what is *not* expected) and limitations how far the complexity of the task goes (constraints). The idea of such a set-up is that by reducing complexity, the design work may attain a certain *depth*, rather than width. In addition, by setting all participants an identical task, the results should become *comparable*. The experience is that such an approach does not lead to identical results, but on the contrary, to a wide range of varied results. From such a collection insights may be gathered concerning relevant design *themes*, recurring motives and the effects of structural and compositional *variation*.

In this case the (academic) design environment is used to learn *about* design attitudes and methods. The rôle of the initiators is 'curatorship', the procedure is primarily explora-

a For a summary of the Architectural Intervention programme and its results, see: Klaasen, I.T. (2001) *The Architectural Intervention (http://ai.bk.tudelft.nl).*

tive. Design products are not considered research products (except of course in the light of the individual designerly research of the participants and their learning processes), but a collection of artefacts to be analysed and compared (and with other design precedents) for the benefit of research.

Examples of design driven projects in an educational setting are Form Studies / Media Studies workshops at the TU Delft Architecture faculty.[a]



126 *Type III:* Design workshop based research

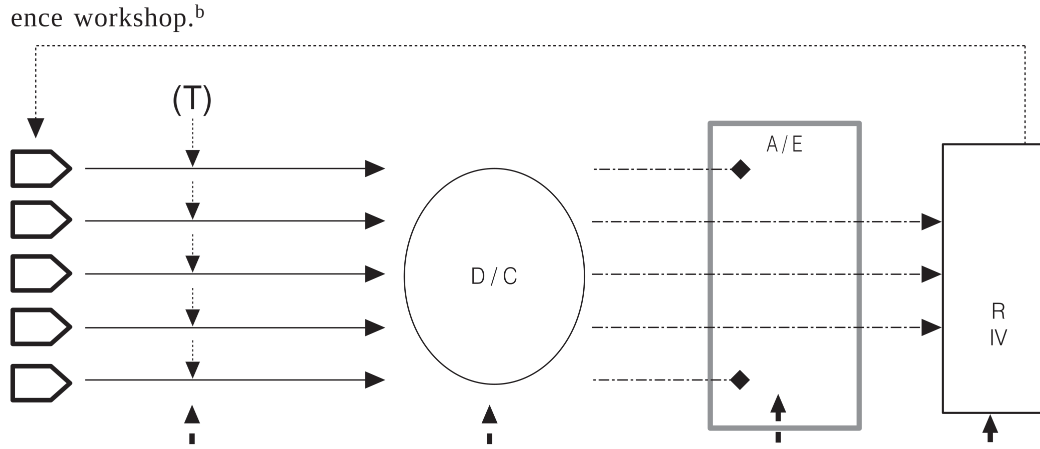
Type IV: *Designerly workshop based research*

In *designerly* workshop projects the methods indicated in type III are taken a step further. In this case it is not a matter of learning about compositional qualities of designs afterwards, but to target particular issues of interest and *infuse* these into workshop projects with active designerly enquiry by the participants.

This means that a workshop is set up consciously as an experimental, simulated working environment. The tasks may be organised relatively loosely; as in a pilot study – in order to explore procedures and gather information. On the other hand, a more strictly organised research 'construct' can be set up, for the benefit of empirical study, with clearly defined expectations laid down in working hypotheses, to be tested within the workshop environment. The process can be monitored in different phases of development. In such a case a 'game' situation with pre-conceived rules, constraints and formats may prove beneficial for research, creating a platform for systematic comparison of (intermediate) results and in-depth analyses. Such an experimental approach may target on *compositional* themes, but also focus on more *methodical* issues, like the influence of different (combinations of) design media.

In principle, such an approach involves setting design tasks, but could also in principle involve group driven *designerly studies*, as indicated in type VIII.

In the course of the Dynamic Perspective research project, the Delft Media Group has been working on ways to develop such types of workshop based empirical research. Examples of pilot studies are the Imag(in)ing study[a] and the Imaging Imagination EAEA conference workshop.[b]



127 *Type IV:* Designerly workshop based research

a Apart from the series The Table / The Bench / The Bridge: Breen, J.L.H. (1996) *Learning from the (in)visible city, design media experiments in an educational setting;* Breen, J.L.H. (1998) *Learning from the (in)visible city, design media experiments in an educational setting.*

16.7 DESIGN ARTEFACT DRIVEN RESEARCH

In the second category the outcomes of design activity are central to the research undertaking. The research initiative is primarily concentrated on this product of the design process (with a not always very clear line of development). Generally speaking, the design's development cannot be monitored or 're-constructed' conclusively on basis of the process data.

The subject and form of such research may vary. The basis can consist of one *specific* design but can also be a concise *collection* of designs. The method may involve design result *analysis*, possibly involving relevant *references* or even *comparative* studies (A) on the basis of results. Alternately, researchers may attempt to get *behind* the implications and workings of design artefacts by studying *intermediate* design data or even by 'constructing' alternate design *options* in order to throw light on what a design has become through systematic *simulations* of what it *might also* have become (B).

The subject matter of such research may be expected to come from design practice. The artefacts can vary from emblematic, historic *precedents* to *contemporary* products, which may even include designs created in an *educational* setting.

The research output can be descriptive, illustrating and communicating the qualities of artefacts considered worthy of study, but might also more *explorative*, with the intention of discovering more general 'truths' concerning (aspects of) design culture, composition and perception.

16.8 SUB CLUSTER 2A: DESIGN RESULT DRIVEN RESEARCH

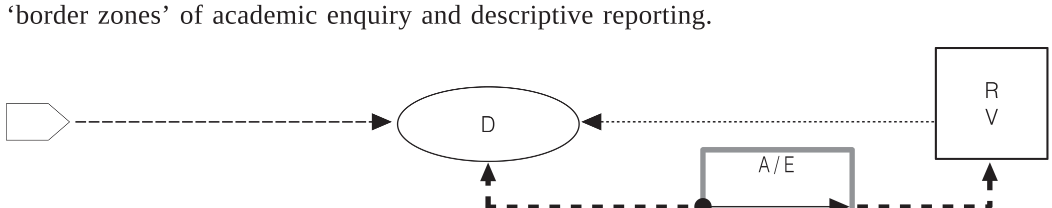
Type V: *Individual design based research*

A relatively familiar form of architectural research, whereby the results of design processes usually form the departure for a detailed, methodical evaluation.

The subject might be a realised building or ensemble, but also a collection of design data (drawings, models, written information), referring to a project not (yet) realised. The method of study usually amounts to analytical evaluation and descriptive documentation of the design artefact, although the researcher may try to 'work back' through the design data in such a way that light may be thrown on how design decisions or working methods have fundamentally influenced the design result. Another method is to place a design in a particular context, by comparing it to precedents, or through cross-referencing (with designs from the same period or with other designs from the same designer or movement).

In such research the definitive design result is usually the dominant factor, whereby the decision-making process is of secondary importance. The approach is primarily descriptive, intending to uncover relevant background information and to offer insights into compositional qualities and cultural or historic importance of the product studied.

As such, the research tends to focus on artefacts considered worthy of mention in the context of contemporary debate. It is important to define beforehand where the emphasis should lie, what the reference points of the study are to be in order to create conditions for *objective* reflection. If this is not the case, the work may be taken as journalism rather than as a *scholarly* undertaking. There are many studies of this sort carried out and published, frequently in 'border zones' of academic enquiry and descriptive reporting.



128 *Type V:* Individual design based research

a Does, J. van der and H. Giró (1999) *Imag(in)ing, a fresh look at design, presentation en communication*.
b Breen, J.L.H. and M. Stellingwerff (1998) *Imaging Imagination, exploring the impact of dynamic visualisation techniques in the design of the public realm: results of the EAEA Conference workshop*.

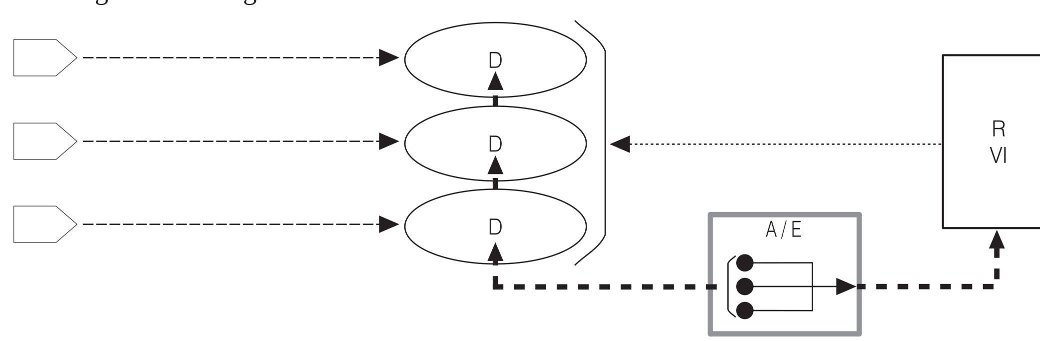
Type VI: Comparative design based research

An approach with distinct similarities to type V. However, in this type of architectural research the design *cases* studied are usually grouped and *juxtaposed* in such a way that they may (be expected to) 'throw a light' on each other, to offer insights concerning characteristic *analogies*, as well as crucial *differences* between the objects of study.

Case based studies are an efficient way to study compositional aspects of architectural artefacts. Exploration of design aspects of such 'collections' of projects or oeuvres can shed light on underlying themes and convictions and the effects of different architectural design *interventions*. Such analytical, comparative research, on basis of built environments and design documents, tends to be *explorative* in nature, involving not only description of what there is, but also identification of distinguishing *consistencies* and patterns in *variation*.

The format of output may influence working methods. For instance: an exposition format may be chosen, in order to allow viewers to make their own comparisons. This means that the material is to be ordered and visualised in such a way that it will facilitate such mental activity. Apart from familiar descriptive methods, more *designerly* approaches may be employed, for instance by making new drawings, schemes and models on the basis of existing artefacts. This can be instrumental in *communicating* results to others, but can also contribute to *discoveries* in the context of the research process itself.

An example of a study involving unbiased investigation and documentation of artefacts by groups of students was the 'Raumplan versus Plan Libre' project, a comparative study focusing on the design modes of Loos and Le Corbusier.[a]



129 Type VI: Comparative design based research

16.9 SUB CLUSTER 2B: DESIGN(ERLY) ENQUIRY DRIVEN RESEARCH

Type VII: *Design document based research*

In document based research it is not only the *end* result that counts (although it is obviously taken into consideration), but also the overall design *process* leading up to the final product explored.

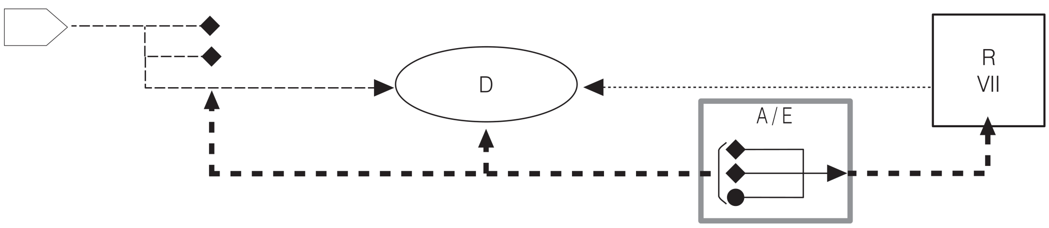
This may be done in order to add to the body of knowledge concerning the artefact(s) in question, but in addition can shed light on a designer's design *motives*, *attitudes* or *methods*. The research may also have a more general ambition, like identifying representative design *phenomena* and their effects. The subject of study could be a specific design artefact but also a collection of designs with some identifiable relationship.

There are parallels between this type of approach and type VI. Apart from being descriptive, such a research can often be said to be explorative. The process involves 'reconstructing' design choices from data which may not always be consistent. An example: a 'definitive' design drawing which does not correlate with photographs of a (possibly demolished) realised building. The *interpretation* of design intentions and the effects of design options and solutions require a *detective* spirit, the researcher attempting to uncover what is 'behind the *event*' of the design in a rational way.

Specific aims and methods may vary per project. It may be necessary to 'fill in the gaps' and possibly even to *extrapolate* design developments on the basis of existing data. Alternately, the starting point might be an altered building, whereby the task is to *reconstruct* the design virtually as it once was - or was *intended* to be.

a Risselada, M. (1988) *Raumplan versus Plan Libre: Adolf Loos and Le Corbusier 1919-1930*.

Research on the basis of design data is relatively familiar. An example of an exercise involving active interpretation by students was the ‘Un-built Loos’ project at the TU Delft’s Architecture Faculty. The task was to ‘complete’ house designs by Adolf Loos which had never been built (like asking music students to complete an ‘unfinished’ symphony). This potentially innovative project deserves to be worked out more convincingly and documented more systematically.[a] A recent example of a document driven research project was the international Mel’nikov study, in which the use of spatial models played an important rôle.[b]



130 *Type VII:* Design document based research

Type VIII: *Designerly interpretation based research*

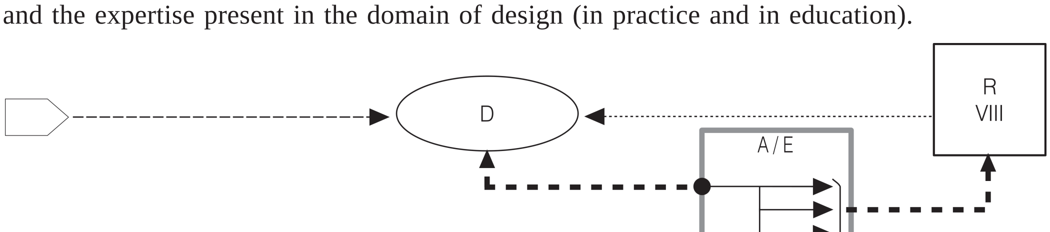
Designerly interpretation provides opportunities for bringing together research ambitions and *design expertise* present in the profession (and to a certain extent in the design education environment). The underlying motives and ambitions of such research are to discover more about specific designs or the ‘science of design’ (which does not necessarily imply considering design *as* a science).

Such research, involving *designerly interpretation* also calls for a ‘*detective*’ attitude and as such there are distinct parallels with type VII. However, in this type of study the researcher generally has less information to ‘go’ on. Such a lack of ‘clues’ means that clues need to be *constructed*, allowing design considerations to be played back and forth in a kind of ‘mental experiment’.

The researcher may take a ‘design perspective’, using designerly modes of *enquiry* to ‘get under the skin’ of the design project. In this way the researcher (or designers invited to take part in the research project) can generate ‘simulated’ design options, in order to identify and clarify aspects of *real* design results. Such designerly *variations* may be developed and compared with the actual result in a relatively systematic way in interpretative ‘cycles’ involving: designerly orientation, variation, evaluation and explication. For this to be possible, a methodical framework needs to be constructed beforehand and the design aspects to be addressed need to be identified and defined. As always in result driven research, such interpretative projects should not start ‘from scratch’. The basis may consist of one or more design *precedents*, which will be explored using the working methods of designers within a methodically transparent research ‘construct’.

Such an approach does not have to stand on its own. Combinations are conceivable, such as with type VI (by taking a group of design results as a starting point involving cross referencing and comparison) or with type VII (by combining existing information with ‘constructed’ information. More ‘players’ can be involved, as in type IV. In addition, different combinations of design media can be used. Such research is primarily explorative - and will often be carried out in combination with methods mentioned earlier - but empirical research on the basis of hypotheses is conceivable.

Although this approach is still relatively speculative, it deserves to be developed further, as it potentially builds a bridge between the empirical approach of scientific research and the expertise present in the domain of design (in practice and in education).



131 *VIII:* Designerly interpretation based research

a Saariste, R., M.J.M. Kinderdijk et al. (1992) *Nooit gebouwd Loos; plannenmap van huizen ooit door Adolf Loos ontworpen nu door studenten uitgewerkt.*

b Meriggi, M., M. Fosso et al. (2000) *Konstantin Mel’nikov and the construction of Moscow.* For an impression of the research process, see: Mácel, O. and R. Nottrot (2001) *Leningradskaya Pravda, 1924.*

16.10 PERSPECTIVES

If we wish to *extend* the range of design orientated research, other methods have to be found - or developed - doing justice to the creative *variation* characteristic for architectural composition.

New opportunities for innovative and imaginative design research may be offered by integrating active forms of *designerly enquiry* into research. Designerly working methods can create new opportunities for architectural and environmental design research. The experiences in educational settings and explorative workshop projects mentioned may give an indication of the types of design driven trajectories to be explored and pursued further.

The methodological component of design driven research projects should not be under-estimated. If results are to stand up to scrutiny by researchers from other disciplines, 'research by design' projects will need to be logically and transparently constructed, as well as clearly and consistently reported. A great deal may be learned from existing empirical research methods.

The challenge facing researchers of design ought to be to employ existing design knowledge and experience whilst creating new *designs* for imaginative and innovative research.

EVALUATING

C EVALUATING

In addition to the intended effects of a design as they are formulated in the programme of requirements many effects not intended and further consequences may become manifest. This part of the book discusses if and how these effects can be predicted ex ante or be measured ex post.

Ex post evaluation of buildings

The effects of a design can be ascertained in the most simple and precise way after the building process, when the object has been taken into use. By that time circumstances in terms of policy, culture, economics, technicalities, ecology and space are also known. In these fields the effects must be evaluated seperately, and, furthermore, social debate determines the weight of each field. In the contribution of Van der Voordt en Van Wegen methods and techniques of evaluating research ex post are discussed. A lot of experience has been gained in this both nationally and internationally. The contribution focuses on a discussion of relevant themes for evaluation, linked to quality assessment and optimal matching between demand and supply. A combination is advocated of comparative description and analysis of precedents and the empirical measurement of the achievements of the building. Utilisation study in the form of Post-Occupancy Evaluation (POE), site visits and checking the design against the programme of requirements, norms and results from evaluative study done elsewhere are the most important sources.

Ex ante research

It is crucial to be able to make already during the development stage of the plan a guess into the effects of the programmatic choices and design decisions. Prophesying these effects before the object is realised (ex ante) is not simple. Hulsbergen and Van der Schaaf show that systematic analysis of effects in the form of evaluative study ex post may serve well. Such an evaluation necessitates formulation of a perspective within which the effects will manifest themselves; in political, cultural, economical, technical, ecological and spatial terms. Results from evaluating research ex post are an important source for so-called 'pre-design research'. An excellent means to discover critical uncertainties is the study of scenarios wherein alternative views of the future are thought through with regard to spatial impact and their relationships to possibilities, desirability, and likelihood.

Ex ante performance evaluation of housing

Thomsen discusses an instrument to evaluate the quality of housing. This so-called cost-quality test is an important tool for evaluation of plans; both ex ante and ex post. Thus, not only the most important qualities in terms of usage are unveiled; also criteria for evaluation and assessment of the planned or realised achievement of housing and individual dwellings are highlighted. By relating quality to costs a motivated estimate can be of the optimal ratio between both.

Evaluating prototypes

Some of the advantages of ex post evaluation could be realised ex ante by making a prototype. Van der Voordt describes some criteria for that kind of research, illustrated by a study by design of prototypes of correctional facilities and health care facilities.

Comparing and evaluating drawings

In the final contribution De Jong shows how drawings can be used as a means to evaluate designs ex post and ex ante. He emphasises the importance of a clear legend and a transformation of different drawings to the same scale in order to be able to compare designs in different contexts.

Conclusion

The different contributions show that a long tradition exists in evaluating of designs ex post and ex ante. However, most evaluations of functional aspects are prepared and executed by researchers with a background in social sciences, whereas designers or architectural critics do most evaluations of formal aspects. Integrative evaluations including functional, formal, technical and economical effects might lead to a better mutual understanding of different parties involved in the design and building process and lead to a growing body of knowledge of architectural, urban and technical design.

17 EX POST EVALUATION OF BUILDINGS

THEO VAN DER VOORDT
HERMAN VAN WEGEN

Literally, 'evaluating' means to assess something's 'value'. It would seem that the term orginated in the banking world, where evaluation stands for appraisal in terms of the stock exchange, and for determining prices in cash. In the case of evaluations in the discipline of architecture, it is relevant to distinguish between product orientated evaluations – for instance, of a commission, design, contracting or realised building – and process orientated evaluations: for instance, of the course of the process from initiative up to and including usage and maintenance; or solely honed to the design process. In this contribution we are concentrating on 'ex post' (afterward) evaluation of buildings. For a study of an 'ex ante' (before) evaluation we refer to the contribution by Hulsbergen and Van der Schaaf

Important questions include: is a building used in accordance with the intentions of all involved parties? Are daily users satisfied with their accommodation? To what extent does the actual energy consumption fit the expected energy consumption? To what extent do laymen and experts agree on its architectural quality? Is the building designed and constructed according to the standards of the Building Code?

In order to understand the design and be able to interpret the results of a product evaluation, it is important to include the implementation process in the evaluation. How has the planning process come about? On which considerations are the design decisions based? What kind of expertise was used in the programming phase, the development of the architectural concept, and other stages of the process? Is it characterised by an inter-action of design and research and an effective participation by clients and users? To what extent did legislative prescriptions and economic constraints act on the design?

From ex post evaluation, one can learn a lot about the building's positive and negative aspects. These lessons may be used to improve the building itself. Furthermore, the results can be used in new building processes, provided that they are presented in an accessible way, one that is attractive to designers, clients and consultants. Examples include an annotated typology of design solutions, briefing and design guidelines, does and don'ts, a database with well-documented and annotated projects, or a decision support system. These instruments can be used in ex ante evaluation of architectural concepts, preliminary and final designs in so-called pre-design research. (figure 132). In the present contribution a survey is given of relevant aspects of judgement; and of methods and techniques to measure these aspects.

a. Project orientated knowledge development
- Ascertaining whether expectations have been honoured
- Determining whether objectives have been attained
- Signalling of unintended and unforeseen effects
- Hunting down bottle-necks
- Blowing off steam
- Providing guidelines for the desirable programme and design (ex ante)

b. Project transcending knowledge development
- Theory building
- Development of decision-support systems
- Formulating designing guidelines and performance requirements
- Charting advantages and disadvantages of variants of the solution
- Preventing mistakes
- Formulating guidelines for spatial policy
- Providing guidelines for the making of laws and rules
- Building a database of reference projects
- Insight in factors of success & of failure

132 Objectives of evaluation

17.1 THEMES FOR THE EVALUATION OF BUILDINGS

First one has to decide *what* ought to be evaluated. Ever since the '60s, so-called *Post-Occupancy Evaluation (POE)* or building-in-use studies have come to the fore.[a] POE is the process of systematically collecting data on occupied built environments, analysing this data, and comparing them to performance criteria. POEs are particularly aggravated by users' needs, preferences and experiences.

The main themes for Post-Occupancy evaluation are usage and experiencing. Sub-themes are, for instance, appraising the main structure and separate spaces, the experiencing of the form in which the building is appearing, complaints corning inner climate and behavioural aspects (lack of space, privacy, social contact etc.) Technical aspects (carrying structure, facilities and their likes) are often only taken into account as far as they are influencing the use and well-being of the users.

Architectural magazines tend rather to see buildings from the designers' perspective. Publications like *'The Architect'* and *'Archis'* are concentrating on the design concept and the design

a Preiser, W.F.E., H.Z. Rabinowitz et al. (1988) *Post-Occupancy Evaluation*. See also Voordt, D.J.M. van der and H.B.R. van. Wegen (1989) *Van gebruik naar initiatief*.

a. Functional aspects
- availability
- accessibility
- effectiveness
- ergonomic safety
- social safet
- spatial orientation
- territoriality, privacy and social contact
- physical well-being (light, sound, temperature, draft, humidity)
- potential for change / flexibility / adaptability

b. Aesthetic aspects
- quality of image
- beauty
- originality
- order and complexity
- representation
- cultural-historical value
- meaning

c.. Technical aspects
- fire security
- constructive safety
- material-physical quality
- environment safety
- sustainability

d. Economical and judicial aspects
- budget
- costs of investment
- running costs
- time investments and time planning
- laws & legislation

133 Themes for evaluating buildings

tools employed; like spatial working, proportional relations, colour, materials, inter-dependence between components, or the lack thereof. The design and approach of the individual designer is often compared to reference projects from architectural history (the 'precedents') and visions of other designers. These subjects are also central in the study within the course Architectonic Designing of the Faculty of Architecture at Delft University. Examples are the study by Risselada of the designs of Loos and Le Corbusier and the one of Saariste *et al.* of projects never executed by Loos; the collection of building plans of, amongst others, Risselada and Barbieri *et al.* and the Architectonic Studies by Van Duin and Tettero.[a] Many of these studies are rather plan analyses than evaluations ex post, in which it is endeavoured to attain a valuation as objective as possible on the basis of explicit yard-sticks of judgement.

Over the years, growing awareness emerged about regarding the importance of *Total Building Performance Evaluation*, abbreviated BPO.[b]

In this contribution, an attempt is made to find integration between usage, technique, aesthetics and technology. Various surveys may be found in the literature of relevant evaluation themes.[c] Although each source is mentioning different themes, while compartmentalising them differently, many similarities may be observed. In figure 133 it is tried to find a common denominator. Although focusing on the evaluation of realised buildings, many of these themes are also useful for evaluating a brief, commission or a design.

For ease of survey the aspects are ordered in four categories:

- Functional aspects like accessibility, efficiency, health and safety, spatial orientation, territoriality, flexibility, thermal comfort;
- Aesthetic aspects, for instance beauty, originality, complexity, cultural values, symbolic meanings;
- Technical aspects like lighting, acoustics, fire safety, building physics, sustainability; Economic and legal aspects: investment costs, exploitation costs, legislation.

This classification can be traced back to the tripartition of Vitruvius: utilitas, venustas, firmitas, extended by costs and judicial aspects. It also refers to the definition of architecture as a synthesis of function, form and technology. Elsewhere the category 'behavioural aspects' is occasionally discerned. Themes like territoriality, privacy and social contact are then grouped under that heading. Figure 133 shows them in the box describing functional aspects.

This survey is an elaboration of evaluation criteria for quality, costs and time. Costs and time are relating to economical aspects. What did the building cost? Was cost-cutting needed in order to stay within the budget? How much time was needed for programming, design and realisation? Quality is comprised of all three aspects and refers to the reality of the building's qualities – in this to be characterised objectively – as well as to valuation of these characteristics; often along subjective lines. Along them it may be ascertained objectively what the sizes are of the building, which material was used for its front and roof and what colours were used – for instance – for walls and doors. Next, it may be ascertained whether this is functional. aesthetically responsible, or 'friendly' in terms of the environment.

17.2 MATCH BETWEEN DEMAND AND SUPPLY

An evaluation can be interpreted as an assessment of congruence between objectives and means, and between demand and supply. The demand consists of desires, preferences, expectations and goals of the parties involved, partly laid down in the brief. The supply is the building itself. Three different levels can be distinguished: site, building and rooms. Site refers to the location of the building, its position in the immediate surroundings, and aspects like traffic access, available amenities, image and synergy of a mix of functions. The relevant characteristics of the building include layout, number and nature of entrances (main entrance

a Duin, L. van (1985-1991) *Architectonische studies 1-7;* Risselada, M. (1988) *Raumplan versus Plan Libre: Adolf Loos and Le Corbusier 1919-1930;* Tettero, W. (1991) *Ministerie van Sociale Zaken en Werkgelegenheid;* Saariste, R., M.J.M. Kinderdijk et al. (1992) *Nooit gebouwd Loos; plannenmap van huizen ooit door Adolf Loos ontworpen nu door studenten uitgewerkt;* Barbieri, S.U., L. van Duin et al. (1997) *Plannenmap: bibliotheken;* Barbieri, S.U., L. van Duin et al. (2000) *Plandocumentatie theaters*. See for a brief discussion the submission of Lans en Van der Voordt on descriptive research.

b Preiser, W.F.E. and U. Schramm (1998) *Building Performance Evaluation. Time-Saver Standards for Architectural Data.*

c Preiser, W.F.E., H.Z. Rabinowitz et al. (1988) *Post-Occupancy Evaluation;* Benes, J. and J.K. Vrijling (1990) *Voldoet dit gebouw? Het bepalen van functionele kwaliteit, SBR Rapport 222.;* REN, Stichting (1992) *Real Estate Norm. Methode voor de advisering en beoordeling van kantoorlocaties en kantoorgebouwen. Tweede versie;* REN, Stichting (1993, 1994) *Real Estate Norm. Bedrijfsgebouwen. Eerste versie;* REN, Stichting (1994) *Real Estate Norm. Quick Scan Kantoorgebouwen. Eerste versie.*

or side-entrance, public or private), and spatial configuration, e.g. clustering of related functions (figure 135). Relevant characteristics of rooms are shape and size, materials applied, interior/exterior relationships, facilities etc. A tool for an integrated analysis in post-design research may be to use a matrix, with spatial and functional features indicated in the columns, and goals and values in the rows. According to the items in figure 134 their inter-relations can be recorded in the cells.

An example: we want to ascertain functionality of a hospital. To that purpose we have first to determine and describe characteristics of the building and its location; its place on the map of the city, gross size of floor-surface, compartmentalisation, proportions of rooms. On the basis of all these characteristics, readily available for objective measuring, we are trying to come to a judgement on availability, accessibility and usability of the building for staff, patients and visitors. With this in mind we analyse routing, the frequency with which a route is used, requirements in terms of space and location for beds and bedside-cupboards. On the basis of a confrontation between both type of data, we evaluate whether the location, or building, characteristics have been tuned adequately to requirements, wishes and preferences.

A careful linking of the judgmental aspects to straightforward characteristics of the location and the building is essential for the possibility of applying the results of evaluation study in the practice of building. It makes no sense to state that there are problems – say, in terms of spatial ordering, or social security – when no suggestions can be derived from there for planning, programming, designing, building and maintaining buildings!

17.3 QUALITY ASSESSMENT

Evaluating means determining the value of something. This is closely related to ascertaining quality. Quality is usually defined as the degree to which a product meets one's requirements.

Strictly speaking, according to this definition a building should be rated as sound as soon as it is obeying its programme of requirements; for in that document the demands of the principal have been recorded. However, checking a design or a building against a brief is not good enough. Many wishes of the principal will never be voiced; partly while they are supposed to be self-evident; partly while he is not conscious and aware of them; for instance by lack of knowledge of today's possibilities. The judgement of the daily users and visitors is relevant as well. Often their demands and wishes have not been recorded in the programme of requirements at all; or to an insufficient degree. The same applies for demands of government or private ruling by lobby organisations. Along with the programme of requirements other yardsticks should be used.

With reference to Burt[a], we use a more comprehensive definition of quality:

'Quality is the totality of attributes which enables to satisfy needs, including the way in which individual attributes are related, balanced and integrated in the whole building and its surroundings.'

According to Van der Voordt and Vrielink[b], four steps are needed for ascertaining the quality of a building:

- Determining which aspects should be taken into account
- Measuring relevant variables
- Evaluation of the outcome of measuring
- Weighing the importance of the various aspects.

Analysis figure 133	Description		
	Local characteristics	Characteristics of the building (figure 135)	Characteristics of the different spaces
- Suitability			
- Accessibility for users and visitors			
- Related functions together concerning short running lines			
- Needed user space and room for attributes.			
- Etc.			

134 Matrix for evaluating the matching between ends and means

- External skin (façade, roof)
- Load-bearing construction
- Services and ducts
- Arrangement
  - Floorspace (net, gross, rentable, division per function, etc.)
  - Compactness (proportion surface of the façade/floor)
  - Main scheme of the building
  - Number of floors
  - Opening up (entries, hall, passage, stairs, elevators)
  - Spacial arrangement (relations between rooms, zoning)
- Separate rooms
  - Function (destination, activities, number of users)
  - Form, sizes and floor space
  - External relation (view, daylight, sunlighting, distance to the entrance)
  - Internal climate (lighting, heating, ventilation)
  - Finishing (material, colour) of walls, floors and ceilings
  - Interior design
  - Character of the boundaries (open / closed, bearing / non bearing, fixed / flexible)
  - Position in relation to other rooms (distance, barriers)
- Investment costs
- Running costs

135 Characteristics of the building

a Burt, M.E. (1978) *A survey of quality and value in building*.
b Voordt, D.J.M. van der and D. Vrielink (1987) *Kosten-kwaliteit wijkwelzijnsaccomodaties*.

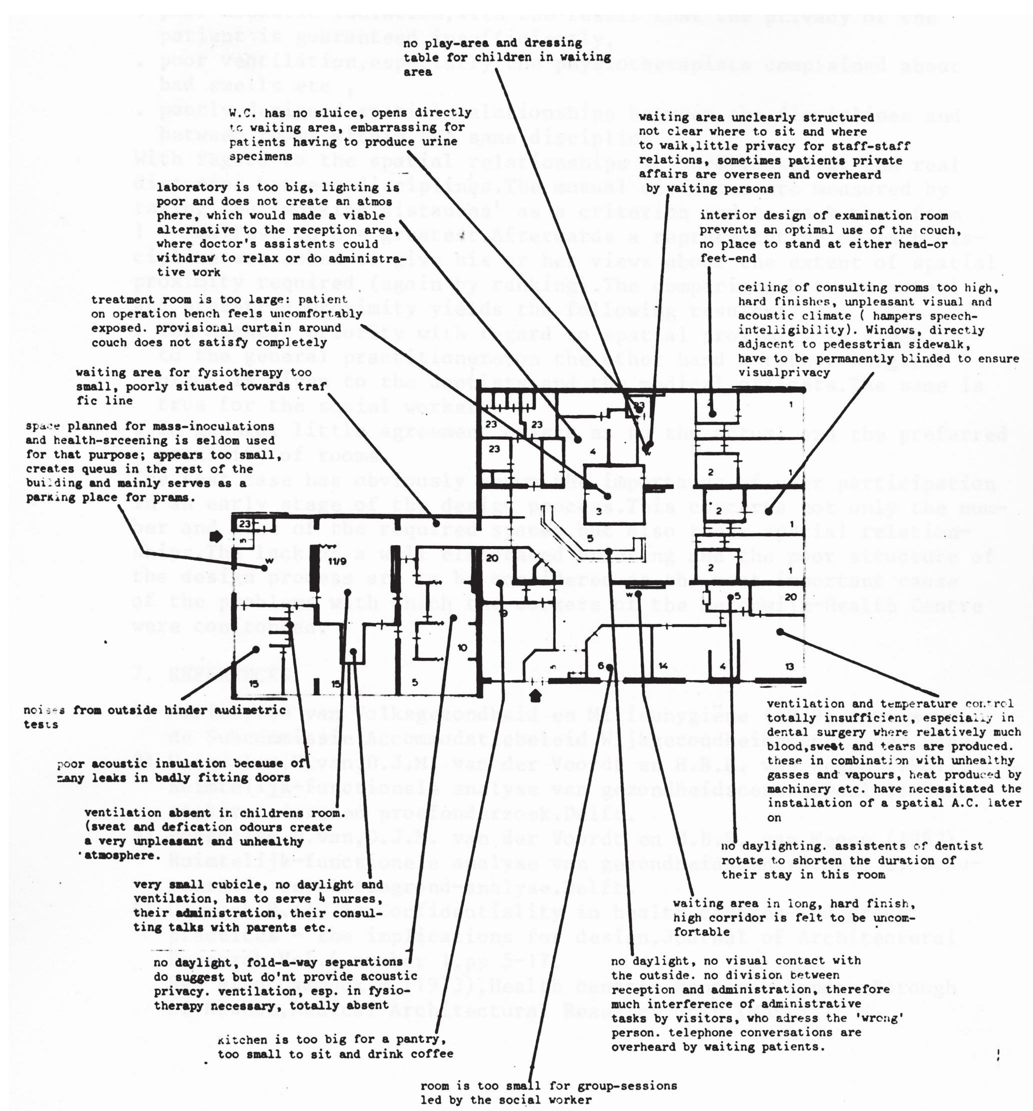
a. Selection of themes for evaluation

The list of themes for a product orientated evaluation, presented earlier, may serve as a checklist of what aspects should be included in the evaluation. This choice is also dependent on the purpose of the evaluation. Only by way of an exception, an all-encompassing evaluation will be the goal. In an evaluation linked to a project, there is often a down-to-earth reason; say, an immediately assumed vacancy, a 'misfit' between organisation and office-concept, an energy-bill running too high. Then, it is obvious to focus evaluation on a clear diagnosis of the problem and on directions towards solving it. While applying innovative solutions, the evaluation will be focused usually at evaluating the innovative measures. An example is the current bull-market in evaluating office innovations.[a] When guidelines for buildings with a specific function are concerned, it stands to reason to focus the evaluation to the spatial conditions in order to facilitate this function optimally. An example is the evaluations of buildings for housing and caring for senior people as made by the Faculty of Architecture.[b]

b. Measurement

When the themes for evaluation are known one has to ascertain how the aspects can be measured. Therefore, we need an unambiguous description of the aspects and clear instructions for measuring relevant variables.

In research jargon one talks about 'operationising'. If we would want to judge, for instance, the flexibility of a building, we could define that concept as 'the degree to which the



136 Results from an evaluation of Health Centre Merenwijk, Leiden.[c]

a See for instance Beunder, M. and P.J. Bakker (1997) *Innovatief werken in kantoorgebouwen, evaluatie van een hotelkantoor, wisselwerkplekken en activiteitgerelateerde werkplekken*.

b Breuer, G.S. and H. van Hoogdalem (1992) *Nieuwe woonzorgvoorzieningen voor ouderen;* Voordt, D.J.M. van der and D. Terpstra (1995) *Verpleeghuizen: varianten en alternatieven*.

c Hoogdalem, H. van, D.J.M. van der Voordt et al. (1981) *Ruimtelijk-functionele analyse van gezondheidscentra, onderzoekprocedure en proefonderzoek.*

building is able to accommodate, without breaking and fixing, changes in the organisation.' Next, it should be ascertained which variables are of importance in that respect; to wit, characteristics of the building (for instance carrying structure, modularity, sizes of separate rooms) and organisational characteristics (for instance employment changes, or different operations). These variables may be measured by questionnaires, observation, consultation of documents etc.

c. Appraisal

When the results of measuring are known, they deserve a statement of evaluation. In itself, a temperature of 30 degrees Celsius is saying nothing; it is significant only when there is a reference to a particular wish or norm (e.g.: not higher than 22 degrees). One is often working within qualitative classes: for instance a three-point scale (modest, average, good) or a five point scale (the same; extended by 'insufficient' and 'excellent'). A familiar example is the method employed by the League of Consumers in judging consumer products. It should be clear for each class which scale values are belonging to it. They may be based, for instance, on results of evaluative studies, or on norms, laws and rules. This values are not static but developing within time; also because of critical reflection by experts on existing buildings, comparison to other buildings and testing of new insights. Often it is not possible to measure quantitatively; for instance for variables like image quality or aesthetics. In that case the way out is qualitative description.

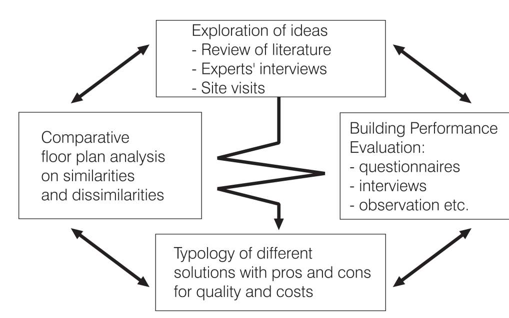
d. Weighing

In the experiencing of the observer not all aspects are equally important. Obviously, some aspects outweigh others. In order to give a balanced final judgement, it may be useful to give weighting factors to the various (partial) aspects. By this, a weighed addition is made of partial qualities, in which priorities can exercise their rights. Usually this weighing is part of a 'multi-criteria method'; for instance to select between locations.

Following these four steps enables the passing judgement on the quality of a building; differentiated per aspect, as well as in the form of a comprehensive assessment; in this case a weighed addition of evaluation of the aspects studied.

17.4 RESEARCH METHODS

There are numerous methods of data collection, like questionnaires, individual and group interviews, behavioural mapping and so on, each with its pros and cons.[a] Globally solid instruments like the Real Estate Norm, Serviceability Tools and Methods and other scaling techniques are used to measure functional aspects like usefulness, accessibility, health and safety, and flexibility (see figure 140). It is recommended to combine different methods in order to increase reliability and validity. The final choice depends on the research subject and constraints like time, money and available expertise. A 'quick and dirty' inquiry needs a different approach than a critical scientific study. An analysis of documents may also help to understand a building and evaluate its performance. A special application is the method of comparative floor-plan analysis.[b,c] By comparing a wide range of building layouts for similar organisations, one can obtain a good understanding how goals and values can be expressed in spatial solutions. It offers the opportunity for developing a spatio-functional typology of design solutions. The particular combination of comparative floor-plan analysis and ex post evaluation of representative cases is an excellent way of developing guidelines for programming and design. A POE gives insight into underlying arguments, user experiences with different design solutions, (dis)advantages for use and perception, and (dis)congruencies between spatial systems and social systems. The process of comparing floor plans and Post-Occupancy Evaluation has an interactive and iterative nature and may proceed in various steps. On one hand, hypotheses, questions, ideas of designers and their clients, review of literature and researchers' own hunches may guide the research. On the other, the plans themselves



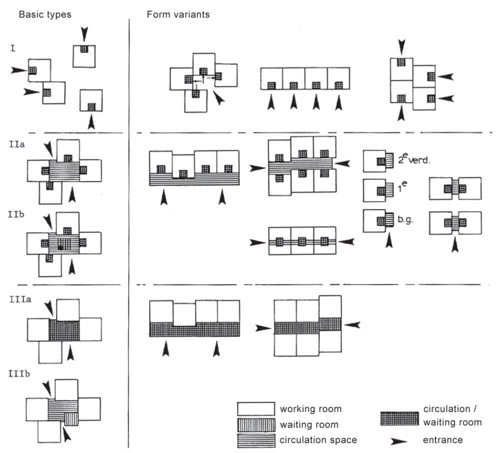
137 Comparative floor-plan analysis and ex post evaluation in design research

a Steffen, C. and D.J.M. van der Voordt (1978) *Belevingsonderzoek stedelijk milieu, methoden en technieken;* Zeisel, J. (1985) *Inquiry by design: tools for environment-behavior research;* Bechtel, R., R. Marans et al. (1987) *Methods in environmental and behavioural research;* Verschuren, P. and H. Doorewaard (1995) *Het ontwerpen van een onderzoek;* Swanborn, P.G. (1996) *Case-study's: wat, wanneer en hoe?;* Baarda, D.B. and M.P.M. de Goede (2001) *Basisboek methoden en technieken*.

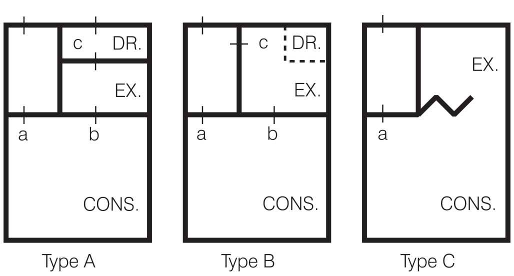
b Hoogdalem, H., D.J.M. van der Voordt et al. (1985) *Comparative floorplan-analysis as a means to develop design guidelines*.

c Voordt, D.J.M. van der, D. Vrielink et al. (1998) *Comparative floorplan-analysis in programming and design*.

generate ideas and hypotheses to be checked against other sources. As a result, spatial architectural choices become more understandable, recognisable and debatable. Behavioural aspects can be connected to design variants, while sufficient freedom remains for independent conscious choices for the most suitable design.



138 Typology of health-centres



139 Different design solutions for the separation between consulting and examination

An example of different design solutions for buildings with similar function is the variety in types of health centres. A comparative analysis of 50 health centres – co-operative ventures of general practitioners, neighbourhood nursing, physiotherapy and other disciplines – demonstrates that in practice three spatial-functional basic types have emerged, with an increasing degree of spatial integration:

Type I: location the only common characteristic
Type II: entrance as well as internal space for circulation shared
Type III: entrance and circulation space in common, as well as waiting room

Within this ordering form variants are discerned. Typology is a tool for making the parties concerned conscious during the stage of programming and designing of possible solutions. By adding the results of evaluative study – for instance advantages and disadvantages with regard to recognition, privacy and spatial conditions for co-operation – parties concerned can quickly come to a well-considered choice.

An example at room level is the separation between consulting and examination spaces of a General Practitioner. In practice, three basic types are found. In Type A, the suite is subdivided into a dressing cubicle (DR), an examination space (EX), and a consulting space (CONS), all separated by solid walls with soundproof doors. In type B, there is no dressing cubicle. Sometimes a curtain can be drawn to separate a dressing space. In type C, a curtain or a high bookshelf has replaced the solid wall with a door between the examination room and the consulting space. Door c has disappeared as well.

The meaning of this variation is related to emphasis on either efficiency or privacy. In the case of A, separate examination room with soundproof doors (a and b), the patient's 'flow' can be settled in a timesaving way. A patient is called into the consulting room through door a. If the need for closer examination arises during consultation, the patient is sent into the examination room through door b and asked to undress. In the meantime, door b is shut and the next patient can be called into the consulting room and asked to wait, while the doctor returns to the (now undressed) patient waiting in the examination room. Having finished the examination, he asks the patient to dress and leave the room through door c while he returns through door b to the patient waiting in the consulting room, etc.

Problems with this procedure may arise when relatives or friends escort the patients. Furthermore, doctors as well as patients increasingly consider this pipeline procedure impersonal. Although door c in type B still can be found in most practices, it is taken out of use by being locked, blocked by shelves, or even permanently sealed so as to improve acoustic insulation. The resulting relational pattern is similar to type C. But, objections still remain regarding combining consultation and examination into one room, even if they are separated by a curtain or bookshelf. A functional objection is that some examinations require complete darkness. Odours generated by undressing should be confined to, and extracted from, the examination room. From a psychological point of view, consultation and examination require a different 'decor': consultation needs a business-like 'office' surrounding or a more informal 'living-room like' atmosphere, while undressing and examination call for a clinical, 'bathroom like' atmosphere. Therefore, most doctors and patients prefer clear separation of the two atmospheres, as shown in type B.

Method	Sources	Aspects	Notes
Real Estate Norm (REN)	REN, Stichting (1992) Real Estate Norm. Methode voor de advisering en beoordeling van kantoorlocaties en kantoorgebouwen. Tweede versie; REN, Stichting (1993, 1994) Real Estate Norm. Bedrijfsgebouwen. Eerste versie.	functionality; convenience; comfort; safety; elaborated in 140 part aspects	developed for offices; seperate REN for industrial buildings
Real Estate Norm Quick Scan (REN QS)	REN, Stichting (1994) Real Estate Norm. Quick Scan Kantoorgebouwen. Eerste versie.	functionality, spatial-visual quality; technical quality; environment; elaborated in approx. 50 part aspects	developed for offices
Building Quality Assessment (BQA)	Baird, G. and N. Isaacs (1994) A checklist for the performance evaluation of buildings and building services; Bruhns, H. and N. Isaacs (1996) Building quality assessment.	company; location; construction; space; inner climate; installations; elaborated in approx. 60 part aspects	developed for offices
Serviceability Tools and Methods (STM)	Davis, G. and F. Szigetti (1996) Serviceability tools and methods.	places to work; real estate and managemant; laws and rules; elaborated in 108 part aspects	elaborates ORBIT-studies (Becker, F.D. and W.R. Sims (1990) Matching building performance to organizational needs in performance of buildings and serviceability of facilities.)
System of certification for offices (Certificatiesysteem voor kantoorgebouwen)	Centraal Beheer (1993) Certificatiesysteem voor kantoorgebouwen.	economical factors; technical factors; commercial factors; social factors; elaborated in 138 part aspects	developed for offices
Real Estate quality analysis (Vastgoed Kwaliteitsanalyse (VAK))	Feld, C.J.B. ten and F.J.M Huffmeijer (1997) Vak-analyse biedt inzicht in haalbaarheid herbestemmingsprojecten.	functional quality; technical quality; costs	elaborates REN
Healthy Building Quality (HBQ)	Bergs, J.A. (1995) De werkbare kantooromgeving.	air quality; heating comfort; available space; privacy; light; perception of work	continuation of the Building-in-use method (Vischer, J.C. (1989) Environmental quality in offices.); kindred to the Toets gezond kantoor (Rolloos, M., C. Cox et al. (1999)
Evaluating in architect's firms	Leenheer, R. (1997) Evalueren bij een architectenbureau, inclusief een evaluatie handleiding.	safety of use; orientation; social integration; user's convenience; social safety; view	developed for housing with care for the elderly
Elderly in hospitals	Lüthi, P., M.N. Niclaes et al. (1994) Ouderen in ziekenhuizen, problemen en oplossingen voor bouw en inrichting.	spatial orientation; sensoric qualities; safety; privacy; social contact	developed for the elderly in hospitals
Working paper evaluation methods	Wagenberg, A. F. van, et. al. (1992) Werkboek evaluatiemethode.	functionality; orientation; privacy; social contact	quality of use and perception of general hospitals
Manual for accessibility	Wijk, M., J. Drenth, et al. (1998) Handboek voor toegankelijkheid.	integral accessibility	formerly Geboden Toegang; applicable on buildings, dwellings and exterior space
Senior's label	Donk, D. van de (1994) Seniorenlabel, consumentenkeurmerk geschikt voor alle leeftijden.	accessibility; safety	consumer's hallmark suitable for all ages
Manual Upgrading ('*Opplussen*')	Scherpenisse, R., J. Singelenberg et al. (1997) Opplussen, aanpassingen voor bestaande woningen.	accessibility; safety	adapting existing dwellings for all ages inclusive the elderly
Delft Checklist Socially Safe Designing	Voordt, D.J.M. van der and H.B.R. van Wegen (1990) Sociaal veilig ontwerpen, checklist ten behoeve van het ontwikkelen en toetsen van (plannen voor) de gebouwde omgeving; Voordt, D.J.M. van der and H.B.R. van Wegen (1991) Sociale veiligheid en gebouwde omgeving.	public safety, objective and subjective	developed for buildings and exterior spaces; elaborated by SEV in a Police hallmark Safe Housing (Politiekeurmerk Veilig Wonen)
VAC-Quality indicator	Hilhorst, H.L.C. (1997) VAC-Kwaliteitswijzer, integrale visie op de gebruikskwaliteit van woning en woonomgeving.	usefullness; accessibility; safety; comfort	developed for housing and the housing environment
'*Woonkeur*'	Stuurgroep Experimenten Volkshuisvesting (2000) Woonkeur. Rotterdam, Keurmerk Integrale Woonkwaliteit.	usefullness; accessibility; safety; comfort	Integration of Senior's label, Manual for accessibility, VAC-Quality indicator and Police hallmark Safe Housing
Flexis	Stichting Bouwresearch (1996). Flexis, communicatie over en beoordeling van flexibiliteit tussen gebouwen en installaties	flexibility of buildings and installation	

140 Instruments for measuring the quality of buildings. For the complete description of the references – author(s), title, publisher, year and place of publication, we refer to the bibliography at the end of the book.

17.5 INDICATORS FOR FAILURE OR SUCCESS

In principle, the methods mentioned are all appropriate for finding out whether a building is complying with its objectives and expectations; and has, perhaps, qualities surpassing them. Focused on quality of use, the following data are especially important as indicators for failure or success:

- actual use of spaces and facilities (frequency of use, nature of activities, forms of shared and multi-functional use of space);
- appreciation by the day-to-day users, visitors and passsers-by, as such and as compared to other design solutions;
- the most positive and most negative characteristics of the building according to its users;
- the adaptations implemented in the building since the transfer from builder to owner;
- potential for letting (to be derived from data on empty floor-space, waiting lists, developments in real-estate);
- inclination to move;
- maintenance experience;
- data on maintenance, vandalism, burglary.

17.6 CONCLUSIONS

This Chapter devoted attention to the evaluation of buildings. Next to a survey of possible objectives and evaluation themes attention was given to ways of evaluating. Measuring methods and instruments were listed and commented upon. With this we demonstrated that there are many ways to judge the quality of a design or building in a reasonably objective way. Although thorough evaluations are still exceptional, we may conclude that the methodological aspect of Building Performance Evaluation and Post-Occupancy Evaluation has become a new professional area. Students as well as staff of the Faculty of Architecture may benefit from this; in design-studios as well as in (assisting to) graduation.

At the same time it should be stated that the emphasis has been put upon functional quality. Much more attention was given to this aspect of quality than to judging aesthetic quality. Although appreciation of aesthetic quality is strongly subjective, and will always remain so, further scholarly exploration of criteria, definitions, operationalisations and measuring methods would shed more light on this aspect and would make aesthetic quality a better topic for discussion. An example is the further development of the so-called ‘semantic differential’. This method consists out of a lot of dichotomies; like beautiful-ugly, exciting-boring, original-traditional, simple-complex. It would be interesting to have some recently realised and already slightly ageing buildings judged this way by users, architects, reviewers of architecture and other parties in the process. By relating the results of this study to the design decisions it should be possible to judge form more scholarly than can be done now. It is an important challenge for those who are studying from the vantage points of their separate working environments architectonic designing.

18 EX ANTE RESEARCH

EDWARD HULSBERGEN
PITY VAN DER SCHAAF

" … designers regard themselves as integrators, researchers do not see them in that rôle."

"Instead of regarding designers as practitioners who are supplied with knowledge by researchers, it is possible to see design as the study of potential or desirable futures, thus, putting researchers and designers on a more equal footing." [a]

18.1 EX ANTE AND EX POST

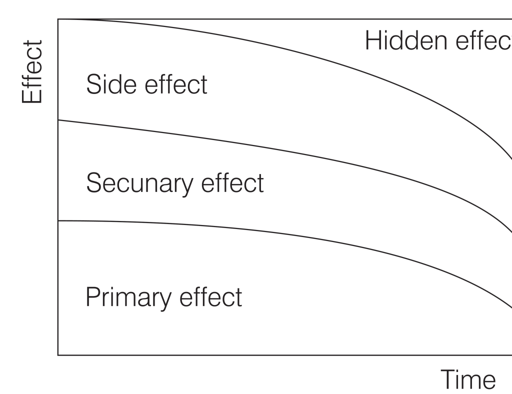
The design is ready. The explanation of the plan is clear and well founded, there are no mis-understandings about the functional programme, there is a clear relation with the adjacent scales, the strategic intervention is defined, the proposal is delineated, the legend is unequivocal. Deliberation, debate or realisation? How to continue?

In a competition different designs are made. Which design should be chosen?

A student shows his design to the teacher for judgement. Can the design be improved? What aspect is essential?

A design has been made to explore a possible future.

These are four cases in which ex ante evaluation can be used to discuss the qualities of a design. Ex ante means 'before'. It is the opposite of ex post, 'after'. With ex post research, a design can be judged on actual effects. Since ex ante research is done prior to the realisation of a design, *actual* effects can not be measured in this type of research. Therefore, in ex ante research evaluation criteria are chosen based on what is *expected* to be significant. Ex ante evaluation is regularly used in policy sciences to determine the *probable* consequences of activities. A well-known form of ex ante research is environmental impact analysis, where environmental consequences of proposed activities and alternatives are studied in advance.[b] Ex ante research can also be valuable to research-driven design in technical disciplines. In this context, the aim of ex ante research is to critically discuss and evaluate future consequences of a design, prior to realisation. One thing is certain: the future is uncertain. The uncertainty will only increase with the time-frame of the study. The more uncertain the future, the harder it is to forecast developments surrounding the design and the wider the variance of possible effects. When the time-frame is lengthened, more hidden effects will be revealed (see figure 141). It is obvious that this complicates ex ante debate.



141 The relationship between time and effect[c]

	desired	undesired
expected	1	2
unexpected	3	4

142 Framework to map consequences

18.2 DIFFERENT FORMS OF EX ANTE RESEARCH

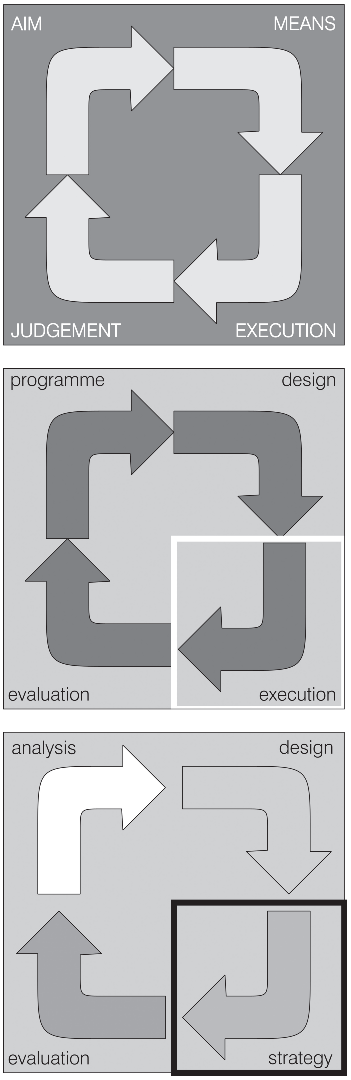
Within the research-driven design context two different forms of ex ante research can be defined. First, ex ante research may compare the quality of the design to the original brief.[c] A design should be a technical composition based on the original design assignment, unless the designer altered the original brief with good arguments (in consultation with the client). Anyway, during the design process, choices are made. Consequently, the design is just one of the possible operationalisations of the original brief. The second form of ex ante research is directed to testing consequences of design choices, with respect to aspects (contexts or perspectives) relevant, but not explicitly stated in the design brief. An example is the effect of design intervention on higher or lower scale levels, or on related sectors.

The second form of ex ante research concentrates not only on expected consequences, but also on not-expected or not-anticipated consequences. A distinction can also be drawn between desired and undesired consequences (see figure 142). Increasing insight in the effects of a design can result in adaptation of the brief and a new design.

18.3 EX ANTE EVALUATION IN ALL PHASES OF THE DESIGN PROCESS

The previous section shows that ex ante research can be useful in different ways when judging a design. Amongst designers there is much difference of opinion as to judging designs.

a Heide, H. ter and D. Wijnbelt (1996) *To know and to make: the link between research and urban design*.
b Lehning, P.B. and J.B.D. Simonis (1987) *Handboek beleidswetenschap*. p.121.
c Source: Peters, J. and R. Wetzels (1998) *Niets nieuws onder de zon en andere toevalligheden*. p.51, Figuur 2-5 Soorten effect.
d It is self-evident that the design also has to comply with legal demands (sizes, construction, environment, participation, etc.). Nevertheless it can be very interesting to check whether the designer has used innovative ways to deal with these demands. See page 1 for programming research.



base cycle
cycle in practice
cycle in education

143 Three descriptions of the planning cycle[c]

The first, most dominant, one is the opinion that work is done when the design is finished. The client then needs to judge and decide. Thereupon the designer can change rôles and becomes, for example, project manager. In this opinion ex ante evaluation can be an important tool for the client.

The second group is of the opinion that when a design is made, judging it is the responsibility of both client and designer, or at least of the profession. In this case ex ante research can be an important tool for both designer – during, and at the end of the design process – and client.

Moreover, any serious discussion about a design, no matter what stage of the process, contains elements of ex ante research. However a study only deserves the denomination 'research' if it is clearly embedded in the planning cycle and respects the demands of research (see figure 143).[a] Design as a process concerns all steps of the planning cycle. The relationship between a design and the cycle clarifies the place of different forms of evaluation research. *Ex ante* research helps to obtain insight into the selected effects prior to execution, while *ex post* research stresses actual effects. *Ex post* evaluation also contributes to the body of knowledge of the discipline to be used as input for new designs. The third form, *andante* (ongoing) research supports the design during execution, and is especially valuable in monitoring long-term processes, e.g. rehabilitation of city centres, districts and neighbourhoods.[b]

18.4 DIFFERENCES BETWEEN DISCIPLINES

Content of ex ante research is not the same for each discipline. The difference is caused by different interpretation of the word 'designing'. Generally designing means creating. In Architecture, Building Technology and Planning this is translated in creating space or the built environment. The product is something, say, a building, façade or city structure. On the other hand, in a discipline like Real Estate and Project Management designing can refer to creating processes or decision support systems (DSS). The content of ex ante analysis changes with the change in interpretation.

Secondly, the built-environment (sub)disciplines differ in object and scale. Evaluation of an architectural design will be more focused on building, while evaluation of an urban design will be more related to collective parties in society and the long-term.[d] The content of ex ante research (focus) will change correspondingly.

Thirdly, there are different products within the same discipline asking for a different accent in the analysis. For example, in architecture a difference can be made between buildings designed with certain qualities, like form or sustainability, and buildings that should be seen as statements. The latter is an artistic and intellectual activity: to give colleagues and the public something to look at and think about.[e] Both types of design are necessary for continuance of society, but evaluating the designs ex ante will result in different accents.

18.5 ONE-SIDEDNESS, PITFALLS AND SIMPLICITY

Discussion on design belongs to the discipline, as periodicals, books and public media show. However, from a scientific point of view, these judgements are limited in usefulness most of the time, as they are based on selective and implicit aspects.[f] Good evaluations, also ex ante, concern:

- positive and negative aspects;
- the object, the, the location and processes and values
- explicit quality criteria;
- contribution of all (future) actors;
- clarity regarding weighing of arguments by critics towards their final judgement.

Designers are familiar with a number of pitfalls when designing.[g] In order to learn from these, ex ante evaluation must pay thorough attention to:

- reciprocal relationship between the analysis and composition;
- relationship between parts of the design;

a Roozenburg, N.F.M. and J. Eekels (1991) *Designing is a special way of solving problems*, p.76. The authors connect designing with the empirical research cycle of A.D. de Groot.
b For a very good text about monitoring and evaluation, see: Moore, B. and R. Spires (2000) The development, monitoring and evaluation of urban regeneration strategies, Chapter 10.
c Hulsbergen, E.D. and I. Kriens (2000) *Planvorming*, Chapter 2
d In this sense the problem of earnings and costs is also different in urban building and in architecture.
e Dijk, H. van (1981) *Maak weer eens een meesterwerk*.
f Langdon, P (1990) *Urban Excellence*, Chapter 1.
g Lawson, B.R. (1990) *How designers think, the design process demystified*, Chapter 12

- relationship of the design to social and scientific questions;
- quality of the data used as arguments to design decisions;
- actual meaning of models used to explain the design;
- relevance of design images to approach the stated problems.

A design can also be evaluated by attention to recent developments; for example, to problems in urban areas.[a] Relevant criteria can be formulated in terms of the consideration the design gives to:

- integrated approach (versus simplistic problem definitions and mono approaches);
- multi-functionality (versus mono-functionality, e.g. only housing);
- mixed ground use (versus one sided use; alternating use of functions and groups, without conflicts; also against neglect);
- local synergy (versus isolated projects);
- public-private and other pp-partnerships (versus insufficiently supported, separate initiatives).

18.6 USING SCENARIOS IN EX ANTE EVALUATION

To determine the effect of a design scenarios can be used.[b] Many people think scenarios predict the future, whilst it is really about getting prepared for the uncertain future. Scenarios can be used in ex ante evaluation to determine possible future developments in the context of the design. Scenarios are images or descriptions of possible, probable or desirable future developments.[c]

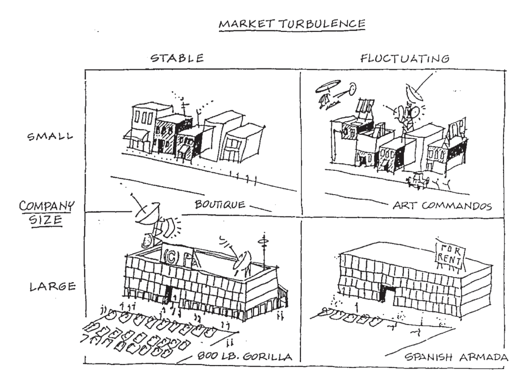
To show how scenarios can be used when making (design) choices we will use the example of an architect designing an office for a client. In the traditional design process architects hardly ever use scenarios. Instead, they try to understand the client as well as possible. This understanding is then used to design a building that in their opinion fits current and future needs of the client best. This way only one of many solutions is designed; as a consequence many buildings need to be renovated or changed only shortly after they are first occupied. Testing the design in various scenarios representing alternative ways of using the future building can prevent this.

The use of scenarios in the design process is described by Brand.[d] He uses the example of a film and television company – Colossal Pictures – operating in a turbulent market. This company had to choose between renovating many small buildings or constructing one big new building (see figure 144). To determine possible consequences of this choice critical developments surrounding the company were determined. Analysis showed that the growth of the company and its need for real estate was mainly dependent on the developments in the film and television industry: would the market stabilise or fluctuate? By analysing the consequences these market conditions would have in both accommodation alternatives, Colossal pictures could make a better founded decision.

18.7 IDENTIFYING CRITICAL SCENARIOS

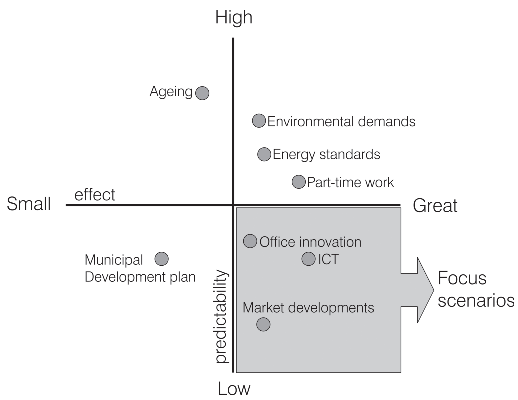
The examples in the previous section have shown the usefulness of scenarios in ex ante evaluation. But, how can one choose the developments that should be included in the ex ante evaluation of a design?[e] Political, spatial, technological, cultural or economic developments? The first step is to determine the right variables for a critical scenario is defining the driving forces. An architect designing a building for a client can, for example, try to identify the forces that will affect the organisation needing accommodation.

To determine the driving forces one can start with analysing past developments. The architect in our example could try to determine what developments influenced organisation and use of the current building in the past. Examples of developments that influenced the use of office buildings in the past are information and communication technology and growth of the number of part-time employees, stimulating double use of workplaces.



144 Colossal Pictures needs to choose between constructing one new building or renovating many small buildings; probable consequences are evaluated ex ante.

a Bekkering, H. (1998) *Stedelijke transformaties*.
b See: Dewulf, G.P.R.M. and P. van der Schaaf (1998) *Portfolio management in the midst of uncertanties: how scenarios can be useful*; also: Dewulf, G.P.R.M., A.C. den Den Heijer et al. (1999) *Het managen van vastgoed binnen een publieke organisatie*.
c Compare: Draak, J. den (1993) *Van blauwdruk naar draaiboek, scenario's in de ruimtelijke planning en volkshuisvesting*, Chapter 1.
d Brand, S. (1994) *How buildings learn, what happens after they are built*.
e See also: Thieme, J.C. , D.J.M. van der Voordt et al. (1989) *Effecten van grootschalige ingrepen, een programmeringsstudie*.



145 Co-ordinate system to map the predictability and impact of developments surrounding the design.

A second way to determine driving forces is a workshop or brain-storm session with the client, experts and future users. What developments do they think will influence the future use of the building? What effects would those developments have on the brief or the usefulness of the current design? This analysis can give insight in the need for flexibility. In a session aimed at determining driving forces, it is important that the people involved let go of the current situation and think about what might happen (as opposed to what they think will happen).

Based on this analysis of driving forces, various scenarios can be defined. There are different ways to define such scenarios. First of all, trends can be extrapolated into the future. This results in a 'trend' or 'reference' scenario. It is however only one possibility. To define more scenarios, it is important to vary driving forces that are hard to predict and that will have big effects on the design. Such driving forces are called 'critical uncertainties'. Moreover, when evaluating a design it is useful to create a bandwidth of scenarios by using extreme scenarios. To determine the critical uncertainties that characterise these extreme scenarios, one can use a co-ordinate system (figure 145) based on the axes predictability (high or low) and effect (great or small).

The difference between the various scenarios should be based on uncertainties located in the lower right corner of the picture, since reasonably predictable developments (like ageing) can develop similarly in every scenario and developments that have no effect will not change the design. Experience shows that scenarios in determining possible consequences are a useful instrument during the design process. However, it is important to keep their number limited: three or four suffice. Too many scenarios will confuse.

When the scenarios have been defined, the next step is to determine the consequences of a design in a certain scenario. A design doing well in more than one scenario is called robust.

18.8 EXAMPLE: THE NETHERLANDS 2030

An organisation using scenarios regularly to determine the effects of the spatial planning policies of the Dutch government is the *Rijksplanologische Dienst* (RPD). In a study 'The Netherlands 2030', the RPD described four different visions of the spatial structure of the Netherlands in 2030. The policy (or strategy) Dutch government needs to pursue to realise these visions differs for every vision. However, the actual consequences of the policy (strategy) depend on developments beyond the government's control, like development of the world economy and the position of the Netherlands in world trade. This means that realisation of the vision depends also on these uncertain developments. To deal with highly unpredictable developments when formulating new policies, the RPD has tested the robustness of various policies by using three scenarios. For each alternative policy the effects in every scenario were determined.[a] This exercise was not performed to provoke selection of a certain policy. The goal was a discussion on the main themes regarding spatial structure of the Netherlands.

18.9 CONCLUDING REMARKS

Most people just want one solution or one explanation; preferably the one they had in mind for a long time, resulting in minimal resistance; or they just invented in discussion.[b] Consequently, opinion about the usefulness of ex ante evaluation during the design process is divided.

Strong emphasis on creative aspects of designing can be a way to distance oneself from 'known' and 'tested' solutions. In that case ex ante e;;valuation might be experienced as a burden instead of a support. Especially thinking about probable or conceivable developments that might influence the design will stimulate the designer to think about the future, prompting new ideas. Moreover, ex ante evaluation helps to expose popular beliefs about benefits, and pays attention to neglected or hidden burdens. Consequently, the actual choices become more realistic. For the practice, scholarship and education of the professions, this kind of research needs further development.

a See: Rijks Planologische Dienst (1998) *Nederland 2030, Discussienota verkenning ruimtelijke perspectieven*.
b Charberlin, T.C. (1965) *The method of multiple working hypotheses* (previously published in 1890, also in 'Science'). The author mentions the 'parental affection' scientists may experience for their hypotheses and expectations.

19 EX ANTE PERFORMANCE EVALUATION OF HOUSING

ANDRE THOMSEN

In several stages of the design process performance checks are needed: either for decisions about the feasibility of the programme and, later in the process, of the draft design; or to check and trim, to optimise, the final plan. The first stage enables the maximum adaptability of the plans with scant information. Towards the final realisation of the building information about the performance grows to a maximum and adaptability diminishes to almost zero. It is, therefore, essential to achieve results of performance evaluation as early in the design process as possible. Ex-ante performance evaluation proves to be a useful approach. It is based in principle on anticipation of future performance using broad and long term experience with similar products. This makes it useful for application to serially produced housing projects.

However, major difficulties are to be solved regarding measurement and assessment of performance as well as practical utilisation.

19.1 MEASURING PERFORMANCE

For performance evaluation a large number of methods is available, varying from Post Occupancy Evaluation (POE) and user enquiry surveys to various kinds of benchmarking. Most often they are based on quality/cost ratings. For early design and development stages simple and ready to use quality/cost rating-methods are most suitable. We will discuss both variables: quality and cost.

19.2 MEASURING FUNCTIONAL QUALITY

Performance of housing products depend mainly on satisfying residents, since this determines the market position of housing estates. Resident satisfaction depends upon a mix of mainly functional qualities (e.g. usable floor space) and subjective preferences (e.g. location). Though quite some research is available regarding resident satisfaction, translation and implementation of functional users preferences in evaluation criteria of built construction are meeting a couple of problems:

The translation of functional preferences, based on dwelling activities, in building construction characteristics. For instance: the activity 'cooking' implicates not only functional criteria for the kitchen floor plan and equipment, but also for heating, ventilation, relation to dining room/table, to be differentiated depending on household type and size etc.

The implementation of a large number of incomparable and partly contradictory aspects in a useful and practicable system. Solving this problem encounters a dilemma. One has to choose between very complicated compiled scorings, leading to insignificant non-transparent results, and simple but questionable undifferentiated results. As a research project targeted at the development of a consumer's test for housing products showed though, a useful and practicable system like the Dutch *Woning Waarderings Stelsel* (Dwelling Assessment System) is largely to be favoured, since it is widely used and recognised as a comparison gauge.[a] Regarding its nature, quality assessment must always be considered a rough and doubtful approximation of the many facets of the reality.

19.3 THE DUTCH RESIDENTIAL ASSESSMENT SYSTEM WWS

The Dutch residential assessment system *Woning Waardering Stelsel*, abbreviated WWS, is an instrument used by Dutch government to determine the quality of a domicile. Determining a reasonable rent is one of its purposes. Quality is expressed in points per quality aspect. The points for shared rooms and facilities, like a laundry room or heating, shared in apartment buildings, are proportionately distributed over the number of domiciles, regardless of size. Per aspect the following points can be 'earned' maximally:

a Thomsen, A.F. (1992) *Towards a consumers test for houses, surveying users-preferences and functional quality;* Thomsen, A.F. (1995) *Woonconsument en woningkwaliteit, prestatiemeting van woningen met behulp van vergelijkend warenonderzoek*.

1	*surface of spaces* (rooms, kitchen, bathroom, shower)	1 pnt. / m²
2	*surface additional spaces* (kitchen extension, storage, attic, garage)	0,75 pnt. / m²
3	*heating*	
	per heated space	2 pnt.
	private furnace in cellar	3 pnt.
	private high yield furnace	5 pnt.
	collective high yield furnace	1 pnt.
	radiator taps per space	0,25 pnt. per tap, max 2 pnt.
	heating elements outside rooms per space	1 pnt., max 4 pnt
	central heating combination	1 pnt.
	water meter	1 pnt.
4	thermal isolation	max 15 pnt.
5	*kitchen* length table top near sink up	
	to 1 metre	0 pnt.
	1 to 2 metre	4 pnt.
	2 metres and more	7 pnt.
6	*sanitary facilities*	
	toilet	3 pnt.
	washing basin	1 pnt.
	shower	4 pnt.
	bath	6 pnt.
	bath plus shower	7 pnt.
6a	*facilities for people with disabilities* per Dfl 500 of the costs incurred by the owner to establish them	1 pnt.

7	*out-of-date*	max. -30 pnt.
8	*private outside spaces*	
	up to 25 m²	2 pnt.
	25 to 50 m²	4 pnt.
	50 to 75 m²	6 pnt.
	75 to 100 m²	8 pnt.
	100 m² and more	10-15 pnt.
	no private outside space	5 pnt. deduct
	carport	2 pnt.
9	*type of domicile*	
	a) single family houses	
	non-attached house	17 pnt.
	corner of house	15 pnt.
	position in between / last of block	12 pnt.
	b) flats in shared buildings	
	ground floor without elevator	6 pnt.
	ground floor with elevator	6 pnt.
	1st floor without elevator	3 pnt.
	1st floor with elevator	5 pnt.
	2nd floor without elevator	1 pnt.
	2nd floor with elevator	4 pnt.
	3rd floor without elevator	0 pnt.
	3rd floor with elevator	4 pnt.
	4th floor and higher without elevator	0 pnt.
	4th floor and higher with elevator	4 pnt.
	16 or less flats per elevator shaft	2 pnt. extra
	c) duplex residences	
	upstairs	1 pnt.
	ground floor	4 pnt.

10	*surroundings*	
	1. trees, flower beds	0 - 1 pnt.
	2. public green	0 - 2 pnt.
	3. playing space young children	0 - 0,5 pnt.
	4. playing space older children	0 - 0,5 pnt.
	5. elementary schools	0 - 1 pnt.
	6. shops for daily provisions	0 - 2 pnt.
	7. urban facilities	0 - 2 pnt.
	8. accessibility of residence	0 - 1 pnt.
	9. public parking	0 - 1 pnt.
	10. stop public transportation	0 - 2 pnt.
	11. traffic load and unsafety	0 - 1 pnt.
	12. state of maintenance	0 - 2 pnt.
	13. distance to industrial buildings	0 - 1 pnt.
	14. attractiveness	0 - 4 pnt.
	15. population density	0 - 1 pnt.
	16. safety	0 - 3 pnt.
11	*noxious situations*	max.40 p. deduct
	serious decline neighbourhood	20 pnt. deduct
	city renovation activities	20 pnt. deduct
	serious noise (industry, air traffic)	35 pnt. deduct
	direct pollution soil or air	40 pnt. deduct
	other soil pollution	20 pnt. deduct
12	*special facilities* exclusively with service flat residences	35% of total 1 t/m 11

Explanation

1,2 Surface
It holds for all spaces that one could stand on them, that they are at least 2 m² large and the height of the ceiling minimally 1,5 metre. Spaces of circulation (corridors) do not count. Absence of a fixed flight of stairs to the attic results in 5 points less.

3 Heating
Each heated space scores 2 point, excepting the 'remaining spaces' (attic, sheds, cellars, garages, etc.). For specific elements of appraisal extra points may result; for instance 3 points extra for a private central heating installation, a quarter point per space extra for the temperature control by thermostat (with a maximum of two points per residence).

4 Thermal isolation
- Double glass 0,4 point per m²
- Roof isolation 2 points per residence
- Wall isolation 1 point per residence
- Wall isolation front 6 points per residence
- Floor isolation 2 points per residence
- Maximally 15 points per residence

5 Kitchen
The length of the working surface near the sink determines the number of points. Built-in sinks count, built-in stove tops do not. Depending on the quality the points may be doubled maximally (1 point per Dfl. 500 investment).

6 Sanitary equipment
Facilities present determine the number of points. Spaces for bathing and showering can only get points if the walls and floor are sufficiently water-tight, if there is access to hot and cold water and if the shower is equipped with the necessary utilities.

7 Out-of-date
Maximally 30 points reduction for ageing and wear; 0,4 point per (calendar)year following the construction of the building. For major maintenance and renovation work after 1970 a compensation applies of the reduction of points (per Dfl. 1000 investment 0,2 point less).

8 Private space outside
These spaces only count if they are minimally 1,5 metre wide and broad.

9 Type of domicile
If the floor of the main living-room of a ground floor residence lies 1,5 metre or more above street level it is regarded as a flat on the first floor. If there are 16 or less flats per elevator shaft this yields 2 points per flat extra. A duplex house is a one-family residence outfitted in such a way that two families can live in it. A domicile that is not free (with a shared flight of stairs and/ or landing) is rated a duplex house. The lower part scores 4 points, the higher part 1. For a dwelling that is not free on the second floor or higher no points are given.

10 Environment
For inconvenient situations up to 40 points are deducted:
- For very serious hindrance of noise by road, rail or air traffic or by industry maximally 35 points.
- For serious decline of the neighbourhood maximally 20 points.
- For urban renovation activities maximally 20 points
- For very serious soil or air pollution in the direct environment of the residence maximally 40 points when the cleaning-up starts within four years
- For other soil pollution a maximal reduction of 20 points.

12 Service flat costs supplement
A service flat is an independent living unit with minimally an emergency installation in it, meals provided by the owner in addition to simple medical or paramedical care and use of spaces for recreation and guest-rooms. For this type of residence the total number of points may be increased up to a maximum of 35%.

146 The Dutch residential assessment system WWS

19.4 THE RESIDENTIAL CONSUMER'S TEST

The WWS system of assessing homes is often applied in The Netherlands for judging the capability and the price/ performance ratio of residential facilities. WWS is mainly applied ex post; parts of it are also useful ex ante. Since WWS does not agree well with preferences of occupants an effort was undertaken in the nineties to develop an alternative instrument, the so-called 'residential consumer's test'; in analogy with comparative study of consumer's products, as they were performed for years by consumer organisations in order to test the price/ quality ratio of products on the consumer market.

Comparative study of products consists largely in a product information system listing the main characteristics of comparable products. A relative evaluation is made then on the basis of formulated criteria, testing levels and weighting factors per aspect, with the interest of the consumer as a decisive force. Usually the final judgement is termed 'Best Buy' and 'Best in Test' for products with the highest score, and 'Money Saver' for products with the best price/ performance ratio. The basis for the development of the test was a design of a quality test, founded on study of sources and interviews. Weak points in this testing method: valuation and weighing are not sufficiently based on occupants' preferences of the several quality aspects; the unsatisfactory way the total score was calculated; and lack of a relation to WWS.

Due to this criticism a new study started, structured in 3 stages:

- Occupants' preferences: a study of relevant quality properties and the degree in which these are related to the domestic properties according to housing consumers;
- Development of the test: the development of a test of housing quality based on the methodology developed during the early stage of the study;
- Operationalisation in practice: 'testing the test' and transfer of the testing methodology.

The essential point of departure for the test to be developed was the preference of occupants, rather than physical properties of housing of most existing methods of housing appraisal: the two should be regarded as independent variables. Searching for a relation between physical performance properties of homes (the objective component) and the preferences of occupants (the subjective component) linked to them; and what is more,a relation that may be measured, is the Achilles heel of this study.

An important conclusion of the first stage was that standard preferences of the occupant do not exist. Wishes and preferences of occupants differ according to composition of the family, age, income perspective, dependence on care, and life-style. In addition realising the preferences of occupants, the 'action space', strongly depends on socio-economical position and conditions prevailing on the real estate market. It proved to be too optimistic to expect that existing study data would be sufficiently available to serve as a basis for the testing methodology.

In Stage 2 – development of the test – determining criteria, testing values and weighting factors stood central. An extensive analysis of existing methodologies was conducted in order to establish criteria and testing values; complemented with technical norms of reference of housing from the available literature. On housing-technical (minimal) norms it was decidedly rich. Based upon it, a comprehensive survey was made, expressed in conditions and boundary values for individual domestic activities. Associating them with importance, in this case with weighting factors based on occupants' preferences (the subjective component) had to face the problem already signalled in stage 1, that can only be solved by conducting the (experimental) testing and the occupants' interviews concurrently. Because of the complexity involved, the decision was made to postpone the working-out of the residential environment as a testing object to later.

aspect / partial aspect	S	W
1. usefulness of spaces		
1.1 bedrooms		
1.2 living-rooms		
1.3 kitchen-rooms		
1.4 sanitary/ bath-rooms		
1.5 traffic space		
1.6 storage/ hobby space		
1.7 space outside		
2. flexibility / potential for change		
2.1 flexibility of use		
2.2 adaptability of layout		
3. connections and connectedness		
3.1 direct relations		
3.2 seclusion and privacy		
3.3 care relation		
3.4 Accessibility		
4. installations		
4.1 heating		
4.2 hot water		
4.3 ventilation		
4.4 shades		
4.5 thermal isolation		
4.6 sound isolation		
4.7 energy connection / plugs / metering cabinet		
5. sun and daylight		
5.1 living-rooms		
5.2 other rooms of residence		
5.3 kitchen		
5.4 daylight other spaces		
5.5 space outside		
6. maintenance		
6.1 maintenance of usage		
6.2 maintenance of installations		
6.3 architectural maintenance		
7. access, safety and living environment		
7.1 access		
7.2 safety		
7.3 neighbourhood and living environment		
7.4 outside / inconvenient situations		

S = score, W = weight

147 Survey main scores

During Stage 3 the housing quality test was tried out in two housing complexes in Delft. The testing concept used is a compromise between mutually contradictory requirements with regard to completeness and practibility. It is mainly a checking list of seven functional quality aspects considered important by occupants. Together they determine the quality of usage of a home.

Next interviews with occupants was the basis for assigning the weighting factors. The usefulness of spaces is measured by ‘function mats’, linked to activities and dependent on capacity. For the remaining partial aspects scoring instructions are provided.

Via a questionnaire to fill in the test results in a schema of quality aspects in which after weighing of the separate scores a total score can be calculated. The weighting factors are based on the results of the occupants poll, in which each partial aspect is scrutinised in terms of the interest of it to the occupant as well as in the one of valuation judgement. Finally, the price / performance ratio can be determined by relating the total score to the costs incurred by occupying the home.

The outcome of the experimental testing demonstrated that the test developed is viable and that the results are reasonably valid. Although the interest scores proved to be sufficiently useful for assigning weights, the question remains whether an occupants’ poll is also sufficiently useful for determining the generally valid weights in a test.

All in all, developing the test proved to be much more complicated than was expected in the preliminary study. Although the development of a ‘working’ test succeeded, doubt as to reaching the aims formulated sufficiently increased. The concept still shows important shortcomings in two respects:

- the test is too complicated;
- the scoring results are for the time being insufficiently useful as unequivocal yardstick of performance

Given the large amount of different and dis-similar properties, the complexity does not surprise. During development, therefore, the well-considered choice was made to work from complete to simple; that is the only way to find out experimentally which aspects and for what households are in which situation of minor importance and might as well be left out, or get, on the other hand, a greater weight. This way it is also possible to trace systematically differences between different types of households that might not show up while working ‘from coarse to fine’. However, the consequence of this choice is that it lasts this way (too) long before the developmental stage results in a practically useful instrument.

The second shortcoming concerns the structural problem of the weighting factors: in this case the relationship between subjective preferences, mainly with a functional character, and the physical properties of the object of those preferences. Only for neutral properties *vis-à-vis* household and income a match that can be implemented can be made.

Finally, question marks could be put with regard to a strong focus on valuation of the quality of usage. Efficiency in use plays a rôle; particularly in the case of cramped blueprints. When the living surface per occupant increases, possibilities of usage also increases and shortcomings become masked and/ or compensated.

Towards a new WWS

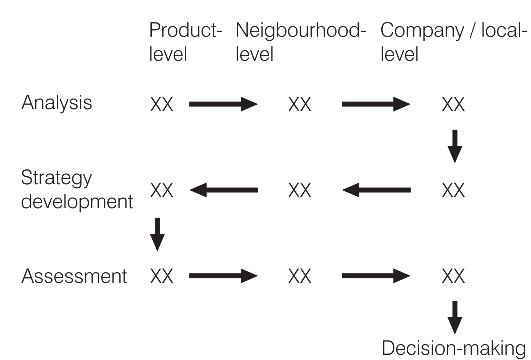
Looking back at the results, the two central problems: complexity of a ‘responsible’ method, and the needed ‘match’ between preferences and object-properties, seem to be a hurdle difficult to take for the time being for application in practice. On the short term, variants of WWS offer a reasonable alternative. Admittedly, they have the disadvantage that the judgement of occupants gets not sufficient weight in them. However, that seems to lead to unsatisfactory results only in a limited number of aspects; furthermore, it can be compensated by simply asking occupants themselves what they think of those aspects. It is an important advantage of WWS that there is a lot of experience with its application and that it is, by and large, - the objective surface and facilities part – accepted by the various parties as a bias for valuation. It is obvious to keep, in any case, that part of the bias without worrying too much about the more subjective part: if the judgement of occupants must be asked in any case, in order to make the match and the new rental policy pre-supposes negotiation between both parties, why should valuation on these points not be made dependent on that negotiation? This way a basic valuation that can be objectified, with surface and facilities, emerges. The points do have a reasonable relation to building performance and may be maintained as a yardstick of points in government ruling. It is certainly desirable to check regularly by study whether the weight attribution in points sufficiently reflects the preferences of occupants. Multiplied by the average price of point on the level of rental or real estate markets a basic rent or reference rent can be calculated. The more subjective part can be replaced by a negotiation margin, the margin of valuation. This is globally in accordance with the other part of the present WWS, where no formal scoring precept is demanded, but at most a margin in percentage of the basic valuation.

19.5 MEASURING COSTS

Though most often used in building construction practice, investment costs are not practicable for assessing performance, optimisation and weighing alternatives. Running costs like maintenance, energy and management costs should be considered just as important as initial building costs. To compare different (re)design and (re)development alternatives a Life Cycle Costs approach using net present value is necessary.[a]

Methods and tools

In recent years a variety of design and decision-making tools was developed based on some kind of quality/cost assessment.[b] They are used for ex ante performance evaluation in the early project development and design stage; and focus on different levels of scale: product-level, neighbourhood-level and company/local-level, and different purposes: analysis, strategy development and assessment. Figure 148 shows the relation between them in the routing of project- (and policy-) development.



148 Routing of project-development[c]

Most of these tools are software applications developed for building and planning consultancy. They calculate integral life cycle costs to compare with qualitative variables, resulting in a performance score. Though practical for quick scan and weighing alternatives, the qualitative variable is the weak component. This can be seen, for instance, in the rather sophisticated Anymo-system, developed as computer software for portfolio analyses of rented dwellings.[d] The system evaluates the market position and performance of the dwellings. Basic determinants are the quality and the rent. Input data are quality aspects, derived from a list of criteria, and scored by a panel of managing staff and or surveyors. Based on the quality score potential gross rents and assets are estimated. The system is clearly market- and product-orientated and may best be applied for weighing alternative interventions regarding the market position of dwellings. The weak point of these market-orientated systems is that market-indicators are rather soft and fluctuating; often just symptoms for deficits to be neglected in decision making.

19.6 CONDITIONS AND RESTRICTIONS

Using these tools we should keep in mind conditions and restrictions. According to Potting *et al.* the tools may be reviewed referring to the following initial goals:[e]

a. rational basis for decisions;
b. efficient use of resources;
c. transparency of effects;

a See Ruegg, R.T. and H.E. Marshall (1990) *Building economics*.
b Flier, C.L. van der and A.F. Thomsen (1996) *Matching alternatives, Design & Decision Support Systems for the management of existing housing stock;* Broeke, R. van den (1998) *Strategisch voorraadbeleid van woningcorporaties, informatievoorziening en instrumenten*.
c Leent, M. van and J.M. van Vliet (1992) *Strategisch woonbeheer*.
d Idem.
e Potting, A. and M. del Canho (1990) *Behelpen als hulpmiddel*.

d. open democratic decision control (discussion of this goal is beyond the scope of this article: see the contribution of Van Loon on page 293);
e. use of professional skills.

a) The tools are meant to offer a rational basis for decision making on programs and plans. As seen above, the qualitative variable is often a weak point. And, apart from that, ratio is not the only ground for decisions. It is wise to take into account that assessment of alternatives in practice is influenced a lot more often by 'irrational' items than people like to admit.
b) The tools should enable more efficient use of budgets and resources. But, the use of them is a matter of optimisation: a rather good decision is not enough, one perfect solution does not exist and there is often more than one good alternative.
c) The tools should give a transparent view of the design process and the effects of programs and plans. This pre-supposes the presence of proper professional skills (see below). They are expected to reduce the complexity of decision making, but the result can be a false simplification of reality. Weighing alternatives should be based on comparable and realistic conditions or programs.
d) The tools should make use of professional skills. The selection of relevant information and parameter values is a matter of profound professional knowledge of housing management and economics: the most tricky part of the system. This includes minimal comparability and knowledge of use and misuse of evaluation methods.[a] Systems for experts may also be used to hide the absence of knowledge and skills, or worse: to generate and proof desired results. It is essential to keep an open and controllable check on input, throughput and output.

Ex-ante performance evaluation of dwellings implies reduction of doubts. Design and decision tools can help to diminish uncertainty and sharpen awareness of risky elements. But, even the smartest tools cannot give a guaranteed solution performing well.

a Lans, W (2000) *Housing evaluation, some methodological considerations*.

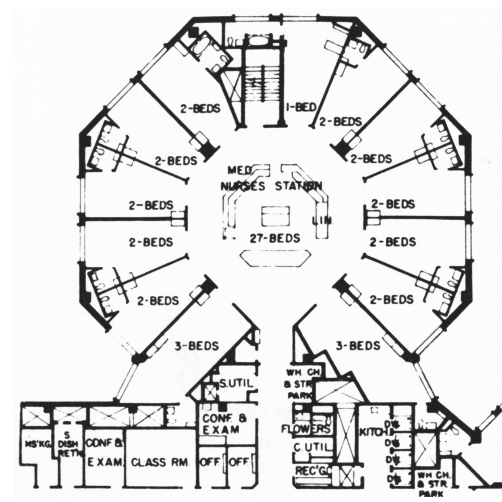
20 EVALUATING PROTOTYPES

THEO VAN DER VOORDT

Prototype design usually includes both ex ante evaluation and ex post evaluation. Ex ante evaluation of a first design may lead either to adaptations or to the conclusion that the design is ready to be built. After construction, ex post evaluation of the building may give rise to improvements. When the improved design is built, practical experiences may give rise to further improvements, and so on. This process may be of a sequential order, but design alternatives may also be tested simultaneously (see also Chapter 50). In this Chapter I will discuss several examples of prototype design with different combinations of ex ante and / or ex post evaluation.

20.1 TESTING DESIGNS FOR HEALTH CARE FACILITIES

In the late sixties a 570-bed hospital building was constructed in Rochester, Minnesota, for use as a laboratory for research into various aspects of hospital architecture.[a] One experiment investigated the impact of three different nursing unit designs on the activities and subjective feelings of nursing staff: a radial, single corridor and double-corridor or racetrack type floor plan. All tests using work-sampling and staff questionnaires were completed with the same administration and hospital staff. A total of 590 different people participated over a period of 82 days. In most instances the radial design turned out to be superior to the double-corridor, in its turn superior to the single-corridor design. The radial design showed less absenteeism and fewer accidents to staff members. Staff spent more time with patients, less time in travel. Physicians and patients also preferred the radials. This shows that specially designed buildings can be used to test theories relating architectural design to perception and behaviour. Such research needs designers to design and researchers to research.



149 The radial type nursing unit design

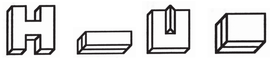
In The Netherlands too, study by design has been carried out in the Public Health System, particularly in Health Centres. Health Centres are co-operative organisations of general practitioners, neighbourhood nurses and social workers; often physio-therapists as well. In several Health Centres a pharmacy, dentist, psychologist and/ or other disciplines have offices.[b] This co-operation under one roof envisages increasing social visibility and the probability of an enduring regaining of health (often from a holistic vision on humanity), as well as using space more efficiently; for instance by sharing reception facilities and waiting-rooms. In the beginning of the eighties the decision was made to develop first-line health care in the New Town Almere entirely along the lines of Health Centres. In order to get more insight into the relationship between programmatic and architectural points of departure, as well as in investment and running costs, four designs were made for the same fictitious organisation. Next, these designs were evaluated in terms of quality of use and costs.[c] Four form variants were studied: peripheral (as many front-rooms as possible) versus compact (with many spaces within the ensemble), and for both variants a one-storey and a two-storey design. Per model two variants for construction were considered: weight carrying façades and inner walls, versus a skeleton structure with non-carrying inner walls. For each model a budget was prepared of the costs of investment, energy supply, technical maintenance and cleaning. Supposing a life-cycle period of 20 years, total costs (of investment plus exploitation) of the compact models proved to be clearly more advantageous than the peripheral models.

a Trites, D.K., F.D. Galbraith et al. (1970) *Influence of nursing-unit design on the activities and subjective feelings of nursing personnel*. For a brief summary see Saarinen, T.F. (1976) *Environmental planning, perception and behavior*.

b Hoogdalem, H., D.J.M. van der Voordt et al. (1985) *Comparative floorplan-analysis as a means to develop design guidelines*.

c Jonge, H. de, W. van Houten et al. (1988) *Prototype ontwikkeling gezondheidscentra Almere*.

d Wener, R., W. Frazier et al. (1985) *Three generations of evaluation and design of correctional facilities*.



	CRITERIA	P-1	P-2	I-1	I-2
1.	Plan-organisation				
1.1	Vertical transport	7	6	7	6
1.2	Situation waiting room	4	6	8	7
1.3	Connection waiting reception	8	8	8	7
1.4	Connection staff-public	4	5	7	6
1.5	Accessibility handicapped	6	5	7	5
1.6	Orientation	6	7	8	7
1.7	Acoustics	7	7	5	6
1.8	Inner climate	8	6	7	5
1.9	Reflection organisation	6	7	8	7
1.10	Usefulness	6	7	8	7
Total plan-organisation		62	64	76	63
2.	Urban architecture				
2.1	Fit to location	4	8	2	4
2.2	Entrance accessibility	6	8	7	6
2.3	Entrance safety	8	6	7	6
2.4	Orientation / sunlight	8	6	7	7
2.5	Stacking / vandalism	5	7	6	7
2.6	Noise hindrance	6	5	7	6
2.7	Construction depth foundation	6	8	6	8
Total urban architecture		43	46	42	44
3.	Future value				
3.1	Extendability	8	6	4	5
3.2	Compartimentation	8	8	5	6
3.3	Reserve space	-	-	-	-
3.4	Multi-functionality	8	7	5	6
3.5	Movability inner walls	-	-	-	-
3.6	Adaptability installations	7	6	5	4
Total future value		31	27	19	21

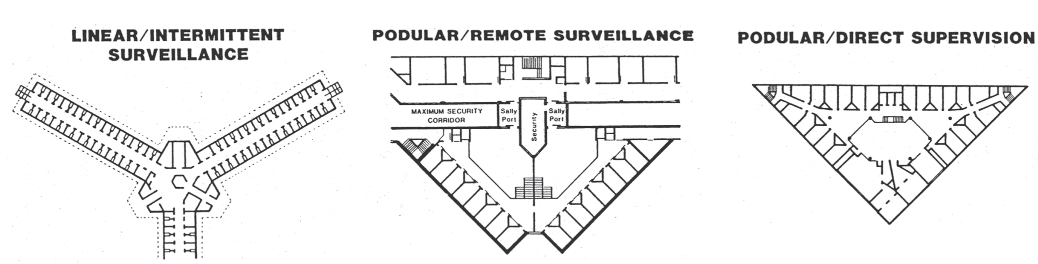
150 Evaluation and ranking criteria

Figure 150 surveys the evaluation criteria and the ranking ascribed to each model by an expert jury.

20.2 PROTOTYPE DESIGN OF CORRECTIONAL FACILITIES

In the mid eighties Wener *et al.*[d] published a paper on the process of data-based design i.e. behaviourally based evaluations in aiding the evolution of a design prototype for correctional facilities. This is a rare, but clear example of a completed cycle of study, build, test and reformulation. As a consequence of a pre-design programming study the Federal Bureau of Prisons rejected earlier models of jail design (generation 0) and developed a new model (generation 1). The old model was seen as oppressive, stressful and dangerous for staff and inmates alike. The new model should provide more humane settings with high levels of security. Basic assumption was that the environment should not be by itself punishing, but should reduce the physical and psychological brutality common in such institutions. Key to the goals of reducing tension and institutional regimentation was the functional unit system in which 40-50 inmates were placed in self-contained housing units. Instead of the usual linear type with intermittent surveillance, the concept of podular/direct supervision was introduced. Officers were placed in the living area, allowing proactive supervision. Each inmate got a single bedroom with a bed, toilet, sink, desk, and outside window. Within units, inmates had considerable freedom of movement through lounge, dining, classroom, and multi-purpose areas. The units were programmed to look non-institutional, by using movable, comfortable furniture, bright colours, and no bars. Most areas were carpeted.

Post-Occupancy Evaluations showed that the facilities were, for the most part, successful. Vandalism and graffiti were almost non-existent; violence and tension were considerably lower than in most other institutions. The staff perceived the environment as safe, clean and challenging. However, the high-rise buildings (12-26 stories) resulted in a frustrating dependency on elevators. Because units were self-sufficient, inmates often spent days or weeks without leaving the area and felt considerable monotony and boredom. Furthermore, two televisions per unit turned out to be too little, and complaints emerged on lack of personal control over physical systems (heating, ventilation). Based on these experiences, a great number of recommendations was made. Most of them were applied in a four storey federal prison in California (generation 2). Again this prison has been evaluated, showing high satisfaction levels overall, but still dis-satisfaction on the ability to individually regulate temperature and fresh air. Other issues of dis-satisfaction were overcrowding (the facility was designed for 383 beds, but in the event used by 520 inmates) and the lack of a secure perimeter beyond the building walls. A desirable result of adopting the direct supervision podular design was to raise the professional competency level for custody staff. Because staff mingles with inmates, they are able to prevent many problems from occurring. The POE-results can be used to improve the prototype again (generation 3).



151 Three different types of correctional facilities

In The Netherlands a study by design of prison systems was also conducted.[a] Considerable shortage of cells for inmates caused an accelerated building programme. Based on systematic analysis of realised projects four models have been developed with well-defined typological differences (figure 152). Particularly the way in which the cells are positioned *vis-à-vis* one another, and with regard to the space outside and to the other facilities, differs:

a. *Model 1: the* radial. The habitation building features two identical wings, four storeys high, at right angles. The cells are opposite one another, the common rooms at the ends. Duplicating both wings generates the so-called 'cross-type', characterised by short walks and ease of surveillance. The idea necessitates a surrounding wall.
b. *Model 2: the* back. This type is provided with a stark, almost blind, outward skin. All spaces are orientated towards the inner court. "Residing" is allocated within two triangular building masses with a lot of inner spaces. The requirement that cells are not allowed to be situated on street level if they adjoin the space outside caused a stapling in five storeys with a surfeit of space on street-level. A surrounding wall is not needed.
c. *Model 3: the* cupola. Point of departure here is a compact form of building. The cells make for the four sides of a square; the pavilion facilities lay in the inside along large viewing apertures. This idea necessitates a surrounding wall.
d. *Model 4: the* atrium. In this model the cells are situated at the outer side, opposite of the pavilion facilities. All parts of the building have been grouped around an area for sports and airing. A surrounding wall is also necessary in this case.

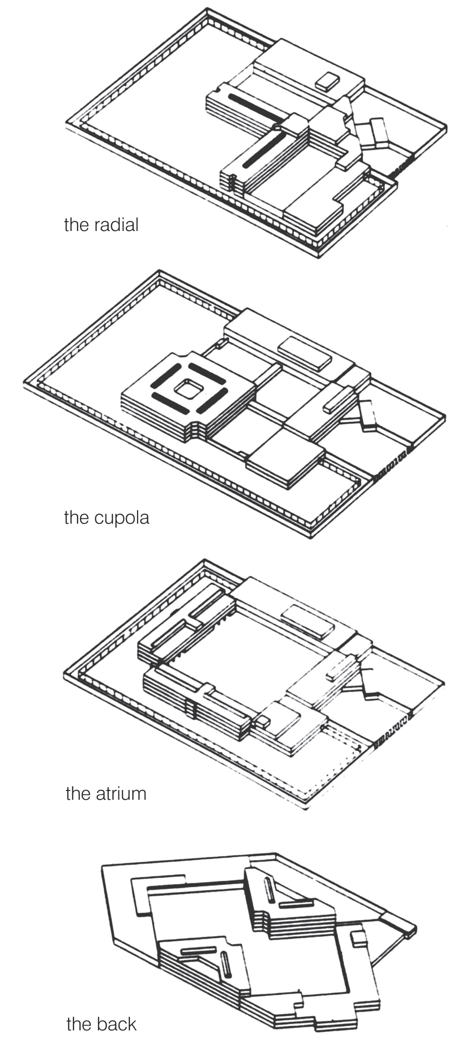
Just as in the case of the study concerning Health Centres, the four models have been compared to one another in terms of costs and quality (figure 153). In this case an important cost variable is utilisation of personnel, an important quality aspect of safety. The costs of construction, including additional costs, those of the site and of Value Added Tax, varied demonstrably between Dfl 254.000 and 360.000 per cell (price level 1989); a lot lower than the 500.000 initially budgeted. This profit mainly stems from sophisticated designs – particularly from a better ratio between net versus gross floor surface than in existing prisons – ascetic use of material and rapid construction.

Model 1 – the radial – boasts the lowest costs per cell, particularly by the lower demand for services of personnel (less static posts).

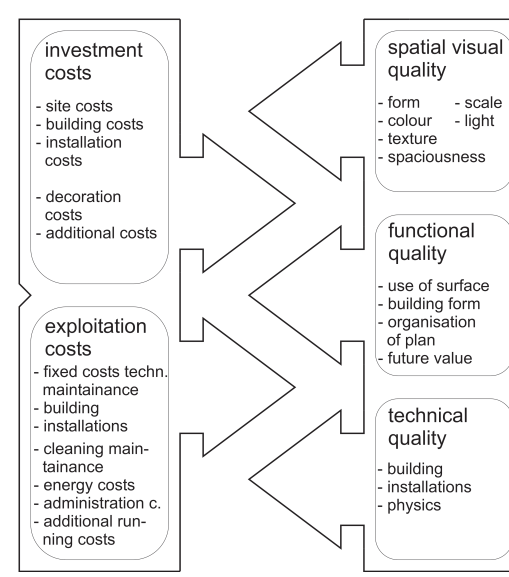
The financial influence of securing the environment proves to be so significant, that model 2 – the back – in spite of the highest costs associated with building itself ends up in terms of total costs in the next but lowest position. Disadvantages of model 2 are mediocre functionality and high level of personnel services. The possibilities for future adjustments are limited.

The financial advantages of the compact model 3 – the cupola – are largely annihilated by the high costs of internal compartmentalising. The model is not readily inspected and requires, just like model 2, a lot of personnel.

Model 4 is the most expensive variant except one; functionally it is rather good, with a reasonable demand for personnel activity. Differences in construction costs, caused by the type of building, are in the order of magnitude of 7% for the cheapest variant. The influence of the technical levels almost triples this. The impact of openings in inner walls and fronts, air-conditioning, sanitary installations and those for security and communication may accumulate to costing differences in the order of magnitude of Dfl 35.000 per cell. This study brought the consequences of some important design decisions to light. In addition to a plan-documentation and analysis of existing prisons, the results were used by government to legitimise empirically the policy for building prisons.



152 Four models for correctional facilities



153 Variables for a cost/ quality comparison

20.3 REFLECTIONS AND CONCLUSIONS

Study by design in conjunction with careful effect analyses may prevent many problems. The examples described demonstrate that considerable advance may be made as far as costs

a Jonge, H. de (1988) *Het beheerste ontwikkelingsproces, voorbeelden van productverbetering;* VROM (1989) *Een vergelijking van penitentiaire inrichtingen in Nederland.*

and quality are concerned. A kindred example is the range of designs for primary schools in the new town Almere in the Netherlands, previously mentioned.[a] By applying extra isolation, recycling heat from mechanically ventilated air, a lot of day-light and automation of electrical illumination, it could be shown for the first generation schools per annum and per building, that on average some 26.000 m^3 natural gas less was needed, compared to traditional school buildings (generation 0). The extra investment could be earned back in less than 10 years. Because of this success in the second generation schools additional energy conserving provisions were implemented, in combination with 'alternative' energy facilities like solar collectors and a wind turbine. It is hoped that this way an additional 2400 m^3 natural gas may be conserved.

In spite of this obvious usefulness of prototype design based on design study and study by design, it is still relatively scarce; and largely exists 'on paper'. This is partly explained by the time and costs incurred by alternative designs and effect-analyses. Another factor is, perhaps, that in design the personal vision of the designer and/ or commissioner is greatly valued. Personal considerations and ideals often guide designs. A thorough effect analysis carries the risk that the design has to change fundamentally. There is also fear of standardisation and repetition; in this case re-producing an existing design solution one more time, in The Netherlands also called 'stamping', a term of derogation. In the long term this can lead to monotony and cultural poverty. However, prototypical buildings are not like mass production products functioning in any context. Each building – even with a generic style or function – is unique in location, orientation, client and user population. Although certain key aspects of the design may stay constant, others necessarily change to fit different needs.

For higher levels of the craft of designing in terms of the profession and of scholarship a continuing exploitation of study by design is crucial. The building blocks: further development of the framework of study (how to make which variables measurable), and establishing databases with reference projects, including plan-analyses and evaluations of costs and quality. Another important condition is the willingness to formulate design objectives and expectations explicitly and openness for objective evaluation. Usually, designers and advisers work together on the same plan during the stage of plan development. It ought to be just as evident that while analysing and evaluating the effects various disciplines should co-operate. Only then 'synthesis' and 'integration' become really meaningful expressions.

a Niesten, J. (1983) *Almere bouwt tweede serie energie-zuinige scholen*.

21 COMPARING AND EVALUATING DRAWINGS

TAEKE DE JONG

Design study, design research and study by design imply already by themselves comparison of different designs or designs in a different stage. Also when considers judging a design 'on its own merit' one employs implicit references. With a scientific design they should be explicit. In design research the designs should be studied empirically (goal-orientated or means-orientated). In design study and study by design they are *made*. Judging them (with norms) supposes evaluating them (with values). Evaluating supposes effect analysis (without values), and effect analysis supposes comparing; by identifying differences and comparing supposes explicit and expressive description. This Chapter provides criteria for these levels of evaluation.

21.1 EXPLICITNESS AND EXPRESSIVENESS

When one plan is more pronounced and eloquent than another (more explicit and unequivocal to understand) it is impossible for the judging agency to compare and, therefore, to judge. Both criteria represent the information content of the drawing, its diversity and the extent to which the designer has reached statements and stimulating ideas (see page 36).

A plan that is not outspoken leaves everything in vague images to the fantasy and the references of the judge. It might be poetical, evocative, productive and innovative (in practice also lucrative as a disguised study of the wishes of the principal), but it cannot be judged scientifically in principle. 'Outspokenness' is a condition for each following criterion. With a means-orientated design sketches lacking that quality may be the object of consideration on its way to an outspoken design.

Next, a design may be outspoken, but lacking richness; e. g. it may comprise only clichés and by the same token not say more than what everybody knew already, even if it is visualised in a new way. This is, for instance, the case when a design would consist out of two interlocking legend units 'built' and 'unbuilt' with the smallest boundary length between them: very outspoken, yet not always rich. With a plan like that one hears the judge sigh "What should I say about this now?" Thus, this criterion is also a condition for all subsequent criteria.

21.2 COMPARABILITY

The drawings of plans to compare should obey some criteria. Plans of a different scale and resolution are hard to compare, also since the legends are not identical per definition. In order to compare a plan with a lower level of scale to one with a higher one, the plan with a higher scale level should get the same legend (Latin: *legenda:* things that must be read). For that purpose one can quickly substitute in a part of the plan standard components (capacity plan). A capacity plan fills the location with the same programme as the design (interpolation) with standard components (zero variant). The design proposed may be compared with this: in which regards is it different, better or worse?

21.3 DOCUMENTATION AND RETRIEVABILITY

The outspoken and rich architectural drawing is only comparable and quotable in a scientific forum and thus open to criticism in a different scientific context, if with it such documentation is provided (key-words, possibly syntactically connected) that the drawing by itself is reducible to scale (frame and grain), site, intention, context, perspective and possible readable effects on the context. These image characteristics are as many foundations for comparison to enable scientific judgement.

21.4 SUPPOSED CONTEXT AND PERSPECTIVE

In contexts the political, cultural, economical, technical and/or ecological-spatial context on different scale level may be involved. Not only a context with a larger scale than the frame of the design plays a rôle, but also the context with a smaller size than the grain of the design (the smallest unity in the design process).

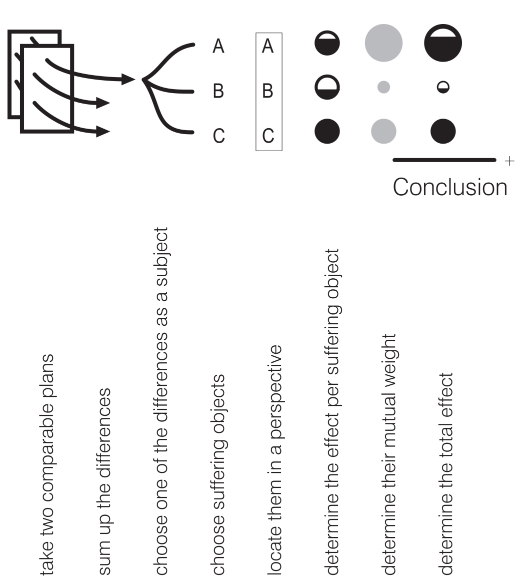
Comparison of plans always takes place implicitly from a given perspective, an expectation with regard to probable political, cultural, economical, technical and/or ecological-spatial developments outside of the design-object. An effect analysis in one perspective may work out entirely differently in another one. In the case of the scientific design it is expected that this personal perspective is made explicit: “I expect a steering national authority, a following regional authority, a shrinking local economy..”, etc. These points of departure may be the same for different effect analyses.

21.5 INTENDED AND NOT INTENDED EFFECTS

After execution (ex post), a design always has many political, cultural, economical, technical and/or ecological-spatial effects. They can be intended or not intended. The intended effects have been determined beforehand as design criteria in a programme of requirements. Usually they are positive and need not be involved in effect analysis. They should be mentioned beforehand as intention, goal formulation, design criteria or design programme and play a rôle in the judgement: “Have the criteria been met?” In this respect an effect analysis would only lead to circular reasoning like: “The goal was to realise a hundred homes; ah well, the design foresees in a hundred homes, so the effect is that a hundred homes have been realised.” The unintended effects (e.g. “Because a hundred homes have been added to my design the shopping centre has become too small.”) can never been foreseen in their entirety, but should receive attention in the apology of a design (intervention).

21.6 EFFECT ANALYSIS

During effect analyses the effects of the differences between two outspoken and rich plans are compared. They enable evaluations based on values, but they do not equal them. They are just condition for evaluations: identical effects may be valued differently. For that reason an evaluation should be preceded by a more objective effect analysis. This criterion of an added effect report with some possible evaluations for a scientific design thus goes beyond the usual criteria for empirical-scientific study. In the apology of a design, attention is asked for the effect of each design intervention on the design itself, and on its context within a perspective.



154 Steps in effect analysis comparing plans

The first step in an effect analysis is to make the plans comparable by bringing the legends of both to the most detailed level. The second and third steps are to make a summary of the differences and to select one difference in order to report the effects of that particular difference. For instance: ‘In this plan the civic centre lies more excentric than in the zero-plan.’ If one would report the effects of all differences in one sweep it is impossible to see which design intervention caused the effects precisely.

The fact that some effects can only emerge through combination of design interventions complicates the situation. The fourth step is to select the categories undergoing the effect, the working (suffering objects)[a]: for instance political, cultural, economic, technical, ecological or spacial objects (their spreading or concentration). On which scale do the effects manifest themselves? To answer that question, see the context diagram on page 38. The fifth step is to consider the effects in the perspective chosen.

21.7 EVALUATION

The sixth step is to determine the positive or negative effect per suffering object and to try to provide them with a numerical value. The seventh step is an evaluation: to ascribe to the suffering objects a mutual weight (for instance: the effect on an ecological object is more important than the effect on a cultural object).

a This term has been chosen since each effect analysis has the form of a full-sentence with a subject (the design intervention at the source of the operation), a verb (working) and an object (the object undergoing the working). See also Chapter 0 on verbal models.

The final step may be a list of effects, multiplied by their weight and a conclusion. Is the design superior to the zero variant? Also the scholar designer who reaches the conclusion that this is not the case (which could show itself in a low appreciation for the design on the appropriate scale level) may receive high scientific regard for the evaluation.

21.8 JUDGING DRAWINGS

Judging pre-supposes comparison as well, even if it is often implicit in who judges and in the person judged (the designer). Both parties do have their references. The judgement 'this is a bad chair' pre-supposes other chairs. By the same token judging requires at least two comparable plans: the design to be judged and at least one comparable 'zero plan' (precedent, reference, example with a comparable programme, a capacity plan[a] in a comparable context, limitation and legends). For a scientific design one such zero-plan, like intended in criterion A, page 28 must be explicit. If a zero-plan is known, the unintended effects this zero-plan has in common with the design to be judged are not open for discussion. If the designer would not make such a reference explicit, the discussion would be endless. Judgement would concern the immense number of thinkable differences compared to all references of the judge. A reference plan concentrates the judgement on meaningful differences. Nevertheless the judge may always introduce other references. Criticism then concentrates on the selection of the reference. The intended effects always stand to discussion as preliminarily formulated criteria.

a For instance a collage with programmatically equivalent components from known plans.

MODELLING

D MODELLING

In empirical science existing reality is modelled. Central in this section stands the making of consistent verbal, mathematical and visual models and their relation to reality.

Modelling reality

There are many types of models, as Klaasen will explain in the first Chapter of this section. It is highly significant, that several types of models are in existence, but not several models of types.

Verbal models

The best described, most widely accepted form of consistency is formal logic. This also is on a higher level of abstraction a model (meta-language) of common language. Verbal models of architectural objects carry on their own level as an object-language the properties of this model. In the corresponding section de Jong adresses proposition and predicate logic, and their linguistic restrictions.

Mathematical models

De Jong elaborates different mathematical tools to be used in architectural, urban and technical design and evaluation. In the mathematical model of a design, connections may be read that enable evaluation of constructive or functional connectedness.

Visualisation and architecture

The language of the drawing is, due to its endless variation, less consistent than conversational language with her verifiable syntax, grammar and inherent logic. Considerable sensitivity as to context and interpretation of the drawing implies both her logical weakness and heuristic prowess at the same time. Yet, consistent and verifiable visual models can be made. Koutamanis gives examples.

The empirical cycle

On a higher level of abstraction the empirical cycle is also a model; according to many – including the author of that Chapter, Priemus – the only consistent model for scientific practice. It can be copied in any research project. That model is broadly accepted. It is based on the growth of knowledge to be generalised by well-defined testing. The time consuming shaping of a hypothesis, like with the architectural design, is in this respect 'free', not further modelled. The usual scientific approach pre-supposes in its turn consistency in discourse.

Forecasting and problem spotting

Mathematical models play an important rôle in forecasts and consequently in problem spotting that may give rise, for example, to the formulation of an architectural programme of requirements. Their conceptual framework is explained in the corresponding Chapter of de Jong and Priemus by way of large-scale examples.

Conclusion

A model demonstrates more relations than a concept or type, let alone an intuition: it is more consistent. However the model is not yet reality and should not be confused with it. Many relations – topographical, situational – will be lacking in the model. Incomplete models of a design may be made in order to make sector effect analyses and to test the design according to certain values and objectives of the relevant stakeholders (evaluations). Sometimes this requires more modelling than the design itself allows. A scale model is a model, if it allows evaluation like that; very realistically, like in a wind tunnel. A sketched-scale model rather has a function for further development of the design; also if it has not, as yet, the consistency of a model with its inter-subjective checking potential.

22 MODELLING REALITY

INA KLAASEN

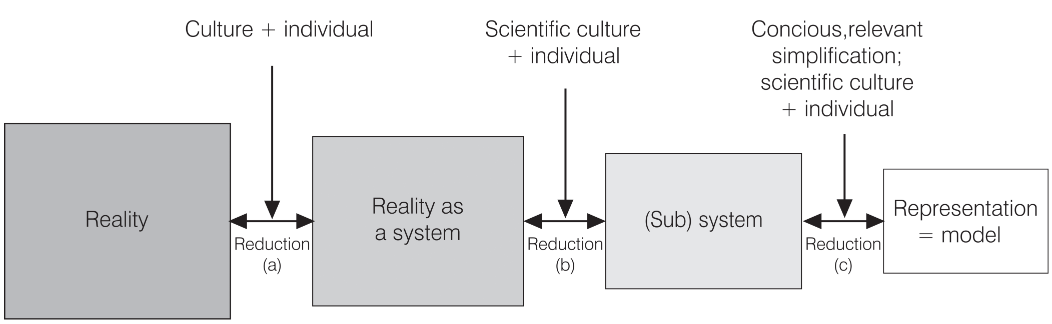
In order to be able to inform, communicate and reflect on (future) reality we must imagine, articulate, calculate and simulate in models. In models reality is deliberately drastically reduced in a justifiable way. Models may be concrete, conceptual or formal. All two-dimensional architectural analyses, exploration studies and designs are conceptual models.

The functions of scientific models may be further classified in explorative, descriptive, explicative and projective functions, concerned with reality in the past and the present, and the probable and / or possible reality in the future. Insofar as architectural models are, contents-wise, made of words and numbers it must be feasible to translate them into spatial models (the so-called ‘medium switch’), or to contribute to the construction of spatial models. With the translation ‘backwards’ to (future) reality it is important to watch out for ‘model over-extension’.

22.1 THE MODEL[a]

A simplified rendering of reality – present or future – is called a ‘model’ of that reality, provided that a structural relatedness exists with that reality and that the model is based on conscious interpretation of that reality (figure 155). Without models science is inconceivable.

In a model, reality is approached from a certain angle. Seen in one way, this angle is determined by (scientific) cultural backgrounds; often without conscious awareness. Seen another way, it is context-orientated; preferably explicitly. An urban architect makes a different model of a residential neighbourhood than a social geographer or civil engineer. Models are not value-free: moreover, they should not be.



155 We may think of reality as a complex of (sub-) systems (a). This simplification (reduction) of reality is made unconsciously and is not only based on the reach of naturally determined human powers of perception and thought, but also on cultural pre-suppositions, where individual differences apply. From this reality we may separate consciously sub-systems (b), based on intentional considerations and (scientific) cultural pre-suppositions that might differ per individual. The sub-systems may be presented next in models of the reality (c).

22.2 KINDS OF MODELS

In a presentation reality may be put into words, numbers, ‘imagined’ on a scale, or simulated. This leads to a classification of types of models:

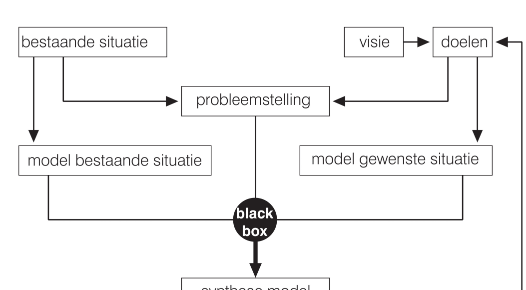
- verbal models
- mathematical models
- spatial models
- mechanical models

A verbal model is a discourse in words (figure 156). In this vein the structure of medical education at Limburg University functioned as a model for re-structuring the architectural education at Delft – with all the pitfalls inherent in the use of an analogue model.[b] A well-known verbal model is *‘Our Common Future’*, the so-called Brundtland Report of 1987.[c]

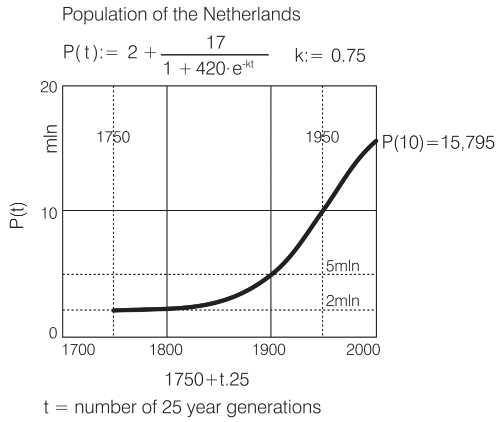
Who does not understand the Dutch language will find the models in figure 156 incomprehensible; to them the models do not have a communicative function. When words are used with different meanings in scientific (sub)cultures of a (scientific) linguistic community, faulty communication may occur.

156 Example of a verbal model, respectively visualised verbal model: procedure graduation project.[d] In this case visualisation does not make the model a spatial one.

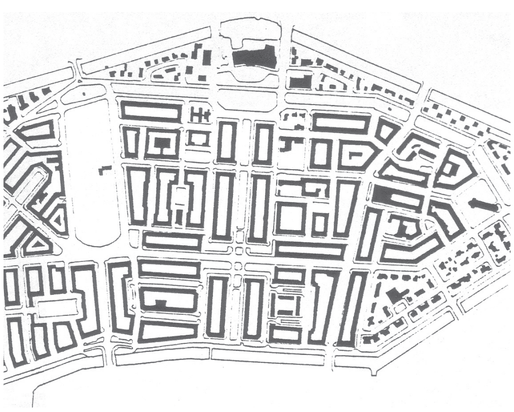
In de door ons gehanteerde werkwijze wordt een onderscheid gemaakt in modelmatige weergaven van de bestaande situatie en mogelijke wensmodellen.
Konfrontatie van beide modellen - these en antithese - leidt vervolgens tot een synthese- en ontwikkelingsmodel. Een ontwikkelingsmodel is te omschrijven als een ruimtelijk kader dat randvoorwaarden stelt en richting geeft aan verdere ontwikkelingen.



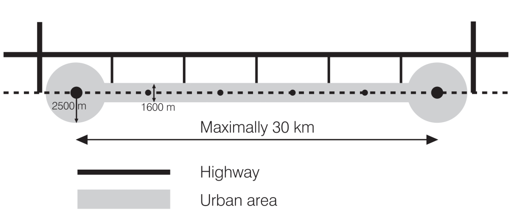
a In the present and following paragraphs use has been made of Bertels, K. and D. Nauta (1969) *Inleiding tot het modelbegrip;* Chorley, R.J. and P. Hagget (1969) *Models in geography, parts I, II and V;* Soest, J.P. van, J. van Kasteren et al. (1988) *De werkelijkheid van het model*.
b Klaasen, I.T. (2000) *Valkuilen bij stedebouwkundig ontwerpen: verwarring tussen model en werkelijkheid*.
c In contrast to previous comparable ‘world models’, the ‘Brundtland Report’ does not include numerical models, because the pre-supposition that a (global) system may be manipulated is too dependent on thinking along causal lines (Soest, J.P. van, J. van Kasteren et al. (1988) *De werkelijkheid van het model*, p. 86).
d Frijlink, F. and L. Leferink (1991) *Waar het leven goed is - een stedenbouwkundig ontwikkelingsplan voor West Brabant*.



157 Graphic representation of an example of a mathematical model with mathematical contents



158 Example of a spatial model on scale: a (possible, future) articulation of a site.[b] Without explanation of the symbols used (legends) this model is incomprehensible to the 'uninitiated'.



159 Example of a spatial model: a principle model of a city resembling a ribbon

160 Depiction of a mechanical model of a rail system[g]

161 Spatial model of a rail system[h]

a Draaisma, D. (1995) *De metaforenmachine, een geschiedenis van het geheugen*.
b Thüsh, M. (1993) *Almere, uitgeslapen stad*, p.140.
c Draaisma, D. (1995) p.26.
d Bertels, K. and D. Nauta (1969) *Inleiding tot het modelbegrip*, p. 38.
e Citation from an interview with Douwe Draaisma on the use of metaphors. Delft, D. van *Zien en niet geloven; het beeld in de wetenschap beslecht zelden een controverse*. See also Draaisma, D. (1995).
f Frey, G. (1961) *Symbolische und Ikonische Modelle*.
g Source: *Miniatuurbanen* (1963) nr. 6, p.170.
h Source: Jacobs, M.; A. Geerse and I.T. Klaasen (1994) *Snelle trein ontspoort in de Randstad*.

A mathematical model is made up of numbers or symbols (Figure 157). All computer models are mathematical models, even if they are presented as spatial models, like GIS products (Geographical Information System) and 3D models.

The '*Limits to Growth*' report of the 'Club of Rome' of 1972 is an example of a report constructed out of mathematical models. In contrast to verbal models, mathematical models employ a universal 'language', with the proviso that this does not apply for its verbal parts.

A spatial model is a spatial rendering of three-dimensional reality (practically always) on scale. Every three-dimensional model is a spatial model, but so are all architectural designs and maps (figure 158 and 159).

(Sub)cultural agents, often hardly consciously experienced, determine how we visualise and depict something. The use of symbols in a 'picture' language may be compared to the one of words in ordinary language. Unlike the case of numbers the meaning is not universal. Symbols must be explained (legends). *"The image is the result of a long sequence of agreements, conventions, codes, tunings, etc."*[a]

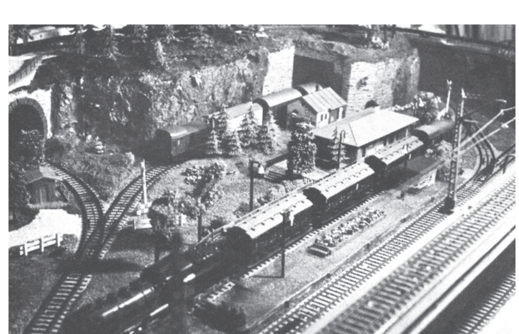
A shape metaphor may be the basis of a spatial model. Examples of shape metaphors are the 'Green Heart' (figure 172) and 'Ribbon City' (figure 159). A well chosen metaphor activates two associative processes at the same time: verbal and visual. This increases the chance that the relevant information is brought across: its communicative value is high.[c] Bertels and Nauta claim that the vague suggestiveness of a metaphor can have great artistic value and cause aesthetic delight.[d]

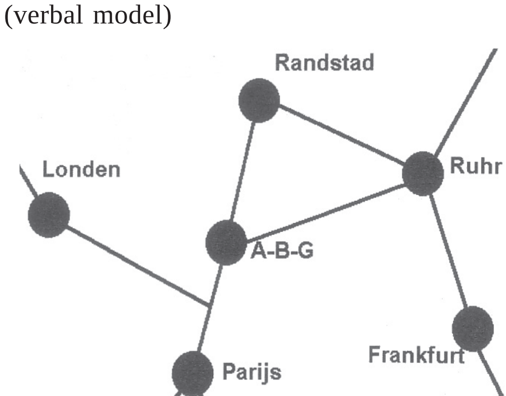
"Images are cognitively enormously compact, they can accommodate mountains of information; information not readily expressed in words. Consider the effort that is needed to enable computers to recognise faces. Images favour the strong points of the human brain. We made drawings before we wrote, we have a fabulous memory for images, better than for text. Add a summarising metaphor to a text and it will be remembered a lot better."[e]

A mechanical model (figure 160) is a model functioning in analogy with its original. It is a spatial model with real time for fourth dimension. An example is a planetarium, a dynamic model of the solar system. The reality of a mechanical model can only be depicted as a spatial model. Aided by a computer a mechanical model may be simulated; compare this to film, a rapid succession of static images.

Given a system in reality, say a rail system, we may opt for simplifications of different kinds, and consequently for models of different kinds. The choice of a type of model is based on the function the model needs to perform and on the personal preference of the makers. The following example is inspired by G. Frey.[f] We may reduce the reality of a rail system to:

- a model railway net (mechanical model; figure 160)
- the positioning of lines of rail and stations (spatial model; figure 161)
- a schedule of the job allocation of railway employees (mathematical model)
- a description in words of the structure of the system, like types of connections and mutual relations, speeds, frequencies of departure (verbal model)





22.3 TYPES OF MODELS IN THEIR RELATIONSHIPS TO REALITY

Models may also be characterised according to their relation to reality. Models can be:

- concrete (spatial and mechanical models);
- model (conceptual(verbal, mathematical, spatial, mechanical));
- formal (mathematical models).

A model composed of empirical identities is a concrete model. Concrete systems and models correspond with 'matter'. Concrete models feature spatial dimensions. Concrete models allow realistic experimenting. Examples: model railways (figure 160), urban / architectural models. Sunlighting studies might be undertaken with the help of such a three-dimensional model (figure 162). Another example is a basin filled with clay, sand and streaming water to study patterns of flow. Architect Geoffrey Broadbent mentions an example of a concrete spatial model – an analogue model – of a non-spatial concrete system; a system without length, width and height.

"The national economy has been represented at the London School of Economics by means of a bath into which water flows at controlled rates (representing income) and out through holes of specific sizes in specific positions (representing expenditure)."[b]

A comparable experiment in urbanism with the help of an analogue model is commented on in figure 163.

A conceptual model is a mental construction (theory, sketch) referring to the (past, present, future) reality. A conceptual model is composed of conceptual identities. Bertels and Nauta used in the pre-computer era the evocative term 'paper and pencil construction'.[d] Conceptual models and systems correspond to 'comprehension'. Conceptual models only lend themselves to thought experiments, also called 'thought models'. Examples are construction drawings and design sketches (figure 158 & 159). A classic example:

'Galilei considered an imaginary experiment involving perfectly spherical balls in motion on a perfectly smooth plane. It would be impossible to achieve these ideal conditions in any actual experiment because of the intervention of friction and imperfections on the spheres. However, this ability to abstract from the conditions of the real world played an essential part in Galileí's formulation of a new science of motion.' [e]

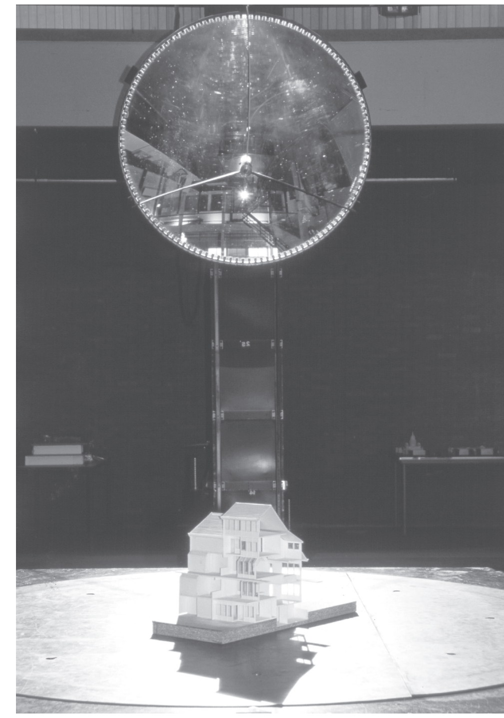
All two-dimensional spatial models, urban / architectural blue-prints included, are thought models. This also applies to three-dimensional models depicted on flat surfaces, and to virtual designs. Conceptual spatial models are, literally, 'thought images'. (Urban)architects will seldom be in a position to experiment with their products; this in contrast to industrial designers, for instance, who can use conceptual models as well as concrete models. A concrete model of a teapot, for instance, can be tested on efficacy.

Finally, a formal model is an un-interpreted syntactic system of symbols (calculus, algorithm). Geographer David Harvey calls an element of a formal (mathematical) model a 'primitive term', and compares it to the – dimension-less – concept 'point'.[f] Only structure imports, not content. Formal systems and models correspond to abstract names.

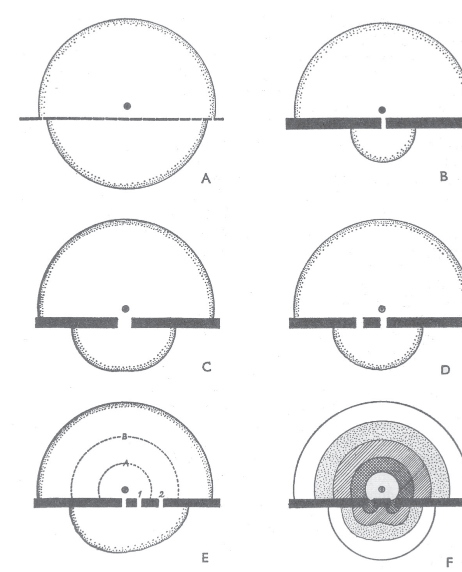
Examples of formal models are un-interpreted mathematical models (consistent conglomerates of mathematical equations) of a concrete hydrological system, for instance (reality is summarised in a series equations) and the formalised conglomerate of Euclid of the conceptual system 'Euclidian space'.

22.4 FUNCTIONS OF MODELS

Models carry information and are consequently instrumental in communication, study and research. The exchange of information may be directed at the transfer, respectively widening of knowledge, but also at action or eliciting action. By the same token models may also be



162 Sunlighting-experiment aided by a model [a]



Blotting paper analogues simulating gross morphological features of river towns. A suggests that where a river can be crossed easily at many points the town will develop almost equally on both banks. B, C and D are examples of the shapes resulting from various restrictions to easy access to the opposite bank. E is a rudimentary growth model, in that when the solvent front reached the line A bridge 1 was added. Bridge 2 was added when the solvent front reached the line B. This process leads to a marked asymmetry in the shape of the part of the town on the far side of the river. F is a plot of the various stages of growth.

163 Depiction of a concrete blotting-paper (analogue) model of an urban system.[c]

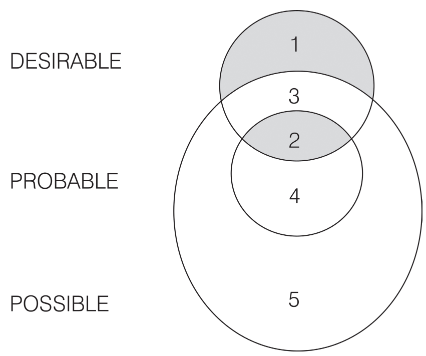
a Source: photographic service, Fac. of Arch. DUT.
b Broadbent, G. (1988) *Design in architecture: architecture and the human sciences*, p. 89.
c Chorley, R.J. and P. Hagget (1969) *Models in geography, parts I, II and V*, p. 763.
d Bertels, K. and D. Nauta (1969) *Inleiding tot het modelbegrip*.
e Commentary on Galilei, G. (1632) *Dialogue Concerning the two Principal Systems of the World*. Source: The Open University (1974) *Science and belief: from Copernicus to Darwin*, unit 3, p. 117.
f Harvey, D. (1973) *Explanation in geography*, p. 452.

interpreted in terms like discussion model, participation model, seduction model, study model, more specifically heuristic model, action model, execution model, etc.

From a scholarly angle models can be classified as follows:

164 Types of models according to their function

function:	*aimed at:*
descriptive model	what (probably) is the case
explicative model	because of what or why that (probably) is the case
predictive or probable-projective model (= trend scenario)	what probably will be the case (probable future)
intentional-projective[a] model (= planning model)	what we have decided that should be the case
(explorative)-potential-projective model (design or explorative scenario)	what possibly can be the case (possible future)



165 In this (spatial, descriptive, conceptual) model the 'probable futures' are a subset of the 'possible futures' and contains the set 'desirable futures'[b], parts of the set 'possible' and of the set 'probable futures'.[c]

This survey is related to the modality schema of Taeke de Jong (figure 165). Establishing a relationship between the model-functions and this schema of modalities generates the following classification:

166 Types of models according to their modality

1 desirable, but impossible	model without an application field (fiction)
2 desirable and probable	trend scenario deemed a desirable development
3 desirable, possible, but improbable	intentional-projective model (planning model, design)
4 undesirable, but probable	trend scenario deemed an undesirable development
5 (still) undesirable[d] and improbable but possible	explorative-projective model (explorative scenario) or potential projective model (design)

A descriptive model is a model of an existing situation or process:

- maps of the existing situation (figure 167);
- descriptions in words or numbers of an urban system;
- programmes of requirements;
- description of the procedure followed (figure 156).

An explicative model does not restrict itself to the 'what' or 'how' question, but addresses the 'why' or 'because of what'; based on insight into the working of processes, traditionally seen from the angle of causal, but also of conditional thought.

An explorative model is used to get insight into:

- what is the case (or what has been the case) or,
- what might be the case (or might have been the case); for instance in the study of the mechanisms of the 'global warming effect';
- future (developmental) possibilities.

167 Descriptive model, conceptual[e]

a Instead of 'projective' the concept 'prospective' may be used. The use of these terms is in the spatial sciences not unambiguous (see, for instance Vught, van and van Doorn (1976) *Toekomstonderzoek en forecasting;* Kleefmann, F. (1984) *Planning als Zoekinstrument*). Here the conceptual descriptions of the leading national dictionary is followed, giving as the first meaning of '*projecteren*' '*ontwerpen*'.
b 'desirable': desired by a given organisation, such as a lobby, political party, a government – or the designer himself.
c Jong, T.M. de (1992) *Kleine methodologie voor ontwerpend onderzoek*, p. 9.
d (Still) undesirable, since 'undesirable' is restricted by ethical boundaries.
e Duijvestein, I (1997) *Mitla*, p.1

Examples of the latter case include (spatial) design studies (study by design) (figure 168) and studies trying to answer the question whether a specific programme might fit, in principle, in an existing plan.

A predictive model (probable projective model) (trend scenario) indicates what probably will happen, given a specific situation, based on insight into the working of processes (figure 169). On the basis of a model of a solar system one can predict that the sun will rise tomorrow, at what time (most probably). Well-known examples of predictive models are those forecasting election results, tomorrow's weather, those of the 'Club of Rome' – among them *'Limits to Growth'* – and the economic models of the Netherlands' Bureau for Economic Policy Analysis.

Descriptive, explicative and predictive models are linked to one another and belong to the domain of empirical sciences.

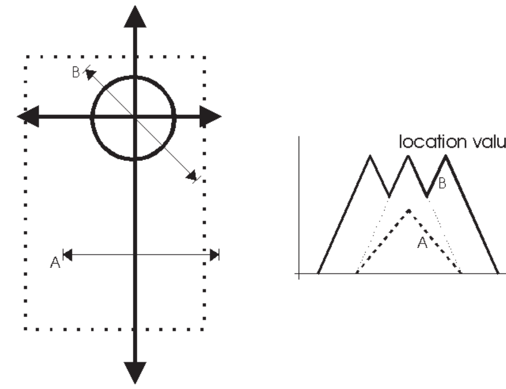
A planning model (intentional-projective model) is a model for a situation, deemed desirable, that does not yet exist, requiring one or more specific actions in order to come in existence ('goal-orientated' design, desirable scenario). Planning models are action models. Examples: the design for a bridge, an educational programme, a holiday trip (figure 170).

In potential-projective, explorative models (designs) possible future situations are rendered, the desirable ones along with those deemed undesirable. Alternative designs are also called 'scenarios'. The original meaning of the word 'scenario' denotes the sequences of actions in the theatre. The use of the term 'scenario' as an alternative projective model was introduced by the American 'Rand' Corporation. 'Rand' theorists, particularly Herman Kahn, developed in the sixties systematically possible futures, to give policy makers insight into (un)desirable effects of policy measures; effect reports, really.[c]

Scientifically understood, a scenario can be viewed as a model with a progressive temporal aspect. From a specific, well described, initial situation, possible future situation are presented in a consistent (logically connected) and plausible way. At the same time usually a trend scenario is made, to lay foundations for recommended changes in policy. Generally, several scenarios are developed to enable comparison. The differences in the scenarios are based on difference in pre-suppositions with regard to factors influencing developments. Figure 171 gives an example of these 'explorative scenarios'.

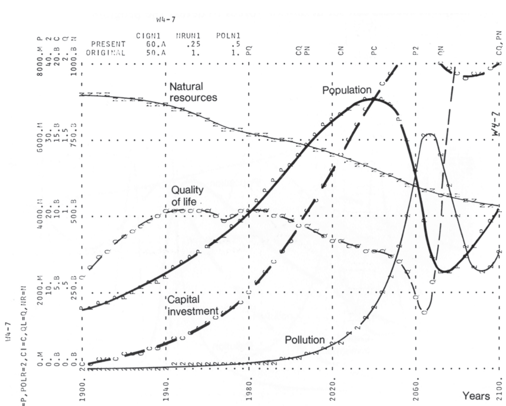
A model for a future reality, or an element of it, is also denoted as a 'concept'. More correct would be 'conception' (both from the Latin '*concipere*': to take together).

In urban design / architecture the notion 'spatial concept' is used in the sense of a rough design. In the initial stage of a design process it is used to facilitate the designer himself, during the later stages of clarifying the design, for instance when communicating with



168 Spatial explorative conceptual model, (left) and conceptual, graphically rendered, mathematical model (right).

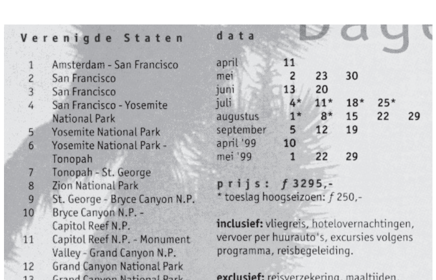
At the crossroads in a ring road, the location-value based on accessibility is equal to that of the central intersection. It may even become equal to it or greater, depending on the quality of the ring road compared with that of the radial roads inside its perimeter.[a]



169 Graphically rendered mathematical, predictive model, conceptual[b]

170 Example of a planning model, from a travel brochure (Travel Agency Djoser, 1998)

171 Five scenarios (explorative-projective models) for the way in which the region of The Hague could accommodate a population increase of 50.000 inhabitants in 2005.[d]



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5	Yosemite National Park	september	5	12	19		
6	Yosemite National Park - Tonopah	april '99	10				
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7	Tonopah - St. George						
8	Zion National Park						
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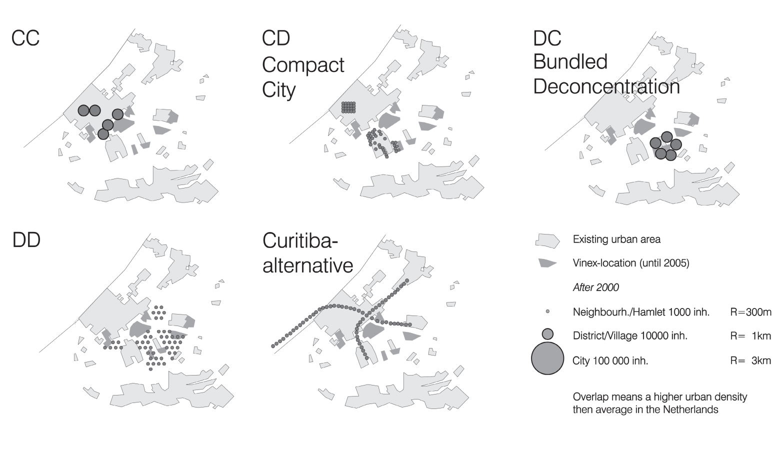


a Klaasen, I.T. and M. Jacobs (1999) *Relative location value based on accesibility: application of a useful concept in designing urban regions*.

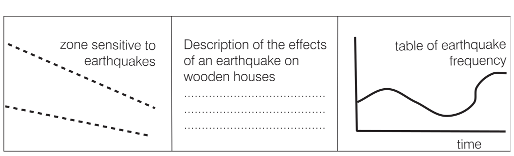
b Lomme, J. , L. Bakker et al. (1988) *Wereldmodellen - een literatuurstudie*, p. 30; source: Meadows, D.L. and D.H. Meadows (1973) *Toward global equilibrium: collected papers*.

c Bell, Daniel (1964) *Twelve modes of prediction: a preliminary sorting of approaches in the social sciences*.

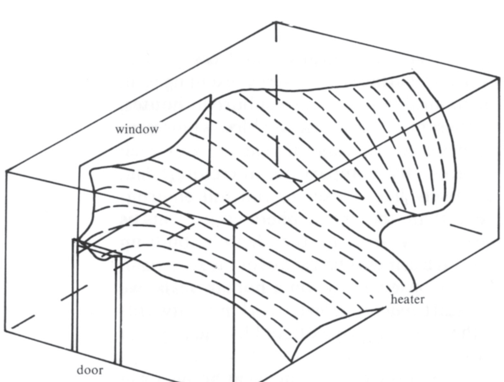
d Source: T. M. de Jong, Delft University of Technology, unpublished.

172 The planning concept 'Groene Hart' (a metaphor).[a]

173 Visualised plan-objective: the proposition "the centre of the city should distinguish itself visually' has been translated into a spatial model.



174 urban / architectural relevant models, respectively:
a spatial differentiation → spatial model;
b spatially undifferentiated qualitative architectural main-lines → verbal model;
c spatially undifferentiated quantitative description earth-quake frequency → mathematical model.



175 Combination of a spatial and mathematical (descriptive) model[c]

parties concerned. In planning, particularly in the policy field the notion 'spatial planning concept' or 'planning concept' is in use. Figure 172 gives an example. It signifies a policy-strategic action concept, and may be purely a means to communicate on the subject with the community and other (government) agencies without (potential) empirical foundation.

Usage of the term 'concept' may cause *mis-understanding* between planners and designers. *"The Randstad/ Groene Hart concept is a strong concept"*, a planner states; and he means to say that the concept has survived decades social-political turmoil and proven to be strategically strong. The urban designer reacts: *"On the contrary, it is a weak concept."*; hinting at the fact that it takes a lot of (political) effort to keep the central area free of urbanisation. The shortest connection between points on the edge of the circle afterall is through the circle.

22.5 USE OF MODELS IN URBAN DESIGN AND ARCHITECTURE

The choice which type of model to use depends on the intention with which reality is approached, the function the model must perform and personal preference of the person making the model. Generalising, we discern in an urban / architectural designing process the following steps (in iterative sequence):

- formulating objectives, programme of requirements, task formulation;
- analysing existing situations, together with its probable developments;
- design study;
- evaluating ('ex ante' and 'ex post').

Models are also used in study by design.

The design approach can be presented in a model: a verbal model (see figure 156). Before the start of the design process this verbal model is a planning or explorative model; when it is finished, a descriptive one (not necessarily the same model). It hinges on the condition that the working procedure demonstrates structure. A listing like 'and then…, and then,…and then…, is just a set of actions, not a model. This verbal model of inter-connections between the actions can be visualised: boxes, arrows, etc.; this is even to be preferred. However, it remains a verbal model, we could call a schema.

A programme of requirements (package of objectives) usually has a plan-like, verbal character. As far as is possible, it is recommended to translate verbal models into spatial ones: the 'medium switch' (figure 173).

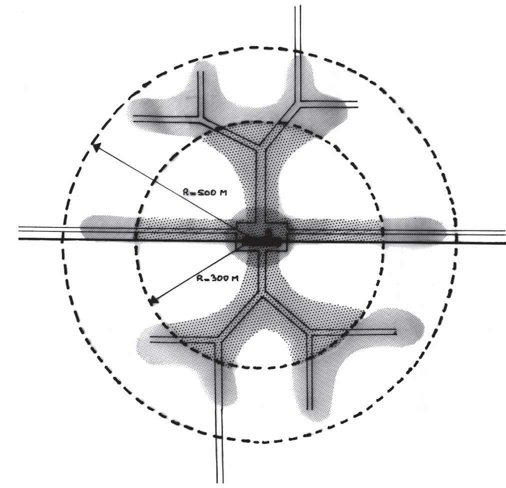
While analysing an existing situation we use descriptive, conceptual or concrete models. Sometimes they are, in their turn, based on other descriptive models. A map showing the potentials of an area for playing field development, for instance, will probably be (partly) based on a soil map.[b] Depending on the kind of properties of the existing situation (including socio-cultural, economic and political-organisational conditions) an analysis model can be verbal, mathematical, spatial as well as mechanical. When analysing probable developments within the existing situation (trend prognoses) we use predictive models.

With a model of spatial reality a differentiation applies within the space modelled (this depends on the 'grain' chosen). Then it makes sense to use a spatial model. This encompasses the differentiating qualitative and quantitative attributes: figure 174a (see also figures 167, 175, 178). If spatial differentiation is not relevant, we can use a verbal model to indicate qualitative properties, and a mathematical model for quantitative ones. A verbal model describes, for instance, the existing building condition of a house or neighbourhood; or predicts them for the probable future (compare figure 174b). A mathematical model gives information, for instance, on the development of average occupancy of homes in a community (compare figure 174c).

Combinations of types of models are possible: see figure 175.

a VROM (1996) *Randstad en Groene Hart*.
b A potential chart can also be made on the basis of a designed situation that has not yet been realised: evaluation ex ante – see later in this paragraph.
a source: Hanwell, J.D. and M.D. Newson (1973) *Techniques in physical geography*, p. 78

In the case of design studies descriptive as well as prescriptive models are used (analyses of the existing situation and its developments); but also explorative-projective models. The resulting designs are always spatial models; they are either intentional-projective models (planning models) or potential-projective models (possible spatial futures).



176 Principle model for the central part of a central town in a region: high concentration of facilities combined with intensive employment and residential levels round the train-/ regional bus station and along the (radial) main thorough-fares; declining density in the peripheral central areas. Mixing collective functions with the residential function originates in the wish to create conditions for social safety.

In urban design and architecture evaluation ‘ex post’ (empirical study) is rather unusual and less feasible with an a (urban) design transcending a certain scale.

An evaluation ‘ex ante’ of a design may focus on the degree to which the programme of requirements has been met, or on the effects in spatial, social and other terms the design will probably or possibly have after execution: effect analyses. With this type of evaluation one should always watch out for circular reasoning: “The high density of homes around the stations will have a positive effect on the quality of public transportation”; that may well be so, since that was precisely why that high density was chosen! Evaluation of effects not intended makes sense, as well as specifying intended effects.

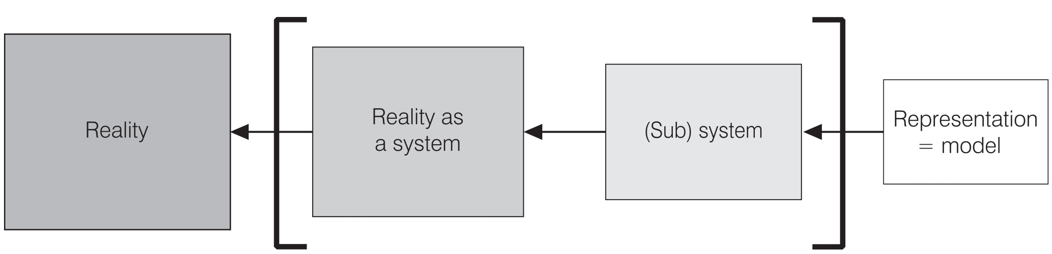
In this type of evaluation we use predictive models that could in principle be verbal, mathematical, spatial or mechanical. However, verbal models seem to be most appropriate, because of the pseudo certainty associated with numbers, and often with spatial models as well.

In study by design, spatial models are used with an explorative potential-projective function. Effect analysis (evaluation ‘ex ante’) provides continuously feed-back during the study.

Image forming is a pre-requisite in visual-spatial processes of thought when intending to attain synthesis, states Muller.[a]

22.6 CONFUSING MODEL AND REALITY[b]

Whenever designers are not sufficiently conscious of the fact that they are working with models only of reality, and/or when they have insufficient insight in the relation between model and reality, mis-conceptions may occur about the possibilities as well as on the limitations of their designs and their analyses: model over-extension. ‘The way back’, from the model to (future) reality is not taken, or is taken in a wrong way. (figure 177; see also figure 155)



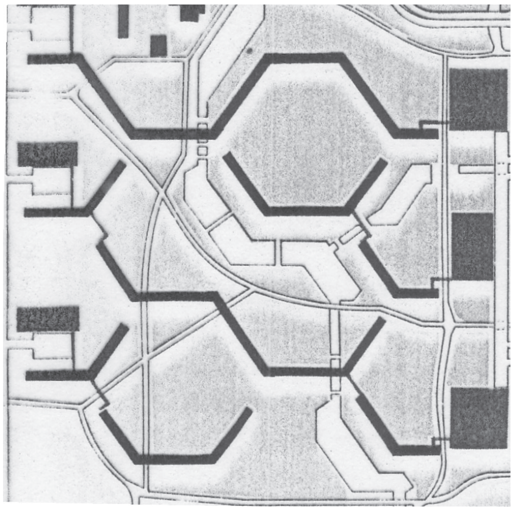
177 Translating a model to (future) reality: ‘The way back’: ‘reductional’ restrictions. Compare figure 155.

Before starting to work with a model, reflection is necessary on its application; pre-suppositions in that context should be checked. Outside the field of application, conclusions are not valid. From testing the model of an aeroplane in a wind-tunnel the conclusion may not be drawn, for instance, that the aircraft will fly in reality as well, since the conduct of the pilot has not been considered in the model.[c] In addition, the ratio between the size of the particles in the air with regard to the size of the model plane differs from the one applying in reality. If the model aeroplane is made of a different material that the real machine (think of architectural models) the field of application is even smaller.

a Muller, W. (1990) *Vormgeven, ordening en betekenisgeving*, p.142

b The present paragraph is based on Klaasen, I.T. (2000) *Valkuilen bij stedebouwkundig ontwerpen: verwarring tussen model en werkelijkheid*.

c Soest, J.P. van, J. van Kasteren et al. (1988) *De werkelijkheid van het model*.



178 The (has-been) surface articulation of the Bijlmermeer (Amsterdam South-East) (Source unknown). The design of this area was a good example of model over-extension. The re-structuring is in full swing

179 Circular residential building by Bofill in Marne-la-Vallée, near Paris. Noises in the heart of the circle are amplified many times by the circular construction (Photograph: Author)

For urban designers some relevant types of model over-extension are:

- field of application is lacking;
- no distinction between model and reality;
- insight into the way in which reality has been reduced in the model is insufficient;
- spatial and temporal confusion of scale;
- confusion of stand-points from which observations are made.

An example of confusion between model and reality is depicted in figure 178. In this design the surface articulation is insufficiently adapted to the specific. The result is very monotonous. This pitfall is known as ‘stamping’ (*stempelen*).

In this example it could also be true that confusion of observation standpoints raises its ugly head. A not uncommon mis-conception among designers – alas – is that the reality designed will be experienced, before too long, from ‘above’; just like the designer experiences drawing board or computer screen: ‘the drawing board perspective’. The observer-in-reality stands or hangs above an area only occasionally. He stands right in the middle of that reality, or at some distance, moves along it, or through it.

Another example is that designers, traditionally strongly focused on visual perception, neglect noise, smell and physical sensations (wind!) or disregard them, because they are hard to depict. The value of a design – in the sense of its implementation potential, and after implementation, its usefulness – depends on the degree in which specific conditions of a site have been taken into account, even if properties are invisible, not to be depicted in a spatial model (spatial analyses), or reduced out of existence (figure 179).

“The disadvantage of designing by drawing is that problems which are not visually apparent tend not to come to the designers attention. Architects could not ‘see’ the social problems associated with new forms of housing by looking at their drawings”.[a]

When one is conscious of the fact that in a model of a/the (possible, future) reality, a lot of reality has been omitted, it will be clear that two situations can not be compared bluntly. The historical island Marken in the former ‘Zuiderzee’ (IJsselmeer) may be just about as large as a yet to be constructed, artificial island in the outskirts of Amsterdam (‘Haveneiland’, part of the development ‘IJburg’), but its distance from the centre of Amsterdam, for instance, defies comparison. The same applies of course for its demographic structure.

The failure is complete when referring to another situation spatial scales are confused (figure 180).

180 De Minister of Physical Planning of the Netherlands compared the ‘Green Heart’ of the ‘Randstad Holland’ to Central Park, Manhattan, New York City. The ‘Amsterdamse Bos’ is already two and a half times as large as that New York park! If the scale ratio of Amsterdam and Manhattan are taken into account, and the kind of utilisation qualities that apply, the Amsterdam Vondelpark and Central Park do have many things in common. (Source: Berg, R. van der (2001) *NL Superbia)*

a Lawson, B.R. (1990) *How designers think, the design process demystified, p. 18/19.*

23 VERBAL MODELS

TAEKE DE JONG

This Chapter discusses verbal models in empirical science. In that context they are logically consistent by definition.[a] However, they will be treated within the context of two other language games just as relevant to Architecture: design and management, (see page 446) where integration and urgency are more important than logical consistency. That is the reason why differences in emphasis on consistency will be discussed as well. Consistency seems to necessitate incompleteness. For analysis this is less dangerous than for synthesis.

Consistency is denoted here by the formal logical model. With this, the relationship of verbal models with reality (reliability) is coming to the fore in the sense of truth or non-truth. However, on a different level incompleteness is remaining a special form of non-truth (half-truth). This demonstrates the restricted contribution of formal logic to the designing of models during the originating stages, when their consistency does not exist as yet, but must be made. That is a different language game. However, this does not detract at all from the importance of formal logic in the discussion of the still varying (increasing and decrasing) consistency aimed at whilst designing. It does not detract at all from the importance of formal logic during the evaluation of the design as soon as it is available in all its completeness. Also in that case the question is raised whether inconsistency is so 'dangerous'. That is a language game as well. One should never forget that a crystal can not grow without a dislocation in its grid.

Next, the subject of causal consistency comes to the fore obviously. However, this form of consistency will be discussed later in the Chapter *'Forecasting and Problem Spotting'* (see page 253). The question of incompleteness will get on the agenda again there, then explicitly in the sense of *'ceteris paribus'*.

23.1 LANGUAGE GAMES

In architecture three distinct language games[b] occur: those of designers, scholars and decision makers (respectively orientated on 'being able', 'being knowledgeable' and 'being decisive'). The utterances of these agents in the building process (respectively 'possible', 'true' or 'binding' or not) can not be expressed completely in one another's language, even when they are using the same words. By this they are causing linguistic confusions hard to disentangle, addressing respectively possible, probable and desirable futures. With it, temporal-spatial completeness, logical consistency and public urgency are becoming topics, respectively.

Grammatically 'verbs of modality'[c] are reflecting the opinion of the speaker on the relationship to reality of what he is saying: possible ('can', 'may'), probable ('will', 'must', 'let') and desirable ('will', 'must', and 'may'; the latter two in a different sense). The language games introduced by this type of verbs are based on different reduction of imaginative realities.

The primary language of design is pictorial. When the designer records the key to symbols (legend) of his drawing, for instance red for urban areas, yellow for agriculture, and blue for water, he reduces the variation within the urban area, agriculture and the water. If he makes his drawing with pre-supposed legend unities, he first selects their site and form (state of dispersion) roughly and subsequently more precisely. So, during the design process he reduces further the tolerances of the design for the benefit of its feasibility.

The empirical researcher reduces reality in more abstract variables (set of related differences), but does not accept that a variable may assume any arbitrary value. He looks for functions between variables to restrict them in their freedom of change in order to make more precise predictions.

The policy maker reduces the problems to a few items on the agenda and tries to reach consensus by arrangements and appointments.

Language games:	being able	knowing	selecting
Modes:	possible	probable	desirable
Sectors:	technique	science	administration
Activities:	design	research	policy
Reductions as to:			
Character:	legend	variable	*agenda*
Space or time:	*tolerance*	*relations*	*appointments*

181 Modal language games

a Nauta, D. (1970) *Logica en model*.
b Wittgenstein, L. (1953) *Philosophische Untersuchungen*. Recent edition: Wittgenstein, L. and G.E.M. Anscombe (1997) *Philosophical investigations*.
c Toorn, M.C. van den (1977) *Nederlandse Grammatica*, p. 91

23.2 MODALITIES

The empirical researcher is using, speaking strictly, exclusively logically consistent models, constructed from well defined concepts and variables.

Already in preparing the legends of his design the designer is disregarding components that do not belong to the legend-unit chosen strictly speaking (like parks in a city, green in red); or he is doing the opposite: over-emphasising details opening up possibilities. Furthermore, the designer is using them during his discourse in a variable significance in order to create intellectual space for the designing. To an empirical scholar the language of the designer is then ambiguous, or poly-interpretable and suggestive. The terms 'red', 'green' and 'blue' are already as variables not well defined, but they are more complete, also given the future possibilities. Utterances on the possible worlds of the design belong partially to 'modal logic', not discussed here.

The agenda of the policy maker is extremely incomplete by necessity. That is the reason why it is an art to get a topic 'on the agenda' of a meeting.

23.3 CHANGE OF ABSTRACTION

If the subject of a sentence is a concrete, touchable, visual, audible reality, the utterance is belonging to the concrete object language; in other cases to a more abstract meta-language (a distinction taken from the logic of classes).[a] Speaking about utterances, as happens in logic and in almost all sentences of the present Chapter, is belonging to a meta-language. This distinction is pre-empting paradoxes occurring if object language and meta-language are mixed within one full-sentence (change of abstraction, see page 37) as in the full-sentence 'What I am saying is a lie'.[b] In written language this is indicated by quotation marks. The change of abstraction may then be indicated by: 'What I am saying' now is a lie. In its turn the meta-language is layered, for if one is talking about logic, one is talking about a meta-language. One is finding oneself then in a high class of abstraction. The object language is layered as well, since one can talk on objects of a different scale, particularly in urban architecture. Changing of scale in a line of reasoning may lead to paradoxes; just think of 'inside' and 'outside', respectively on the levels of room, house, city). This is pre-empted by articulation of scale, as explained on page 37.

23.4 VERBS

Next to verbs of modality (can, shall, may must, will, let be to, dare to, serve to, need to, promise to, threaten to) there are countless independent verbs that may be 'steered' by them ('This building can collapse | has sagged | is being repaired'). By preceding such verbs of modality they can be harnessed for a specific language game (possible, desirable, probable).

Independent verbs are always pointing to a working (a function) or to a 'property' as a result thereof (for instance: 'This building sags'). When the full-sentence is employed in the language game of empirical study a subject from the 'existing' reality is described. It is also possible then to speak of 'models'.

23.5 CONSTRUCTING STATEMENTS

A full-sentence like 'This building is a cube' is providing a (always incomplete) description (predicate) of a subject[c] (in this case in object language a building that may be pointed at). This full-sentence establishes through the verb 'is' a relationship between this special building and more general, compressed earlier experiences ('cube' as an empirical concept of a lower class than the corresponding abstract geometrical concept).[d] 'Buildings are rectangular' is a description of all buildings with, in addition, a more general predicate than 'cube'. What is pronounced in it is not the case, as we know. The world is everything that is the case.[e] Language is also comprising negation of what is the case, and is pre-supposing the capability to imagine; it is possible to speak about what is not the case.

a Whitehead, A.N. and B. Russell (1910) *Principia mathematica*.

b A variant of Emimedes' paradox: 'All Cretans lie, said the Cretan'. If he lies, he speaks the truth; and vice-versa.

c Note, that the building as a real object outside of the sentence is acting as a subject within the sentence. This inversion is characteristic for each form of abstraction.

d Con-cept is Latin for 'taking together'.

e The first proposition of Wittgenstein, L. (1922) *Tractatus logico-philosophicus*. Recent edition: Wittgenstein, L., Pears D.F. et al. (2001) *Tractatus logico-philosophicus*.

A full-sentence always consists of subject and predicate. An utterance is a full-sentence that is the case or not. A design, an order or a vague, ambiguous full-sentence is, for instance, no utterance. Predicate logic is studying the internal construction of utterances and proposition logic their conjoining into assertions (propositions).

23.6 CONJOINING INTO ASSERTIONS

If more predicates are referring to the subject, one must conjoin with words such as 'and', 'not and', 'or', 'neither…nor', 'if…then' single utterances into an assertion:

'This building is a cube *and* (this building) is rectangular'
'This building is a cube *or* rectangular'
'This building is *neither* a cube *nor* rectangular'
'*If* this building is a cube, *then* it is rectangular'

'If a building is a cube, then it is rectangular' is always true, even if the building we are pointing at is no cube, and even if it is not rectangular.[a] Words that are composing utterances into an assertion, such as 'if…then', 'and' 'or', 'nor' can make the assertion they are composing become true, even if not all parts of the assertion are the case.[b] Proposition logic is studying this truth-determining operation.

23.7 COMPOSING LINES OF REASONING

In their turn, assertions may be composed into a line of reasoning by drawing a conclusion from premises. In contrast with utterances in an assertion, all premises in a line of reasoning must be true in order to draw a correct conclusion. The other way around, correctness of a conclusion is not assured even if all the premises are true.

In the following example the premises (above the dotted line) may be true, but the conclusion (below the line) is not valid.

'If this building is a cube, then it is rectangular'
'This building is rectangular'
———————————————————————————— so
'This building is a cube'

This line of reasoning can not be endorsed: purely on the ground of its structure, independent from our experience with cubes and straight angles. However, it is useful in the modality of what is possible. Then the conclusion must be: 'This building may be a cube': then it is valid again. The line of reasoning is also valid when the last premise is inter-changed with the conclusion:

'If this building is a cube, then it is rectangular'
'This building is a cube'
———————————————————————————— so
'This building is rectangular'

A line of reasoning with two premises and one conclusion, is known as a syllogism. A line of reasoning from general to particular is deductive, from particular to general inductive.

An inductive line of reasoning is not valid if the set of premises does not comprise all cases. One can only draw the conclusion that all buildings are rectangular, if one has checked all buildings, while observing for each building: 'This building is rectangular'. There are then as many premises as there are buildings. It is only then that one can draw by complete induction the general conclusion that all buildings are rectangular. Yet, this completeness is virtual. What to do when one is finding buildings in a linguistic environment where the concept 'rectangular' does not exist, or is starting to apply at a certain length of both legs of the straight angle?

Study of the structure and validity of lines of reasoning, independent of their meaning (semantics) is the classical aim of logic (argumentation theory).[c] This entails, in a sequence of a decreasing complexity:

a Note, that 'being the case' relates to parts of the statement and 'being true' to its totality.

b We only talk about (un)truth when talking about statements. (Un)truth is, therefore, always a term from a meta-language.

c See: Eemeren, F.H. van (1996) *Fundamentals of argumentation theory, a handbook of historical backgrounds and contemporary developments*. Dutch translation: Eemeren, F.H. van, R. Grootendorst et al. (1997) *Handboek argumentatietheorie, historische achtergronden en hedendaagse ontwikkelingen*.

- set theory;
- modal logic (language games, modalities);
- class logic (level of abstraction);
- argumentation theory (lines of reasoning);
- proposition logic (assertions), and:
- predicate logic (utterances).

We are starting unconventionally with the smallest unit, the singular utterance, and within it the predicate and within that the full-sentence function.

23.8 FULL-SENTENCE FUNCTIONS AND FULL-SENTENCES

In predicate logic the structure of some assertions discussed here is usually rendered as follows (read for x ‘this building’):

182 Operations with full-sentence functions

Formula:	*Read:*
K(x)	being a cube as a working (function) of x.
R(x)	being rectangular as a working (function) of x.
$\exists x{:}K(x)$	there exists a x, ($\exists$ x), for which it is valid that (:) it is cubic (K(x)).
$\forall x{:}R(x)$	for each x ($\forall$ x) is valid that (:) x is rectangular.
$\forall x{:}(K(x) \Rightarrow R(x))$	for each x ($\forall$ x) is valid that (:) if x is cubic, x is rectangular as well.

K(x) and R(x) are full-sentence functions, names for a working of their argument (x), but not yet full-sentences themselves. The full-sentence functions are lacking a verb that the working of the argument, possibly on an object, is operationalising. Full-sentence functions are predicates without a verb. In addition a full-sentence is in need of a subject, an instancing of the argument (for example x: = this building).

In the language game of the designer full-sentence functions like villa(landscape) – ‘villa as a working of the landscape’ -, or landscape(villa)’- ‘landscape as working of the villa’ are operationalised only by the design. The working itself is not made explicit with a verb, unless it may be termed a design act. Often verbs like that do not exist; their existence is just suggested by the full-sentence function. In addition only the object of the predicate has been named, so that of the working just the object of operating has been named. These full-sentence functions are so useful particularly in this language game since just the direction of the working between the subject and the object is recorded.

In the language game of policy one is waiting for the verdict of a judge or decision of the board. The relation victim(suspect) must be made by juridical investigation in order to come to a ruling. A policy agenda must be become operational in agreements.

In empirical sciences it is precisely the trick to find for such a full-sentence function a formula or (weaker) a formulation, that is making it operational. Exact mathematical operationalising of a full-sentence function is called modelling.

However, a full-sentence function is in empirical study very useful for a function that has as yet not been made explicit in the problem formulation and the forming of a hypothesis; since assertions are in them not yet expected. For instance, one may surmise that the number of buildings or their volume G is a dependent variable of the population variables p and their prosperity w, considered to be independent for the time being. This working is readily noted as a full-sentence function: G(p,w). In that case the problem formulation is ‘To which degree and how is G dependent on p en w?’ A hypothesis that has become operational may read: G(p,w) = p*w. The operator (*) makes the working explicit; the full-sentence function has become a function.

2.9 FUNCTIONS

A full-sentence function becomes a function, when that function K( ) or R( ) has been made explicitly ‘operational’ (e.g.: ‘K( ) := being a cube.’ Or R( ) := being rectangular). The more explicit operationalisation of the 'being a cube of x' is more complicated than of the 'being the square of x'.

K( ) may be defined, for instance, also as 'being squared'. This is becoming operational in a mathematical formula by K(x) := x*x. The multiplication sign (*) is a mathematical verb (operator) for 'multiplied by' that was not yet explicit in K( ).

The symbol := in this formula means 'is defined as' or 'is per definition equal to'. So it is an operator as well, but it belongs to a meta-language *vis-à-vis* the terms at both sides of this operator. It has an essentially different meaning than the = sign ('is equal to' for calculations). By the same token the verb 'is' is ambiguous. That is the reason why well defined symbols originate making a distinction between := and =. In the same vein there is a logical :⇔ sign ('is equivalent to') that can be used to denote a logical equivalence, for example 'is defined as' or 'is per definition equal to'.

In their turn functions are becoming only an assertion (the case or not the case) if the subject x has been substituted (for instance x := 'this building'). If a full-sentence function can be translated by substitution in an assertion that is the case, then it is 'completable'. $K(x):=x^2$ is completable for $x \in \mathbb{R}$ (x as an element of the set of real numbers), but not for x ∈ of the set of buildings.

The full-sentence function may supply more than one subject with a predicate (here p and w). It is then at home on several places. However, if one wants to include more predicates or within them more objects (not just buildings are dependent on population and prosperity, cars as well), there must also be more full-sentence functions. These can be conjoined with the linkage words from proposition logic, like ⇒ to an assertion like K(x) ⇒ R(x).

23.10 A QUANTOR AS SUBJECT

In order to yield a meaningful assertion, the subject of a full-sentence does not need to be one concrete subject. Instead of defining x precisely one to one with reality (name giving) it can also be bound. This is particularly important to mathematics. Also ∃ x ('At least one x', existence-quantor) or ∀ x ('Each x', all-quantor) may yield a logically acceptable subject. In conjunction with the verb ':' ('satisfies') and a full-sentence they may form an assertion. The assertion reads then, for instance, as ∃ x : K(x), 'At least one building satisfies the description 'cube" or ∀ x : K(x), 'Each building satisfies the description 'cube". The second, more general, assertion pre-supposes excellent scholarly breeding. However a generalising scholarly discipline is always looking for assertions with an all-quantor, since such a general assertion enables in a line of reasoning as a premise a wealth of deductive conclusions:

	Formula	*Read:*
1	$\forall x:(x \in X)$	For each x (∀x) it is valid that (:) x is an element from the set X.
2	$\forall x:K(x)$	For each x (∀x) it is valid that (:) x is a cube.
3	$\forall:(K(x) \Rightarrow R(x))$	For each x (∀x) it is valid that (:) if x is a cube, x is also rectangular.
4	$\exists a:(a \in X)$	There is at least one a (∃ a) for which it is valid that (:) a is an element of the set X.
5	$\exists a:R(a)$	There is an (∃ a) for which is valid that (:) a is rectangular (R(a)).

183 Quantor functions

Now we know that the second premise is not the case, if we substitute for x 'building' as an element of the set *all* buildings X. In order to get nevertheless a relatively general assertion, one must restrict the set, for instance to the set 'buildings in this neighbourhood' B, if we know by complete induction that in this neighbourhood all buildings are cubes. Then it is sufficient to change the first premise into $\forall x:((x \in X) \wedge (x \in B))$. The symbol '∧' in this formula means 'and' in a sense well-defined in proposition logic.

23.11 THE CASE OR NOT THE CASE

Formal – mathematical feasible - logic, developed during previous centuries, is a more narrow notion than the concept 'logic' used to be in olden days. The word 'logic' is derived from the word *'logos'*, a Greek word encompassing two illuminating clusters of meaning: speech itself, and giving account, testimonial. Logic as discussed here corresponds especially to the second cluster, as the lore of the right deductions.[a] The smallest possible 'im-mediate' deduction consists out of two propositions, separated by the two-letterword 'so': Holland is in The Netherlands, so The Netherlands are larger than Holland. More common is the 'mediate' deduction of a third proposition, a conclusion C, from two preceding premises A and B ('syllogism'), usually denoted as: A,B | C or

A	If it is winter, I am cold.	
B	It is winter	
	——————————————————————	so
C	I am cold.	

Logic pre-supposes here, that propositions exist that may be the case, or not, but not both (yielding a contradiction) or both a little. This last restriction is removed in 'fuzzy logic', a branch of modern logic, disregarded in the following.

23.12 THE HUMAN POSSIBILITY TO DENY

A description of observations along these lines is only feasible, if we can imagine facts that are not the case. According to the Swiss psychologist Piaget, this capacity emerges in children when they are some eighteen months old. The capacity is hard to determine when it comes to animals, because they cannot express themselves to us in a way we can understand. Our brain must offer space to the not-here-and-now.

A filing cabinet should be ready there, as if it were, with the image 'it is winter', 'it is not winter', 'I am cold' and 'I am warm. As soon as something is the case, the box is full, as soon something is not the case, the box is empty. This has created space in our imagination for the true *and* false and thus for lies and deceit, but also for abstract thought and for the designing of things that are not (yet) there. Only with such an imaginative capacity (a 'logical space') at our disposal, can we arrive at rather general assertions like: 'If the sun starts shining, then I get warm'.

23.13 IF...

The following paragraphs provide an introduction into proposition logic on the basis of one of the most frequently used, and at the same time most confusing, logical operators, the word 'If…'. The 'if … then …' relation is of great interest to designers, since every design is an image of things that do not exist with an implicit promise: 'If you execute this, then you can dwell!'.

Compare the following assertions:

1. If it is winter, I am cold.
2. If it is winter, I could be cold.
3. If I am cold, then it is winter.
4. If I am cold, then it could be winter.
5. I only get cold if it is winter.
6. I am sometimes cold if it is winter.
7. I am always cold if it is winter
8. If it is winter, then I will probably be cold.
9. If it is winter, then you should turn on the heater, or else I will be cold.
10. I would like it to be winter because I am so warm.

The last expression is a wish, with on its background a lot of logical and causal pre-suppositions. The wish itself and its motivation do not belong to the linguistic game of logic, neither does the command (9) preceding it. In *both* expressions the hidden supposition "I will probably get warm" is a prediction or expectation that only becomes a fact, so true or false, if I really got warm. The grain of time is too small in the case to claim unambiguously a true or a false statement. Logic is necessary to arrive at such an expectation, but expectation itself

a More thorough introductions: Jong, W.R. de (1988) *Formele logika, een inleiding;* Eijck, J. van and E. Thijsse (1989) *Logica voor alfa's en informatici;* Sanford, D.H. (1989) *If P then Q, conditionals and foundations of reasoning;* Benthem, J.F.A.K. van, H.P. van Ditmarsch et al. (1994) *Logica voor informatici*.

surpasses the laws of logic. Assertions 1- 8 may be translated without complications into statements of the proposition-logical type.

23.14 STRESSING THE LOGICAL FORM

In order to study the type and its associated validity of the 'if..then..' relation as such, it is necessary that for the assertions used, any other assertion could be substituted without impairing the validity of the logical form itself.

If somebody makes an assertion, the logical investigation consists, therefore, especially in the search for counter-examples for which that type of the deduction becomes false. The assertions in the deduction are made variable then and the deduction gets the more abstract form 'if p then q'.[a] To avoid possible confusion, we choose an example of the first assertion where the temporal aspect is absent:

'If I am in Holland, then I am in The Netherlands'.

It is remarkable that this assertion can be 'true' if the partial statements are not the case, for instance, if I am in Hamburg. I am not in Holland then, not in The Netherlands, but *if* I am in Holland, I am also in The Netherlands, that stays 'true', even in Hamburg. It is also true when I am in Breda or of course, in Holland. The only case when I cannot uphold my assertion is when I am in Holland and it comes out that I am not in The Netherlands.

The truth-value of the assertion as a whole, depends this way on a specific combination of truth- values of the sub-statements 'I am in Holland' (P) and 'I am in The Netherlands' (Q). This may be summarised in a 'truth-table'. There are four possibilities:

	I am in Holland	I am in The Netherlands	Example	'If P then Q'
	P	Q		$P \Rightarrow Q$
1	Not the case	Not the case	Hamburg	True
2	Not the case	The case	Breda	True
3	The case	The case	Delft	True
4	The case	Not the case	?	False

184 If truth table

23.15 DIFFERENT KINDS OF IF-STATEMENTS.

That was a clear example. But, if one returns to the old example 'If it is winter, then I am cold' and substitutes it, according to this table, I would be allowed to say 'If it is not winter, then I am not cold'.

If someone has difficulty with that, it may be that he still values implicit causal presupposition.[b] It might also be that he envisages another 'If…then..' relation than the one above, to wit 'If and only if' (iff):

	It is winter	I am cold	Example	Iff
	P	Q		$P \Leftrightarrow Q$
1	Not the case	Not the case	no winter, not cold	True
2	Not the case	The case	no winter, cold	False
3	The case	The case	winter, cold	True
4	The case	Not the case	winter, not cold	False

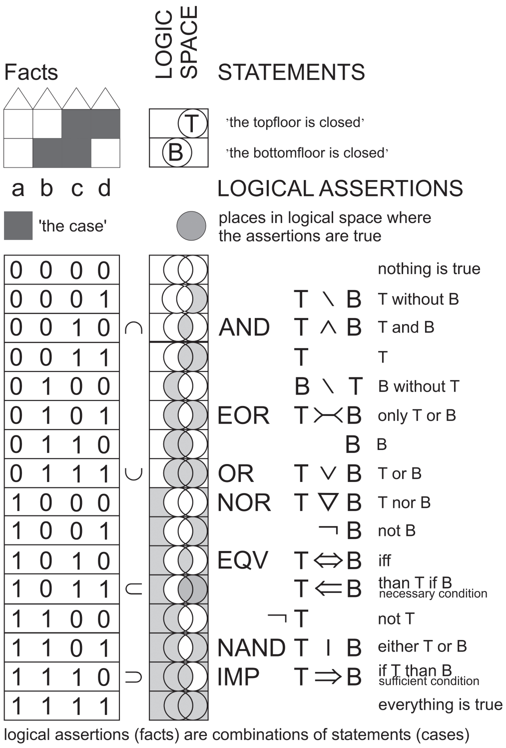
185 Iff truth table

If we substitute this example again in that of paragraph 23.14 case 1 proves to be not to our liking. Suppose I am in Breda and say to a southerner 'If I am in Holland, then I am in The Netherlands'. He is of the opinion, that I intend this reversibly and answers that that is not true, because I am not in Holland and yet in the Netherlands. Guilelessly, I mean the implication; he thinks that I mean the offending equivalence. I hope he knows the truth tables, for else this mis-understanding will never be sorted out.

a That is, by the way, also the title of a fine book on the history of logic: Sanford, D.H. (1989) *If P then Q, conditionals and foundations of reasoning*.

b Hawkins, D.J.B. (1937) *Causality and implication*.

propositional logic



186 Complete truth table

23.16 DISTINCTION BY TRUTH-TABLES

This shows how useful it is, that formal logic has developed different symbols (*implication* ⇒ and *equivalence* ⇔) and different logical operators for this confusing ‘If.. then..’ proposition. This distinction was possible by controlling the truth of the ‘If P then Q’ statement for each of the four states of affairs where P en Q can be combined. For ‘⇒’ it turned out to be the sequence true, true, true and false (simplified by 1110), but for ‘⇔’ it turned out to be true, false, true and false (simplified by 1010).

Do the other combinations like 0000, 0001, 0010, etc. also mean something? It is easy to ascertain, that there are 16 such combinations that we can summarise in a table. A complete table like this appeared for the first time almost simultaneously shortly after the end of WW I in Wittgenstein’s ‘*Tractatus*’[a] and with two other authors.

23.17 SUFFICIENT CONDITION

Just suppose, that four situations a, b, c and d are discerned for a residence under construction expressed in the combination of two assertions: ‘The top floor has been provided with a façade ’ T, the bottom floor has been provided with a façade B, and the situation in which this is not the case. For these four cases a, b, c and d we verify now the assertion ‘If the top floor has been provided with a façade, then the bottom floor has also been provided with a façade’, crisply expressed as: ‘T ⇒ B’:

187 If truth table

	Topfloor closed	Bottomfloor closed	Example	‘If T then B’
	T	B		T ⇒ B
1	Not the case	Not the case	a	True
2	Not the case	The case	b	True
3	The case	The case	c	True
4	The case	Not the case	d	False

Only if the top floor has been provided with a façade, and the bottom floor not, we can not validate the assertion ‘If the top floor has been provided by a façade, then the bottom floor has been provided with a façade as well’. So we have verified that ‘T ⇒ B’ is true for the first three cases, but not for the last case: (1110, ‘sufficient condition’).

23.18 EQUIVALENCE

Now, if a contractor is saying: ‘If the top floor has been provided by a façade, *only* then also the bottom floor has been provided with a façade’, case b is also invalid (1010, then and only then if, ‘taoti’, ‘equivalence’ iff).

	Topfloor closed	Bottomfloor closed	Example	‘If T then B’
	T	B		T ⇔ B
1	Not the case	Not the case	a	True
2	Not the case	The case	b	False
3	The case	The case	c	True
4	The case	Not the case	d	False

188 Iff truth table

23.19 NECESSARY CONDITION

However, if the contractor is saying: ‘Only if the top floor has been provided with a façade, then the bottom floor has been provided with a façade’, then case d is suddenly valid again, but only case b not (1011, ‘necessary condition’).

	Topfloor closed	Bottomfloor closed	Example	‘If T then B’
	T	B		T ⇐ B
1	Not the case	Not the case	a	True
2	Not the case	The case	b	False
3	The case	The case	c	True
4	The case	Not the case	d	True

189 Then … if truth table

a Wittgenstein, L. (1922) *Tractatus logico-philosophicus*.

Each known logical operator like $\Rightarrow$, $\Leftrightarrow$ and $\Leftarrow$, for example 'and', 'or', 'neither..nor', 'either..or', proves to have a place on a truthtable (see diagram). Logical operators are more readily understood as equivalents of the set theoretical concepts $\cap$, $\cup$, $\subset$, $\supset$ or from drawings in which the sets are overlapping.

Symbolical rendering and its definition with the truth-table is now making an unambiguous distinction between the inclusive 'or' ($\vee$, OR) and the exclusive 'either …or' (>-<, EOR, XOR). The confusion of 'and' ($\wedge$), and the inclusive 'and' in the sense of 'and/ or', the logical 'or' ($\vee$) in daily parlance can not occur anymore. These logical operators should not be confused with sequential computer commands in an algorithm, such as the 'IF…THEN…' statement. That belongs to a different language game: the one of commands used for the execution of certain activities.

23.20 MODUS PONENS, TOLLENS AND ABDUCTION

In the examples below we assume that the implication ($\Rightarrow$) is intended throughout.
We accept the following deduction:

(1) If I am in Delft, then I am in The Netherlands.
Well: I am in Delft
———————————————— So:
I am in The Netherlands

We do not accept:

(2) If I am in Delft, then I am in The Netherlands.
Well: I am in The Netherlands.
———————————————— So:
I am in Delft.

Yet we accept:

(3) If I am in Delft, then I am in The Netherlands.
Well: I am not in The Netherlands.
———————————————— So:
I am not in Delft.

This seems obvious with examples directly connectible to enclosing sets (Delft is *in* The Netherlands), but why should we not accept (2) for example:

(2*) If it is winter, then I am cold.
Well, I am cold.
———————————————— So:
It is winter.

if we accept:

(3*) If it is winter, then I am cold.
Well, I am not cold.
———————————————— So:
It is not winter.

In these examples causal explanations are playing a confusing rôle. We know that the examples 2 and 2* are logically not valid, but this line of reasoning is often used in medical practice, historiography, forming empirical hypotheses and in legal matters.

Suppose, a murder has been committed:

(2**) If X commits a murder, one finds his DNA
Well, his DNA has been found
———————————————— So:
X has committed the murder

(3**) If X commits a murder, one finds his DNA
Well, his DNA has not been found
———————————————— So:
X has not committed the murder

Examples 1 and 3 are known, respectively, as *'modus ponens'* and *'modus tollens'*. Peirce has called the logically not-valid line of reasoning of form 2 'abduction'.[a] Abduction is used for finding a cause, even when one can never be sure of it.

a Peirce, C.S. (1992) *Deduction, induction, and hypothesis*

23.21 VERIFYING LINES OF REASONING

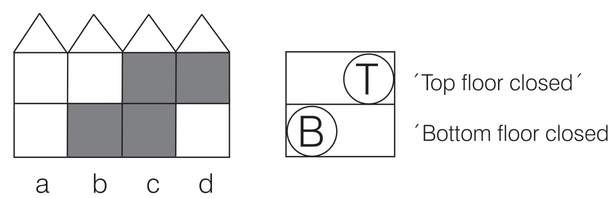
We focus here on an example used previously in which no set theoretical or obvious causal connections are clashing with the logical connections.

(1) If top floor closed, bottom floor closed
Top floor closed (T)
———————————————————— So:
Bottom floor closed (B)

(2) If top floor closed, bottom floor closed
Bottom floor closed (B)
———————————————————— So:
Bottom floor closed (T)

(3) If top floor closed. Bottom floor closed
Bottom floor not closed (not B)
———————————————————— So:
Top floor closed (not T)

Again, we are distinguishing the following state-of-things (situations):



190 Three situations

and render the case and not the case with utterances, true and untrue with assertions both with respectively 1 and 0 in order to verify tree lines of reasoning:

	1 modus ponens			2 abduction			3 modus tollens		
	$T \Rightarrow B$	T	B	$T \Rightarrow B$	B	T	$T \Rightarrow B$	not B	not T
a	1	0	0	1	0	0	1	1	1
b	1	0	1	1	1	0	1	0	1
c	1	1	1	1	1	1	1	0	0
d	0	1	0	0	0	1	0	1	0

191 Modus ponens, tollens, abduction

For $T \Rightarrow B$ the well-known substitution has been given, the assertions T, B, not T and not B have been derived from the drawing. Lines of reasoning are valid, when the premises and the conclusion are all true; or are 'the case' (1). With abduction there is a chance in situation b that conclusion T is not the case, even if both premises are true or the case.

So, one is not permitted to inter-change without damage premise and conclusion. A deduction is 'valid' when it is impossible to construct a counter example where the propositions are 'true', while the conclusion is 'false' (b). If one would accept that, any conclusion would be allowed.

23.22 INDUCTION

Lines of reasoning do not need to make use of an 'if…then..' operator. In the form of examples, we will now make use of the quantors and the 'and' operator in order to add a new form of reasoning. The first three of the following examples are known by now as deduction (1 and 3) and abduction (2). The fourth (4) was noted previously in page 191 as induction; although it is probably an incomplete induction here.

(1) All houses in this neighbourhood are a cube
This house is in this neighbourhood
———————————————————— So:
This house is a cube

(2) All houses in this neighbourhood are a cube
This house is a cube
———————————————————— So:
this house is in this neighbourhood

(3) All houses in this neighbourhood are a cube
This house is not a cube
———————————————————— So:
This house is not in this neighbourhood

(4) This house is in this neighbourhood and is a cube
Also this house is in this neighbourhood and is a cube
Also this house is in this neighbourhood and is a cube
———————————————————— So:
All houses in this neighbourhood are a cube

For the first three forms of reasoning a general rule prevailed, but how to lay hands on such a rule? Example (4) enables this to happen by empirical induction. Since this is seldom complete, empirical science largely consists out of collecting samples. They must be statistically representative for the whole set studied in order to be able to draw a more general probable (not necessary) conclusion (generalisation). The tacit reasoning underlying this pre-supposition looks like an abduction. The more general rule may be used next in its turn in logically valid deductive forms of reasoning as a premise in order to make forecasts.

23.22 INNODUCTION

The example following does not belong to the logical language game, not even anymore to the language game of the empirical. The 'But' is marking an inductive part, the 'So' a deductive part. Without 'But' the reasoning is resembling abduction, but a negation has been inserted that yielded between (2) and (3) already a valid reasoning.

(5) I am not warm.
———————————————————— But:
If I build a house, then I am warm.
———————————————————— So:
I build a house.

This line of reasoning is important to designing. It is a variant of *innoduction*.[a] A line and a new fact (in the original sense of '*factum*', Latin for 'made') is added to the assertive premise 'I am not warm'. The line between 'But' and 'So' is no premise and no conclusion in the classical sense of the word. It is a new idea and a pre-supposition, construed on occasion of and following from (and so not on an even ranking with) the asserting premise. There also could have stood 'If a build a moderated microwave in my coat, then I've got it warm'. Although no premise, each change in this assertion is affecting the conclusion immediately. The 'But' signifies a shift in the passively asserting language game to an active pragmatic language game. It is introducing a negation of what is the case.

23.24 THE EMPIRICAL CYCLE

Now compare the following description (1), proposition (2), deduction (3) causal explanation. Do they have a 'logical form' in common with the world?

1. It is winter and I am cold.
2. If it is winter, I am cold.
3. It is winter, so I am cold.
4. It is winter, hence I am cold.
5. It is winter, but I am not cold.

In all these cases two propositions are connected: 'it is winter' and 'I am cold'. They have been connected with the word 'and', 'if…', 'so', 'hence' and 'but not', depending on the stage of our intellectual processing of our impressions (the 'empirical cycle', see page 249).

If I have experienced (1) repeatedly, I can conclude (2) for the time being. This kind of conclusion leads from specific statements to a more general one (induction). From this more general proposition, another specific statement (3) may be deducted (deduction). The third statement is an incomplete syllogism, since (2) is not mentioned. In the practice of language there is quite a lot not mentioned.

23.25 TACIT PRE-SUPPOSITIONS

Any reasoning lacks lots of premises, for example 'suppose we are human, suppose we have thoughts and a language to communicate, suppose you want to listen to me, suppose you do not kill me for what I say, suppose this building does not collapse, then I could tell you something'.

Culture contains a huge reservoir of unmentioned pre-suppositions. In the practice of language that is efficient, but it makes different cultures hard to understand. Making cultural pre-suppositions explicit is as hard as to get a description of water from a fish. The fish cannot compare its element with something else: for a description of the water, the possibility of its negation is necessary. Without difference, nothing can be perceived, chosen, described or thought.[b]

Also the general statement 'If it is winter, then I am cold', is only under certain pre-suppositions a fact, as long as we do not turn the heater on, put on warm cloths, take a warm shower, etc. Logic is oblivious of these conditions that are often so interesting to a designer by pre-supposing implicitly that the other circumstances stay equal (*ceteris paribus*).

23.26 PERCEPTION

The *expression* of a perception is closest to the 'world'; *facts* are perceived and expressed in a sentence. Consider the next example:

If the sun starts shining, I get warm
The sun starts shining
———————————————————— So:
I get warm

According to Wittgenstein[a] the world is the totality of the *connections* (facts), not of the *things.* Basically I do not perceive the sun as a thing, but as a 'shining connection', for my first perception is 'something shines' (compare, 'something moves'), next I ask myself: 'What is that?' 'Something shines' can be rendered in formal logic as "there is an x' (∃ x) 'for which holds that' (:) 'x shines' (S(x)). Predicate logic codes that, like ∃ x:S(x). By the same token, shining is a function of x. It is still a variable, x: it may be a lamp or a sun, but it does shine. For convenience sake 'on me' is forgotten. That is not without importance, for it establishes a connection, a link. Next I can emancipate 'x shines' as 'the shining of x' that I can envelop by the function B 'beginning': ∃ x:B(S(x)). Something starts shining, what is that? The sun: ∃ z:B(S(s))! I have now substituted an independent name (s) of something that begins B shining S. What do I have gained here by substituting a noun? Is it not just the name, that other

a This term is suggested by Roozenburg, N.F.M. (1993) *On the pattern of reasoning in innovative design*. as an alternative for 'innovative abduction'. This term was suggested by Habermas for a form of abduction that was not explicit in Peirce. However the form of innoduction presented here does not co-incide with the form Roozenburg uses in his paper.

b Jong, T.M. de (1992) *Kleine methodologie voor ontwerpend onderzoek*.

people have given to the thing, as much as a naming function s=N(x)? My formula extends: ∃ x:B(S(N(x))); where is the end? What is named?

By percieving this *connection* I can, for instance, distinguish the shining and the shone unto as active and passive things. Subsequently I can name these things with nouns, make them independent and use them as a subject 'Sun' and object 'that tree' or 'myself' as expressed in a sentence. Barring lies, the fact takes here from the world the barriers of the *impression* and the *expression* to land from that world into the sentence 'the sun is shining'. The fact that someone utters this full sentence is in its turn a new fact that has to take these hurdles again with other people.

A story to match can be told about the second statement 'I get warm' in spite of a number of new philosophical problems, like the meaning of the word 'I', the subjective experience of 'being cold', eventually as a 'property' of the 'I', the possible independence of the concept 'cold', etc. We leave those problems for what they are.

23.27 GRAIN

We assume that both perceptions have landed 'well' into the sentence, and that both are 'the case'; we consider both to be 'true'. They are two facts, combined by the word 'if … then …'. This little word establishes no causal connection like 'hence'; it just denotes that two facts on the same place and within a certain period ('here' and 'now') both are simultaneously 'the case'. That special condition is of importance, because of the local fact that the sun will shine somewhere else, the period imports, while the sun will set before too long. Each perception or observation implies place and time and a size of them both, the 'grain' of it.

In this case the grain was definitely smaller than half the surface of the earth and smaller than half of the 24 hours the earth takes for one spin around here axis, but larger than a point and a moment, since both do not have to occur simultaneously in an absolute sense, but for instance within the period of reliability of the assertion, a short time after one another. The under limit may be determined by asking across which area the observation was extended (in the second statement restricted to 'I'), and for how long the situation (the state of affairs) lasted.

The expression of the observation can now also be made more precise by indicating within the grain of time a sequence:

'First the sun starts shining and then I get warm'. Now suppose that it becomes cloudy next and that I'm getting cold. This expression of the facts is admittedly true, but I leave so many facts out of consideration (a 'half-truth'), that on the basis of this body of facts I can never arrive at a simple hypothesis, education or causal explanation that is known to us now.

a Wittgenstein, L. (1922) *Tractatus logico-philosophicus*.

24 MATHEMATICAL MODELS

TAEKE DE JONG
REIN DE GRAAF

A curriculum in mathematics for the Architecture Faculty at Delft University, taught for a few years during the nineties by the Mathematics Faculty, was ill-suited to the architecture staff, including its examples and references. So, the students who could not understand what use it was, experienced more nuisance than stimuli while designing, and were avoiding mathematics in the curriculum as a whole, where other disciplines could compensate for low grades in mathematics. The practice of design was doing well with high-school maths with some extensions, so why bother?

The realistic production of form is, as always, superior to the abstract mathematical detour via form description by Cartesian co-ordinates, even if fractal forms are generated. The mathematician and designer Alexander has been more successful with his '*Pattern Language*' [a] than with his '*Notes on the Synthesis of Form*'.[b] The remainder of mechanics and construction physics is being taken care of by specialised consultant agencies and computers following delivery of a sketched design. No senior designer has any recollection of the content of mathematical education (s)he was exposed to during the sixties and seventies, when it was compulsory, while the practice featured nothing that might benefit from remembrance.

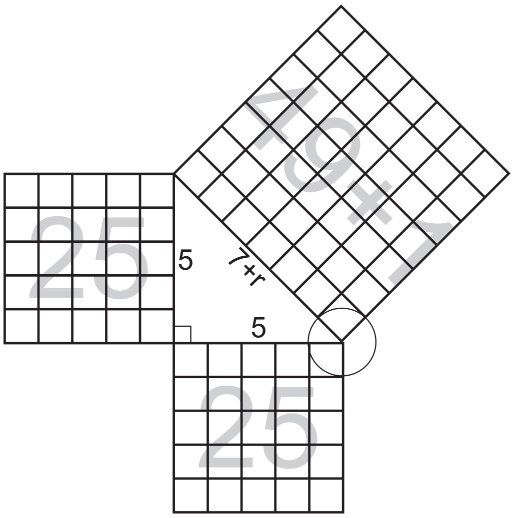
Of the lecture notes on architecture, 'geometry', 'graph theory', 'transformations and symmetries', 'matrix calculation' and 'linear optimising', 'statistics', 'differential and integral calculation' composed and, in the nineties, introduced in a simple form with the problem-orientated education only the latter may be found in the Faculty's bookshop anno 2002. This last relict is due to the tenacity of the sector Physics of Construction. During the more mature years of building management matrix calculation for optimising exercises is being brushed-up from high-school maths. Then one is lacking the lost foundation in the first year. With the slow filtering-through of end-user friendly computer applications, as there are spreadsheets and CAD (pixel and vector presentations of form) during designing a new interest is dawning. Computer programs like Excel, MathCad, Maple or MatLab do ease experimenting with mathematical formulae as never before.

From these mathematical ingredients, also adopted by Broadbent[c] as relevant to architectural design, maybe a new mathematics for architecture might be composed. Architecture itself and civil engineering, it should be remembered, were standing at the cradle of mathematics. This Chapter does not pretend to stand at the birth of a new building mathesis. As urban architects, its authors fall short of the proper attainments. However, it gives a global survey of mathematical forms that may be employed in architectural design – with a reading list – providing linkage with a new element as a point of departure: combinatorics. Whoever wants to brush up on high-school maths[d] or to get a bird's eye view of mathematics as a whole[e] is referred to publications pertaining thereto. Experimenting with the Excel computer programme is especially recommended. In spite of that, Euclid's answer to the question whether there would not be a simpler way to study geometry than his 'Elements'[f] is still applicable: "There is no regal road to geometry'.

24.1 ORIGINS

Mathematics is a language developed in order to describe locations, sizes (geometry), numbers (arithmetic)[g] and developments from observations (measurements and counts), to process these descriptions and to predict new observations on that basis. In this vein, until 500 BC, for the founding of cities in Greek colonies a square of 50 x 50 plethra (a 'plethron' is some

a Alexander, C. (1977) *A pattern language*.
b Alexander, C. (1964) *Notes on the synthesis of form*.
c Broadbent, G. (1988) *Design in architecture: architecture and the human sciences*.
d Kervel, E (1990) *Prisma van de wiskunde 2000, wiskundige begrippen van A tot Z verklaard*.
e Reinhardt, F., H. Soeder et al. (1977) *dtv-Atlas zur Mathematik*. Dutch translation: Reinhardt, F. and H. Soeder (1977) *Atlas van de wiskunde*.
f A complete interactive version of the 'Element', the 'Bible' of geometry, may be found on the internet: http://aleph0.clarku.edu/~djoyce/java/elements/usingApplet.html. It is argued on this site and its links that omitting the Euclidean method in education and exchanging it for a derivation from set theory is detrimental to the logical deduction of conclusions from axioms via propositions to new propositions. The site is interesting by the possibility to change geometrical schemes. This demonstrates the operational character of mathematical propositions and formulae.
g A distinction that was made by the Greek mathematician Proclus.



192 Pythagoras

30 metres) was paced off thanks to a diagonal of 70 plethra, in order to realise straight corners.

Pythagoras (580 – 500 BC) – or one of his pupils – next provided the well-known proof that the ratio should be slightly larger than 7 to 5; while the square of 7 is just one unit less than 25 + 25. From the womb of geometry, thus, the arithmetical insight was born that real numbers ℝ exist – such as the square root of 2, or the real length, derived therefrom, of the diagonal – not to be attained by simple partitioning (rational, ℚ) of natural numbers (ℕ = 1, 2, 3 …). Geometry – literally: 'measuring of the land' – owns its first described development to the annual flooding of the river Nile. In ancient Egypt, floods wiped out the borders between estates and property, so that each year it had to be determined geometrically who owns what; as seen from standpoints which were not flooded. Arithmetic has roots in Phoenician trade. The Greek Euclid (around 300 BC) collected knowledge in both senses of his day and age in his book *'Elements'*, (via the Arab world) the cornerstone of all education in geometry well into the twentieth century. Euclid used earlier texts, but derived as the first the propositions of geometry by logical reasoning from 5 axioms.[a] With this, a process was completed emancipating mathematics from empirical practice of measuring and counting examples.

24.2 THE MATHEMATICAL MODEL IS NO REALITY

Since then, mathematics can, like logic, without observing the sizes of input (non-empirically, a priori) come to new forms of insight (synthetic judgements). Logical proof dominating, they are accepted as new insight also without observing sizes of output. The philosopher Kant (1724 – 1804) struggled with the question how that is possible at all: synthetic judgement *a priori*.[b] For an empirical-scholarly theory always states that in the case of an independent observation from a set X, a corresponding independent observation from a set Y follows. If the elements of X and Y may be put in a corresponding, following, order so that they form the variable x and y, one may interpolate observations that have not been performed, while at constant conditions (*ceteris paribus*) – not included in the model – extrapolating to the future. A regularity of their correspondence is regarded as a working between them: y(x). Probable (causal) as well as possible (conditional) workings exist. If, for instance, the size of the population (x) is increasing, the number of buildings (y) is increasing as well following a hypothetical working y(x).

The larger the number of observations (n), the more convincing the theory. If one can demonstrate, by way of one hundred time sequences[c] (n = 100) that between the two of them a working (function) may be defined that convinces more than one single correspondence in the past year (n = 1). At larger numbers of independent input observations, the scholar can look for a mathematical working y = f(x) (e.g. y = ½ x) producing the same results as dependent observing (modelling). A just input and output must show a perceptible relation to reality, not the mathematical operations employed by way of a model. Different (mathematical or real) workings (functions) may yield the same result. As soon as other facts are observed than those predicted, the empirical theory is rejected; not necessarily the mathematical discourse playing a rôle therein; although the two occasionally get confused. If the predictions are confirmed, in its turn, the mathematical working model is often regarded as 'discovered' reality ('God always calculates').[d] However, this is not necessary in order to accept a theory (until the opposite has been proven).

24.3 MATHEMATICS IS THE LANGUAGE OF REPETITION

Just as in daily parlance, in logic and mathematics as well, concepts (statements, expressions) are used and composed into a model (declarations, sentences, full-sentence functions[e], workings, functions) with operators like verbs and conjunctions. Logic is using these operators particularly in the case of conjunctions (for instance: if P, then Q) mathematics the verbs

a Non-Euclidean geometry rejects one or more of these axioms.
b Kant, I. (1787) *Critik der reinen Vernunft*. The programme of this study is summarised particularly clearly in the Preface to this edition. A short introduction to Kant: Schultz, U. (1992) *Immanuel Kant*.
c A well-known publication of CBS is *'X years in time series'*, e.g. Centraal Bureau voor de Statistiek (1989) *1899-1989 negentig jaren statistiek in tijdreeksen*.
d 'Ηο θεοσ αει γεομετρει', according to a famous Greek statement.
e See Reinhardt, F., H. Soeder et al. (1977) *dtv-Atlas zur Mathematik*.

(functions such as adding and summing). Logical deductions in mathematics usually have the logical linguistic form: 'if working P, then working Q'. However daily parlance has the capacity to name *unique* performances. This primal declarative function of everyday language has the character of a contract. Only when the performance has been witnessed anew is there a rational ground to start counting. *What is repetitive is food for mathematics*. For all mathematical operating, name-giving, as in everyday language, is – usually implicitly – pre-supposed. However, mathematics is of no use in unique performances. If one stone weighs one kilogram, then two stones weigh only two kilograms if they are 'equal'. This equality (here in terms of size and material) can only be agreed on by normal words. Sub-dividing dissimilar stones in equal fragments (transforming sizes in numbers, analysis) can make unique specimens elective for counting, and then for mathematical operations based on that counting. The question whether that can be done will always remain; as in Solomon's judgement: two times half a child means no child anymore. In analysis a connectivity, incorporating the essence of the architectural object, may get lost and will remain lost during synthesis to a different magnitude (counting). The scale paradox may be a nuisance while sub-dividing an object again and again in increasingly smaller parts, in order to compose next from this a different order of magnitude or to predict it (infinitesimal calculation, differential and integral calculation). The other, lost properties – in a specific context – may be taken into account next in the formulae (increasing validation, see page 258), but this is just shifting the problem.

24.4 SERIAL NUMBERING

Serial numbering (sequential numbering) just pre-supposes difference in place, not similarity in nature. I can enumerate the total of different objects in my room (or letter them) in order to be able to see later whether I am missing something, but this serial numbering does not allow mathematical operations. In spite of the fact that they are mathematically greatly important, since ordered difference of place (sequencing) is crucial in number theory.[a] The serial number serves as a label, name, identification (identification number, ID number, or index, in the case of variables) that may prevent exchanging, missing and double counting. By the same token, it is impossible to calculate with these numbers, although 'serial numbering' is pre-supposed silently in the case of 'counting'. Sequencing of numbers has in principle no other purpose than that it is staying the same, even if the numbered objects are changing later in place. The number stabilises differences in place ever witnessed as if on a photograph.

Nevertheless, the sequence, in which one is numbering, often gets, in practice, a meaning (for instance: in the order of arrival), allowing conclusions. Although one is inclined to introduce with an eye on that some logic in a numbering (categorising), it is halted sooner or later, while numbering is incurring lapses or lack of space. At current capabilities of information processing, this is why it is advisable, for instance, to open in a spreadsheet a database next to the column with sequential identification numbers (always to be produced independent of the shifting row and column numbers!) new columns in order to distinguish categories on which one wants to sort. For the mathematics it is important that it is possible to number input and output numbers, to index, identify and retrieve from a database in a fixed sequence and combination. The serial number is the carrier of the difference of place in a database. A reliable database is carrier of differences in nature and place in the reality (not that nature and place itself). To ensure that an identification code will always be pointing at the same object it should be invariant during the existence of that object. Additionally it is not allowed to have meaning in terms of content, such as a postal code and house number combination, for this changes in the case of home-moving the corresponding 'object'.

24.5 COUNTING

Observations can only be expressed mathematically if they are occurring more than once (in a comparable context) and may be harboured as 'equal' in any sense in a set. Only then can

a Russell, B. (1919) *Introduction to mathematical philosophy*. Frege, G. (1879) *Die Grundlagen der Arithmetik, Ein logisch mathematische Untersuchung über den Begriff der Zahl*. English translation: Frege, G. (1968) *The foundations of arithmetic: a logico-mathematical enquiry into the concept of number*. Dutch translation: Frege, G. (1981) *De grondslagen der aritmetica, een logisch-mathematisch onderzoek van het getalbegrip*.

one count them. The equality pre-supposition of set theory and mathematics is sometimes forgotten, or all too readily dissolved, by analysis (changing scale by concerning smaller parts). In this way an area of 1000 m^2 can be measured by counting, but each square metre has in many respects a different value that makes the area found in itself (without weighing) meaningless. The equality pre-supposition can lead to mathematical applications without sense, when the set described is too heterogeneous qua context or object for weighing. In this vein I can count the number of objects in my room, but each and every mathematical operation on this number alone does not lead to useable conclusions. Some objects are large, others small, some valuable, others not; or not elsewhere. From the number I might perhaps derive the number of operations in case of moving home, but these actions will be differing in their turn with the nature of the objects. Still I can say: “If I throw away something, I have less to move.” If I throw away a moving box with that argument, I have less to move, but this has no relation anymore with the effort (larger without the box) of moving that may have fostered the argument. Mathematical modelling would be misleading here and requires a comparable context.

So: some equality in nature is already pre-supposed when it comes to counting. Curiously enough, a difference is also pre-supposed: when counting, I am not allowed to point at the ‘same’ object twice (double counting). The objects pointed at should differ! What this difference in identity exactly is, is left here undecided;[a] for reasons of convenience we call it ‘difference of place’, although this does not cover, for instance, the problems involved in counting moveable objects like butterflies on a shrub, mutually exchanging places. A number, or variable, therefore pre-supposes equality of nature and difference of place, even if that place is not always the same.

The equality in *nature* pre-supposed when it comes to counting does require the definition of a set (determining which objects we count or not). This definition is pre-supposing within the set defined equality, but at the same time to the outside difference with other sets. This paradox is explained elsewhere in the book as a ‘paradox of scale’ or ‘change in abstraction, see page 37. In addition the ‘nature’ is not possible to change during counting. It is not allowed to use one century for counting one basket of apples, since it is likely that after an age like that the apples will not exist anymore.

The difference of place pre-supposed at the moment of counting does require a unique indication of place (which objects were already dealt with or not yet). By the same token such an indication of place is pre-supposing distances between the places (intervals) or between their centres (core to core distance); if that would not apply they would not differ and be unique. The size of the places indicated (scale) should be equal to the one of the objects placed (extension); if that would not apply one place could contain several similar objects, pre-empting identification of the objects themselves. Rather paradoxically, difference of place (uniqueness) is also pre-supposing an equality of scale (unit or order of magnitude) in order to guarantee that uniqueness. An object without scale (a point) may still be identified by mutual intervals. If these are small enough, points may produce a line, a surface or a volume.

24.6 VALUES AND VARIABLES

Therefore, we are counting by pointing at similar objects differing in their various places (in order to avoid double counting). Since that place may change, we make a snapshot, stating for the differences of place a randomly chosen, but fixed sequence, numbering(serial). To each indication a different name is given, number(serial). The final number is the number(quantity) or figure. Sometimes the sequence is of no importance, so that it is possible to restrict oneself to a uniquely identifying naming (nominal values). When the sequence imports, the values are termed ‘ordinal’. Next, when the intervals between the objects numbered are equal, we call the number an ‘integer’. This enables operations with interval-values such as adding, subtracting, multiplicating and dividing, without the need to indicate, count

a Frege, G. (1879) *Die Grundlagen der Arithmetik, Ein logisch mathematische Untersuchung über den Begriff der Zahl*. This problem is described in paragraphs 34 to 54 and proves to be not as easy as it seems.

or re-count the objects and their places. With this different counts may be predicted from certain counts, but the result may also be a ‘non-object’. By naming this outcome ‘zero’ according to a price-less discovery of the world of Islam, and even by extending it after boundless subtracting with ‘negative numbers’ calculating is not restricted to objects accidentally present.

This is opening the road to calculation without reference to existing objects. By taking zero for a point of departure with at both sides the same interval as between the other numbers, the distance of this zero point to two numbers can provide a relational number (rational value). This is the foundation for measuring. Sometimes this results in fractions, that may be expressed in ‘rational numbers’. If they are represented as points on a line of numbers, it becomes apparent that in between the numbers resulting from division of integral numbers still other values exist (real numbers). Ratios can also yield a relation between numbers of different kinds of objects (for instance inhabitants per residence: residential occupation). The set of values of one kind is called ‘variable’. Function theory tries to work out arithmic rules for predicting, from the development of one variable x, another variable y. It is often difficult to determine, whether x and y entertain also a causal relationship, or are just demonstrating some connection (correlation); for instance on the ground of a common cause, a third variable, or if a great many causes and conditions are at work.

Particularly in probability calculus chances and probability distinguishing between these various kinds of values is important.[a] Then large numbers of results of a process are taken into consideration and the chance of a few of them is calculated (event). Extreme values are occurring less often as an outcome of many natural processes than values in-between. As a measure for the distribution between the extreme outcomes the average and its mean, the median and the modus are used. The average of a large number of values can only relate to interval values or rational values. In the case of ordinal values, no average exists, but a median (as many outcomes with a higher as with a lower value). In the case of nominal values it is also impossible to calculate a median; then a modus can be used (the number of values occurring most frequently).

When a set of values X is now compared to a different set Y in order to find between both a correlation, various statistical arithmetic methods (tests) exist, depending on the kind of values representing X and Y. In figure 193 the nominal values have been distinguished in dichotomous (yes – no) or non-dichotomous (multi-valueous).

	Y		
X	Nominal	Ordinal	Interval & ratio
Nominal (dichotomous)	Cross-table	Mann-Whitney	- Big sample: t-test/ANOVA - Small sample, Y normally distributed: t-test/ANOVA - Small sample, Y not normally distributed: Mann-Whitney
Nominal (not dichotomous)	Cross-table	Kruskal-Wallis	- Big sample: ANOVA Small sample, Y normally distributed: ANOVA - Small sample, Y not normally distributed: Kruskal-Wallis
Ordinal	Not applicable	Rank-order correlation	- Rank-order correlation
Interval & ratio	Not applicable	Not applicable	- Big sample: Pearson-correlation - Small sample, X and Y normally distributed: Pearson correlation - Small sample, X and Y not normally distributed: rank-order correlation

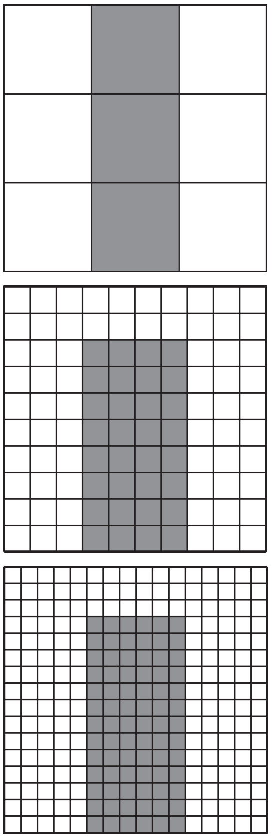
193 Summary of tests on paired chance variables X en Y[b]

24.7 COMBINATORICS

As soon as counting has been mastered, one may name on a higher level of abstraction the internal categories (k), pre-supposed to be homogeneous, and unique places (n) themselves; number and count them. Allocating over the available places the kinds and within it the number of kindred cases (p) is the subject of combinatorics. It is pre-supposed in numerical systems and, therefore, a fundamental root of mathematics. This way the number of possible arrangements of 10 names over 2 places equals 100, over 3 it is 1000. Due to the Islamic discovery the notation of large numbers by combination of cipher names has become simple and more accessible to calculations.

Combinatorics may also be regarded as a basic science for architectural designing. More generally, one may calculate the number of possible arrangements, without any restriction, of k categories over n niches as kn. When it is supposed that 100 different kinds of building materials (among them air, space) may be used on a site of $100m^2$, with 1 mln inter,connecting allocation possibilities of 10 x 10 cm, this is yielding already in a flat surface many more design possibilities ($100^{1000000}$) than there are atoms in the universe (10^{110}). The designer is travelling, so to speak, in a multiple universe of possibilities, where the chance of

a Stevens, S.S. (1946) *On the theory of scales of measurement.*
b Leede, E. de and J. van Dalen (1996) *In en Uit. Statistisch onderzoek met SPSS for Windows.*

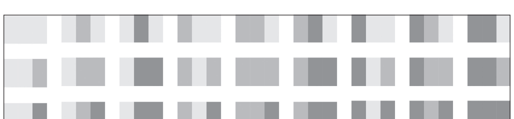


n = 9 k=3, scheme

n = 100 k=32, rough draft

n = 256 k=78, Windows-icon

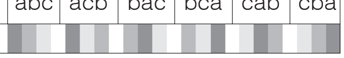
194 A programme, approx. 1/3 of the site, spread over the ground in 3 resolutions.



aaa	aba	aca	baa	bba	bca	caa	cba	cca
aab	abb	acb	bab	bbb	bcb	cab	cbb	ccb
aac	abc	acc	bac	bbc	bcc	cac	cbc	ccc

195 V(3,3) = 3^3 = 27 variations

niches n	just as much *different* colours as niches					
1	a					
2	ab		ba			
3	abc	acb	bac	bca	cab	cba



196 P(n) = n! : 1, 2 en 6 permutations

4	abcd	acbd	bacd	bcad	cabd	cbad
	abdc	acdb	badc	bcda	cadb	cbda
	adbc	adcb	bdac	bdca	cdab	cdba
	dabc	dacb	dbac	dbca	dcab	dcba

197 P(4) = 4! = 24 permutations

198 Combinatorial explosions

a Formulation derived from Reinhardt, F., H. Soeder et al. (1977) *dtv-Atlas zur Mathematik*.

b Deelder, J.A. (1991) *Euforismen*.

meeting a known design is practically nil. With this, to all practical purposes, infinite number of possibilities no rational choice is possible by taking them all into account. Also, when restricted by a programme of requirements, in which the units 'space' must be positioned in certain amounts in inter-connection, the number of possibilities is still practically infinite. The various mathematical disciplines passing muster in the following paragraphs as possibly relevant for architecture, are described there as rational restrictions of this number of possibilities.

The designer, faced by a white sheet of paper or a blank screen, is asked to indicate on it difference in place (state of dispersion; form) and in kind (colour). The differences in nature are contained in a range to be generated (the 'legend', in its original connotation) spread in k units of colour (e.g. the programme) over n niches (appropriate fields, for instance on the grounds of the site); the differences in place.

How many different states of dispersion can be generated in total? In mathematics the branch of combinatorics deals with that kind of 'arrangements' in finite sets and with counting the possibilities of arrangement under suitable conditions.[a]

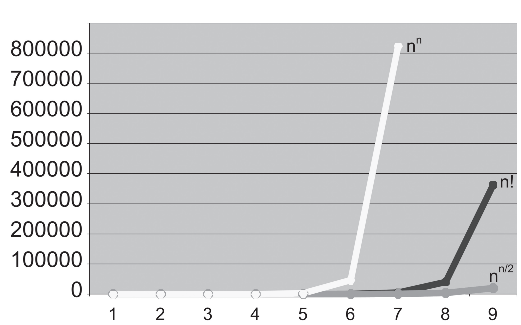
If a range of k = 3 colours is available for colouring n = 3 fields, 3^3 = 27 variations apply. In this way the colours red, white and blue combined with three fields yield 27 distinct flags. More generally: V(n,k) = k^n (variations with repetition). With as many colours as niches the expression reads n^n.

Among them, however, there are many cases in which colours have been repeated or omitted. True 'tricolores' are but few. The first condition to be added amounts to the presence of all three colours. Colour one has 3 positions available; for the second 2 remain; and for the third 1. This limits the number of cases to 3 x 2 x 1 = 6, abbreviated to 3!, so-called permutations. More generally, one may write: P(n) = n! (permutations without repetition).

24.8 TAMING COMBINATORIAL EXPLOSIONS

Permutations restrict the ultimate number of variations: 3!, is less than 3^3; n! rises less fast than n^n, but faster than, for instance $n^{n/2}$, when only half the amount of niches is used for the number of colours 'Factorials limit the largest powers'. Yet, permutations do increase fast enough to lead to a 'combinatorial explosion' on higher values for n.

How to select from all these possibilities? To many people this is a crucial question in personal life and in designing. With so many possibilities a conscious choice does not apply actually, so that during the reduction of the remaining possibilities, still not yet imaginable, one is guided by contingency, emotion of the moment, sensitivity for fashion, or routine. Deelder says: '*Within the patches the number of possibilities equals those outside them."*; as long as the resolution is lowered.[b]



Although mathematics is used generally in order to arrive at *singular solutions*, where different possibilities are not taken into account to the dismay of the designer, this discipline may also be used to *reduce the remaining possibilities* within exactly formulated, but in other respects freely varying conditions (for instance a scale system of 30 x 30 x 30 cm)[a] and to survey them. The branches of mathematics relevant to architecture are therefore seen here as the formulating of these *restrictions on the total amount of possible combinations*.

- *Systems of measure* are mathematical sequences reducing the sizes of components to convenient sizes.
- *Geometry* restricts itself to connected (contiguous) states of dispersion (shapes) such as lines, planes, contents, which can be described with a few points and with a minimum of information as to their edges.
- *Graph theory* restricts itself to the connections between these points (lines with or without a direction) regardless of their real position.
- *Topology* formulates transformations of forms and surfaces, so that one form can be translated in another one by a formula. This involves the direct vicinity of each point in the set of points determining this surface. For minimising the curved surfaces between the closed curves (soap skins) the forgotten mathematical discipline of the calculation of variances is necessary.[b] This mathematics is also applied to the tent roof constructions of Frei Otto. However, this discipline is too complicated to be introduced in this context.
- *Probability theory* and its application in *statistics* restricts itself to the occurrence of well-defined events, for instance the happening of one or more cases among the possible cases in a given space or time.
- *Optimising* by *linear programming* aided by *matrix calculations* formulates the remaining exactly restricted possibilities as the 'solution space'.

Next to these mathematical restrictions there are any number of intuitive restrictions causing the disregard of possibilities. If one recognises, for instance, in the illustrations of figure 194 the image type of a door in a wall, the basis of the door (programme k) should lie in the lower part of the wall (the space present n), unless a staircase is drawn as well.

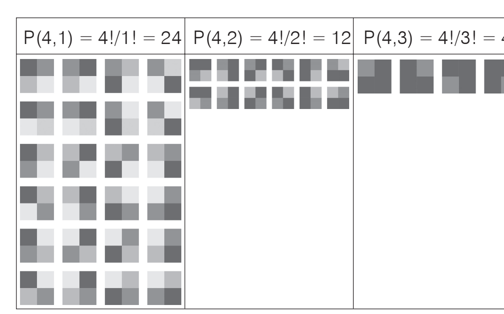
24.9 THE PROGRAMME OF A SITE

With variations (k^n) and factorials or permutations (n!) alone it is impossible to determine the number of cases when a particular colour has to be present in a predictable amount (a quantitative 'programme' per colour). With a programme for an available space n, where one colour (for instance black) has always to be present at least p times P(p,k) = n!/p! possibilities exist (permutations with repetition). The p! in the denominator of the ratio restricts the explosive effect of n! in the numerator at higher values of n, except of course, if it equals 1. That applies in the first column of the figure below; if p = 1 (so p! = 1) it has no effect on the ratio; the number of permutations P remains, as in the previous example with letters, 4! = 24. At p = 2 (p! = 2) and p = 3 (p! = 6) the number is restricted.

The larger the programme p of one colour (in this case black) with regard to the total space available, the less possibilities remain for other colours to generate cases. Evidently, p, the number of colours surfaces to be distributed may not exceed the space n available. The formula pre-supposes that the niches remaining will be filled with as many different colours. They generate the additional cases, not requiring attention from a programmatic point of view.

If not only the programme p, but also the complementary remainder n - p is combined into one colour, no other colours remain to generate additional cases. A permutation with two colours, p_1 and p_2 equals the formula n! / $p_1!p_2!$ The possible arrangements of programme p1 and the remainder p2 develops into n! / p!(n-p)! (Newtons binomium)[c].

Within both surfaces, the sequence in which the niches are filled in with one colour is now irrelevant. The only consideration of importance left is the number of different instances in which one quantity p is allotted to n possibilities without a rôle for its own sequencing.



199 Permutations in 4 niches, with at least k = {1,2,3} black elements combined with other hues.

a An example of a measure-system with equal measures also applies, by the way, to the choice of a resolution.
b Hildebrandt, S. and A. Tromba (1985) *Mathematics and optimal form*. Dutch translation: Hildebrandt, S. and A. Tromba (1989) *Architectuur in de natuur: de weg naar optimale vorm*.
c In case 0!, 0! = 1 by definition.

C(4,1)	C(4,2)	C(4,3)
1x2x3x4/ ((1x)(1x2x3)) = 4	1x2x3x4/ ((1x2)(1x2)) = 6	1x2x3x4/ ((1x2x3)(1)) = 4
abbb,babb, bbab,bbba	aabb,abab,abba, baab,baba,bbaa	aaab, aaba, abaa, baaa

200 Combinations in 4 niches of 2 colours

This entity plays a leading part in statistics. Factor p then is the number of possibilities of an event, n – p is its complement of possibly not happening that event. So, not only possibilities in space apply: n may also reflect time. A little counter-intuitively the common expression is 'combinations'; and one simplifies the formula P (n, p_1, p_2) = n! / p_1! p_2! to C (n,p) = n! / p! (n - p)! ; or shorter still: $\binom{n}{p}$, 'n over p' (combinations without repetition).

Without fail, one will experience the highest level of freedom of design if a one-colour programme occupies half the site available (p1 = p2); a sound reason to plead with the principal for as much open space as space built. At higher resolutions as shown in the diagrams on page 208 even the number of black-white combinations rises again explosively C(9,3) = 84, C(100,32) = 140 000 000 000 000 000 000 000 000 (1,4E+26 for short in Excel), the Windows-icon shown (16pixels x 16pixels = 256pixels), amounts at 78 black pixels C(256,78) already to 1,2149E+67 images. Excel calculates this with the command = COMBIN(256,78).

Again, the greatest freedom to design is found in an equal distribution between black and white pixels: C(256,128) = 3,50456E+75. If 256 colours can be used the variance formula is 256^{256} (10^{616} or 2^{2048}). This exceeds the number of atoms in the universe by far (10^{110} or 2^{365}). If one studies, for instance, 5625 locations of 1 km^2 in the colours 'built' (815) and 'open' (4818), approximately 10^{1008} or 2^{3349} alternatives exist for the present 'Randstad' area in the Netherlands. The average PC cannot deal with this. Excel digests in this case at great pains p=156.

In this sense the designer is travelling in a multiple universe of possible forms (states of dispersion). The chance one runs into a known form is, in this combinatorical explosion, negligible

The number of elements of the programme (legends units, colours, letters) may be raised above 2; within the total sum of n, of course. This enables the calculation of the numbers of cases belonging to a specified programme on a location. If one wants to allocate for instance 4 programmatic elements to n fields, there are P(n,p_1,p_2,p_3,p_4) = n!/p_1!p_2!p_3!p_4! design possibilities. The total of the colour surfaces p_1+p_2+ … desired is again not allowed to exceed, of course, the surface available in total n. With a computer programme such as Excel one can calculate, for instance, that the possibilities of allocating 4 types of usage of 25m^2 each to an area of 100 m^2 is 2,5E+82.[a]

24.12 THE RESOLUTION OF A MEDIUM

A pen, pencil or ball-point draws points and lines occupying a minimal surface, corresponding with the thickness of the material. Surfaces may then be depicted by filling in the surface with such lines. A computer screen is building an image from tiny surfaces (picture elements, pixels) that suggest contiguous lines or surfaces. This resembles the difference in the history of art between the Florentine (line-orientated) and the Venetian (point-orientated) 'disegna'. A usual screen features 1024 x 768 pixels.

A pixel-orientated program (paint- or photoprogram) just supports the colouring of these points like in painting. If a 'line' or 'surface' is over-written, the only way to restore it is to fill in the previous colour of the over-written pixels. More often than not foreground and background are not distinguished in layers allowing display layer by layer, or in combination.

A computer drawing program (vector program, drawing program or CAD) just takes together the essential points of a drawing into a matrix of co-ordinates and translates the drawing into pixels between these points as soon as it is activated. The pixels in between are not being remembered during storage, so that mass-storage space requires less space than a pixel image. In the case of an enlargement of the drawing or of a detail, the resolution adapts itself automatically, so that the lines are not blurred.

a This can be done with the formula: =FACT(100)/(FACT(25)*FACT(25)*FACT(25)*FACT(25))

A vector is a matrix with one column (or row) that in the flat plane just needs two co-ordinates to be defined from an origin. In the figure alongside three vectors a, b, and b-a have been drawn. They illustrate the calculation rules that are of great service in drawing programs and applied mechanics. The line segment AB is represented by the co-ordinates of the vectors a and b; the points in between are calculated by giving a co-efficient I between 0 and 1 a sequence of values provided by the formula l (b-a)+ a.

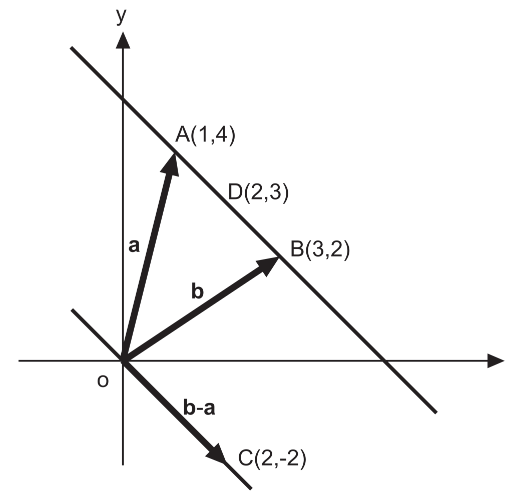
vector substraction			l =0,5	
A	**B**	**b**-**a**	l(**b**-**a**)	l(**b**-**a**)+**a**
1	*3*	2	1	2
4	*2*	-2	-1	3

This way I=0,5 yields the point in between D(2,3). The larger the number of values calculated, the greater the resolution of the line segment AB.

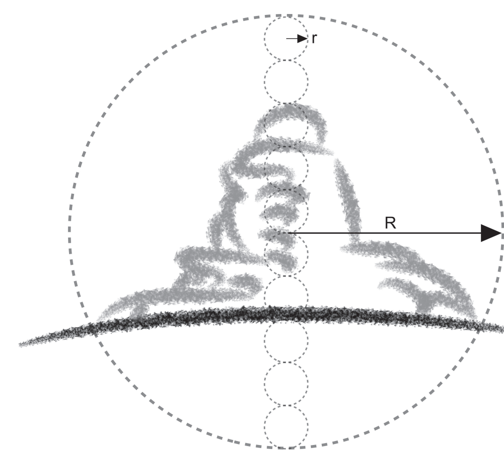
The combinatoric explosion of possibilities is already drastically reduced during the initial stage of the design by the coarseness or, in reverse, the resolution of the drawing. That is something different than the scale of a drawing.

The position of a deliberately coarsely sketched line must be judged according to commonly understood conventions within certain margins. The size of such a margin surrounding a drawn point we call ‘grain’. We call the radius R of the circle inscribed in the drawing as a whole ‘frame’, and the ratio of the radius r of the grain to R ‘resolving capacity’, or ‘resolution’. The ‘tolerance convention’ could be interpreted as ‘any sketched point may be interpreted within a radius r, by that interpretation transforming the rest of the drawing accordingly’. The tolerance of the drawing is expressed by r.

A sketch with a grain of roughly 10% of the frame is known as a loose sketch. It is used in an early concept, a type or a schema. It is often produced with a felt-tipped pen; with the same order of magnitude as the grain of the drawing, by that means stressing the tolerance convention. A ‘design’ hardly has a smaller resolution than 1%. A blue-print or computer screen does not exceed 0,1%. Only at this level things like details in the woodwork of a door and its frame in a wall are displayed. The total concept of a work of architecture is highly influenced by details, observed by the zooming eye of an approaching user.



201 Defining line segments by vectors

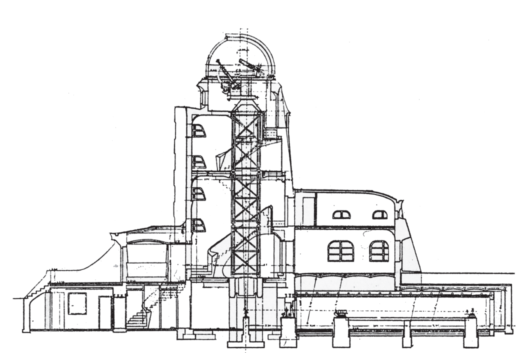


The radius r of a grain here is approximately 10% of the radius R of the frame.

a Source: Media-centre, Fac. of Arch. DUT. After: Zevi, B. (1970) Erich Mendelsohn, opera completa, p.65.

202 Mendelsohn *Einsteinturm* (Potsdam, 1920) [a]

Sketch approx. 10% resolution



Drawing approx. 1% resolution

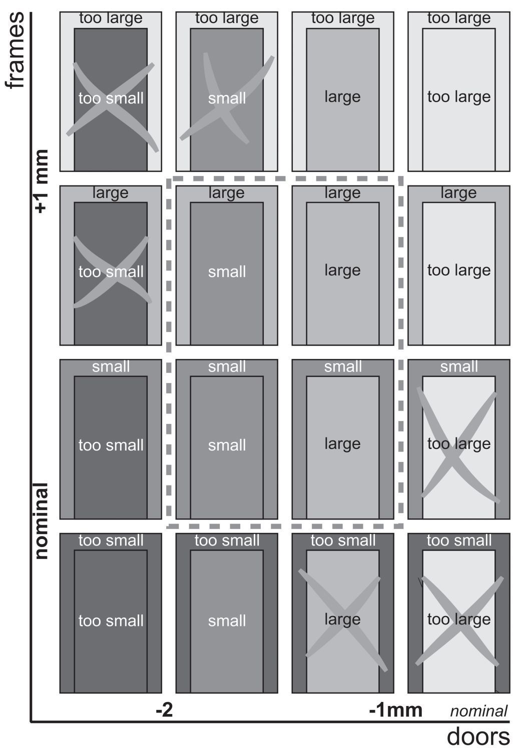
Screen approx. 0,1% resolution

24.11 THE TOLERANCE OF PRODUCTION

A door should be slightly smaller than its frame in order to acquire a functional fit. In addition a carpenter or machine makes frames and doors respectively slightly larger, or smaller, than the nominal size written on the blue print.

This is also taming the mathematical use of positions behind the comma for architecture and technique in general. One is not allowed to think anymore in terms of numbers representing a point on the line of numbers: they are representing a margin, a band-with, a distance or class on that line. The nominal size is indicated on the blue-print, but it is certain that this precise size will never be delivered.

The frame should be equal or larger than the nominal size, the door should be smaller, but how much? The limits put to this product tolerance must be calculated by weighing the price of the precision and the performance of the door as a closure. If the tolerance of the frame opening is 0 to + 1mm, and the tolerance of the door –1 to –2 mm, the crack-width will be 1 to 3 mm, divided over two sides.



203 Acceptible and not acceptible sizes

In order to decide whether to accept a batch of doors and frames or to send them back, no absolute measures are taken into account, but rather margins, classes such as ‘too small’, ‘small’, ‘large’ or ‘too large’. They may vary within limits of tolerance. In the case of the frames of the example alongside these limits are *vis-à-vis* the nominal size M:

‘too small’ < M + 0 mm < ‘small’ < M + 0.5 mm < ‘large’ < M + 1 mm < ‘too large’,

while for the doors the nominal measure:

‘too small’ < M – 2 mm < ‘small’ < M – 1,5 mm < ‘large’ < M – 1 mm < ‘too large’.

In first instance one assumes that they are not too small, nor too large (zero-hypothesis, dotted contour in the drawing) while a few are measured in order to see whether they are belonging to these classes yes or no. However on the basis of a random selection one can refuse the batch frames and doors on false grounds (fault of the first kind) or accept them on false grounds (fault of the second kind). The first fault is a producer’s risk, the second fault consumer’s risk. Since two different risks apply, both faults can not be minimised by taking the minimum of their sum. For instance the consumer’s risk may be systematically smaller than what one may derive from the second fault. If the producer, for instance, is delivering systematically too large or too small frames and doors, one may settle for a smaller refusal. If both are within reasonable margins (too) large, they will still have an acceptable fit and width of the crack (above right in figure 203). This also applies for a systematic deviation to the smaller side (below left). Only when the frame is (too) small and the door at the same time (too) large (below right), or vice-versa (above left), does the sizing cease to be acceptable.

Normal dwelling			Flat building Van Tijen (1932)	
n	v	h	v	h
9			2.85	27.15
8			2.85	24.30
7			2.85	21.45
6			2.85	18.60
5			2.85	15.75
4			2.85	12.90
3			2.85	10.05
2	2.6	8.0	2.85	7.20
1	2.6	5.4	2.85	4.35
0	2.8	2.8	2.70	1.50
				-1.20

204 Arithmical series in building

24.12 NOMINAL SIZE SYSTEMS

A restriction to multiples of 30 cm (little less than a foot) is a well-known bridle to sizes in construction of buildings. It reduces the combinatoric explosion of design possibilities. A grid like that is used to localise foundations, columns and walls without design efforts for smaller sizes. A grid may have a different size in any one of the three dimensions. A preceding analysis of usage may yield an appropriate size of the grid for a specific function. The distinct multiples of the size of the grid yield distinct functional possibilities. In the preceding paragraph a grid is implicitly used.

An arithmatical series has an initial term a, a reason v and a length n. The terms increase along a straight line by steps of v, starting with a. An example is the height of the first floor a of a building and its successors with a height of v, resulting in the series of heights h (normal dwelling and flat building[a], $a=v_0$).

a Van Tijen, *Bergpolderflat* (Rotterdam, 1932) N.V. Woningbouw; Barbieri, S.U. and L. van Duin (1999) *Honderd jaar architectuur in Nederlands, 1901-2000*, p. 194

Another example concerns a building with one oblique wall, like the KPN building by Renzo Piano in Rotterdam. The oblique wall commences on first floor level. The initial term is representing here the fixed surface per floor (supposed to be 100 m^2). The n-th term indicates the surface at the level of the n-th floor. The sum of the terms is the total surface of floors at the oblique wall.

In these examples the reason remains equal, in the next example the reason changes each next n. A sequence well-known from architecture and other arts is Fibonacci's sequence: a new term equals the sum of two previous terms (figure 206).

The reason v is variable now, but the ratio r between two adjacent terms converges at last to the 'Golden Rule', 'Golden Section' or 'Divine Proportion': the smaller number (minor m) than has a fixed ratio to the larger number (Magior M). The Magior M, again has the same ratio to the sum of both:

$$m : M = M : (m + M).$$

From $\frac{m}{M} = \frac{M}{m+M}$ follows: $M := \frac{1}{2} \cdot m + \frac{1}{2} \cdot \sqrt{5} \cdot m$

For m = 1 follows for M/m and m/M:

$\frac{1}{2} + \frac{1}{2} \cdot \sqrt{5} = 1.6180340$ and: $\frac{1}{\frac{1}{2} + \frac{1}{2} \cdot \sqrt{5}} = 0.6180340$

In the case of a geometrical series the ratio r is a factor of multiplication, so that the ratio of two adjoining terms is a constant. A geometrical series can be continued for negative values of n while the array remains positive for real architectural purposes.

Applications of geometrical series are found in the financial world, like in compounded interest and in annuities. An investment of € 1000,- at an interest of 5% yields after 1 year € 1000 * 1.05 = € 1050. After two years this is € 1050 * 1.05 or € 1000 * 1.05 * 1.05 = € 1102.50.

Experiencing sound is also an example of the geometrical series. An increase of sound to the amount of 10 dB is experienced as twice as loud; an increase of 20 dB as four times.[a]

length	starting term	reason	array	sum
n	a	v	a+v*n	
9			190	1450
8			180	1260
7			170	1080
6			160	910
5			150	750
4			140	600
3			130	460
2			120	330
1			110	210
0	100	10	100	100

205 Arithmical sequence with sum

length	starting term	reason	array	ratio
n	a	v	$v_{n-1} + v_n$	r
9		5,5	8,9	1,62
8		3,4	5,5	1,62
7		2,1	3,4	1,62
6		1,3	2,1	1,62
5		0,8	1,3	1,63
4		0,5	0,8	1,60
3		0,3	0,5	1,67
2		0,2	0,3	1,50
1		0,1	0,2	2,00
0	0,1	0,1	0,1	1,00
		0	0,1	

206 Fibonacci's sequence

length	starting term	ratio	array
n	a	r	$a*r^n$
9		2,000	51,20
8		2,000	25,60
7		2,000	12,80
6		2,000	6,40
5		2,000	3,20
4		2,000	1,60
3		2,000	0,80
2		2,000	0,40
1		2,000	0,20
0	0,1	2,000	0,10
-1		2,000	0,05
-2		2,000	0,03
-3		2,000	0,01

207 Geometrical sequence

a See also Lootsma, F.A. (1999) *Multi-criteria decision analysis via ratio and difference judgement.*

length	starting term	ratio	array	
n	a	r	a+r*n	
9		1,618	7,60	
8		1,618	4,70	
7		1,618	2,90	
6		1,618	1,79	
5		1,618	1,11	
4		1,618	0,69	
3		1,618	0,42	▲
2		1,618	0,26	m+M
1		1,618	0,16	M
0	0,1	1,618	0,10	m
-1		1,618	0,06	M-m
-2		1,618	0,04	▼
-3		1,618	0,02	
-4		1,618	0,01	
-5		1,618	0,01	

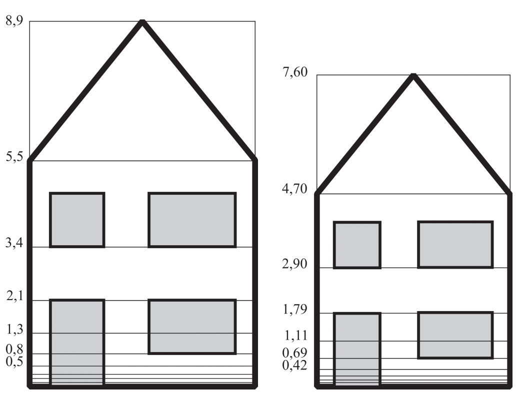
208 Golden Section

< 1947	Red array			Blue array
0,2	0,2			0,3
0,3	0,4			0,4
0,5	0,6			0,7
0,9	0,9			1,1
1,4	1,5			1,8
2,3	2,4			3,0
3,7	3,9			4,8
6,0	6,3			7,8
9,8	10,2			12,6
15,8	16,5	Modulor		20,4
25,5	26,7	27		33,0
41,3	43,2	43		53,4
66,8	69,9	70	86	86,3
108,2	113,0	113	140	139,7
175,0	182,9	183	226	226,0
283,2	295,9			365,7
458,2	478,8			591,7
741,3	774,7			957,4
1199,5	1253,5			1549,0
1940,8	2028,2			2506,4
3140,2	3281,6			4055,4
5081,0	5309,8			6561,8
8221,3	8591,5			10617,2
13302,3	13901,3			17179,0

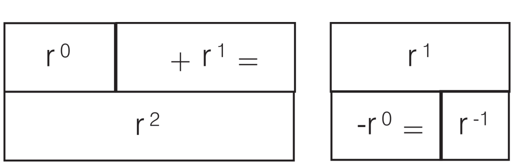
209 Measure systems of Le Corbusier

length	starting term	ratio	array	
n	a	r	a+r^n	
9		1,325	1,26	
8		1,325	0,95	
7		1,325	0,72	
6		1,325	0,54	
5		1,325	0,41	
4		1,325	0,31	▲
3		1,325	0,23	$r^n+r^{n+1}=r^{n+3}$
2		1,325	0,18	
1		1,325	0,13	r^{n+1}
0	0,1	1,325	0,10	r^n
-1		1,325	0,08	
-2		1,325	0,06	
-3		1,325	0,04	
-4		1,325	0,03	$r^{n+1}-r^n=r^{n-4}$
-5		1,325	0,02	▼

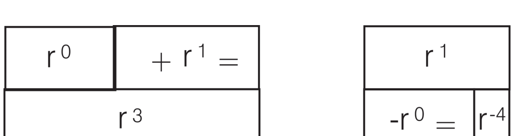
213 The plastic number



210 Fibonacci house & Golden Section house



211 Golden Section



212 Plastic Number

For architectural applications most geometrical series are not very useful, because adding architectural elements next to eachother (juxtaposition) produces new sizes, not recognisable anywhere else in the series. However, when we choose the Golden Section as a ratio we get figure 208. Now, every adjacent pair of sizes is flanked by their sum and difference, just as in the non geometrical Fibonacci sequence. Adding and subtracting of adjacent terms do not produce new sizes. The differences in use of both proportion rules are only visible in the smallest stages.

Many attempts have been made to recognise the Golden Section in nature and the human body. Until 1947 Le Corbusier took the human length of 1.75 m as a point of departure. Later, he started at 182.9 (red array) and 2.26 m (blue array): the reach of a man with a hand raised as high as possible.

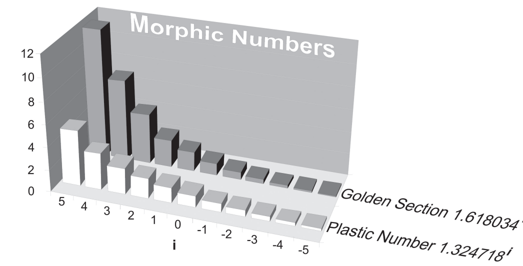
The red and the blue columns are featuring steps with a stride too wide between the terms for architectonic application. For this reason, Le Corbusier combined them and rounded them off in the Modulor. There are many other attempts in making the possibilities of the design with scale sequences easy to survey and well to maintain in the design decisions with a pre-supposed, built-in beauty.[a]

The problem of too large steps with the Golden Section was later solved by Dom van der Laan. He selected the ‘plastic number’ r = 1,3247180 for a ratio. This is a solution of the equation $r^1 + r^0 = r^3$ as well as of the equation $r^1 - r^0 = r^{-4}$

Since any number may be substituted for the initial term a, for instance another term from the series, the more general formulae $r^{n+1}+r^n=r^{n+3}$ and $r^{n+1}-r^n=r^{n-4}$ may be employed. In the row below this means that the formulae can be shifted, while keeping the mutual distance constant.

a Kruijtzer, G. (1998) *Ruimte en getal*.

The sum and the difference between two consecutive terms are returning in the series as at the Golden Section, albeit 2 places upward or 4 places downward, rather than by 1 each time. Therefore they are forming with addition and subtraction no new measures while preserving the ratio r. Aarts *et al.* have demonstrated that this ratio is, next to the Golden Section, the only one with this property.[a] Together they are called ‘morphic numbers’.



214 Morphic Numbers

24.13 GEOMETRY

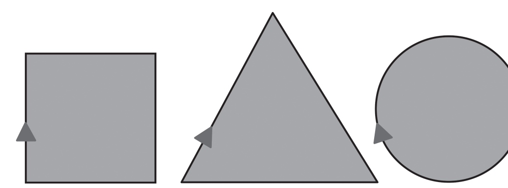
It is impossible to imagine a door distributed in tiny slits across a wall. Geometry restricts itself to contingent states of dispersion (lines, surfaces, contents) that can be enveloped by a few points, distances and directions. This pre-supposition of continuousness lowers the amount of combinatorial possibilities dramatically. The extent to which this geometrical point of view restricts the combinatorial explosion, is the subject of combinatorial geometry: it studies distributions of surfaces and the way these are packed.

However, the often implicit requirement that points in one plane should lie contingent within one, two or three dimensions is more obvious and self-evident in the case of a door, than in the one of a city. That is the reason why urban design is interested in non-contingent states of dispersion. The possibilities are restricted geometrically, following the often implicit pre-supposition of rectangularity. Particularly efficient production suggests this pre-supposition.

When one limits oneself to enclosed surfaces or enclosed spaces and masses, three simple shapes may be imagined in a flat plane: square, triangle and circle. Why are they so simple? They survive as geometrical archetypes in geometry and construction everywhere.

Their simplicity may be explained by the minima added in words to the diagram. This gives at the same time a technical motivation for application. A minimal number of directions is for production - e.g. sawing and size management - an effective restriction. Any deviation influences directly the price of the product. A minimal number of directional changes (nodes) is constructively effective (also from a viewpoint of stiffness of form). A minimal variation in directional changes(one without interruption, smooth) is effective with motions in usage; when one keeps the steering wheel of a car in the same position, a circle is described at last. They have been drawn in the diagram, with an equally sized area (programme). Their circumferences then are roughly proportioned like 8 : 9 : 7.

Our intuition meets its demasqué, by keeping the area equal: the triangle wins out. This visual illusion may be used for spaces needing particularly spatial power.

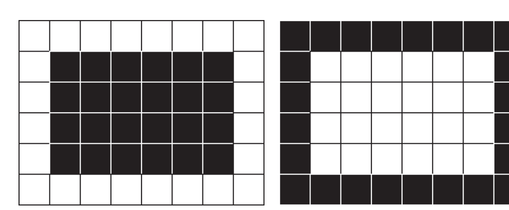


Minimal number of *directions* in one loop | Minimal number of *changes of direction* in one loop | Minimal *variation* of changes of direction in one loop

215 Simple shapes

A second example of the capacity of geometry to lead to counter-intuitive conclusions about areas is the seeming difference in surface between the centre and the periphery as Tummers emphasises.[b] In the diagram alongside they equal one another.

Functions characterised by the importance of inter-connectedness at all sides - like greenery, parks - tend to be better localised centrally, while differently structured functions (e.g. buildings) are better placed peripherally.



216 Apparent difference in surface between centre and periphery

The triangle is playing an important rôle in geometry because all kinds of shapes on flat or curved surfaces and stereometrical objects may be thought of as being composed out of triangles. Measuring the surface, also on bent surfaces (geo-metry), is dependent on insight in the properties of triangles (triangulation) since it establishes a one-to-one relationship between lines and angles (trigonometry). In the measuring of angles (goniometry) next to the triangle the circle plays a crucial rôle. Descriptive geometry[c] makes images of three-dimensional objects on a two-dimensional surface (projections), so that they may be reconstructed eventually on a different scale. With this, descriptive geometry is a fundamental discipline for architecture and technical design in general; for this description enables in its turn a wealth of mathematical and designing operations. The triangle also plays an important rôle in the technique of projecting.

a Aarts, J.M., R.J. Fokkink et al. (2001) *Morphic Numbers*.
b Tummers, L.J.M. and J.M. Tummers-Zuurmond (1997) *Het land in de stad. De stedebouw van de grote agglomeratie*.
c Berger, M. (1987) *Geometry I and II;* Wells, D.G. and J. Sharp (1991) *The Penguin dictionary of curious and interesting geometry;* Aarts, J.M. (2000) *Meetkunde*. Dutch translation: (1993) *Woordenboek van merkwaardige en interessante meetkunde*.

These subjects have already been described thoroughly and systematically by Euclid in his 'Elements' around 310 BC. Until in the twentieth century this book has been the basis for education in 'Euclidean geometry'. The work is available on the internet with interactive images and it is still providing a sound introduction into elementary geometry, as always.[a] Together with the co-ordinate system of Descartes geometrical elements became better accessible to tools from algebra such as vectors and matrices (analytical geometry).

When objects can be derived with rules of calculation in a different way than by congruency, equal shape or projection, when they can be represented or shaped into another, 'topology' is the word. The properties remaining constant under these transformations – or oppositely change into sets of points – can be described along the lines of set theory or with algebraic means. This is leading to several branches of topology. What is happening during a design process, from the first concept via typing to design, is akin to topological deformation, but it is at the same time so difficult to describe, that topology is not yet capable of handling.

On the other hand, the existing topology is already an exacting discipline, pre-supposing knowledge of various other branches of mathematics, before the designer may harvest its fruits. Nevertheless, it is conceivable that a simple topology can be developed, restricting the combinatorical explosion of design possibilities rationally in a well-argued way, in order to generate surprising shapes within these boundary conditions. It would have to describe constant and changing properties of spaces, masses, surfaces and their openings in such a way, that complex architectural designs could be transformed in one another via rules of calculation. With this, architectural typology and the study by transforming design would be equipped with an interesting tool. The computer will play a crucial rôle in this.

When a design problem can be described in dimension-less nodes and connecting lines between them, graph theory could be a predecessor.

	input		output				
figure	nodes	connections per intersection (valence, degree)	branches = nodes x valence/2	planes = branches - nodes+ 2	connections = branches x 2	boundaries = branches x 2	boundaries per plane (valence) = boundaries / planes
tetrahedron	4	3	6	4	12	12	3
cube	8	3	12	6	24	24	4
octahedron	6	4	12	8	24	24	3
K3,3	6	3	9	5	18	18	3,6
K5	5	4	10	7	20	20	2,9

217 Nodes and connections in regular solids

24.14 GRAPHS

When one notes in a figure only the number of intersections (nodes) and the number of mutual connections per intersection (valence, degree of the node) we deal with a graph. A graph G is a set 'connecting points' (nodes, points, vertices) and a set of 'lines', branches (arcs, links, edges), connecting some pairs of connecting points together. A branch between node i and node j is noted as arc (i,j), shortened arc^{ij}. Length, position and shape of the connecting points and branches are without importance in this. (In architecture the relative position of the connecting points *vis-à-vis* one another will probably be of importance.)

Among many figures corresponding types may be discerned wherein neither length nor area play a rôle (e.g. designing structure, not yet form and size). This enables the study of formal, technical and programmatical properties in space and time even before the sizes of the space or the duration in time are known.

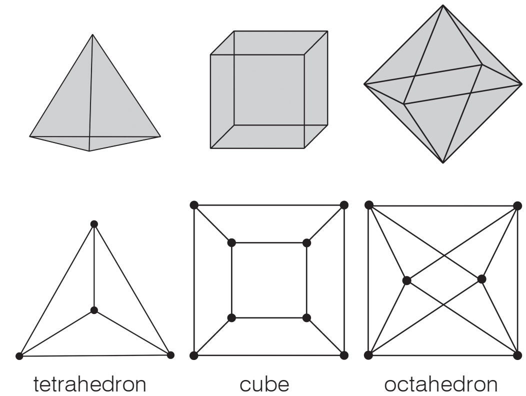
A cube may serve as an example. It has 8 nodes. Each of them has 3 connections. This fixes the number of connecting lines (branches) : 8 x 3 / 2 = 12. For each connecting branch occupies 2 of the 8 x 3 connections in total.

Following the formula of Euler, the number of planes = number of branches - number of nodes + 2. As soon as the planes (still without dimensions) come into the picture, we deal with a map. By the same token it suffices to count in a figure the intersections and their valencies in order to be able to calculate the number of branches and planes in the map. The regular solids can be represented in a plane by a graph.

a Euclides (310 BC) The Elements (http://aleph0.clarku.edu /~djoyce/java/elements/usingApplet.html)

Based on this, the terminology of graph theory is readily explained. These are single graphs: there are no cycles arriving at the same node as the one of departure; or multiple connections between two nodes. Furthermore, they are regular: in each node the number of connections per graph is equal.
The tetrahedron has a complete graph (K) unlike the other two, where possible connections - the diagonals - fail. The graph of the cube clearly demonstrates that the outer area should be in calculated in order to count 6 planes. It is as if the cube is 'cut open' in one plane, in order to 'ex-plane' it on the page. It is immaterial which plane serves as outer plane. Graph theory does not yet distinguish between inside and outside.

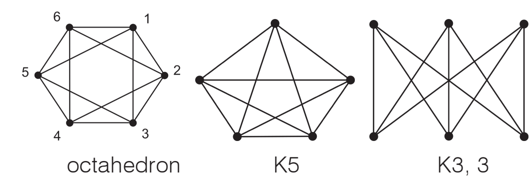
The graphs of the tetrahedron and the cube are 'planar': the flatland does not feature crossings without intersection. Figure 219 shows to the left an 'isomorph graph' for the octahedron where the number of nodes equals the number of valencies. Compare the octahedron graph with the one of figure 218.



218 Regular solids as a graph

The branch between nodes 6 and 1 of the octahedron may be 'contracted' in such a fashion, that one node remains, where all other branches end previously ending in 6 and 1, with whom they were 'inciding' or 'incident' in the parlance.

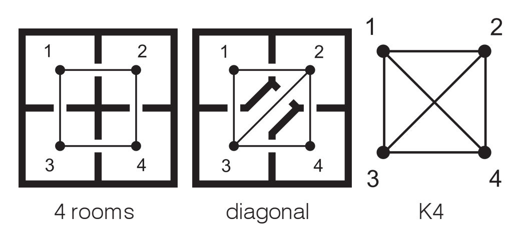
If a graph yields to contraction to K5 or K 3,3, it can be proven that it is non planar. Architectonically this is especially important: by the same token no blueprint can exist that relates all the relationships as recorded in the graph.



219 Octahedron, K5, K3,3

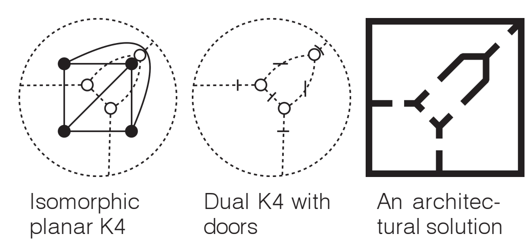
According to K4, each of the four rooms, may be linked by 3 openings mutually among themselves. The left shows the solution with two openings where one may circulate. The corresponding graph (a circuit) has also been drawn. The middle one demonstrates a solution where only two of the four rooms have 3 doors. To solve the complete graph K4, a 'dual map' must be drawn. To do that, K4 is made isomorphically planar, and the planes are interpreted as 'dual nodes'. The outer area of the graph is involved as a large, encircling dual 'node'.

These dual nodes (white in the drawing below) should be connected in such a way by dual branches (dotted lines) that all planar branches will be cut through just once:



220 Four connected rooms

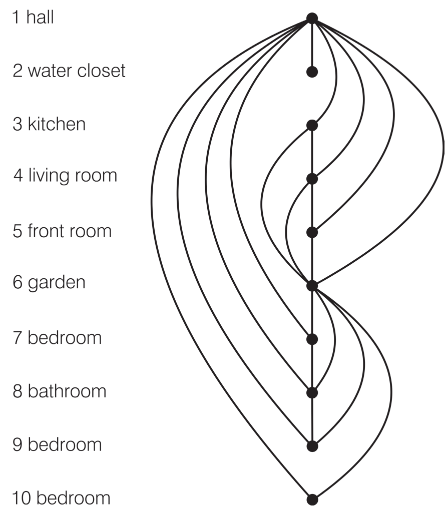
These cuttings through have become 'doors' (or windows) in the dual graph. The dual lines are 'walls' of a dimension-less blue-print and the dual points are constructive inter-connections. If this prototypical blue-print is regarded as 'elastic', it can be transfigured in an isomorphic way into a design, by giving the surfaces at random forms and shapes. Type K4 is usual for bathrooms and museums.



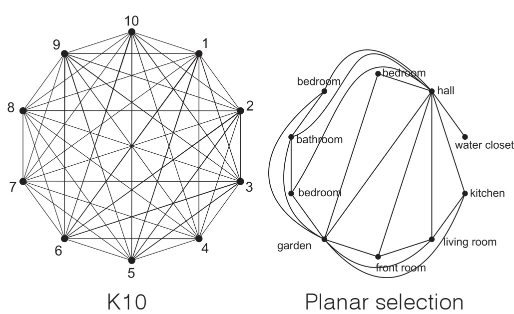
221 Dual graph

From a fundamental point of view, no solution exists in flatland for 5 rooms, each sharing one door with all other rooms (K5): no planar graph could be drawn of K5.

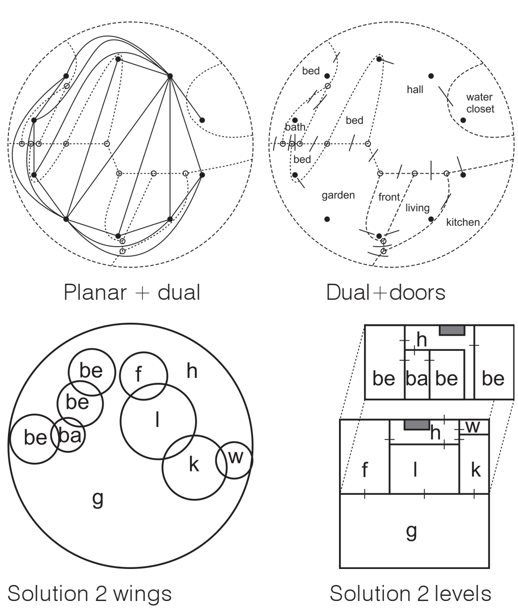
By regarding each space firstly as a node between other spaces, the design possibility of programmatic requirements can be verified along the lines of graph theory. Suppose, that the programme of relations between rooms in a dwelling results in the following scheme:



222 Possible relations between rooms



223 Planar selection of possible relations



224 Different solutions of the same dual graph

This graph demonstrates that a third bedroom (10) can not be connected to the bathroom if it is already connected to the hall (1) and the garden (6). When the requirement that all bedrooms should give to the garden is skipped (the connection 9-6), a solution exists in which all bedrooms give access to the bathroom.

At 10 rooms, combinatorially speaking 10!/2!8! = 45 relations exist (K10). They can never be established directly (made planar).

Yet, the selection of the relational scheme can be made planar, therefore, it has a solution. With their high valence (number of doors), the hall (1) and the garden (6) are crucial. If these nodes are removed, a 'non-conjunctive' graph originates. Following that, it may be decided to give the rooms 6 to 10 a separate floor; or even its own location. If a node alone allows this freedom, it is termed a 'separational node' The minimal number of nodes n that can be taken away with the incident branches in order to make them non-conjunctive makes the graph 'n-conjunctive'. It is an important measure of cohesion in a system. In the figure following possible realisations are given by drawing the dual graph (figure 224).

A map of the national roads of our country is an example of a network. Each branch is denoting a stretch of road, each node a crossing or roundabout. By supplying branches with a length the user can determine quite simply the distance between his point of departure and that of his destination. If the traffic streams across the network and their intensities are known it is easy to determine the traffic load on each branch. A network like this may also represent the traffic deployment within a building, where the branches stand for corridors, stairs and elevators. Then it can be determined, for instance, how many students change places in between classes in the building. This gives a basis for deciding on dimensioning the corridors e.t.q.

The organisational structure of an enterprise may also be depicted in a network. If this structure should be expressed in the building at the design of a new office, this network may form a point of departure; one may derive from it which departments are directly linked to one another with the wish to realise this physically in the new building.

By the same token networks enable the structure of a building or an area, without describing the whole building or the whole area.

A graph with a weight (stream, flow) of any type (time, distance), on its branches, is called a network.[a] If this flow displays a direction as well, the network is termed a directed graph. A path is a sequence connecting branches with a direction and a flow. A network is a cyclical network, if a node connects with itself via a path. The length of the path is determined by the sum of the weight of the paths concerned. The length of the shortest path between two nodes may be determined by following, step by step, a sequence of calculating rules, the shortest-path algorithm.[b]

An algorithm in this vein exists for the longest path, the 'critical-path method'. This method is used in 'network planning' in order to determine, within a project, the earliest and latest moments of starting and finalising each and any activity of the project; and, consequently the minimal duration of the project.[c] In this, the nodes represent the activities, the branches the relation between the activities.[d] The start of an activity (successor) is determined by the time of finalisation of all preceding activities (predecessors). With regard to the network planning, it is feasible to monitor the progress of (complex) projects; as well as to survey the consequences of retardation of activities. However, the problems caused by retardation are not able to be solved. In order to achieve such a solution one has to employ other techniques; like linear programming (LP).

a With a 'network' usually a directed network is implied.
b Amongst others, used in programmes like Route Planner, to calculate the shortest path from A to B.
c For instance: in order to calculate the time required to realise a building or site.
d This form of representation is known as an AON-network: Activity On Node. Initially only AOA-networks were used with the activities on the arrows (Activity On Arrow). In that case the flow on the arrows represent the temporal duration.

24.15 PROBABILITY

An event is a subset of results A[a] from a much larger set of possible results Ω[b] (a set much larger) that might have yielded different results as well. The chance of an event of A well-defined instances taking on ‘what had been possible’ Ω is - expressed in numbers - A/Ω. Often it is not easy to get an idea of what would have been possible; certainly when Ω has sub-sets dependent on A, for the event may influence the remaining possibilities.

Say, that the number of possibilities for filling in a surface with 100 buildings from 0 to 9 floors is 100^{10}. Two of these possible events have been drawn in figure 225: an example of ‘wild’ and one of ordered housing. The chance that with a maximal height of 9 floors one of the two will be realised exactly is 2 in 100^{10} (summation rule).

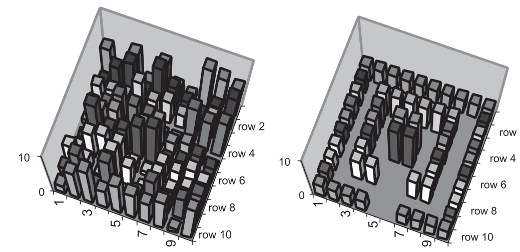
The wild housing leaves the elevation of a building completely to contingency. As a consequence in 100 buildings the average elevation is approximating the middle of 4,5 between 0 and 9. The average of 2.2 floors of ordered housing is deviating more from the mean than the one of wild housing and, therefore, less ‘probable’. In the matrix alongside the elevations from the drawing of the wild housing have been rendered.

It is as if a dice with ten faces has been thrown one hundred times. The rows form every time a sample of 10 ‘throws’ from the 100. Such a partial event in the first row of buildings can already yield 10^{10} (10 000 000 000) averages with only 10! = 3 628 800 *different* averages (less than 0,4%!). If one studies from among them all the 10 averages comprising the natural numbers (0 to 9) one must conclude that for 4 and 5 the maximum of possible combinations exist (9!/4!5! = 126).

In order to get any other average a lower number of combinations is available. For a result of an average of 0 or 9 , for instance, just one thinkable combination exists (the improbable events of 10 zeroes or 10 nines. The averages are condensing themselves between 4 and 5. The combination possibilities of the above are representing this way the chance density. In the column in question a Gaussian curve is, therefore, manifesting itself.

Obviously, this applies to the columns (events) as well. In figure 228 the mean, median and mode of the columns are *cumulatively* rendered by taking each time more columns into account.

The larger the number of throws, the closer the average approximates 4,5. However this does not apply as yet for the median (as many results above as below) and even less for the mode (the highest result). Their deviations of the mean are indicating asymmetrical, skew distributions.



225 Wild and ordered housing

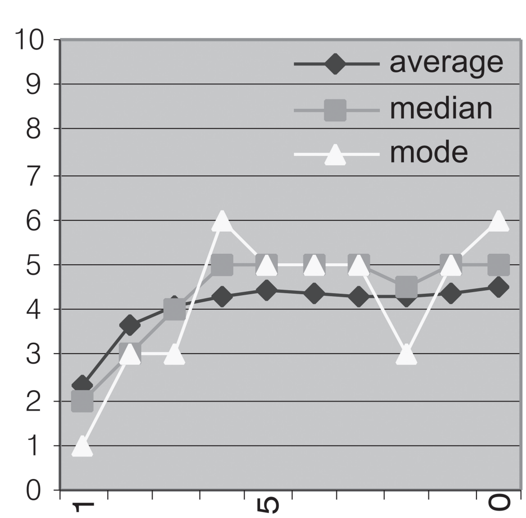
columns	1	2	3	4	5	6	7	8	9	10	mean per row
rows											
1	5	0	6	1	6	2	1	8	7	6	4,2
2	1	5	7	2	8	5	3	1	4	7	4,3
3	3	3	3	7	4	5	3	1	5	1	3,5
4	2	3	6	5	4	0	0	9	7	8	4,4
5	1	6	6	1	5	7	3	4	2	0	3,5
6	0	9	5	6	8	9	2	3	6	4	5,2
7	1	6	7	6	2	1	5	4	6	4	4,2
8	5	3	0	8	5	0	6	3	5	8	4,3
9	3	8	1	9	0	3	8	4	6	9	5,1
10	2	7	9	5	8	7	6	8	1	9	6,2
				Average for the total:							4 , 5

226 An average of means

rows			mean per row
9!/0!9! =	1	0 0 0 0 0 0 0 0 0 0	0
9!/1!8! =	9	combinations for the mean	1
9!/2!7! =	36	combinations for the mean	2
9!/3!6! =	84	combinations for the mean	3
9!/4!5! =	126	combinations for the mean	4
9!/5!4! =	126	combinations for the mean	5
9!/6!3! =	84	combinations for the mean	6
9!/7!2! =	36	combinations for the mean	7
9!/8!1! =	9	combinations for the mean	8
9!/9!0! =	1	9 9 9 9 9 9 9 9 9 9	9
		Average for the total:	4 , 5

227 Possibilities to compose averages from the 10 numbers from 0 to 9 an average

n =	10	20	30	40	50	60	70	80	90	100
mean	2,3	3,6	4,1	4,3	4,4	4,4	4,3	4,3	4,4	4 , 5
median	2,0	3,0	4,0	5,0	5,0	5,0	5,0	4,5	5,0	5,0
modus	1,0	3,0	3,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0



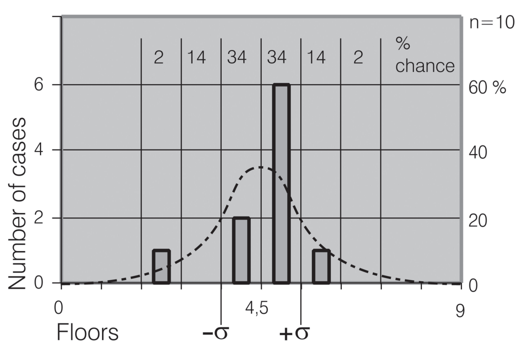
228 More results stabilise the mean

a This Latin capital is properly chosen, in view of its form-equivalence with the stream that ‘comes out’ of an urn.

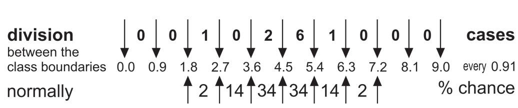
b This Greek capital is properly chosen, in view of its form-equivalence with the urn, proverbial in statistical textbooks, turned upside-down and producing arbitrarily red and white marbles.

The mean reduces the variation of a large set of numbers to one number. The variation itself is then very partially acknowledged with the 'standard deviation' sigma (σ). Some 2/3 of the cases differ usually less from the mean than this standard deviation. Some 95% lies within 2 x σ from the mean (95% probability area). This gauge σ only makes sense in the cases condensing themselves by combination possibilities around a mean. This is not applicable, for instance, for the individual cases of the example above. They have each an equal chance for 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9 floors. The mathematically calculated 'standard deviation' on this basis would amount to some 5 floors at each side of the 4,5. Within this wide margin, not carrying meaning, all results are falling; not just the two thirds of them. However, the 10 columnar averages do concentrate themselves at the total average; for from average values like 4 and 5 more combinations of individual elevations could be composed than from extremes such as 0 or 9. If we consider the spreading of these 10 more 'obedient' outcomes, then the standard deviation may be calculated from the sum of the outcomes and the sum of their squares (squared sum):

Column-number	1	2	3	4	5	6	7	8	9	10	sum
outcome (means)	2,3	5,0	5,0	5,0	5,0	3,9	3,7	4,5	4,9	5,6	44,9
square	5	25	25	25	25	15	14	20	24	31	209,8
Standard deviation σ = ROOT((sum of squares – sum of outcomes ^ 2/n) / n)										n=10	0,91



229 Classes of observations



230 Chance within class boundaries

Mean μ as well as standard deviation σ may be used for the comparison of the event in the bar graph with a corresponding normal distribution (μ,σ) of the chance density that is approached in the case of very many events. This distribution represents the total of probable possibilities Omega Ω at a given μ and σ against a back-drop from which the event A is one outcome.

At both sides of the average with a sigma of 0,91 floors five classification boundaries have been distinguished with 0 and 9 for extremes. The number of cases between 4.5 and 5.4 floors is above expectancy.

Employing classification boundaries in this manner it may be seen at once in how far these results could have been expected on the basis of a normal distribution of chances. The case of a columnar average of just 2,3 floors (in the left column of the wild housing area) is rather far removed from the total average. Each average number of floors under 2,7 or above 6,3 lies outside the 95% probability area (14+34+34+14 = 96).

Now the usual mistake of policy makers and statisticians is neglecting these cases; or even using them as a point of departure for establishing norms. Contrariwise the designer is specialised in improbable possibilities from the available combinatorial explosion of possibilities, albeit within a context ruled by probabilities.

24.16 LINEAR PROGRAMMING (LP)

Imagine we want to invest on a location of 14.000 m^2 within 16 months in as much housing (D units) and facilities (F units) as possible:[a] (see also page 301)

asked: number of units	mln Dfl investment	1000 m^2 surface	months building time per unit
D	5	2	1
F	8	1	2
maximize	Z	14	16

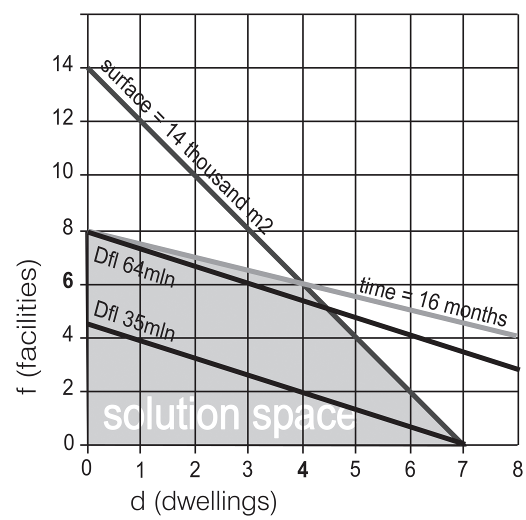
231 LP problem

What to build? In other words: what are F, D and Z? The objective (Z maximised) implies making 5D + 8F as large as possible (maximising it) under the following boundary conditions: (also known as restrictions or constraints)

Max!	$Z = 5D + 8F$			(maximize this investment Z within
	$2D + 1F$	$\leq$	14	x1000 m^2 surface and
	$1D + 2F$	$\leq$	16	months, while
	F	$\geq$	0	F and D are not negative)
	D	$\geq$	0	

232 LP operationalisation

All points (combinations of D and F) within the solution space satisfy all constraints, but not all fulfil the requirement of optimisation of a maximal Z. When no facilities are to be built (F=0) the surface restriction 2D+1F ≤ 14, determining the maximal value of Z, is restrictive, resulting in D = 7 dwelling units to be built in 1D + 2F = 7 months. The investment will be 5D + 8F = 35 mln. If no dwellings are to be built (D = 0), the maximum duration of building becomes the limiting factor, realising 8 units of facilities within 16 months. The maximum investment Z would be 64 mln. This is not yet maximal. Considering only the surface constraint, F = 14 units of facilities could be built on the site resulting in an investment of 112 mln, but that would take too much time: 28 months.



233 Solution Space

Next, we want to know for which point within the solution space the investment represented by the function 5D + 8F, is maximal.

In the origin (D=0, F=0) the investment will be zero, so Z = 0. Moving the line to D > 0 and / or F > 0 will increase Z. We will find the solution after moving this line as far as possible from the origin *without* leaving the solution space. In this case this point (4,6) The investment will be 5 * 4 + 8 * 6 = 68. The lines through this point define the solution. The boundary conditions are then called 'effective'. Removing or changing one of the boundary conditions will amount to changing the solution. Were there, for some reason, 15.5 months available, we could realise 4.2 dwelling-units and 5.7 facility-units. If a feasible solution has been found, the solution will always find itself in a corner point (intersection of two lines); unless the object function (objective) is parallel to the boundary condition determining the solution.

This simple example already shows how sensitive optimisations are *vis-à-vis* their context (two weeks less building time results in a different solution) and how important it is to re-adjust continuously the boundary conditions, which are quickly considered stable, or to vary them experimentally in sensitivity-analyses with regard to different perspectives, changing contexts. This requires tireless calculation in order to be able to react to changing conditions. If such boundary conditions are within one's own sphere of influence they may also be considered as objectives. This way the choice of what is called an end or a means gets a different perspective.

Often designers manage to annihilate boundary conditions deemed stable: suddenly, different objectives become interesting. This sensiti-vity with regard to context only increases, if more boundary conditions or objectives are taken into account; for instance, the valuation of occupants of facilities (e.g. 3) in contrast to dwellings (5) : then maximize 3F + 5D, while keeping, for example, the budget constant. The solution space now has 5 rather than 4 corners, which might be more optimal in one way or another.

a Convention used: names of unknown variables in capital letters, names of known ones in under-case. In multiplication known precedes unknown, so: a * X

With a problem with n variables and m restrictions, the cornerpoints number m+n / m!n!.

In case of a LP problem with 50 variables and 50 restrictions some 10^{29} equations must be solved. That is a time-consuming task even for the fastest computer. Luckily, it is not necessary to study all corner points. Proceeding from an initial solution obeying all conditions (and admitted or feasible solution) far fewer corner-points have to be investigated in order to find a solution; approximately m+n. The procedure to follow is known as the Simplex method (see page 223), that finds an eventual solution in a finite number of steps. With this the inequalities are transformed into equalities by adding 'slack variables' or 'remainder' variables before the inequal sign:

$$\begin{matrix} 2D + 1F \le 14 \\ 1D + 2F \le 16 \end{matrix} \quad \text{becomes} \quad \begin{matrix} 2x_1 + 1x_2 + x_3 = 14 \\ 1x_1 + 2x_2 + x_4 = 16 \end{matrix}$$

This way unknown variables have been added. With two of them, such as F and D, optimisation can still be visualised on a piece of paper. If more than two dimensions of decision are to be made variable, one is restricted to the outcome of an abstract sequence of arithmetical operations like the Simplex method, a method employing matrix calculation.[a]

24.17 MATRIX CALCULATION

Take a system of equations, for instance:

$$\begin{array}{rcrcrcrcl} 2x_1 & - & 3x_2 & + & 2x_3 & + & 5x_4 & = & 3 \\ 1x_1 & - & 1x_2 & + & 1x_3 & + & 2x_4 & = & 1 \\ 3x_1 & + & 2x_2 & + & 2x_3 & + & 1x_4 & = & 0 \\ 1x_1 & + & 1x_2 & - & 3x_3 & - & 1x_4 & = & 0 \\ \hline a_1x_1 & + & a_2x_2 & + & a_3x_3 & + & a_4x_4 & = & b \end{array}$$

Usually the co-efficients, the unknown variables and the results are symbolically summarised as **Ax** = **b**. In this **A**, **x** and **b** represent numbers concatenated in lists (matrices) or columns (vectors)[b], in this case:

$$\mathbf{A} := \begin{bmatrix} 2 & -3 & 2 & 5 \\ 1 & -1 & 1 & 2 \\ 3 & 2 & 2 & 1 \\ 1 & 1 & -3 & -1 \end{bmatrix} \quad \mathbf{x} := \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} \quad \mathbf{b} := \begin{bmatrix} 3 \\ 1 \\ 0 \\ 0 \end{bmatrix}$$

This way the sum of the products $2x_1 - 3x_2 + 2x_3 + 5x_4$ equals the first number of **b** ($\mathbf{b}_1 = 3$), the next one $1x - 1x_2 + 1x_3 + 2x_4$ equals $b_2 = 1$, etc. This shows how matrix multiplication of each row of **A** with the column vector **x** works. In the imagination the column must be toppled in order to match each a with its own **x**. In order to calculate such a sum of products at all, the number of columns should of course, be equal to the number of rows of **x**. Considering that the number of rows of **A** conversely is not equal to the number of columns of row vector **x**, vector multiplication **xA** is impossible here: in matrix calculation **Ax** is not the same thing as **xA**. One cannot divide matrices and vectors[c], but often it is possible to calculate an inverse matrix $\mathbf{A}^{-1}$, so that one may write **Ax** = **b** as $\mathbf{x} = \mathbf{A}^{-1}\mathbf{b}$.[d] By that, one can not only determine n unknown variables in n equations by substitution, much writing and many mis-calculations, but also by applying the Gauss-Jordan method; or in the case of more solutions **b** by the (inverse matrix):

$$\mathbf{A} := \begin{bmatrix} -14 & 37 & -3 & 1 \\ 17 & -45 & 4 & -1 \\ -5 & 13 & -1 & 0 \\ 18 & 47 & 4 & -1 \end{bmatrix} \quad \mathbf{x} := \mathbf{A}^{-1} \cdot \mathbf{b} \quad \mathbf{x} := \begin{bmatrix} -5 \\ 6 \\ -2 \\ 7 \end{bmatrix}$$

The point of contact of the two equations of paragraph 24.16 may be determined easily both graphically and by substitution, but in the matrix guise the solution would look like this:

$$\mathbf{A} := \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix} \quad \mathbf{b} := \begin{bmatrix} -3 \\ 4 \end{bmatrix} \quad \mathbf{x} := \mathbf{A}^{-1} \cdot \mathbf{b} \quad \mathbf{x} := \begin{bmatrix} 6 \\ 4 \end{bmatrix}$$

a Further reading: Hillier, F.S. and G.J. Lieberman (2001) *Introduction to operations research*.

b X is a column vector, XT the same sequence as a row vector

c Horssen, W.T. van and A.H.P. van der Burgh (1985) *Inleiding Matrixrekening en Lineaire Optimalisering*. describe in which cases that is possible.

d For instance in Excel A-1 is calculated by the function {=MINVERSE(A2:D5)} and x by {=MMULT(F2:I5;K2:K5)} if you indicate a field of 4 x 4, call the function, select the necessary inputfields A-1 and b and close with ctrl-shift.

Matrix A can also be used for calculation of the area and number of times needed to realise any combination of number of dwellingunits and number of facilityunits. If we want to know how may units can be realised within a given area and time, we have to solve the problem $\mathbf{x} = \mathbf{A}^{-1}\,\mathbf{b}$. In real life the number of variables and constraints are not equal. Neither is it necessary to consume all available space and time. So inequalities will be introduced. The result is that the number of solutions may be infinite. Therefore the linear objective-function has been added. Among all solutions find that one that results in a minimum or maximum value of the objective function as shown in 24.16.

The essential operations, with regard to the solving of a system of equations by means of the Gauss-Jordan method are: multiplying all co-efficients of one row with an identical factor adding a multiple of a row to a (different) row.[a] These operations are also essentially important with regard to the Simplex algorithm, to be discussed next.

24.18 THE SIMPLEX METHOD

The Simplex Method comprises two stages:

Stage 1: Look for a starting solution obeying all restrictions. Such a solution is termed an 'admitted solution'.

Stage 2: As long as the solution is not optimal: improve the solution whilst continuing to obey all restrictions.

The algorithm will be explained by way of a problem with just 2 restrictions. The origin is then an admitted starting solution, so that Stage 1 can be passed.[b] The problem from paragraph 24.16 serves as an example. First of all the inequalities are re-written as equalities with remainder variables:

	max		F		D		remainder variables				
i	$a_{i,s0}$ Z		$a_{i,1}$ x_1		$a_{i,2}$ x_2		$a_{i,3}$ x_3		$a_{i,4}$ x_4		b
0	1 Z	+	-8 x_1	+	-5 x_2	+	0 x_3	+	0 x_4	=	0
1	0 Z	+	1 x_1	+	2 x_2	+	1 x_3	+	0 x_4	=	14
2	0 Z	+	2 x_1	+	1 x_2	+	0 x_3	+	1 x_4	=	16

The crucial data have been re-written as a 'Simplex Tableau' below.

j			0	1	2	3	4	
i	Con	Bas	Z	F	D	Surf.	Time	b
0	Z		1	-8	-5	0	0	0
1	Surf.	3	0	1	2	1	0	14
2	Time	4	0	2	1	0	1	16

Simplex Tableau 1

The rows are numbered as i = 0…2, the columns as j = 0…4. Row 0 represents the target function, rows 1 and 2 the restrictions. Column 0 belongs to the Z value, columns 1 and 2 to the 'real' variables, dwellings D and facilities F, columns 3 and 4 to the remainder variables of the restrictions. Column b contains the values of the basic variables x_3 and x_4 named in column Bas (establishing together the basis); in the present case these are the initial remainder variables with a factor $a_{i,3}$ or $a_{i,4} = 0$. The value of the variables with a factor $a_{i,3}$ or $a_{i,4} = 0$ are not mentioned in this column (non-basis) and equals 0.

Next, it will be attempted to improve upon this initial solution by repeatedly exchanging a non-basic variable against a basic variable to be removed.

Step 1: Optimising test

If all elements within the row are larger than zero (Z>O), the basic solution belonging to this tableau is optimal. If row Z contains negative values, select column c with the most negative value, in this case column 1, variable F. This column is termed pivot column (axle). The appropriate non-basic variable is now introduced into the basis.

a A more elaborate introduction in matrix calculation in: Lay, D.C. (2000) *Linear algebra and its applications*.

b The algorithm for stage 1 is with a small addition equal to the one of stage 2.

Step 2: Selection of the basic variable to be removed

To determine the maximum value that this variable can take under the condition that all restrictions continue to be obeyed. Select the row r for which the ratio of the value b_r and $a_{r,k}$, with $a_{r,k}$ larger than zero, is minimal. This row becomes the axle or pivot row, element $a_{r,k}$ the axle or pivot, in this case $a_{2,1}$ with value 2. The basic variable belonging to this row (column Bas) has now been removed from the basis.

Step 3

Transform pivot column into unit vector with in the place of the pivot $a_{2,1}$ = 1: multiply the pivot row by 1 / pivot (normalising pivot row):

row							
2	0	2	1	0	1	8	times 0.5
	0	1	0.5	0	0.5	4	

Now subtract an appropriate multiple of the pivot row from the other rows, so that the pivot column becomes 0 (a_{ik}) in each case. Then go back to step 1.

row							
0	0	- 8	-5	0	0	0	
substract	0	- 8	-4	0	-4	-64	times -8
	0	0	-1	0	4	64	
1	0	1	2	1	0	14	
substract	0	1	0.5	0	0.5	8	times 1
	0	0	1.5	1	-0.5	6	

The tableau now has the following appearance:

j			0	1	2	3	4	
i	Con	Var	Z	F	D	Surf.	Time	b
0	Z		1	0	-1	0	4	64
1	Surf.	3	0	0	1.5	1	-0.5	6
2	Time	1	0	1	0.5	0	0.5	8

Simplex Tableau 2

Since row 0 still contains negative elements, the solution found is not yet optimal. Steps 1 through 3 are repeated once again. The variable to be introduced is now 2, the variable to be removed the slack (3) with the surface restriction (row1). The pivot row now becomes

row							
1	0	0	1 .5	1	-0.5	6	times 0.67
	0	0	1	0.67	-0.33	4	

The other rows become:

0	0	0	- 1	0	4	64	
substract	0	0	- 1	-0.7	0.33	-4	times 1
	0	0	0	0.67	3.67	68	
2	0	1	0 .5	0	0.5	8	
substract	0	0	0 .5	0.33	-0.17	2	times 0.5
	0	1	0	-0.33	0.67	6	

The tableau now becomes:

j			0	1	2	3	4	
i	Con	Var	Z	F	D	Surf.	Time	b
0	Z		1	0	0	0.67	3.67	68
1	Surf.	2	0	0	1	0.67	-0.33	4
2	Time	1	0	1	0	-0.33	0.67	6

Simplex Tableau 3

This solution is equal to the graphical solution found previously (homes 6, facilities 4, investments 68).

24.19 FUNCTIONS

In colloquial speech sentences are formulated in which an active subject x operates on a passive object y. The verb in the sentence describes this operation. In logic a sentence like that, telescopes in a 'full-sentence function' y(x): 'y as operation of x' . In the same way mathematical formulae can be made which translate an input x (argument, original) according to a well-defined operation (function, representation instruction, e.g. 'square') into an outcome y (output, function value, image, depiction, e.g. the square). The outcome is represented as an operation of x: $y = f(x)$; e.g. $y = x^2$. The value of the independent variable x is chosen from a set of values X (the domain), the definitional range of the function.

Each value from this set corresponds to only one outcome from a set Y (range, co-domain, function value field) with possible values of y. With a given input the outcome is therefore certain.[a] That is why a function value x in a graph never runs back, like in the graph of a circle. There are just decreasing, increasing or unchanging values of y in the direction of x in the graph, allowing in one way unmistakable differentiation (rating growth) and integration (summing from x_1 to x_2).

Because of this function, it is the ideal mathematical means to describe causal relationships. It supposes that each cause has one consequence, but the same consequence may have different causes. If the sun starts shining, the building warms up, but the heat in a building may also result from the function of a heating system.

However, when cases should be studied in which one architectural design can have different effects, workings, functions according to circumstances, each effect should be modelled as a separate function.

Functions like that are alternately activated by steering functions according to circumstances. Since these functions change with the context, this context should be introduced as a set 'exogenous variables' and be included as parameters (for instance co-efficients, factors) in the functions. These exogenous variables to be introduced may be modelled next in a wider context as output of other functions. It results in a dynamic system of functions and magnitudes.

A computer programme for mathematical operations like MathCad, Maple, Mathematica or Matlab should then be extended with a modelling programme, say Simulink or Stella.

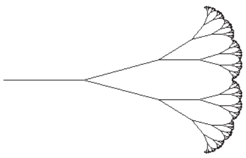
24.20 FRACTALS

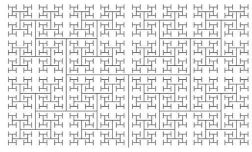
Fractals are mathematical figures exhibiting self-similarity. A central motif returns in every detail. They result from rather simple functions; but these are being calculated many times using their own output; say 100.000 times.

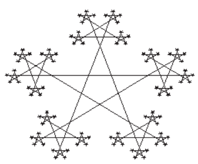
In practice one is forced, while working with a computer, to stop calculating after a few rounds, given the resolution capacity of the screen (for instance a high-quality colour screen). By using an artificial trick it is possible to zoom in on a detail: that is to say, to depict a detail enlarged, simply by introducing a smaller, well-chosen 'window'. Then it is possible to make more rounds (details of a higher order) visible. As a rule, one sees the central motif back in the details. With a computer of modest performance characteristics one is hindered in this enlarging by storage capacity as well as processing speed.

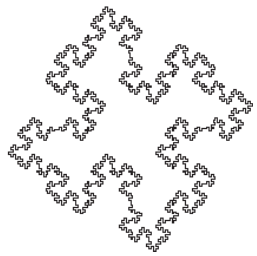
Professional study in the area of Fractals is conducted in institutes with access to very powerful and fast computers and video screens of large size and very large numbers of pixels. (Amsterdam, Netherlands; Bremen, Germany; Atlanta, Georgia, US).

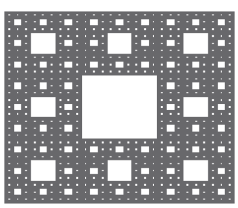
a In the reverse, however, an outcome may be produced by different values of the input.

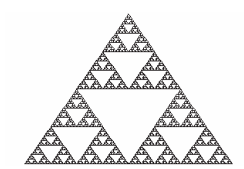

Branching


Branching 90 ⁰


Branching star


Koch's replacements


Sierpinsky's carpet


Sierpinsky's triangle

234 Fractals

One may distinguish, according to the way they are generated, 4 kinds of fractals:

- Repeated branching (tree fractals)
- Replacement ('twists', 'turning curves')
- JULIA- and CANTOR- sets, based on the formula: z1 = z2 + C

As well as an extraordinary type:

- The MANDELBROT set.

In the case of repeated branching beautiful structures are emerging, based on a triangular star, a H, internal triangles (sieve of Sierpinski), forking, pentagram star, respectively a star with 7 points. There is an analogy with biological structures like a tree under an angle caused by the wind, an arterial system, the structure of a lung.

With repeated replacement a straight line segment — is replaced by, for instance -^- , or ^, or |¯| a meander. This way 'twists' are originating, turning curves, curves baptised with the name of their discoverers, like Levy, Minkovsky, Koch, etc.[a] In the latter there is an analogy with a coastal line; it may be helpful to determine the length of a coastal line and of other whimsical contours.

With repeated transformation (displacement, turning, disfiguring, including diminishing) figures originate resembling leaves, or branches with leaves. Applying a large number of such appropriately chosen transformations may generate images of non-existing forests, non-existing landscapes with mountains and fjords and even of a human face.

Even 'fractalising' an image of a realistic object can be done: that means to say to determine for a sufficient number of transformation formulae each time the 6 parameters in such a way, that they will render that image with great precision.

Further development of this technique is of importance for transmission of images; since these are already determined by a small set of numbers.

In the case of repeated, iterated, application of a formula like z = 2 + C, (where z and C are so-called 'complex numbers', that can be represented by a point {x, y} respectively {A, B} in the complex plane, thus allowing calculation of a new point z as the sum of (the old) z squared and the constant C) results in helixes; shrinking or expanding, depending on the initial value of z. For certain initial values of z border-line cases originate. That is causing then 'curves' with a bizarre shape: a JULIA set. Sometimes it is a connected curve, sometimes the curve consists out of loose, non-connected parts, depending on the value of C.

A set of points C (A,B) establishes the MANDELBROT set. If the computer is ordered to make a drawing of all points C that might deliver a connected JULIA set, another interesting figure is emerging displaying surprisingly fractal character as well. Whilst zooming in on parts of that figure one discovers complex and fascinating partial structures where in the details de key motifs materialise again and again. Compared to the other fractals discussed here the MANDELBROT fractal is of a higher order.[b]

24.21 DIFFERENTIATION

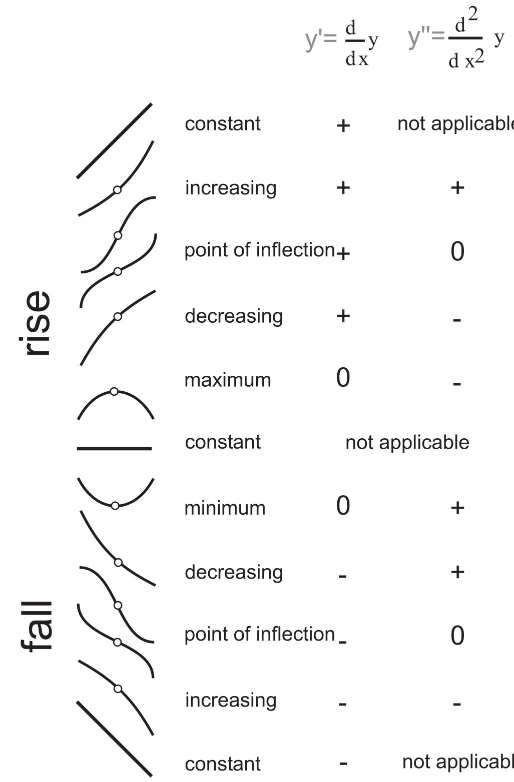
From the difference of two evenly succeeding values in a sequence in space or time one can derive the change at a given moment or position. Also, these derived differences can be put into a sequence. If all 'holes' between two contiguous values in a sequence are filled (Cauchy-sequence; for instance the sequence of values of a continuous function y), one does not speak any longer of a 'difference', Greek capital delta (Δ), (for this has reached its limit to zero), but of a 'differential' (d). If the difference in value dy that has approximated zero is divided by the distance in space or time dx between both values that has also approximated zero a 'differential quotient' dy/ dx results.

a See http://library.thinkquest.org/26242/Full/index.html
b Mandelbrot, B.B. (1983) *The Fractal Geometry of nature*.

In the graph of a function this quotient stands for the inclination at a certain place or moment. How flat or how steep a motor road is, is also indicated by the ratio between height and length (in percentages). However, in the case of the derived function both are approaching zero, so that they relate only to one point of a curve, instead of a trajectory. The quotient y'= dy/ dx is positive in climbing, negative in descending (see corresponding figure).

A lot of rules exist in order to formulate for a given function for all values at the same time a derived function. Since Leibniz and Newton these derivations can be proved by and large; but it is not strictly necessary, to know that proof in order to use the rules. Still the question remains, whether the mathematical insight aimed at in an education benefits from absence of proof in the Euclidean tradition. However this insight does not benefit either from applying without comprehension these rules learned by heart. Computer programs like MathCad, Matlab, Mathematica or Maple do apply these rules automatically and unerringly, so that all attention can be concentrated on the external behaviour of the functions and their derivations.

In the table of figure 235 one may see that minima, maxima, and turning points can be found by putting the derived function y'= 0 or the derived function of the derived function y'' = 0, and then calculate the corresponding y. This is especially important for optimising problems. However if one knows of a certain function for instance just that is rises increasingly, one can search contrariwise for a formula for y for which y' as well as y'' is positive. For this reversed way (integration) a body of calculation rules is also available.



235 Properties of derived functions

24.22 INTEGRATION

Imagine, that one determines for a symmetrical ridged roof for the time being the width to cover, for instance b = 10m, the height of the gutters (gh) to left and right gh1 = gh2 = 4; the height of the ridge rh1 = rh2 = 9 and the ridge position rp = 0.5b. Then the slope of the surfaces of the roof is depending on this. In Mathcad the calculation looks as follows:

Width and ridge position of a roof:

b = 10	rp = 0,5b
roof-plane left	roof-plane right
gh1 = 4, rh1 = 9	rh2 = 9, gh2 = 4

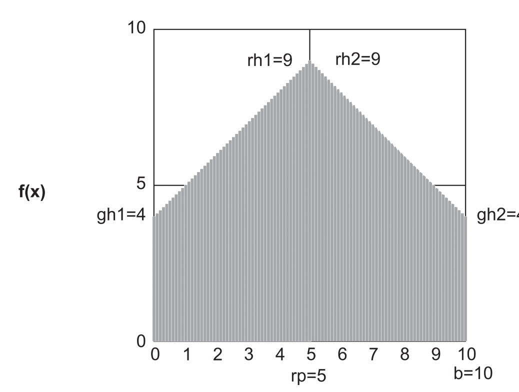
The roof-slopes are now:

$$h1 := \frac{(rh1 - gh1)}{rp} \qquad h2 := \frac{-(rh2 - gh2)}{(b - rp)}$$

The mathematical formula describing the course of the left half between x = 0 (left gutter) and x = rp (ridge) is h1x, to which is added the height of the gutter. However, the part to the right had a descending slope h2 and therefore a different formula between ridge x = rp to the gutter at the right (x = b). Mathcad can assemble both formulae to one discontinuous function f(x) with an 'if-statement': 'if x < rp, then f(x) = gh1 + gh2, else f(x) = rh + h2(x – rp)'. This is described as follows:

Wall function: $f(x) := \text{if}(x \le rp, gh1 + h1 \cdot x, rh2 + h2 \cdot (x - rp))$

Summed surface area of the wall from 0 to b: $\int_0^b f(x)\,dx = 65$



236 A wall as a function

The integral over the width gives the surface area of the front wall. When one is now also taking into account de depth y, this surface may be integrated one more time over y in order to get the cubic content.

Suppose, that the ridge position with the depth y is varying according to a randomly chosen formula rp(y), then the roof slopes h1(y) and h2(y) also vary in depth y:

$$rp(y) := \frac{10 - y}{3} + rp$$

$$h1(y) := \frac{(nh1 - gh1)}{rp(y)} \qquad h2(y) := \frac{-(rh2 - gh2)}{(b - rp(y))}$$

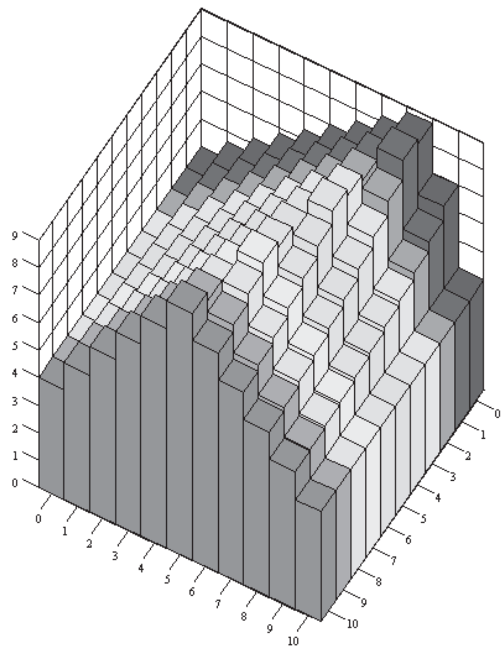
The wall function now becomes a building function with two variables f(x,y). In the wall function one should only substitute for the constant np the variable rp(y) and do the same for h1 and h2:

$$f1\,(x\,,y) := \text{if}\,(\,x \le rp\,(y)\,,gh1 + h1\,(y)\cdot x\,,rh2 + h2\,(y)\cdot(x - rp\,(y)\,)\,)$$

When one substitutes for x and y discrete values from 0 to 10, one can store the values in a 10 x 10 matrix Mx,y = f1(x,y). It can be made visible as in figure 237:

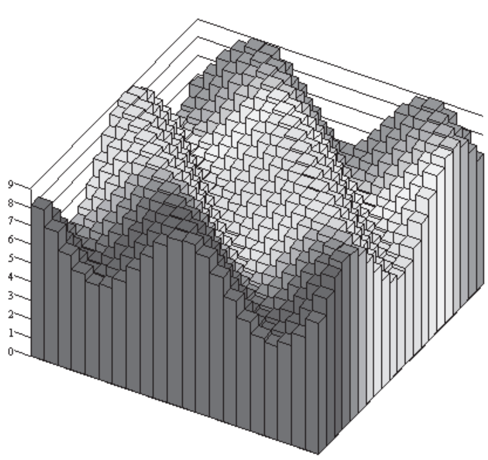
$$\sum_{x=0}^{10}\sum_{y=0}^{10} M_{x,y} = 757.067$$

$$\int_0^{10}\int_0^{10} f1\,(x,y)\,dx\,dy = 649.997$$



237 A house as a function

When the values over rows and columns are summed in the matrix one gets a first impression of the content; the double integration of the function f1(x,y) over x and y obviously yields a more exact calculation. This is particularly convenient, when one is opting for smoothly flowing roof-shapes, for instance the house in figure 238.



238 A house with waved walltops as a function

Differential and integral calculus may be understood along the lines of spatial problems; but it is more often applied in the analysis of processes. In that case the differential dx is often indicated by dt and the growth (or shrinkage) on a particular moment in time by:

$$\frac{d}{dt}f\,(\,t\,)$$

A well-known example is the acceleration with which a body rolls from a variable slope, like a raindrop from the roof. In architecture calculations for climate control are mainly the ones using differential and integral calculus.

24.23 DIFFERENTIAL EQUATIONS

Population growth offers an example of growth that may grow itself, sometimes constant (k) with the size of the already grown population P(t) itself:

$$\frac{d}{dt}P\,(\,t\,) = k\cdot P\,(\,t\,)$$

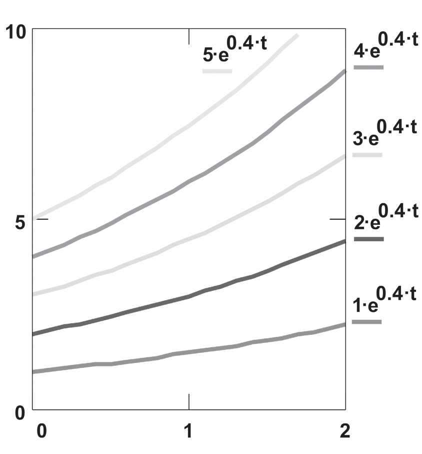
One may verify this even when not knowing a formula for P(t). Such an equation, where an unknown function is occuring together with one or more of its derivations, is called a differential equation. Also in daily parlance primitive differential equations are used: ‘If the population is increasing, the population growth is becoming correspondingly larger’.

Solving a differential equation entails finding formulae for the unknown function (here P(t)). Since the derived function of e^{kt} is equal to ke^{kt},

$$\frac{d}{dt}e^{\,k\cdot t} = k\cdot e^{\,k\cdot t}$$

the derived function of e^{kt} (ke^{kt}) is easy to calculate. This is the reason for a preference to express functions as a power of the real number e = 2,718.

However, if one solution for the differential equation is $P(t) = e^{kt}$, this does not need to be the only solution. Usually, there is a whole family of solutions. We could have substituted, for instance, Ce^{kt}; for its derived function is Cke^{kt}, so that the differential equation also holds in that case. The solutions in the following are by the same token just a few of an infinite number of possible solutions for k = 0.4 (e^k=1,5), for instance as in figure 239.



239 Powers of e

In order to get to know which formula of this family is the right one, we must know the outcome on any specific moment in time, for instance t=0 (initial value). Supposing that we know that the population was initially 2 people, then we can calculate C from Ce^{kt}=2.

Given that $e^0=1$, C=2 applies for each k. In this family of equations C is always the initial value. From this follows the only formula that is correct: $P(t)=2e^{kt}$. However, this would mean that if every person would have after 25 years (a generation) 1.5 children on the average (three per couple), there would be after 2000 years (80 generations) $1.579 \cdot 10^{14}$ children.

The hypothesis of constant growth with regard to the population used in our differential equation is not correct. There are limits to the growth put to it by the sustaining power of the environment. This is demonstrated by many other species than *Homo sapiens* and the real course of the population since 1750 in millions of inhabitants.

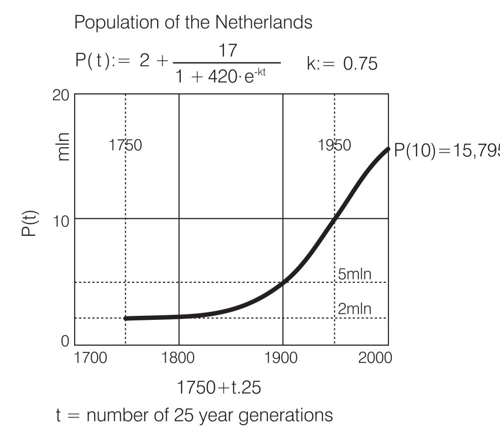
Exponential growth is only valid in the case of relatively small populations. Nearing the boundaries G – established by the size of the habitat – the growth slackens (see also page 257). We can add a term to the differential equation realising this:

$$\frac{d}{dt}P(t) = k \cdot P(t) \cdot \left(1 - \frac{P(t)}{G}\right)$$

If P(t) is small compared to G, the term within the brackets approaches 1, so that our original hypothesis remains valid; in the other case the growth becomes 0, or even negative. Logistical curves like the following comply:

$$P(t) := 2 + \frac{17}{1 + 420\, e^{-k \cdot t}}$$

The function is a variant of the function mentioned as an example on page 257. Differential equations are employed to generate from a hypothesis families of functions, allowing selection based on known initial values.



240 Simulated population of The Netherlands

23.24 SYSTEMS MODELLING

Any system has a border; beyond it exogenous variables serve as input for the first functions, they meet within the system. The output of these functions serves on its turn as an input for subsequent functions, sometimes operating in parallel. The system as a whole delivers in the end an output of tables, images, animations or commands in a process of production.

If a system is modelled on a computer, it is a program that just like a word processing program, awaits input and eventually a command to execute (e.g. the command ‘print’). A programming language like Basic, Pascal, C or Java, contains, except mathematical functions, a host of control functions, like ‘print(programming language)’ , and control statements like ‘do…while’, ‘if …then… else’.

The ‘if…then…’ function, as applied to the ‘wall-function’ on page 227 is a good example for understanding how during the input in a system and during the course of the process – depending on the circumstances – it may be decided which function should operate on the incoming material next and to which following function the result should be passed next as input.

25 VISUALISATION AND ARCHITECTURE

ALEXANDER KOUTAMANIS

25.1 RÔLES FOR VISUALISATION

Visualisation of real and imaginary space is a traditional strong point of architectural education and practice. Even when architectural design is removed from the influence of visual arts, the architect makes extensive and intensive use of visual methods and techniques in the development of a composition, the specification of a design product, the communication of more abstract concepts, and the analysis of design ideas. As a result, knowledge of the world's architecture stems more from published images than personal experience.[a]

Emphasis on visual matters in architecture is not accidental. Human inter-action with natural and built environments is predominantly visual. A wide spectrum of human activities, from aesthetic appreciation to planning of actions, relies heavily on visual information and makes use of visual means to analyse and formulate states and conclusions. Visualisation was a significant aid to understand and control complex processes. Widespread employment of pictorial instructions for e.g. assembling a piece of furniture, putting on a life jacket or tying a tie in a Windsor knot demonstrates the extendibility of relatively simple visual representations.[b]

Recent technological and cultural changes form a new context for a re-evaluation of the significance of visualisation for architecture. Pictures are re-emerging as vehicles for storage, manipulation and communication of information, especially in relation to the visual environment.[c] Such changes are a useful antidote to the aesthetisation of pictorial representation — of which design disciplines are often found guilty. Moreover, they agree with the primary dual purpose of visual representations in designing:

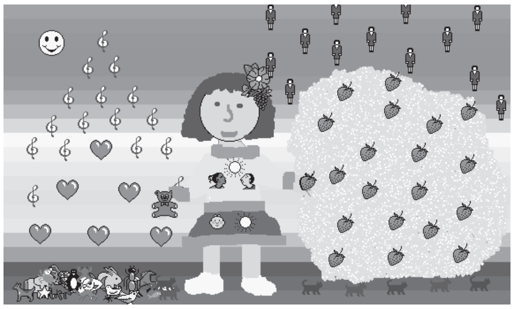
- registering input and output to cognitive processes: internal mental representations are refreshed and reinforced by creating external versions and subsequently internalising them again through perception.
- communicating design ideas: from visual / geometric specification of forms to be built to analysis of functional patterns.

25.5 THE DEMOCRATISATION OF COMPUTER TECHNOLOGIES

The re-emergence of pictures as information carriers relates to computerisation. Current developments suggest that we are entering an initial phase of the computer era. The most striking feature of this phase is democratisation of information technology. After two decades of relatively slow development, restricted to the initiated, the computer is becoming a ubiquitous appliance linked to a new information infrastructure. Computerisation of the workplace was followed by an increasing presence of computers in entertainment and at home.

While the computer's value in increasing efficiency has been amply proven, as in production and management of building documents, its applications have yet to lead to higher quality and performance in designing the built environment or in the built environment itself. The availability of computational power is not matched by methodical utilisation of computing for improvement of current practices. Most computing applications in architecture and planning are sporadic *ad hoc* transfers of technology that may resolve isolated problems, but do little to relate the solutions they provide to their wider context. The transition from analogue to digital media was restricted initially to two-dimensional representations (line drawings) matching limitations of available technology and priorities of architectural practice. Subsequent addition of the third dimension to two-dimensional drawings and production of photo-realistic renderings on the basis of three-dimensional models was also geared to efficiency and productivity rather to than new forms of expression.[d]

a Evans, R. (1989) *Architectural projection*.
b Gombrich, E. (1990) *Pictorial instructions*.
c Lopes, D. (1996) *Understanding pictures*.
d Mitchell, W.J. (1992) *The reconfigured eye;* Mitchell, W.J. and M. McCullough (1995) *Digital design media*.



241 Drawing by an eight-year-old (1996, KidPix on a Macintosh Powerbook 165c)

Still, the new technologies are already having a profound influence on architectural visualisation in three significant ways. The first is that, by making computational power available, affordable and relevant, they provide more efficient and economical implementations of pre-existing analogue techniques, as well as new, complementary tools. Younger generations are particularly proficient in digital visualisation. Figure 241 is a casual drawing by an eight-year-old with the program KidPix on a Macintosh Powerbook 165c. Despite the added difficulty of having to master the trackball of the particular computer model, the drawing comes very close to the child's drawings on paper. Even the use of standardised elements in the computer programme echoes her application of self-adhesive and stencilled figures.

The early familiarity of today's children with computer visualisation, their natural acceptance of cognitive and manual ergonomics, as well as their high exposure to related media, like video and arcade games, suggest that digital tools will soon cease to be an alien technology in architectural education and practice. Even thorny issues like digital sketching (cf. figure 241) will be resolved simply by the future users' proficiency in both the digital and analogue versions.

A second potential contribution of modern visualisation technologies is provision of sharper, more reliable and hopefully more intuitive geometric tools. The practical and conceptual necessity of describing three-dimensional objects with coherence, accuracy and precision created a strong but strained relationship between architecture and geometry. A frequent complaint is that orthographic projections may fail to register salient features of their subject. Consequent rebellion against the "tyranny of the box" oscillates between giving up geometry altogether and adopting other, more complex geometries —choices with an outcome never fully explored.[a]

The third influence of democratisation of computer technologies on architectural visualisation lies in that it opens a wide and exciting new market for visualisation in information systems. Graphical interfaces are frequently developed for spatial forms, as for example the Internet with VRML. The architects' experience in representing spatial patterns visually has led to the assumption that design of these interfaces and of inter-action in information space adds to the scope of architects who are arguably better suited to such subjects than other design specialists today.

25.3 REPRESENTATION: A DEFINITION

A suitable working definition of what a representation is and what it does can be derived from Marr.[b] According to this, a representation is a formal system for making explicit certain entities in a transparent manner, i.e. together with an explanation of how the explicitness is achieved. The product of a representation as applied to a specific entity is a *description*. Familiar examples of representations include Roman and Arabic numerals (decimal or binary). Figure 242 contains alternative descriptions of the number 17 produced by different representations.

242 Alternative representations

In each of them a number is described on the basis of a finite set of symbols and a rule systems for composing a description from the symbols. Arabic decimal numerals use the following set:

$$S_A = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$$

These symbols are correlated to a number in the following manner of positional notation:

$$n_n * 10^n + n_{n-1} * 10^{n-1} + \ldots + n_1 * 10^1 + n_0 * 10^0 \Rightarrow n_n n_{n-1} \ldots n_1 n_0$$

For example:

$$1 * 10^1 + 7 * 10^0 \Rightarrow 17$$

a Evans, R. (1995) *The projective cast, architecture and its three geometries*.
b Marr, D. (1982) *Computer vision*.

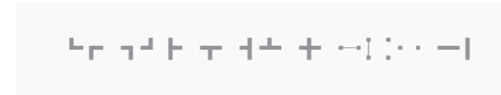
Arabic binary numerals make use of a smaller set of symbols and corresponding decomposition rules: $_B = \{0, 1\}$

$$n_n * 2^n + n_{n-1} * 2^{n-1} + \ldots + n_1 * 2^1 + n_0 * 2^0 \Rightarrow n_n n_{n-1} \ldots n_1 n_0$$

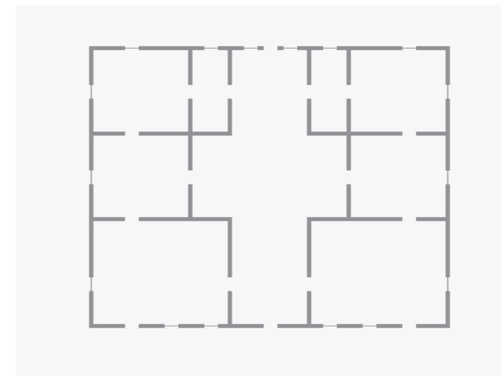
For example:

$$1 * 2^4 + 0 * 2^3 + 0 * 2^2 + 0 * 2^1 + 1 * 2^0 = 10001$$

Architectural representations are essentially similar in structure. They consist of symbols for spaces and/or building elements, relations between the symbols and correspondence rules for mapping the symbols and their relationships to the subject of representation. Figure 243 depicts the symbols of a basic set of building elements. The set is sufficient for describing orthogonal floor plans, like the one in figure 244, as two-dimensional arrays comprising generic building elements.[a]



243 A basic set of symbols for floor plans.



244 Floor plan created with the symbols of figure 243.

25.4 IMPLEMENTATION MECHANISMS

The significance of spaces and building elements in architecture has not been realised in practical design computing and visualisation. Drafting and modelling programs generally employ lower level geometric primitives, like points, lines and simple surfaces for the outlines of building components. Moreover, these geometric symbols are seldom grouped together into a coherent description of a component and have few, if any, explicit relations to other elements.

A useful distinction, also from Marr[b], is the one between representation and implementation. For every representation there are several alternative implementations, usually depending on the context of the application. For example, binary numbers can be represented with Arabic numerals (1 or 0) or with states of switches (ON or OFF). Both refer to the same representation: the implementation mechanisms change; not the actual symbols used in the representation.

The elevation of implementation mechanisms like lines and surfaces to primitives of architectural design is symptomatic of two general conditions in computerisation of architecture. The first: most digital techniques are direct transfers of analogue practice. This almost always includes unquestioning acceptance of the implementation mechanisms of an analogue representation as the basis of its digital equivalent. The second: an underlying mystification tendency, confuses implementation mechanisms and visualisation techniques with spatial form and perception. The use of spaces and building elements as primitives of architectural design representation is too prosaic to allow far-fetched associations and loose metaphors, which can be easily accommodated in neutral geometric justifications.

25.5 ELEMENTS AND RELATIONSHIPS

Research into the structure of symbolic representation focuses on two issues:

- which primitives should be employed and at what level,[c] and
- the possibility of units (chunks, partitions, clusters more structured than simple nodes and links or predicates and propositions.[d]

The primitives issue can be resolved by the analysis of existing representations of the built environment. These traditionally assume a direct, atomistic form. A conventional representation like a map or floor plan comprises atomic elements like individual buildings or building components. These elements appear at an abstraction level appropriate to the scope of the representation. Depending on the scale and purpose of a map, buildings are depicted individually or concatenated into city blocks. Similarly, a floor plan at the scale of 1:50 depicts building components and elements that are ignored or abstracted at 1:500. Most other aspects of built form remain implicit, with the exception of those indicated as annotations by means of colouring and textual or symbolic labels conveying information like grouping per sub-system, material properties or accurate size. Relations between elements, like the align-

a Koutamanis, A. (1995) *Recognition and retrieval in visual architectural databases*.
b Marr, D. (1982) *Computer vision*.
c Brachman, R.J. and H.J. Levesque (1985) *Introduction*.
d Brachman, R.J. (1985) *On the epistemological status of semantic networks*.

ment of city blocks or the way two walls join in a corner are normally not indicated —unless, of course, they are the subject of the representation, as in detail drawings.

Using formalisms like semantic networks, frames, scripts and objects, elements are brought together in associative symbolic representations that share the following features:

- representation consists of objects and relations between objects;
- objects are described by their type, intrinsic properties and extrinsic relations to other objects;
- properties are described by constraints on parameters;
- relations are described by networks of constraints linking objects to each other.

A comparison of such representations with conventional architectural drawings reveals that architecture is handicapped by omission of explicit relationships between elements. The reasons for this omission have to do with representational complexity and range from the user's unwillingness to input multiplicity of relevant connections, to the computer's inability to handle them efficiently and effectively. Consequently, architectural associative symbolic representations has restricted greatly focused generative systems where structure and intention can be controlled.

More ambitious representations have attempted to integrate all relevant aspects and entities. Their main intention: resolving real design problems as encountered in practice. However, large or holistic representations have a size and complexity that often make representations unmanageable both for computers and humans. Problematic maintenance and lack of predictability in the behaviour of such representations, especially following modification and augmentation, limit severely their applicability.[a]

25.6 ELEMENTS

Architectural composition is often equated to arranging items chosen from a finite set of 'solid' building elements and/or 'void' space forms. Building elements traditionally attract more attention than spaces. Especially within the confines of a single formal system we encounter relatively compact and well-ordered collections of building elements which form the *sine qua non* of the system. The best example of such collections is the orders of classical architecture, where canonisation of the system was achieved by standardisation of a small subset of building elements. The conspicuous presence of these elements in classical buildings led to the view that a building with classical proportions cannot be classical if it does not contain elements from the classical orders.[b]

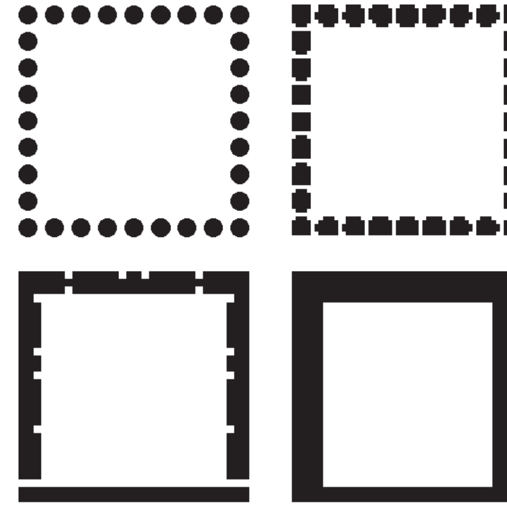
The attention paid to the arrangement and articulation of a specific subset of building elements has propagated a particular image of architectural design that is more akin to fine arts than to engineering. Even after the classical orders were dismissed by modernist architecture and replaced by abstract systems based on proportion and standardisation, this image remained an implicit yet powerful part of architectural methodology. Probably the best examples are the ideas on industrialisation in building developed and applied after WW II. These were dominated by standardisation of building elements in size and type and modular co-ordination for the arrangement of these elements. The resulting hierarchical system of building elements and positioning constraints bears similarities with the classical orders. The image of architectural design as arrangement and articulation of a finite set of building elements has been influential in computer-aided architectural design. It suggested a graphic system where the designer selects objects from a database and integrates them in a design by means of simple geometric transformations.

A significant issue relating to the elements of architectural representations is the duality of 'solid' building elements and 'void' spaces in the representation of the built environment. Spaces are less frequently chosen as the atomic elements of architectural composition than building elements. This is frequently attributed to the implicitness of spaces in conven-

a Gauchel, J., S. van Wijk et al. (1992) *Building modeling based on concepts of autonomy*.
b Summerson, J. (1980) *The classical language of architecture*.

tional analogue representations like floor plans. A possibly more significant reason is the equation of spatial arrangement to a fixed pattern locally elaborated, annotated and studded with building elements. Such an interpretation appears to underlie traditional design practices, as well as computational design studies including space allocation[a], shape grammars[b] and similar generative systems.[c]

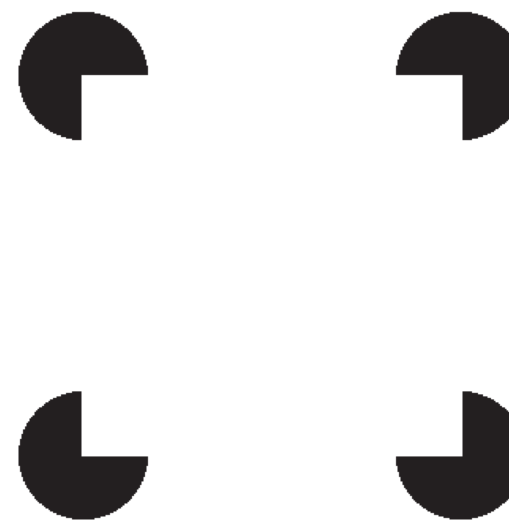
In cognitive studies the representation of objects by their parts and modules has been a common hypothesis for computational and cognitive studies of vision and visual recognition.[d] According to this hypothesis, a visual scene is parsed into components, normally corresponding with the canonical parts of the objects depicted in the scene. The representation derived from a scene has a multi-level structure, each level corresponding to a different abstraction level. At the highest level an object is represented as a single component analysed into smaller components at subsequent (lower) levels. For example, a human form starts as a single component, then sub-divided into components for head, torso, arms and legs. Each component is further sub-divided, e.g. an arm into upper arm, forearm and hand. Again the hand is analysed into components for palm and five fingers.[e]



245 Elements and abstraction

Elements are straightforward to define and recognise in a multi-level structure; but their applicability is limited to a small range of abstraction levels. In figure 245 the actual elements (top left) are thirty two bullets arranged along the sides of an imaginary square. Nevertheless, the image is normally described simply as a square. Rather than describing the atomic parts we group them in one pattern denoting the overall configuration. The same effect can be achieved by lowering resolution of the image, as in figure 245 (sequence: top right, bottom left, bottom right). By doing so, the individual parts progressively lose individuality and fuse into a solid square.

In other situations the actual elements are interpreted as something different than what they actually are. In figure 246 the four incomplete disks are interpreted as four complete black disks partially occluded by an illusory white square.[f] The instability and degradation of elements suggest that beyond certain levels of abstraction atomic elements are replaced by co-ordinating devices. These devices can be derived by purely visual processes (figure 245). This, however, does not preclude the existence of these co-ordinating devices as separate entities existing independently of the elements and which may appear in representations with or without elements.



246 Elements and illusory contours

Despite limitations in applicability of elements, it is assumed that, at a low level (before significant abstraction occurs), the representation of complex visual scenes can be based on a small set of basic components. Biederman proposed that this set can be reduced to 36 simple components, called *geons*.[g] Similar principles have been employed for recognition of line drawings of three dimensional scenes where the repertory of possible edge junctions was reduced to a small number of configurations labelled with respect to convexity/concavity.[h] In an austerely trihedral environment the number of possible junction configurations is just 18.[i] The same applies to representation of spaces in orthogonal floor plans (figure 243 and 244), where 8 types suffice.[j]

The arrangement of elements is normally represented in terms of an associative structure linking discrete components to each other with spatial/geometric relationships.[k] As with the number of elements, it is proposed that the number of basic relationships is quite low. Geons relate to each other by means of five edge properties.[l] In line drawings correlation of edge junctions takes place on basis of the labelling of each edge with respect to convexity / concavity in an iterative constraint propagation procedure.[m] In orthogonal floor plans each space corner is linked to two other corners, one in horizontal, one in vertical direction. For a given space corner type there are two possible types of corners it can be linked to in either direction.[n] This also suggests that certain relationships are implicit in the type of the elements: each element is characterised by specific expectations concerning type and position of elements to which it relates.

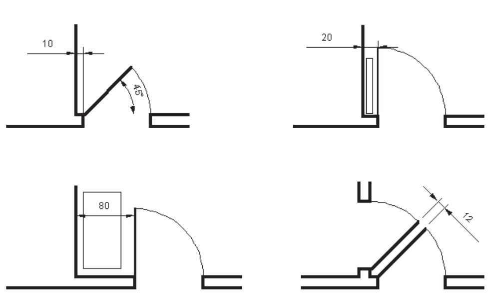
a Eastman, C.M. (1975) *Spatial synthesis in computer aided building design*.
b Stiny, G. and W.J. Mitchell (1978) *The Palladian grammar*.
c Hersey, G. and R. Freedman (1992) *Possible palladian villas*.
d Brooks, R.A. (1981) *Symbolic reasoning among 3-D models and 2-D images;* Marr, D. (1982) *Computer vision;* Tversky, B. and K. Hemenway (1984) *Objects, parts, and categories;* Biederman, I. (1987) *Recognition by components: a theory of human image understanding;* – (1995) *Visual object recognition*.
e Marr, D. (1982).
f Kanizsa, G. (1979) *Organisation in vision. Essays on Gestalt perception preager*.
g Biederman, I. (1987, 1995).
h Guzmán, A. (1966) *Computer resolution of three dimensional objects in a visual scene;* Clowes, M. (1971) *On seeing things;* Huffman, D. (1971) *Impossible objects as nonsense sentences;* Mackworth, A.K. (1973) *Interpreting pictures of polyhedral scenes;* Waltz, D. (1975) *Understanding line drawings of scenes with shadows*.
i Winston, P.H. (1992) *Artificial Intelligence*.
j Koutamanis, A. and V. Mitossi (1992) *Automated recognition of architectural drawings;* Koutamanis, A. (1995) *Recognition and retrieval in visual architectural databases*.
k Marr, D. (1982); Winston, P.H. (1992).
l Biederman, I. (1987, 1995).
m Waltz, D. (1975).
n Koutamanis, A. and V. Mitossi (1993) *Computer vision in architectural design;* Koutamanis, A. (1995).

25.7 LOCAL CO-ORDINATING DEVICES

While representation of elements in both analogue and digital design practice is explicitly supported by symbolic techniques, less importance has been attached to the way in which elements are integrated in a design. This is normally left to the designer who has to position and connect each new element in a building representation with little help from his instruments. For example, many drafting and modelling systems still fail to address the physical impossibility of two objects occupying the same space, let alone attempt to interpret the designer's intentions in overlapping objects. In analogue design media, this is a logical consequence of their implementation structure. An analogue representation is perceived, recognised and interpreted by the human viewer. Computerised representations, on the other hand, are not limited by human interpretation. On the basis of explicit relationships between objects the computer can provide meaningful feedback on the basis of qualitative and quantitative analyses complementing and supporting the designer's creativity.

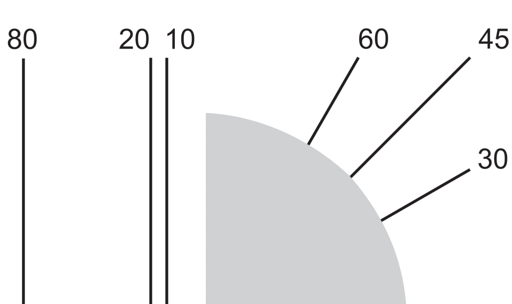
Frequent absence of meaningful explicit relationships between elements in architectural representations does not imply lack of knowledge on the subject. Architectural and building textbooks deal extensively with relationships between building elements and components. The positioning of one element relative to another derives from formal, functional and constructional decisions and has consequences for the articulation and performance of the building. Textbooks provide guidelines ranging from ergonomically sound distances between chairs and tables to correct detailing of joints in roof trusses. Frequent and faithful use of textbook examples has resulted in a corpus of architectural stereotypes. Even though stereotypes may lead the designer to repeating known solutions, they help reach levels of reasonable performance in designing and in the built environment. By obeying underlying rules and reproducing textbook stereotypes, the designer ensures conformity with norms of building regulations, professional codes and general empirical conclusions.

In textbooks, aspects of a recommended configuration are usually presented separately in a proscriptive manner, by means of sub-optimal and unacceptable examples. These are annotated with the relevant relationships and usually ordered from general to specific and from simple to complex. It is assumed that the reader of the textbook makes a selective mental aggregate on based on the aspects that apply to the problem at hand. Despite that, incompatibilities between different aspects and examples are seldom addressed in textbooks. Forming an aggregate representation is generally a straightforward hill-climbing process. For example, in designing a door, one starts with basic decisions relating to the door type on the basis of spatial constraints and performance criteria. Depending upon the precise type, the designer proceeds with constraints derived from adjacent elements and activities. In the case of a single inward opening left hinged door of standard width (figure 247), these constraints determine position and functional properties of the door, i.e. the distance from elements behind the door, and the swing angle, orientation and direction enabling the projected entrance and exit requirements. These can be adjusted by other factors unrelated to the initial decision. For example, the existence of a load-bearing element in the initial place of the door may necessitate translation of the door and hence a re-formulation of the initial design problem.



247 Textbook representation of local co-ordination constraints

Similarly to textbooks, templates offer useful insights into stereotypical interpretation of local co-ordination constraints. In templates, building elements usually appear as holes or slits. Each one is accompanied by annotations in the form of dents, notches and painted text. These facilitate geometrical positioning of a form, as well as geometric interpretation of spatial constraints. The configuration of forms and annotations typically represents a simplified fusion of parameters reduced to typical cases (figure 248). Even though superimposition of different patterns makes the template less legible than the more analytical textbooks, the template comes closer to the mental aggregate of the designer.



248 Template representation of local co-ordination constraints

The manner in which local constraints are centred on elements, the connections between elements and their stereotypical treatment in designing suggest that mechanisms like frames or objects would be appropriate for representation of local co-ordination devices. In a frame-based representation the relationships of e.g. a door with walls and other elements of the immediate context can be described as slots and facets linking the door frame with frames of walls, spaces and other elements. Such an implementation strategy has obvious advantages for the representation of local co-ordination devices, for example with respect to inter-changeability of elements by means of abstraction and inheritance. It is quite plausible that a single prototype would suffice for representation of all kinds of doors. This could facilitate manipulation of doors in computer-aided design, including automated substitution of one door type by another, if needed; due to spatial conflicts or a change in the designer's preference.

25.8 GLOBAL CO-ORDINATING DEVICES

Global co-ordinating devices generally appear in two forms. The first: sketches and diagrams explaining the general spatial articulation of a design. Such abstract representations —even if devised post factum— are commonly seen as embodiment of the driving forces in the development of the design. For our purposes they form a useful précis which can be placed at the top of a multi-level representation. The second form: the product of formal analysis. Usually applicable to more than one design, it is expressed in more abstract terms: grids, zoning schemes. Probably the most celebrated of such devices is the 5 x 3 grid proposed by Wittkower as the underlying grid of Palladian villas.[a]

This grid is universally accepted as the canonical formal expression of the intuitive perception of the Palladian villa's "triadic composition" of two symmetrical sequences of spaces laterally flanking the central series of spaces along the main axis.[b] As a result, the 5 x 3 grid forms the basis of most Palladian studies, including the Palladian shape grammar.[c] In it, the first stage invariably concludes with the definition of the 5 x 3 grid which serves further as a template for definition of spaces and positioning of building elements.

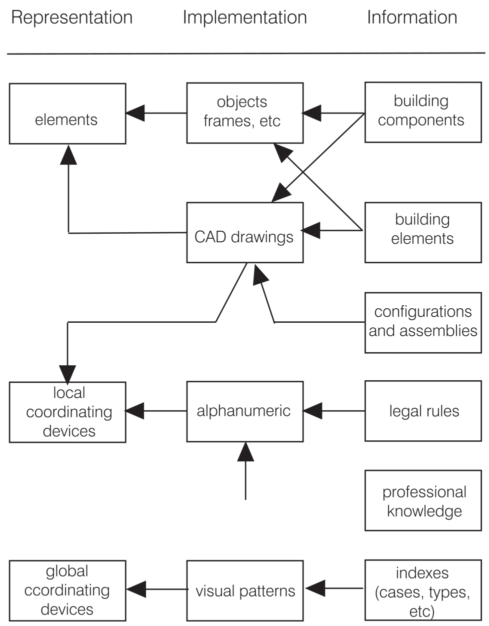
Global co-ordinating devices can be derived by visual abstraction eliminating the individual characteristics of elements and returning a skeleton, as in figure 245. This does not imply that these abstractions are accidental products of various, possibly unrelated design decisions. Another option is to treat devices like the Palladian 5 x 3 grid as prototypical patterns systematically repeated in variations. Such a view underlies most computational studies, even though there is no historical evidence that Palladio set out to exhaust the possibilities presented by a single pattern. The 5 x 3 grid appears to be an fusion of different preoccupations and influences, from notions of harmony to the traditional centralised arrangement of the local house type.[d]

25.9 MULTI-LEVEL DESIGN REPRESENTATIONS AND INFORMATION NETWORKS

Integration of all entities in holistic associative structures applies to design problems of limited size and complexity. As a problem expands to more elements, aspects and abstraction levels, atomistic associative representations grow beyond what is manageable for computation by computers and for direct comprehension by humans, even if compact implementation mechanisms like frames and objects are employed. In multi-level representations networks of architectural elements are complemented by local and global co-ordinating devices at different levels of abstraction. These devices integrate relationships in consistent and coherent local or global frameworks regulating positioning and properties of elements. Multi-level representations build on the natural abstraction of architectural representations; evident in the conventional sequence of drawings at different scales: 1:200, 1:100, 1:50, 1:10.

One main advantage of multi-level representations comprising elements, local and global co-ordinating devices is connectivity to external information sources. The increasing availability of design information on networks like the Internet makes connectivity a pre-requisite to integration of such networks in designing. The ability to instigate searches by means of intelligent, autonomous agents that collect appropriate information, to integrate this informa-

a Wittkower, R. (1952) *Architectural principles in the age of humanism*.
b Ackerman, J.S. (1977) *Palladio*.
c Stiny, G. and W.J. Mitchell (1978) *The Palladian grammar*.
d Ackerman, J.S. (1977).



249 Multi-level design representations and information retrieval

tion in design representations and to maintain a dynamic link with the original source of the information are already available on a limited or experimental basis.

Integration of hypermedia possibilities in drafting and modelling systems and addition of vector information in hypermedia interfaces to the Internet currently focus on dissemination of information on building elements and components. These are distributed as CAD documents to be downloaded from an Internet site and subsequently integrated in a design. Dynamic linking of a local document to the representation of a component or element on a remote system is also feasible.

With respect to integration of on-line information on elements a multi-level representation is similar to any analytical representation. The advantages of multiple co-ordinated levels on top of the networks of elements emerge when we consider integration of other kinds and forms of information. One such kind already being distributed through the Internet, but frequently escaping attention, are relationships and constraints that constitute local co-ordinating devices. This information is normally included in texts describing or analysing legal codes and regulations, as well as professional knowledge of the kind encountered in textbooks. Identification and extraction of relevant items from these documents is conceptually non-trivial but technically straightforward, given the hypermedia structure of current Internet interfaces.

These items can be linked to a design representation in the same way as elements, with the difference that elements are self-contained, while textual or mathematical information on rules and regulations constrains items and relationships between items. The explicit representation of local co-ordinating devices, either embedded in elements or as separate, superimposed entities, facilitates direct connection to external alpha-numeric values (figure 249). This permits precise control of input and constraint propagation in a design, for example for analysis and modification of specific aspects due to a change in the legal framework of the project. Co-ordinating devices are equally significant in guiding information retrieval. The constraints encapsulated in local co-ordinating devices often determine acceptability of an element to a particular situation.

As a result, network search routines can derive part of their parameters from the relevant local co-ordinating devices in the design, test the retrieved elements against the requirements in these devices and receive feedback on relevance of the search. Global co-ordinating devices can also be employed this way, especially for assemblies and sub-systems of elements. Such parts of a design are becoming increasingly available as examples of the application of principles, systems or elements.

The proliferation of ideas on case and precedent-based design could also increase the number of on-line configurations of elements. Their manipulation for retrieval and integration in new design can only be achieved by analytical means matching the complexity of the configurations. However, we may expect that most information on cases, prototypes and precedents will be at a high level of abstraction. This suggests that global co-ordinating devices can be used for indexing designs in a database and, hence, as query terms for retrieval of whole designs. The utility of current indexing schemes (usually on basis of a controlled vocabulary) demonstrates the advantages of such search intermediaries. Local, and especially global co-ordinating devices can enrich indexing with visual schemata which can be directly matched to the searcher's own graphic input.[a]

25.10 ANALYSIS AND REPRESENTATION

Well-defined design representations are a pre-requisite to analysis and evaluation of building behaviour and performance. With the increasing complexity of the built environment and rising requirements of environmental quality, analysis and evaluation of programmatic and functional aspects are becoming one of the highest priorities in architecture. Unfortunately, architectural analysis (and design) has been driven by normative models belonging to either of the following deontic approaches:

a Gross, M.D. (1995) *Indexing visual databases of design with diagrams*.

- *Proscriptive*: formal or functional rules that determine the acceptability of a design on the basis of non-violation of certain constraints. Formal architectural systems like classicism and modernism, as well as most building regulations are proscriptive systems.
- *Prescriptive*: systems that suggest that a pre-defined sequence of actions has to be followed in order to achieve acceptable results. Many computational design approaches are prescriptive in nature.

Dominance of a specific system or approach in a historical period has been instrumental for the evolution of architecture. It allowed in concentration of effort on concrete, usually partial problems within the framework of the system and hence supported innovation and improvement.

The eclectic spirit of recent and current architecture reduces the value of normative approaches, as it permits strange conjunctions, far-fetched associations and unconstrained transition from one system to another. In addition, the computer provides means for analyses and evaluations of a detailed and objective nature. These dispense with the necessity of abstraction and summarisation in rules and norms. This does not mean that abstraction is unwanted or unwarranted. On the contrary, abstraction is an obvious cognitive necessity, that emerges as soon as a system has reached a stable state. Consequently, one can expect emergence of new abstractions on the basis of the new detailed, accurate and precise analyses. It is quite probable that several older norms will be among the new abstractions.

The main characteristic of new forms of analysis is that they follow an approach we may call *descriptive.* They evaluate a design indirectly, by generating a description of a particular aspect comprising detailed measurable information on the projected behaviour and performance of the design. This description is normally closely correlated with formal representation of the design and therefore permits interactive manipulation, e.g. for trying different alternatives and variations. In short, the descriptive approach complements (rather than guides) human design creativity by means of feedback from which the designer can extract and fine-tune constraints.

In functional analyses it has become clear that most current norms and underlying principles have a very limited scope: control of minimal specifications by a lay authority. They are often obsolete as true performance measures and grossly insufficient as design guidance. The solution presented by the descriptive approach is substitution of obsolete abstractions by detailed information on functionality and performance, for example abandonment of Blondel's formula of stair sizes in favour of an ergonomic analysis of stair ascent and descent by means of simulation.[a] The analysis is performed in a multi-level system connecting normative levels to computational projections and to realistic simulations in a coherent structure, where assumptions of one level are subject of investigation at another level.[b]

25.11 AESTHETICS

The intuitive appreciation of aesthetic preference has been a hallmark of architectural design in practice. It has also been one main reason for conflict between architect and lay person, as the latter's appreciation of built form and space is less tempered by dominant architectural doctrines and more by the élite dictating good taste and 'vogue'. As vogue is often at odds with architectural history and criticism, architects have been reluctant to change what they consider to be part of their methodical background. The predominance of the intuitive approach agrees with many types of human inter-action with the built environment and its representations. This agreement adds an element of common sense to architectural analysis that may temper indifference to practical problems. However, common sense can be distorted or refuted by expert opinion and interpretation, especially if specific human experiences do not involve directly measurable performance criteria. Such distortions and refutations have contributed to the deep dichotomy between form and function in architecture and to the frequent

a Mitossi, V. and A. Koutamanis (1996) *Parametric design of stairs*.

b Koutamanis, A. (1995) *Multilevel analysis of fire escape routes in a virtual environment;* Koutamanis, A. (1996) *Elements and coordinating devices in architecture: An initial formulation*.

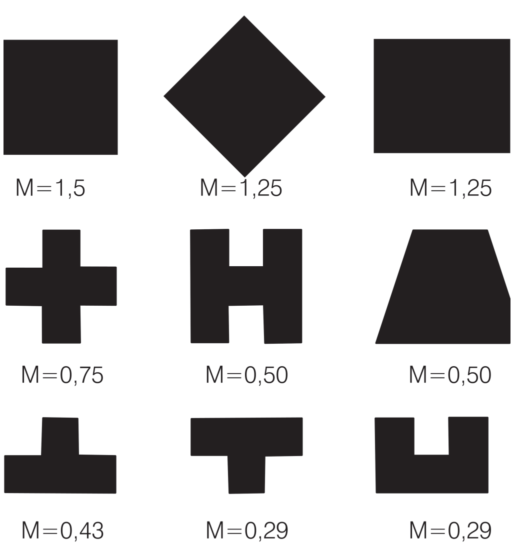
elevation of formal considerations to the highest priority in architectural design, either as a priori norms and canons or as direct and inescapable consequences of functional issues and problems.

In the descriptive approach the principles of architectural aesthetics are drawn from perceptual and cognitive sources; and these principles are connected to architectural issues, strictly in this order. In other words, rather than starting with ordering, the existing architectural aesthetic norms and then proceeding to a search for cognitive relevance and justification, we apply general computational models of perception and cognition to architecture. This leads to an analysis that does not derive from a normative architectural model or system. Therefore, it does not exhibit any bias towards specific approaches but potentially accommodates all possible architectural systems. Different systems correspond to variations in the analysis with respect to the configuration of analytical devices, as well as to (parametric) differences within each device. The common basis of the different systems and of the corresponding analyses is an objective representation of the architectural object, i.e. a description not relating to a specific architectural formal system.

The distinction between the derivation of a description, its interpretation and finally its evaluation, is common to computational studies of vision but also of aesthetics.[a] Its particular value lies in that it stresses affinity between figural goodness in perception and aesthetic appreciation of built form. Figural goodness has been linked to aesthetic response by means of the relation between perceptual arousal and complexity.[b]

25.12 AESTHETIC MEASURES

The first significant attempt to quantity aesthetics was by the American mathematician George D. Birkhoff who, following, among others, Leibniz and Pythagorans, proposed that the aesthetic experience relies on principles of harmony, symmetry and proportion. Three successive phases:[c]



250 The aesthetic measure of isolated polygonal forms according to Birkhoff [e]

- arousal and effort of attention;
- the feeling of value or aesthetic measure which rewards the effort of attention; and finally
- the realisation that the perceived object is characterised by a certain aesthetic order.

Birkhoff states that the effort of attention is proportional to the complexity (*C*) of the perceived object and links complexity, the aesthetic measure (*M*) and aesthetic order (*O*) in the basic aesthetic formula:

$$M = O / C$$

Complexity is generally measured by the number of elements in the perceived object. For example, in isolated polygonal forms complexity is measured by the number of distinct straight lines containing at least one side of the polygon, similarly to the gratings of rectangular dissections.[d] The measurement of order varies with the specific class of objects to be evaluated but generally takes the form of the sum of weighted contributing elements:

$$O = ul + vm + wn + \dots$$

where $l, m, n, \dots$ are the independent elements of order and $u, v, w, \dots$ indices which may be positive, zero or negative, depending upon the effect of the corresponding element. Aesthetic order and consequently aesthetic measure are relative values which apply to specific classes of objects, so restricted that intuitive comparisons of the different objects becomes possible. There is no comparison between objects of different types.

Birkhoff suggests that order relates to associations with prior experience and acquired knowledge triggered by formal elements of order, that is: properties of the perceived object, like bilateral symmetry about a vertical axis or plane. Formal elements of order with a positive effect include repetition, similarity, contrast, equality, symmetry and balance. Ambiguity, undue repetition and unnecessary imperfection have a negative effect. For example, a rectangle

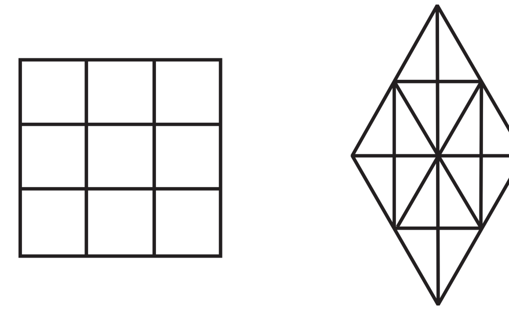
a Stiny, G. and J Gips (1978) *Algorithmic aesthetics. Computer models for criticism and design in the arts*.
b Berlyne, D.E. (1960) *Conflict, Arousal and Curiosity*; - (1971) *Aesthetics and psychobiology*.
c Birkhoff, G.D. (1933) *Aesthetic measure*.
d Steadman, J.P. (1983) *Architectural morphology*.
e Birkhoff, G.D. (1933).

not quite a square is unpleasantly ambiguous, according to Birkhoff. Also a square whose sides are aligned with the horizontal and vertical is superior to an unnecessarily imperfect square which has been rotated about its centre by 45 degrees "because it would be *so easy* to alter it (the rotated square) for the better" (p. 25).

In the example of isolated polygonal forms aesthetic order is measured by the formula

$$O = V + E + R + HV - F$$

where *V* stands for vertical symmetry, *E* for equilibrium, *R* for rotational symmetry, *HV* for the relation to a horizontal-vertical network (reference framework) and *F* for unsatisfactory form. "Unsatisfactory form" encompasses too small distances between vertices or parallel sides, angles too near to 0 or 180 degrees and other ambiguities, diversity of directions and lack of symmetry.



251 Examples of horizontal-vertical networks according to Birkhoff[a]

Ingrained aesthetic prejudices reduce applicability and reliability of Birkhoff's aesthetic measure. The highest values are achieved with symmetrical forms with the least number of parts. The square with sides aligned to the vertical and horizontal is the clear winner among polygonal forms, followed by the square rotated by 45 degrees and the rectangle with horizontal and vertical sides. Still, the aesthetic measure is important to our investigation for three basic reasons relating rather to the way the measure is calculated than the measure itself.

The first is that it equates beauty with order. While this does not hold for aesthetics in general, it is obviously relevant to prescriptive and proscriptive architectural formal systems where conformity to canons and rules, often explicitly and paradigmatically expressed, constitutes the usual measure of formal acceptability.

The second reason is factoring aesthetic order into discrete, independent formal elements each with a limited scope. The third reason is the rôles of order and complexity in the aesthetic measure and their affinity with information processing and the rôle of figural goodness in perception. This affinity was not lost on Birkhoff's epigones who linked aesthetic measures to information theory.[b] The applicability of Birkhoff's approach to architectural aesthetics is consequently restricted to:

- analysis of factors contributing to aesthetic appreciation and preference and
- evaluation of an object with respect to each of these factors.

25.13 CODING AND INFORMATION

Probably the greatest shortcoming of Birkhoff's approach is that it fails to take account of perception, that is, of processes by which an object elicits a pleasurable reaction. By linking aesthetics to perception we depart from the objectiveness of Birkhoff's measure and adopt an inter-subjective model of aesthetic appreciation stressing the cognitive similarities that exist between different persons and cultures.[c] Inter-subjectivity also allows to correlate different aesthetic approaches, i.e. different architectural formal systems.

Gestalt psychologists have formulated a number of principles (or 'laws'), like proximity, equality, closure and continuation, which underlie the derivation of a description from a percept by determining the grouping of its parts.[d] Probably the most important, certainly the most mysterious of the Gestalt principles of perceptual organisation is *Prägnanz* or *figural goodness* which refers to subjective feelings of simplicity, regularity, stability, balance, order, harmony and homogeneity arising when a figure is perceived. Figural goodness ultimately determines the best possible organisation of image parts under the prevailing conditions. As a result, it is normally equated to preference for the simplest structure. The view of perception as information processing has led to attempts to formulate figural goodness more precisely. Given capacity limitations of the perceptual system and the consequent necessity of minimisation, it has been assumed that the less information a figure contains (i.e. the more redun-

a Birkhoff, G.D. (1933) *Aesthetic measure*.
b Bense, M. (1954) *Aesthetica;* Moles, A. (1968) *Information theory and esthetic perception*.
c Scha, R. and R. Bod (1993) *Computationele esthetica*.
d Köhler, W. (1929) *Gestalt psychology;* Koffka, K. (1935) *Principles of Gestalt psychology;* Wertheimer, M. (1938) *Laws of organisation in perceptual forms*.

dant it is), the more efficiently it could be processed by the perceptual system and stored in memory.[a]

Arguably the most powerful model in this line of investigation was Leeuwenberg's coding or *structural information theory*.[b] According to Leeuwenberg a pattern is described in terms of an alphabet of atomic primitive types, like straight-line segments and angles at which the segments meet. This description (the *primitive code*) carries an amount of structural information (I) equal to the number of elements (i.e., instances of the primitives) it contains. The structural information of the primitive code is subsequently minimised by repeatedly and progressively transforming the primitive code on the basis of a limited number of coding operations:

- iteration, by which the patterns

  a a a a a a b b b b b b (I = 12) and *a b a b a b a b a b a b* (I = 12) become respectively 6 * [(*a*) (*b*)] (I = 3) and 6 * [(*a b*)] (I = 3)

- reversal, denoted by *r* […]:

  a b c = r [*c b a*] (I= 3) — reversal allows the description of symmetrical patterns (Σ):

  a b c c b a = *a b c* r [*a b c*] = Σ [*a b c*] (I = 4)

  a b c b a = *a b c* r [*a b*] = Σ [*a b* (*c*)] (I = 4)

- distribution:

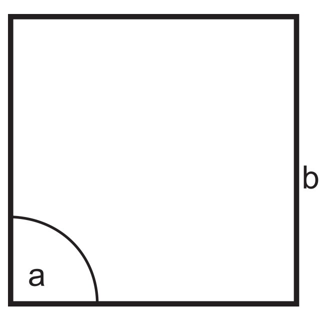
  a b a c = <(*a*)> <(*b*) (*c*)> (I = 3)

- continuation (⊂…⊃), which halts if another element or an already encoded element is encountered:

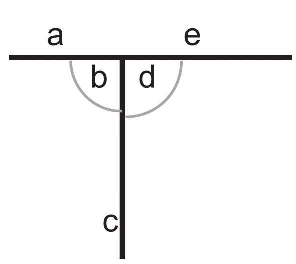
  a a a a a a a … *a* = ⊂*a*⊃ (I = 1)

The coding process returns the *end code*, a code whose structural information cannot be further reduced. The structural information (I) of a pattern is that of its end code.

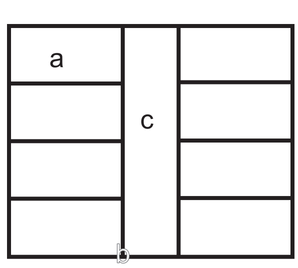
The structural information of a pattern is a powerful measure of its figural goodness. By equating a figure's goodness with the parametric complexity of the code required to generate it we can both derive the different descriptions an image affords and choose the one(s) that contain the least information.



252 Coding of square: abababab = ⊂a b⊃ (I = 2) (repeat a and b until reaching the starting point again, structural information is 2)



253 Coding of branching with bifurcation signs: a {b c} d e (after c return to end of a and proceed to following d)



254 Coding of a floor plan:
aaaabcbaaaa = 4 * [(a)] b c b 4 * [(a)]
= Σ [4 * [(a)] b (c)]
(I = 5)
(mirror 4 times a connected to c by b, structural information is 5)

25.14 ARCHITECTURAL PRIMITIVES

The main problem of theories of perceptual organisation, from Gestalt to structural information theory, is that they are developed and discussed within abstract domains of simple, mostly two-dimensional patterns and elementary primitives like dots and line segments. Such basic geometric forms should be treated with caution in evaluations of design aspects, as they refer to implementation mechanisms rather than to symbols of spatial representation. An extension to the three-dimensional forms of the built environment and to complex two-dimensional representations employed in architecture involves the problem of determining the primitives of these domains. Use of spaces and building elements as primitives demonstrates clearly the potential of structural information theory. In figure 254 coding of a floor plan on the basis of spaces yields a succinct and accurate description of spatial articulation.

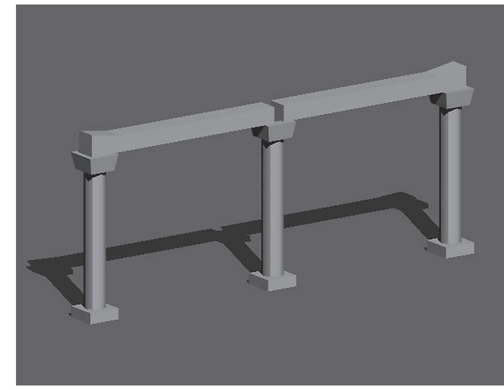
The end code is a symmetric tripartite configuration of two space groups flanking a central space.

Attempts to discover or define the primitives of architectural perception are impeded by confusion between the real built environment, its architectural representations and conventions underlying these representations. For this reason, we should make a sharp distinction between analysis and manipulation of representations and perception of and inter-action with the built

a Attneave, F. (1954) *Some informational aspects of visual perception;* Hochberg, J.E. and E. McAlister (1954) *A quantitative approach to figural 'goodness'*.

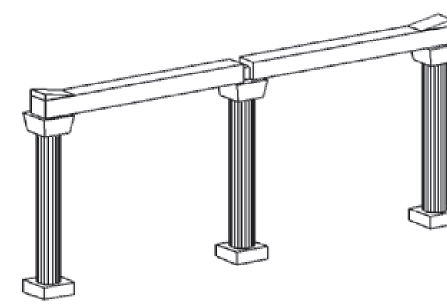
b Leeuwenberg, E.L.J. (1967) *Structural information of visual patterns. An efficient coding system in perception.;* – (1971) *A perceptual coding language for visual and auditory patterns*.

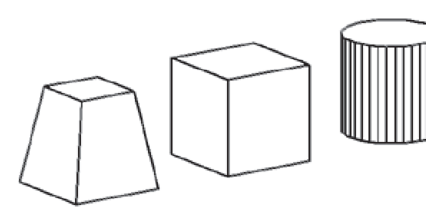
environment. The former rely firmly on architectural conventions and should be accordingly considered from the viewpoint of architectural knowledge. The adoption of building elements and spaces as the primitives of such representations offers pragmatic advantages that should not be neglected. On the other hand, a preferable starting point for the perception of built form and space are general computational models of perception and recognition, possibly enriched with constraints of architectural representation. These models provide a better understanding of perceptual and cognitive devices that also underlie architectural design and analysis. In addition to their direct applicability to the analysis and recognition of realistic architectural scenes they could ultimately also lead to improvements in existing architectural representations.


255 An architectural scene

Following low level processing, the first stage in recognition of a scene is invariably decomposition of its elements into simple parts, like the head, body, legs and tail of an animal. The manner of the decomposition into parts does not depend on completeness and familiarity. An unfamiliar, partly obscured animal or even a nonsensical shape are decomposed in a more or less the same way by all observers.[a] Detection of where parts begin and end is based on the *transversality principle* which states that whenever two shapes are combined their join is almost always marked by matched concavities.[b] Consequently segmentation of a form into parts usually occurs at regions of matched concavities, i.e. discontinuities at minima of negative curvature. The results of the segmentation are normally convex or singly concave forms.

At first sight one might expect that there is an unlimited number of part types. However, with his *recognition-by-components* theory Biedermann proposed that these forms constitute a small basic repertory of general applicability, characterised by invariance to viewpoint and high resistance to noise. He calls the forms geons and suggests that they are only 24 in number.[c] Geons can be represented by generalised cones, i.e. volumes swept out by a variable cross section moving along an axis.[d] A scene is described by structured explicit representations comprising geons, their attributes and relations derived from only five edge properties.


256 A decomposition of figure 254 into geons


257 The geons in figure 256

A combination of structural information theory and recognition-by-components provides a comprehensive basis for evaluation of figural goodness in architectural scenes. Coding geons according to structural information theory permits, moreover, grouping of a higher order than local binary relationships. This allows the development of multi-level representations which are less complex, better structured and ultimately more meaningful than atomistic relational representations.[e] In addition, the combination of the two theories makes it possible to establish general preference criteria for alternative descriptions on the basis of code compactness, which in turn relies on formal grouping principles.

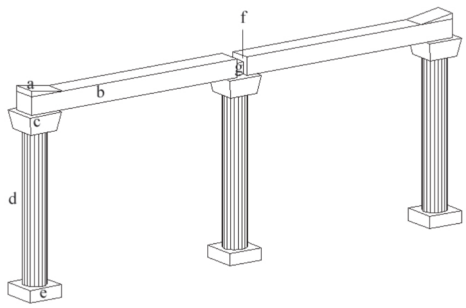
The application of this combination to architectural scenes concentrates in first instance on definition of primitives and relationships. In that respect, the only deviation from the original theories concerns the relationship ignored in coding. In structural information theory this is horizontal alignment. In architectural scenes this changes to vertical alignment, in compliance with the general architectural bias for the vertical as canonical orientation. We presume that this bias refers both to a general reference frame reflecting the significance of the vertical in the real world (e.g. gravity) and to a specifically architectural reference frame which relates to the interpretation of general orientation preferences in architecture.

On this basis, the scene of figure 255, 256 and 258 can be coded as follows:

a b {c d e} f g {c d e} f g b {c d e} a (*I* = 17)
<({c d e})><(a b) (f g) (f g b) (a)> (*I* = 11)

The use of distribution in the second version of the code makes the grouping of the elements comprising the column explicit, as well as the repetition of the group in the scene. This reflects the translational symmetry of the scene (colonnade). The bi-lateral symmetry that char-

a Biederman, I. (1987) *Recognition by components: a theory of human image understanding*.
b Hoffman, D.D. and W. Richards (1985) *Parts of recognition*.
c Biederman, I. (1987); – (1995) *Visual object recognition*.
d Binford, T.O. (1971) *Visual perception by computer;* Brooks, R.A. (1981) *Symbolic reasoning among 3-D models and 2-D images*.
e Koutamanis, A. (1996) *Elements and coordinating devices in architecture: An initial formulation;* – (1997) *Multilevel representation of architectural designs*.



258 Coding of figure 256

acterises the total scene is largely lost because of the integrity of the elements and groups in the scene. Bi-lateral symmetry would be discovered in the code, if line segments were used as primitives. This would have meant encoding the outline of the elements rather than the elements themselves and would permit splitting of a column into two symmetrical halves with respect to the vertical axis. However, the advantage of discovering and describing explicitly this accidental bi-lateral symmetry in a repetitive configuration like a colonnade does not counter-balance the corresponding multiplication of structural information in the primitive code and the initial detachment from the reality of the perceived integral components / geons.

25.15 THE EVALUATION OF ARCHITECTURAL FORMAL GOODNESS

Recognition-by-components and structural information theory provide the basis for:

- recognising and representing the solid elements of an architectural scene;
- grouping the recognised elements in multiple alternative configurations;
- evaluating alternative configurations with respect to coding efficiency; and
- establishing preference for one or two dominant configurations which represent the intuitively acceptable or plausible interpretations of the scene.

These operations link the representation of the built environment to perception and figural goodness. The necessary deviations from established conventional architectural representations reflect the choice of general cognitive and perceptual theories as starting point of the investigation. It is proposed that architectural representations and in particular:

a) the use of outlines to denote solid entities and spaces and
b) the deterministic decomposition into known components

should be reconsidered with respect to the recognition-by-components theory and related vision research.

The addition of a memory component to structural information theory would facilitate transition from the basic level of the primitive and end codes to known configurations denoting familiar objects.

The representation of spaces remains a problem deserving particular attention and further research. The use of outlines, as in figure 254, is the obvious starting point, as it conforms to the way we read floor plans and other conventional representations; and to existing computational representations like rectangular arrangements and shape grammars. This would allow exploration of structural information theory and recognition-by-components in the application areas of these representations. From a cognitive point of view, however, the outline of a space in two or three dimensions might not be a relevant or meaningful representation. It has been proposed that surfaces could form a representation level that not only links higher with lower vision,[a] but also agrees with the Gibsonian perception of space in terms of surfaces which fill space.[b]

This view differs entirely from the mainstream Euclidean co-ordinated organisation of perceived space whereby the two dimensional retinal image is enriched with depth information derived primarily from binocular disparity. Perception of space in terms of surfaces stresses the biological and ecological relevance of these surfaces as containers of different actions and as subjects of their planning. One example of this relevance is locomotion for the ground surface and related generally horizontal surfaces.

Another issue requiring further study concerns the essentially bottom-up character of both recognition-by-components and structural information theory. The addition of a memory component to the system, i.e. a database of geon configurations corresponding to known, familiar entities, would facilitate processing of information at basic levels and permit rapid

a Nakayama, K., Z. He et al. (1995) *Visual surface representation: a critical link between lower-level and higher-level vision*.
b Gibson, J.J. (1966) *The senses considered as perceptual systems*.

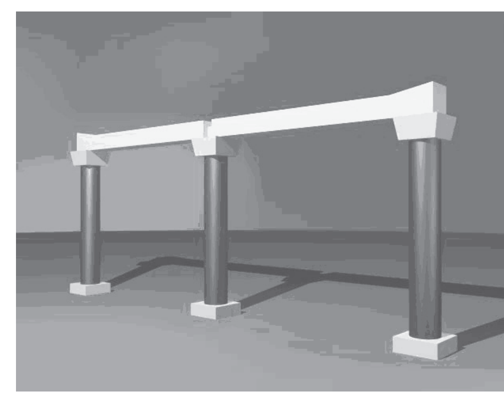
transition to higher levels of the representation. As these configurations would represent compact structures with respect to structural information, we assume that exposure to and recognition of similar or equivalent scenes leads to transformation of earlier experience into memories influencing our understanding and aesthetic evaluation.[a]

25.16 PROJECTING APPEARANCES

The difference between pictorial and other descriptions (e.g. textual) is commonly explained by resemblance. A picture represents a subject by the intended resemblance of its pictorial properties to the visual perception of its subject. Some interpretations of resemblance may lead to limited views, like assimilation of the experience of seeing a picture to the real life experience of seeing the picture's subject, which moreover are unrelated to the symbolic structure of a picture's content.[b] Nevertheless, resemblance remains an appropriate vehicle for investigating perceptual and cognitive issues in visual representation.

Architectural visualisation has been rather ambivalent with respect to the resemblance issue. On one hand, most basic design representations combine orthographic projection of canonical views with conventional symbolisation. On the other, axonometrics, isometrics, perspectives and especially the rendered ones consciously attempt to project or reconstruct a veridical visual experience. This ambivalence stresses correspondence of composition and projection in architecture to Euclidean and projective geometry. In both architecture and geometry a historical shift can be detected from measurement and accurate representation of a picture's subject to the picture itself.[c]

Proliferation of affordable computer tools for photo-realistic visualisation is placing even more emphasis on the architectural picture. The connectivity of these tools to the standard CAD documentation of design practice means that computer-rendered photo-realistic perspectives are often used instead of simpler images which would convey the same information, especially when the photo-realistic version includes too many assumptions concerning colour and material. It is ironic that some of the more interesting additions to computer visualisation include references to simpler rendering techniques from the past. For example, figure 260 has been rendered with the Illustrator 2 plug-in for 3D Studio MAX. In their attempt to reproduce the quality of colouring and backgrounds in comic books, such techniques are an alternative to the standard, almost photo-realistic renderings (figure 259). The abstraction of comic book imagery is arguably better suited to most stages of the design process, as well as to human recognition of built form.



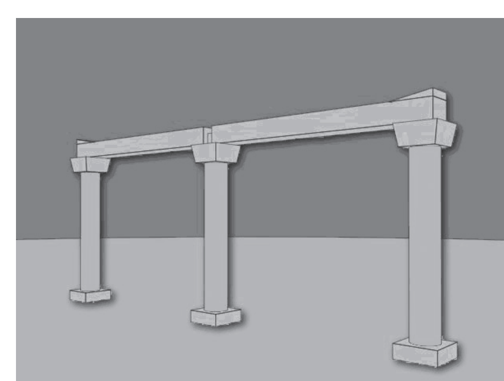
259 Image produced with the standard (scanline) 3D Studio MAX renderer

25.17 BEYOND INTUITION: SCIENTIFIC VISUALISATION

Design analysis was traditionally performed with normative rule-based systems geared to generative approaches. Numerous dissections of the design process have resulted in a multiplicity of models attempting to describe the steps a designer takes in the quest for a satisfactory solution. Most models also aspire to prescribe the optimal sequence of design actions. What they propagate is a form of *orthopraxy* (as opposed to the orthodoxy of formal systems such as Classicism and Modernism). Their underlying assumption is that if one follows the sequence of design stages prescribed in the model, one can arrive at a design *satisfying* the programmatic requirements.

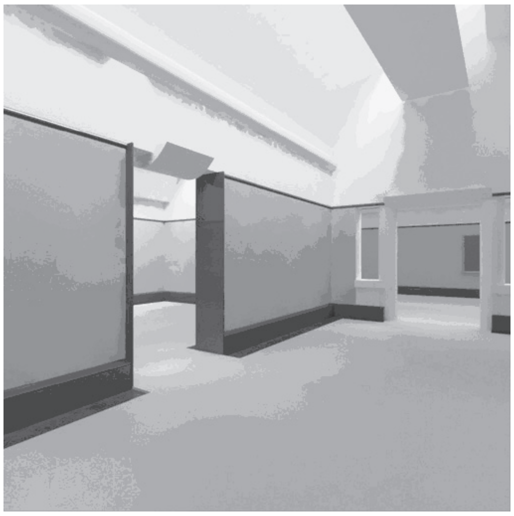
It is unfortunate that no such model to-date can match the intuitive performance and creativity of the human designer. Based on metaphors and similes, most models do little beyond explaining a few specific aspects of designing. Moreover, while they may improve the designer's awareness of actions and decisions, they seldom lead to the development of new, better tools for higher effectiveness and reliability in the face of today's complex design problems. Perhaps the main reason for the scarcity of such tools lies in a lack of interest in the analysis of design products.

Historically such an analysis was subservient to synthesis. Long before terms like functional and programmatic analysis were invented, buildings and design decisions were parsed

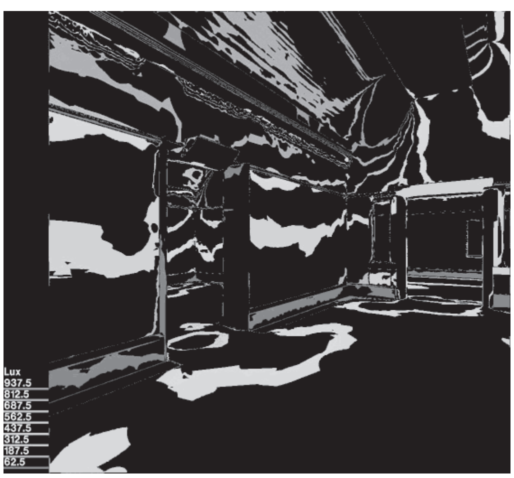


260 Image rendered with the Illustrator 2 plug-in for 3D Studio MAX

a Scha, R. and R. Bod (1993) *Computationele esthetica*.
b Goodman, N. (1976) *Languages of art: an approach to a theory of symbols;* Evans, G. and J. McDowell (1982) *The varieties of reference;* Lopes, D. (1996) *Understanding pictures*.
c Evans, R. (1995) *The projective cast, architecture and its three geometries*.



261 Photo-realistic light simulation (Radiance image by A.M.J. Post)



262 Light simulation: false colour intensity analysis in the space of figure 262 (by A.M.J. Post)

towards an identification of their causes and effects, and subsequently formalised into rules and stereotypical "good" solutions serving as the basis of most building regulations and design textbooks. Rules and stereotypes have a proscriptive function mostly. They attempt to offer design guidance by pointing out errors and inadequacies, i.e. what falls short of established norms.

Proscriptive approach also underlies computational studies focusing on the analysis of designs using the same or similar rules transformed into expert or knowledge-based systems. In these, a design is described piecemeal; which permits correlation of the relevant aspects or factors with the rules. The end product of the analysis is an acceptability test based on matching the constraints of the solution space. The added value of such systems lies in provision of feedback facilitating identification of possible failure causes.

Design analysis is moving towards a new paradigm, based rather on simulation than abstractions derived from legal or professional rules and norms. Recent developments in areas like scientific visualisation provide advanced computational tools for achieving rich detail and exactness, as well as feedback for design guidance. Close correlation of photo-realistic and analytical representations (figure 261 and 262) clarifies and demystifies the designer's insights and intuitions. Moreover, the combination of intuitive and quantitative evaluation offers a platform of effective and reliable communication with other engineers who contribute to the design of specific aspects, as well as comprehensible presentation of projected building behaviour and performance.

25.18 DYNAMIC VISUALISATION

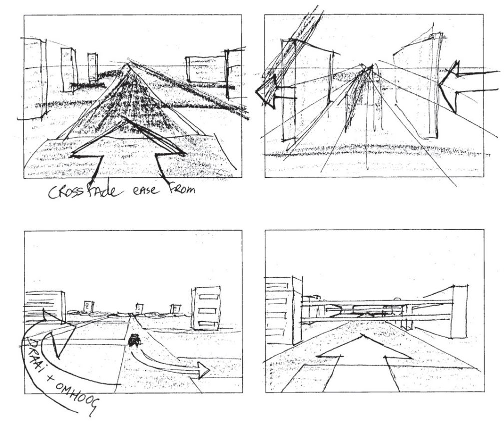
Dynamic visualisation is often presented as the pinnacle of architectural representation, the fullest form of visual realism. By including movement of one sort or another in a three dimensional representation the designer adds depth and time to the subject under controlled conditions, i.e. in the framework of a specific event or state. Since a dynamic description is a sequence of static, photo-realistic images, the results can be superior to other representations for visual inspection, analysis and communication.

As with photo-realism, a frequent argument for dynamic visualisation is the ease with which it can be produced out of three dimensional design representations. While this is true for simple, undemanding movements of the camera or in the scene, more complex subjects and presentation techniques require knowledge and skills beyond the scope of architecture. These are best found in filming. They range from camera positioning and movement to lighting and editing, mixing and visual effects. The technical aspects are largely integrated in the digital tools, but the architect must effectively step into the film director's chair so as to co-ordinate, guide and manage the process.

Directing a dynamic description is a rôle that in principle fits the architect as specifier and co-ordinator of design and construction of a project and who does not necessarily have physical involvement in actual building. However, the fulfilment of the rôle necessitates substantial transfer of filming knowledge complementing the technical possibilities of digital dynamic visualisation. Ironically most of this knowledge refers to techniques for reproducing on film environments and events without actually having the camera there and then. Even when shooting on location artificial lighting and sets are used to enhance resemblance to the scene envisaged in the script. In the studio everything is not only artificial, but also opportunistically fragmented so as to minimise cost without loss of effectiveness and efficiency. The techniques involved in making a coherent and believable sequence of images from short takes of such fragments and illusions forms the core of the knowledge that has to be integrated in architectural visualisation. Several techniques have already been adopted in architectural design. Matting, for example, is widely used nowadays in making composite images from rendered perspectives of new designs and photographs of their prospective sites.

The main problem with filming techniques is that they run contrary to the holistic undercurrent of architectural design and CAD. The use of partial models for different aspects and abstraction levels does not agree with the idea of a single, complete and integral three-dimensional representation for the whole design. On the other hand, a multi-level modular representation is capable of accommodating the practicalities of dynamic architectural visualisation without sacrificing coherence and consistency of the representation.

Most filming techniques are born out of necessity. However, they are not restricted to compensating for practical limitations. They also offer the means for constraining and controlling a process. One such device is the storyboard, a series of annotated drawings, essentially similar to a comic strip (figure 263). The drawings depict the découpage of the film, i.e. its structure in terms of takes, camera positions and movements. The application of storyboarding in architectural visualisation on the basis of a modular co-ordinated representation adds a vertical co-ordinating device responsible for specific aspects arranged in a sequential way.



263 Storyboard extract (by I.R. van 't Hof)

26 THE EMPIRICAL CYCLE

HUGO PRIEMUS

26.1 SELF-CONTAINED APPROACH

For decades, a generally accepted research methodology existed in behavioural and technical sciences; taught for decades by faculties at institutions of scientific education. In all these educational programs, the letters M&T form a fixed component of the foundation course; methods and techniques of research are a part of every student's standard equipment, and certainly of every graduate.

Presently, the Faculty of Architecture at the TU Delft is looking for its own building methodology, its own design methodology. This does not happen with knowledge from, and reference to, the classical methodology of research at other faculties, nor does it happen together with faculties in other countries where people study architecture and learn design, nor together with other TUD sub-faculties in which building (Civil Engineering and Geosciences) and/or design (Industrial Design Engineering) play a central rôle, and not even together with the associated Faculty of Architecture at the TU Eindhoven. Is this wise? No. Is it effective? No. Are there good reasons for this self-contained, eccentric approach? No.

26.2 SCIENTIFIC FORUM

Let me take the methodology of the behavioural sciences for a starting point, as I learned it 35 years ago from Prof. Dr. A.D. de Groot, one of my supervisors. De Groot is author of the standard work, '*Methodologie. Grondslagen van onderzoek en denken in de gedragswetenschappen*' and was trained as a psychologist.[a] Many followed him, like Baarda & De Goede and Swanborn, each in his own way.[b] Some decidedly more modern authors also concur with the approach presented by De Groot, who strongly emphasises the rôle of the scientific forum. The nomological network of every science (discipline) is constantly in motion, thanks to new empirical data, new insights, new questions, new answers. Discussions within the forum, i.e. the international community of leading researchers (peers) in the field, constantly determine which insights and theories are considered 'true', or labelled untenable. In this process, international associations and/or networks of researchers in the respective domain play a crucial rôle, like international conferences and workshops, along with international journals.

This is a problem for architectural research. The CIB (Conseil International du Bâtiment) is not orientated towards design, the UIA (Union Internationale des Architectes) is not orientated towards practicing of academic science, and there are not many international scientific activities in the field of design. While there are indeed respected international scientific journals, like *Environment & Planning Ed. B (Planning and design)* and *Built Environment*, no designer from Delft has published in them since Olim's day.

Research methodology is first and foremost a habitus: an active willingness to write down insights, justify them, make them verifiable to others, make oneself vulnerable, seek out critics, and allow others to take a look behind the scenes. This is the function of debate in the scientific forum, epitomised in presentations and discussions during international conferences, and in articles and commentaries in academic journals. The faculty is familiar with this phenomenon, for example in the form of the successful Ph.D. conference of architectural schools, organised in Delft several years ago (with Herman van Wegen and Theo van der Voordt as driving forces), or the conferences launched by Arie Graafland. But, on the whole, design research gets unsatisfactory marks. The architectural intervention seems to have been a very local renovation until now.

a Groot, A.D. de (1961) *Methodologie: grondslagen van onderzoek en denken in de gedragswetenschappen*. English translation: (1969) *Methodology: foundations of interference and research in the behavioural sciences*.

b See e.g. Swanborn, P.G. (1991) *Basisboek Sociaal Onderzoek;* Baarda, D.B. and M.P.M. de Goede (2001) *Basisboek methoden en technieken*.

26.3 EMPIRICAL CYCLE

The empirical cycle can be used as basic scheme for a logical-methodological consideration of research, thinking, and reasoning in empirical science. The cycle according to De Groot:

- *Phase 1: Observation*: collecting and grouping empirical factual material; forming hypotheses;
- *Phase 2: Induction*: formulating hypotheses;
- *Phase 3: Deduction*: deriving particular consequences from the hypotheses, in the form of verifiable predictions;
- *Phase 4: Testing*: of the hypothesis, or hypotheses, based on the possible results of predictions in new empirical material;
- *Phase 5: Evaluation*: of the test results with regard to the proposed hypothesis/hypotheses and/or theory/theories, and to possible new, related research.

Phase 1 can be classified almost completely under the psychological induction process. It is assumed that a researcher rarely collects material without some "viewpoint". He chooses, selects, or abstracts from certain data or aspects, groups and registers according to certain criteria. Throughout, at least certain implied hypotheses have inevitably already been decided upon.

In Phase 2 these hypotheses are specified. A hypothesis only becomes a hypothesis if it has been formulated so that particular consequences and specifically concrete, verifiable predictions can be derived from it (operationalisation), then to be tested. This takes place in Phase 3: from a general hypothesis a concrete prediction is derived, one which is strictly verifiable.

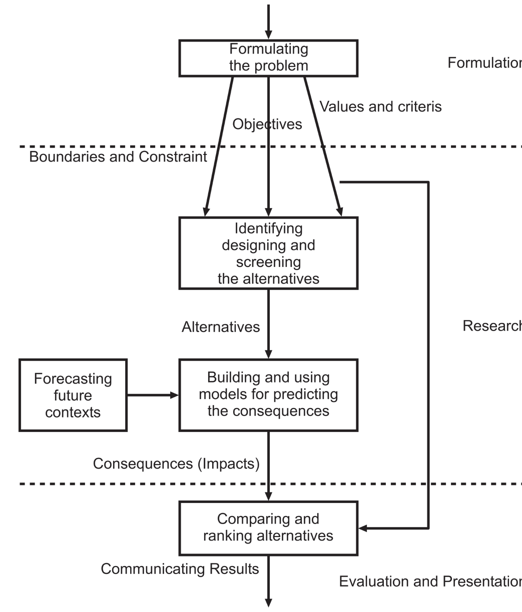
Testing hypotheses (Phase 4) has to do with a general connection presumed to exist in, or apply to, a collection of elements considered to be non-identical. On this basis, the researcher makes his prediction regarding cases not yet researched. The results of this test are evaluated in Phase 5. What is the value of the test results? Do they support the hypothesis? Must the hypothesis be dismissed? And what happens to the theory to which the hypothesis is connected? Can it be maintained? Does the theory have to be adjusted? Or completely dismissed?

For Phases 3, 4, and 5, i.e. deduction, testing, and evaluation, there are many statistical techniques and means of calculating probability. These three phases seem to be far removed from the culture of architectural design. Design more closely resembles the processes that take place in Phases 1 and 2: the observation and the "devising" of hypotheses. But, it would be strange to conclude that design could be adequately described using De Groot's empirical cycle. And this was never De Groot's presumption. What is important, is that a designer making a design for a building ensures that his design (which can be compared to a hypothesis) be verifiable. This can, for example, take on the form of a Post Occupancy Evaluation: an evaluation of the building's use. Before an architect makes a design, it is advisable that he learns from prior experience. He needs to become acquainted with previously executed evaluation research, and to be able to interpret the results of this research well. When he has completed his design, he must be able to declare that the design can stand up to the test of experiences and evaluations from comparable buildings that have already been built (precedents).

Even if the designer wants to give maximal space to his creativity, he can be supported by research methods like systems analysis.

26.4 SYSTEMS ANALYSIS

Systems analysis is a craft developed in the United States (for instance by researchers from the Rand Corporation), that was gradually introduced to Europe. This approach is popular with the sub-faculty of Technische Bestuurskunde (Systems Engineering, Policy Analysis and Management). The standard work is the *'Handbook of systems analysis. Overview of uses,* *procedures, applications, and practice'* edited by Hugh J. Miser and Edward S. Quade. What follows has been extracted from Chapter 4, *'The Methodology of Systems Analysis: An Introduction and Overview'* by W. Findeisen and E.S. Quade. These authors make use of the diagram alomgside (see figure 264).



264 System analysis: procedure (according to Findeisen & Quade).[a]

Distinctions are made between the following components:

- Formulating the problem;
- Identifying, designing, and screening possible (solution) alternatives;
- Pre-calculating future contexts of "states of the world";
- Constructing and using models for predicting results;
- Comparing and classifying the (solution) alternatives.

Systems analysis is specifically orientated towards the future. The procedure begins with the formulation of a problem. Without a problem, there is no need to think up solutions. The goals are specified, along with the values and criteria, as well as the borders and limits. One can only talk of a problem when a goal has been introduced, along with the obstacles related to reaching this goal. For a designer, this can be a programme of requirements for a building, as well as budgetary pre-conditions. The problem is that what is desired is a building that has not yet been built, one for which the design must first be made.

Step 2 involves identifying, designing, and screening alternative solutions. Here, designing as a solution-orientated strategy is the primary concern. What is interesting is that Findeisen & Quade fail to mention a single word about any specific solution, but instead discuss alternatives. In general, there are many roads to Rome, and only later will it become apparent which road best meets the requirements. In this second phase, there is ample space for fantasy and creativity. As long as an alternative can be verified according to the pre-determined requirements, this is the criterion that determines whether or not an alternative "complies" with this stage.

In Step 3, we take a look into the future and investigate how the world will look in 10 or 20 years, or even further along. What demographic and economic changes are to be expected? In the Netherlands, we can fall back upon the body of work of the *Centraal Bureau voor de Statistiek* (Statistics Netherlands) (population prognoses), the *Centraal Planbureau* (Netherlands Bureau for Economic Policy Analysis) (economic prognoses), and the *Rijksinstituut voor Volksgezondheid en Milieu* (National Institute of Public Health and the Environment) (environmental prognoses). We do not need to choose between these three calculations. Sometimes it is more useful to construct a sensitivity analysis: how adequate is a certain (solution) alternative under various presumptions about the future?

The results, per alternative, are pre-calculated in Step 4, using models that are constructed and then applied. This is an art that hardly anyone within the Faculty of Architecture possesses, and thus professional help would need to be called in here. During Phase 4, we investigate how each alternative would actually turn out concretely, under various presumptions. A given solution might, for example, achieve good results under economically favourable conditions, but may fall short when interest rates increase or if economic growth stagnates.

With the help of the criteria specified in Step 1, the alternatives are compared and classified during Step 5. This can take place based on various presumptions. Ultimately a choice must be made. This means dealing with uncertainty, since no one knows precisely what the future will bring. The policy of the decision-makers plays a major rôle here. Are they trying to reduce risks? Or aiming for extraordinary results? What priorities are they setting with regard to how the building will be used?

a Findeisen, W. and E.S. Quade (1985) *The methology of systems analysis: an introduction and overview*, p.123.

Systems analysis is an extremely suitable tool for helping designers. It forces the designer to consider criteria, values, and goals, that have been specified in advance necessarily. It introduces the desirability of thinking in alternatives, of scanning the future. Alternatives are evaluated *ex ante*. The balancing of various alternatives becomes discussable, and in part even quantifiable. Discussion between various designers, each of whom believes in his or her own design principles, will be removed from the realm of nagging and mutual condemnation. This allows both long-term and short-term discussions of uncertainties, and supports policy considerations of the final decision-maker. In short: an ideal tool for the architectural engineer.

26.5 OPENING THE SHUTTERS

If the Faculty of Architecture takes the search for a methodological foundation seriously, it should continue to build on long-standing, carefully developed, generally applied research methods and techniques. This is the language spoken in scientific education and research, the language of the NWO *(Netherlands Organisation for Scientific Research)* and the STW (Technology Foundation), as well as the one of the international scientific forum. This basic methodology must be offered in the foundation course, so that architectural education can be considered scientific education.

These methods should be employed in architectural research, and the ill-will and bungling which currently exist in the faculty with regard to empirical research (exceptions excluded) must be cast aside. Every designer must be able to evaluate critically the results of empirical research. Toward this end he must be thoroughly familiar with the methods and techniques used.

A complication in the discipline of architecture is heterogeneity. Each building, every location is unique. The formation of theories implies that one is striving for generalisation. In a domain where heterogeneity holds the trump card, there is a tendency to emphasise the uniqueness of the object considered. The tension between uniqueness and generalisation is interesting, but certainly not fatal. The same tension is familiar in psychology: each person is completely unique; yet it remains possible (and wise) to make generally applicable statements about human behaviour in certain situations and circumstances.

If the faculty wants to concentrate more on design in addition to the induction phase, and wants to offer a better methodological substantiation for design, its practitioners should be required to steep themselves in systems analysis, a craft pre-eminently useful to designers. Systems analysis reasons in a problem-orientated way, and stimulates the researcher or designer to think of alternative solutions in evaluating and balancing these alternatives. One must be explicit about the criteria by which these alternatives will be tested. This introduces goals and values to the order of the day. These interesting currents of discovery blowing into the world of methods and techniques need not exist exclusively in the corridors of the Faculty of Architecture in Delft, but rather should encourage communication between researchers., teachers, and students from other faculties and other universities, both domestically and abroad. These currents are an invitation to participate in international conferences, and in the circuits of refereed scientific journals, authors, as well as reviewers. Currently there is not much evidence of such an open, external orientation. The shutters of the Architectural Building seemed to be closed in regard to issues of research methods and techniques. Would it not be a good idea to open these shutters wide for once?

27 FORECASTING AND PROBLEM SPOTTING

TAEKE DE JONG
HUGO PRIEMUS

Scientific forecasting and problem spotting calls for models of a reality within which one tries to make predictions. In this Chapter some crucial concepts will be treated that are involved during modelling. They are treated in large-scale examples, since examples like these feature fewer boundary conditions complicating forecasting than examples on a small scale. Forecasting the size of the world's population is after all, easier than the one of an individual household. As long as one believes in the human freedom of choice, forecasting on the level of the individual is even impossible. Only with large numbers may a meaningful relation be established, up to now, of one event A with the possible results W (chance = A/W, see page 219). That is the reason why 'chance' is a central model in a science aiming at generalising statements for the future. These are needed to come to grips with the future and its problems.

Forecasting study cannot do without this concept of chance. At increasing numbers, the choices of individuals group themselves around an increasing stable, 'reliable', mean against which the deviation of individual cases may be measured. From a range reliable numbers or averages as a function of time, a trend can be read, that may be generalised eventually to a mathematical formula (curve fitting). If this trend is undesirable, we have spotted a problem. A sequence of numbers X may be related to any other sequence of numbers Y -not only to a time axis- if in the swarm of graphical dots a line can be drawn, the line of regression.

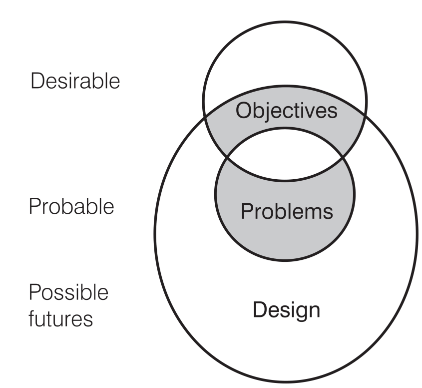
Such a line of regression can be arrived at by many different (non-declarative) mathematical formulae. In forecasting study relations of this type are important in order to arrive at statements like 'If x then y'. That does not say yet that x causes y. However, the effort to explain a statistical coherence remains important.

Departing from such a causal explanation one can sometimes arrive at a mathematical formula. Only who can explain, can predict with authority?[a]

27.1 PROBLEM SPOTTING

The set of all problems is a set of probable, but not desirable futures. An applied empirical study starts with formulating such an undesirable probability (problem statement or formulation). A problem is probable and so can be forecast (signalled). Problem signalling already pre-supposes two predictions: the prediction of wishes and of probabilities. So the problem statement is not the real beginning, but part of an empirical cycle[b], in which problem statement, forecast, new problem statement produce one another

The aim, or objective (several aims), of the study points from that problem to the more desirable future. The future aimed at, from which the aim of the study has been derived, is per definition desirable and not probable (one does not aim at realising tomorrow's sunrise) but possible; as far as we can see. Since an aim is not probable, it can not be forecast. So it must be chosen, posed, often even designed. An aim is an abstract pre-design of an alternative deemed possible for the present situation and its probable development (zero variant). These abstract concepts refer for everyone to comparable situations that usually remain implicit in order 'not to exchange aim and means', regardless of the level of abstractness, such as increased safety or accessibility. However, what is termed 'aim' and 'means' depends on the level of abstraction. The acquisition of a government subsidy can be an aim for a community, but for the country it is a means for a higher aim.



265 Futures and their modalities

a Even if a problem exists in life-size and even if we are for one hundred percent convinced that it is a problem, it is nevertheless more appropriate from a scholarly viewpoint to talk about 'probability'; for we are dealing in principle with the future. Even the etymology of the word 'problem' (Greek *'proballein'*, 'to throw ahead') pre-supposes this. When the threatening event, experienced as a problem, has taken place it has passed its problem status. Next there will probably be many different problems, but they require new problem formulations.

b Groot, A.D. de (1961) *Methodologie: grondslagen van onderzoek en denken in de gedragswetenschappen*. English translation: (1969) *Methodology: foundations of interference and research in the behavioural sciences*.

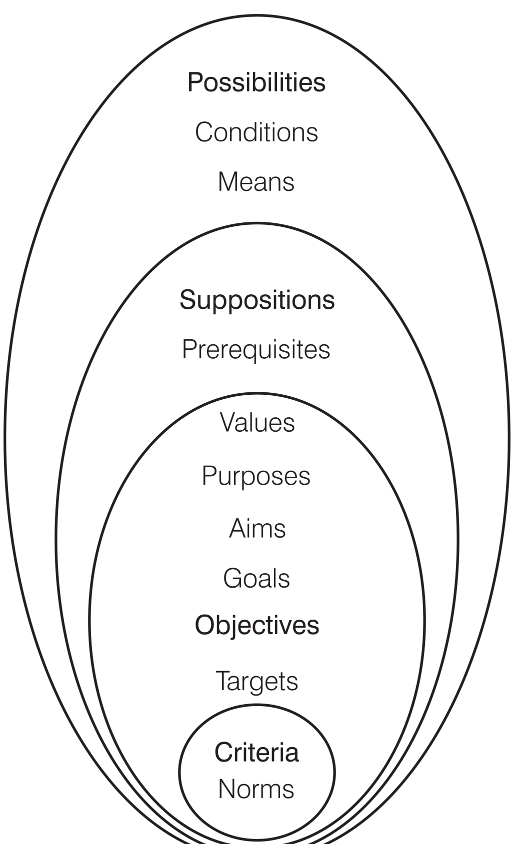
27.2 SYSTEMS' CONSIDERATION

From the problem formulation, further demarcations may be derived allowing separation of a dynamically variable and researchable system from a context that is largely independent (systems analysis).[a] This also results in the constraints within which the system must function. In addition, the problem formulation generates clues how system and context should be reduced to a composite of researchable, valid and reliable (see page 92) variables (operationalisation) with the mutual relations (modelling in functions). The functions are going to be mutually related, so that the output of one function becomes the input of one or more subsequent functions (systems modelling).

An inter-action with a causality in two directions often occurs. These relations within and between functions pre-suppose previous empirical study (empirical cycle) that demonstrated such a relation or that seems probable by reflection. Within the demarcation, the constraints and from the objective, the alternatives are designed (means, pre-supposed solutions, encroachments, with the rôle of hypotheses[b] that can be checked). These alternatives must be weighed (assessment). Against which values or criteria? Between vague values and precise criteria, a wide range of gradation exists.

27.3 CRITERIA OF ASSESSMENT

It is impossible to imagine criteria and norms without objectives underlying them and objectives without the basis of individual or social values. On the other hand, it is possible to imagine values that have not been worked out into objectives as yet and objectives not yet associated with norms. These concepts operationalise subsequently increasingly concretely a desirable future, so far as is possible, so that it may be tested. Along these lines public safety is an important social value that may be made workable (operational) in more specific objectives, like better lighted public spaces, worked out into norms for lighting that can be controlled. The English language is rich in terms for objectives in the various stages between what is strategic and what is operational. In the diagram alongside they have been put in a conditional sequence.



266 From possibility to norm

However, one is well advised to remember that values have been founded on a body of implicit conditions, pre-suppositions and imaginations: culture. As far as they are related to truth, these are the conditions from classical logic (if…then, if…if, then and only if, see page 189). They yield a consistency check with regard to the logic of the discourse, not yet with regard to causal correctness of the premises in the wider area of probabilities. An example: "If public illumination ameliorates security, then illumination will make this insecure, not illuminated place more secure." However, the premise that illumination ameliorates security is always a context-sensitive causal pre-supposition. Moreover, in each and every objective also technical conditions are hidden, allowing checking. They are often implicit (lamps exist, the electricity needed is available and affordable, the neighbours do not experience illumination as cumbersome, implementation is feasible in the municipal council). They delimit what is possible and feasible from what is impossible and are creating room for what is improbable (conditions).[c]

All these conditions, values and their development into objectives and criteria, should be part of the problem formulation. But, then the problem formulation would encompass the study as a whole; it is more advisable to make a rough sketch first to be added to and updated during the study, in periodical consultation with the initiator. The central objective of this is a reduction in which underlying values, conditions, suppositions, means, conditions and possibilities of the problem investigation have been omitted.

However, the investigator is obliged to identify as many of the prevailing values as possible and to make them explicit in order to operationalise them in criteria for the assessment of alternatives. In the classical scheme of Findeisen and Quade (see page 250), this part of the systems' analytical study is rendered with: 'Identifying, designing and screening the alternatives'.

154 Findeisen, W. and E.S. Quade (1985) *The methology of systems analysis: an introduction and overview*.
155 An architectural design may be seen as a hypothesis; in that case it is an object of an evaluating study before or after execution (ex ante or ex post).
156 This is latin for mee-giften.

27.4 ESTABLISHING ALTERNATIVES

One line of text might make a hypothesis, but not a full-fledged design. The systems' analysis requires different hypotheses (alternatives) to test the completeness of the system. Alternatives may emerge for which the system has not an answer yet.

The classical model of the empirical cycle lacks an instruction for establishing hypotheses. The establishing of hypotheses is 'free'. Scientifically spoken, anything can be argued or drawn up, until the hypothesis is refuted[a] or replaced by a better alternative.

But, if the hypothesis is an architectural design, establishing the hypothesis is an important part of the study by design, highlighted in other Chapters of this book. In the process of building generating an alternative for the present situation (zero-variant) may entail 95% of the studying effort. Often just one alternative exists, to be varied upon at best during the process. There is then less time available for problem analysis. In architectural design many more (detailed) decisions are taken than for which the objective can be directive; often even a tacitly presupposed type of building or neighbourhood.

The decisions as to shape and structure outside of the objective - usually regarded as of secondary importance - require insight into a combinatorial explosion of possibilities (see page 208). In order to reduce them, the designer uses not only the problem formulation and the objective (the site and the programme of requirements), but also existing examples (precedents, design study) and types (typological study). The designer is guided by a global concept that allows more aims than formulated in words by the initiator. A sustainable building must be able to serve in a different context after selling it subsequent owners ('robustness' of the design). If the designer varies the context taken to be obvious in the problem analysis as well (study by design[b]), the design may lead to a review of the perception of the problem; and, by the same token, of the systems analysis. This feed-back arrow is missing in the schema of Findeisen *et al.* on page 250.

27.5 EVOKING SYSTEM BEHAVIOUR

Calculating the consequences of an action, alternative, design or hypothesis (evaluating study ex ante, see page 159) requires prediction. Each prediction pre-supposes a context, within which the proposed action functions. Change in context (perspective) changes the consequences of the action.

The sensitivity of the prediction for these changes cannot be avoided in applied study by pre-supposing 'other things being equal' (*ceteris paribus*). One has to highlight the consequences of several actions in several perspectives in order to achieve a more general insight into 'system behaviour' under different circumstances and actions. The construction of these perspectives (future contexts) with unexpected aspects and decision moments (scenarios) will be dealt with in a following paragraph. Scenarios play a rôle within the predictions in the system itself as providers of external exogenous variables (parameters) in the equations on which the systems' model has been built. By changing these parameters in the equations per scenario, additional consequences may emerge.

27.6 GENERALISATIONS

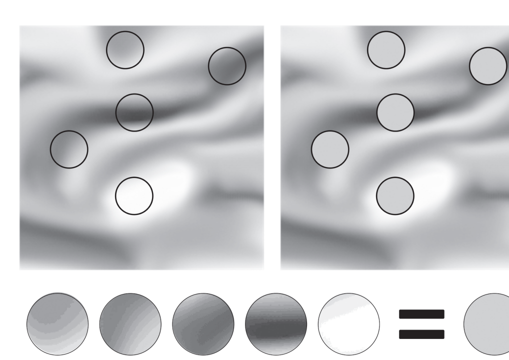
The possibility of forecasting and prediction depends on external generalisations from previous experiences (empiry). Not only external ones apply, also internal. Particularly the use of the average as the most important form of statistical generalisation and its extrapolation in time, meets with opposition from scientific disciplines supposed to deal with a large variety in objects and contexts: especially ecology, organisational science[c] and designing. In ecology this reduction to an average by the analysis of ecosystems is known as the 'mean-field assumption' (see following diagram).This reduction can smooth local variations in such a way, that the character of the object and its context evaporate. At the same time the survey of the specific possibilities of the site ceases to exist. The statistical measure for deviation cannot replace this variation.

a Popper, K.R. (1963) *Conjectures and refutations: the growth of scientific knowledge*. Partly translated in Dutch: (1978) *De groei van kennis*.

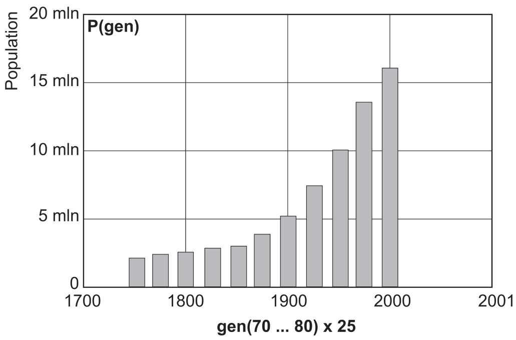
b In the scheme on page 14 this distinction is made with typological study (testing the same design in various contexts) and design study (testing various design variants in the same context).

c Riemsdijk, M.J. van (1999) *Dilemma's in de bedrijfskundige wetenschap*.

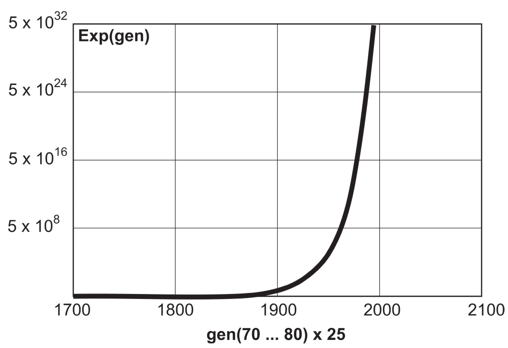
d Derived from Law, R., U. Dieckmann et al. (2000) *Introduction*. p. 4.



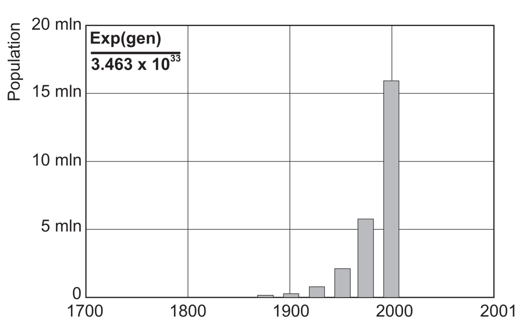
267 Reduction to the average[d]



268 Actual growth of the population in the Netherlands



269 f(Gen) = exp(Gen)



270 The same with parameter

In evolutionary ecology[b] especially a few cases of exception, outside of the 95% area, determine the future course of the ecological process, since these rarities may lead in particular to the emergence of new species and systems. This suggests mathematical chaos functions, featuring, by means of iteration an unpredictable course; they are very sensitive to the minutest variations at first input. Rounding-off strategies in different computer brands may even lead to the circumstance that one and the same formula yields a different outcome on two distinct machines.

All this does not derive from the fact that forecasts, or less explicit, expectations, are the base of acting. By way of an example, we select the growth function of a population.

27.7 CURVE FITTING

The population of the Netherlands has grown during the last three centuries as follows.

The bars in this graph comprise class intervals of 25 years (interpreted here as generations) with the population figures levelled out over the period. First of all, the progress recalls an exponential function f(x) = exp(x); after the industrial revolution reaching the country around 1800.

In figure 269 a part of this function from the beginning of the Christian era has been drawn for the last 10 generations (1750 – 2000 AD). For x Gen (generations) has been substituted.

This function leads from 0 persons in year 0, to an unlikely high population figure of f (80)= 5.541 x 10^{34} in the year 2000 (generation 80). If we divide this number by the current population size of 16 million Dutch (wo)men f (80)/ 16 = 3.463 x 10^{33}, the first parameter materialises in the model that as denominator reduces the last generations (80) to 16 million (figure 230). This does not reflect reality well. The mathematical representation of population growth is differing too much from actual data.

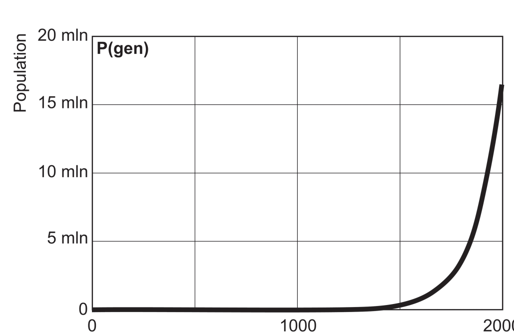
27.8 CAUSAL PRE-SUPPOSITIONS

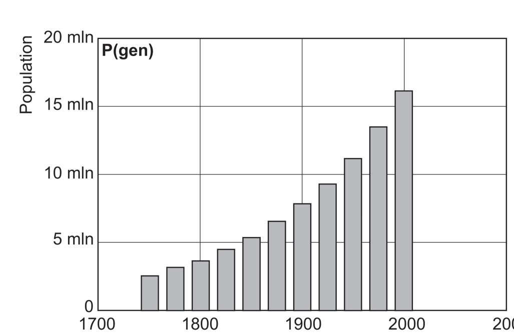
Each generation comprises the number of parents, times their average number of children, plus the parents themselves. In each following generation children become parents, and parents grandparents. They die; and the grandparents should be subtracted from the following generation. This can be rendered in an iterating formula.[c]

$$Pop_{Gen+1} := Children \times Pop_{Gen} + ParentsPop_{Gen} - GrandparentsPop_{Gen-1}$$

For this graph we had to fix the first generation to two people in the year 0 and the number of children to a parental couple through all these centuries to 1.034 on average.

This formula cannot be extrapolated readily to earlier years. However, the slice since 1750 starts to resemble reality. A function allowing more extrapolation would require for the aim of this discourse too many additional parameters from earlier contexts (for instance: a parameter working out negatively for the emergence of epidemics of plague at certain population densities and a medieval state-of-the-art of medical science).





271 The exponential growth of a population

272 Slice of figure 271

b Pianka, E.R. (1994) *Evolutionary ecology*.

c Such a formula takes its own output as an input for a next round. It contains instead of the = sign a sign := (gets) and before the getting sign an index that is one step larger than after the getting sign.

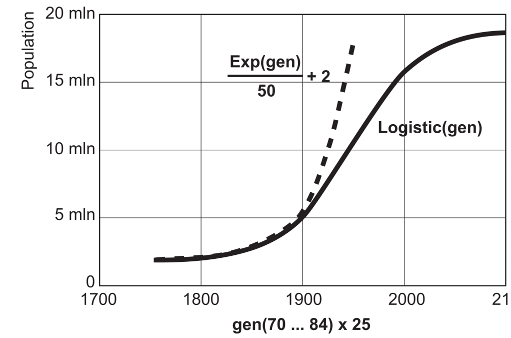
27.9 CONSTRAINTS

If a population approximates its limits, growth lessens. For such a phenomenon mathematics offers the logistical curve.

In a non-iterative form, the formula for exponential growth has an exponent, compare page 229; the logistical curve is an extension with two parameters, the first of which initiates the restriction.

$Exponential_{Gen} = Pop_0 \times Children_{Gen}$
$Logistical_{Gen} = Pop_0 \times Children_{Gen} \times restriction / (Children_{Gen} + Children^a)$

The second parameter, exponent ‘a’ in the denominator of the logistical function, regulates the speed of growth.



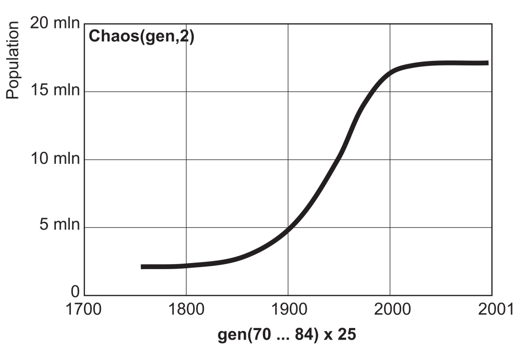
273 The logistical curve

27.10 SENSITIVITY

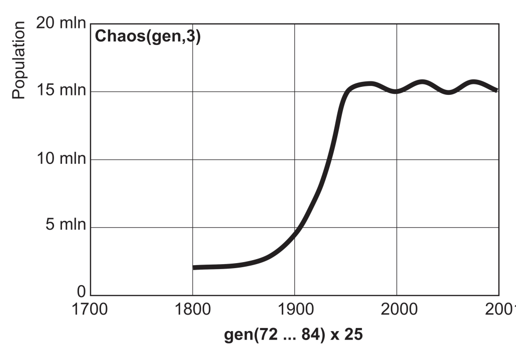
The iterating functions leading to fractal geometry and chaos theory have proven that systems may vary vastly by minimal differences in input and parameters (sensitivity).[a] The following function (chaos function) resembles at the value a = 2 of parameter a the logistical curve.

For an initial value $X_0 = 0.0016$ this function is congruent with the growth of the Dutch population. In order to match it, one must multiply by 30 and to get it to the right height one should add 2. Then, it ‘forecasts’ a stability following the year 2000.

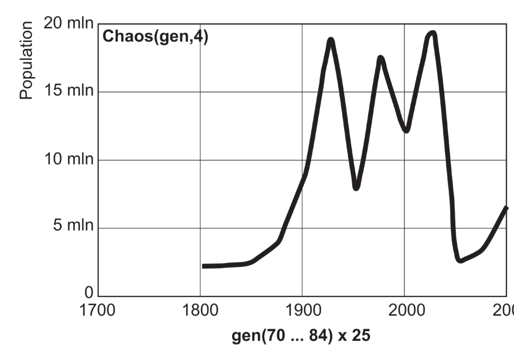
However, if one chooses for parameter a = 3, the function starts to flutter. At a = 4 the function becomes chaotic. And at a = 4.1, an entirely different graph results.



274 a = 274



275 a = 3



276 a = 4

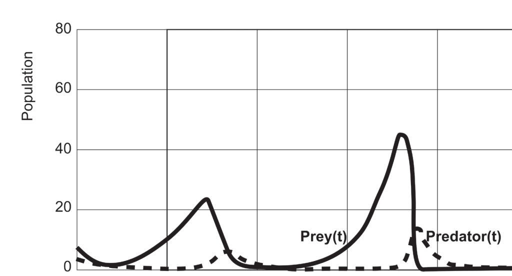
$x_{Gen-1} = ax_{Gen} - ax_{Gen}^2 \quad Chaos_{Gen} = 30x_{Gen} + 2$

27.11 PARAMETERS

A quiet constraint like lack of space results in a quiet smoothing, while wars and epidemics result in wild fluctuations. Rather more causally, fluctuations like that are simulated by the Lotka-Volterra function for preys (like people) and their predators (for instance the plague bacteria or other people in their guise of enemy).

In the case of this function time is input (here at a scale implying nothing particularly from 1 to 150), with the densities of prey and predator for output. They are inter-changing as ‘causation’ of rising and declining. For the densities initial amounts should be stated; as well as the value of the four parameters.

These regulate the waxing of prey if there are no predators, the percentage of animals of prey caught, the death and emigration of predators and increase by consumption of prey. If the value of parameters of this type cannot be ascertained by empirical research, it is possible to arrive at a state that proves to match time series of the past (calibration). In both cases it imports to check the sensitivity of the model to parametrical selection and to report on it. Varying parameters as to their effect on the graph is no punishment anymore, considering current computer capability, and sometimes provides outright sensations. But the larger



277 Lotka-Volterra function[b]

a Broer, H.W. and F. Verhulst (1992) *Dynamische systemen en chaos, een revolutie vanuit de wiskunde;* Broer, H.W., J. van de Craats et al. (1995) *Het einde van de voorspelbaarheid?*

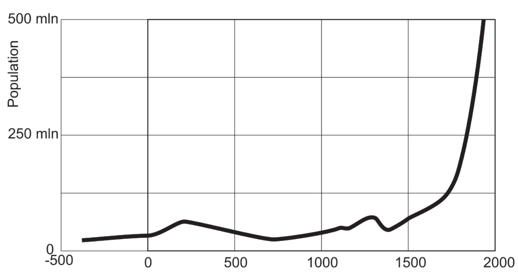
b Mack, Dr. T.P., Associate Professor Department of Entomology, modelled predator-prey dynamics in Mathcad (Alabama) Auburn University.

the number of parameters one may use as 'buttons on the piece of equipment', the more difficult it becomes to determine the influence of each button separately on the result. The influence of one parameter can change drastically, if one turns other dials. If one has 6 buttons at one's disposal, each with at least 10 positions, like in the Lotka-Volterra function, the minimal number of combinations, $6^{10,}$ is already not to be surveyed. Which of the resulting 6^{10} functions should one choose for the model desired?

With the explosion in terms of number of combinations (see page 208) of the tuning of parameters the fringes of realistic modelling are attained often in sciences markedly sensitive to context; as there are architecture, ecology and organisational science.

27.12 EXTERNAL FACTORS

In the case of the Lotka-Volterra function the predator, initially regarded as external factor, has been assimilated within the model (internalisation). While the predator was directly dependent on the availability of prey, they formed together a 'system' that might be modelled with inter-changing causality. Obviously, internalisation cannot digest everything. Quite a few external influences just have to be stated, or to be varied for some scenarios.



278 Population development in Europe

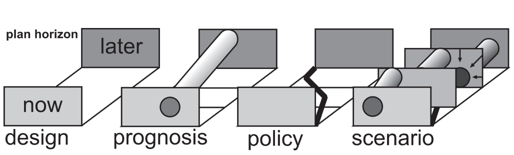
The presumable course of Europe's population[a] shows the consequences of a lot of unidentified external factors, although it is known, that the plague, The Black Death, raged at the end of the Middle Ages.

It seems as if an internal drive to exponential growth is always stinted, until all brakes vanish in modern times. Which factors have been responsible for that: spatial, ecological, technical, economical, cultural, managerial? Pre-suppositions concerning size and nature of immigration and emigration are crucially important for real-life population prognoses.

Determining the parameters for fluctuations like these, and establishing the functions by which they operate, requires more data and more detailed analyses. They may result in data files of parameters that may be consulted through the systems' model during calculation with 'if.. then..' statements. They require knowledge of the influence of spatial, ecological, technical, economical and managerial developments in time series.[b]

Among all influences in the case of population forecasts, for instance, the crucial factor of the average number of children per household (fertility) determines the factor of reproduction. The shorter the time-span of validity of the forecasting, the longer the time series on which the forecast is based (founding period); and the more substantial the explanation enabled by the independent variables, the more reliable the forecast. The Statistics Netherlands (CBS) publishes a population prognosis on an annual basis (in *Monthly Statistics for the Population*).

27.13 SCENARIOS



279 Possible, probable, desirable, image of future and scenario

Although scenarios are made for many reasons (insight, strategy, management inside and interaction between organisations) they are considered here as purveyors of exogenous variables in order to serve systematically forecasting and problem spotting study.

A scenario is not a calculated (prognosis) or an assumed probable future (perspective). A scenario is a time series projected into the future within which managerial, cultural, economical, technical and spatial influences (stemming from actors in these different sectors) are varied consistently and plausibly. It is the description of a possible future, partly designed, that corresponds partly to prognoses and perspectives and that may contain partly policy decisions.

In figure 279, rendered in a sequence lacking intention, it is represented that the design tries to project one whole image on the planning horizon, while the prognosis delimits there an area that might be put to work in a scholarly way. In this area in which the subsequent

a Slicher van Bath, B.H. (1976) *De agrarische geschiedenis van West-Europa 500-1850*. English translation: (1966) *The agrarian history of Western Europe, A.D. 500-1850*.
b For interesting time series, see 'x years of time series' of Statistics Netherlands (CBS), published every five years. The 'x' in this title was successively '85', '90', '95' and '100'. See e.g. Centraal Bureau voor de Statistiek (1989) *1899 -1989 negentig jaren statistiek in tijdreeksen*.

consequences are depicted, there just might be another area than where preceding causes are dwelling. The prognosis departing from a plan, not from the current situation (evaluation ex ante, effect analysis, see page 149), is taking its bearings on uncertain pre-suppositions regarding context (boundary conditions; the tiny arrows in the last drawing).

Policy punctuates a path with limiting values when a part of the policy goal should have been reached (target figure). In principle, a scenario compromises all components although one component may take the lead. If the starting point is the design with a final stage and from there the reasoning is backwards (back-casting), one talk about a prospective scenario, in other cases of a projective scenario. If prognosis stands central, the parlance is 'trend-scenario'; and if, on the contrary, unexpected events play a more important rôle, 'surprise-scenario'. If policy objectives pre-dominate, normative- scenario is the word. In the policy time-path decision moments may materialise that can give the scenario a twist. In order to survey consequences of such decisions, policy scenarios or exploring scenarios are made, with alternative scenarios branching out tree-wise.

27.14 SECTOR SCENARIOS

Scenarios exist emphasising particularly political, cultural, economical, technical, ecological (demographical) or spatial sectors for a driving force. Their yardsticks, research methods and variables differ greatly, which makes them difficult to combine and integrate. Sector scenarios like that are made, for instance, by the Netherlands Bureau for Economic Policy Analysis (CPB, economical scenarios), the Social and Cultural Planning Office the Netherlands (SCP, cultural scenarios), the National Institute for Public Health and the Environment (RIVM, ecological and nature scenarios) and the Consultancy Service for Traffic and Transport (AVV, mobility scenarios).

Often, they are cross-wise combined to more integral scenarios, contrasting with one another (extreme scenarios or contrast scenarios). This contrast is called for to make effective sensitivity analyses in systematic study of the future.

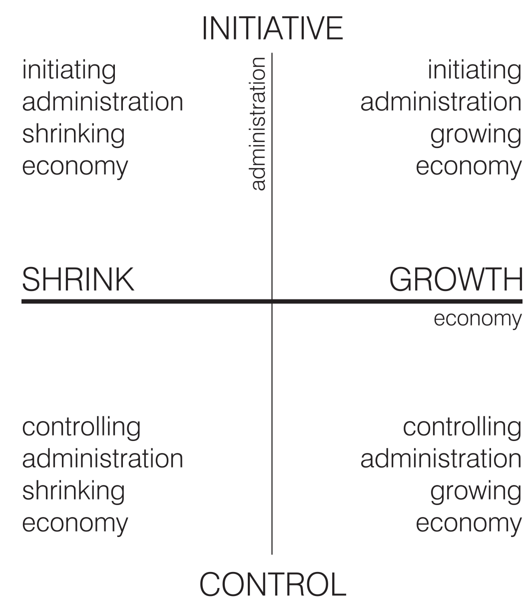
With the 6 sectors mentioned previously, 15 quartets of this type can be produced.[a] One may also contrast, for instance, policy (steering <> following) with culture (tradition orientated <> experiment orientated), technique (combining <> specialising), ecology (homogeneous <> heterogeneous) or space (deconcentration <> concentration).

CPB scenarios vary with the relative strength of European economy in the competition with American or South-East Asiatic clusters, or with the effectiveness of co-operation within Europe itself: Global Competition, Divided Europe and European Co-ordination.

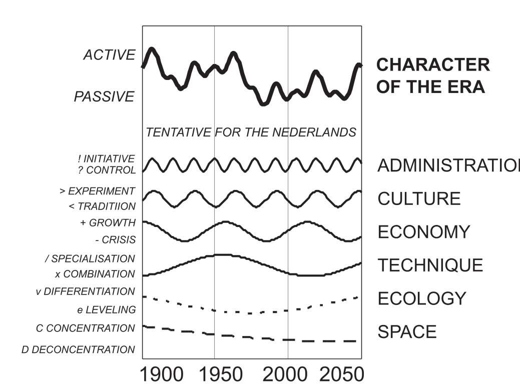
However, these sectors have different time horizons and dynamics; this hinders contrasting them mutually. The figure alongside illustrates this as a series of trend-scenarios fluctuating between the extremes.

In this figure the face of the time is an addition of rather dubious sector trends, depending on the notion that each action calls for an anti-thetical (Hegelian) reaction; so that, between two extremes, an oscillating movement emerges; here depicted as a clean sinus curve. Now imagine that these sinuses have been calibrated on the century now passed; while it has been shown that policy fluctuates by seven years between guiding and following, and culture is shifting within 14 years between traditional and experimental orientation; and so forth

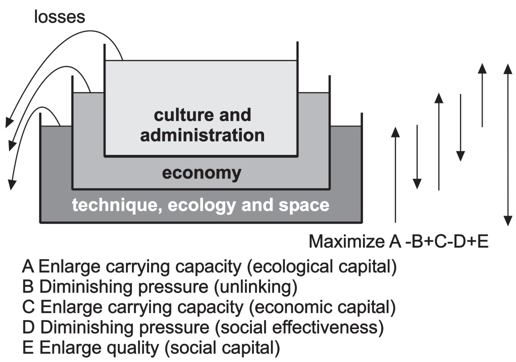
What name should be given to the extremes of their super-position? 'Active' and 'passive' are the, scarcely meaningful, terms chosen here. Balancing developments in different sectors is usually left to politics. Nevertheless, it establishes a scientific challenge that gets attention especially in ecological policy: how does one weigh environmental interest against economical and spatial priorities?



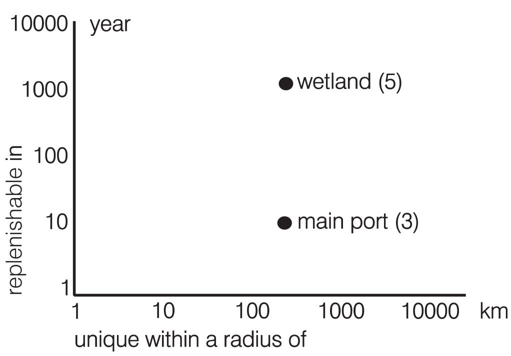
280 Cross-wise integration of sector scenarios



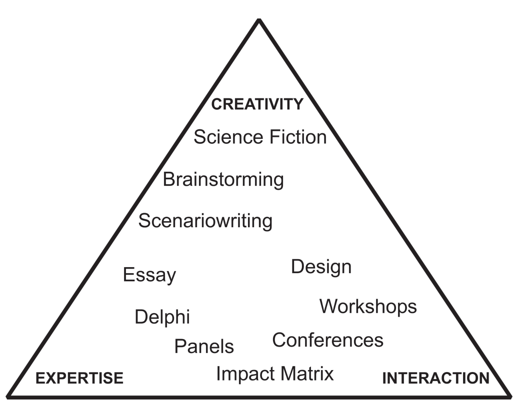
a Combinations of 2 out of 6 = 15. Enter in Excel: =COMBINATIES(6;2) and the result is 15. See page 190.



282 Balancing between sectors



283 Technical balancing of projects



284 Foresight triangle

27.15 POLICY BALANCING

Between the sectors one can pre-suppose conditionality. Technique has its ecological conditions: without food, water or materials, technique would not exist. There are technical conditions for the economy: without dikes in our low delta lands, the economy would not exist either, etc. This leads to a model of sustaining capacity. In it, the sectors do not pre-suppose one another causally (a certain technique leads to a certain economy), but conditionally (a certain technique makes different economies possible).

One may also try to make a more technical judgment, for instance between nature areas and airports. The product of their scarcity in a wide surroundings and the viability to generate them within a particular time, provides a yardstick for comparison.

This diagram pre-supposes that in The Netherlands a main port is unique in a radius of some 300 km, but may be built in 10 years. Wetlands are unique on the same scale, but are only replenishable in a period of 1000 years. The logarithm of the product (the sum of the zero's) is respectively approximately 3 and 5.

27.16 SCENARIO DEVELOPMENT

With emphasis on possibilities, likelihoods or desirables, the builders of a scenario should have access to a wider field of creativity, expertise or actor-orientation than with more causally driven planning. The means in figure 284 are at disposal.[a]

For further explanation we refer to the literature. An example of the Delphi Method is discussed in this book on page 491. The method comprises questioning a group of experts and confronting it quickly with the outcome, so that they might consider again. Next they are interviewed again, so that they may get an idea to what extent the group is going to support views. This usually leads to a convergence of ideas. The cycle may be repeated several times, until the outlines of a scenario manifest themselves.

27.17 LIMITATION SHOWS THE MASTER

Just very large-scale examples have been given here, since they feature a relatively small number of exogenous variables: by the same token they supply, with a grain to match, broader models which are, however, more appropriate for explanation. In the daily practice of study the scenarios of CPB, SCP, RIVM and AVV are usually regarded as given entities; that applies also for the population prognosis of the CBS. With a fitting amount of modesty study then tries to state something in the range of the first 5 years, 10 years at the most. Such a 'forecast' generates subsequently annual verification of the results (monitoring).

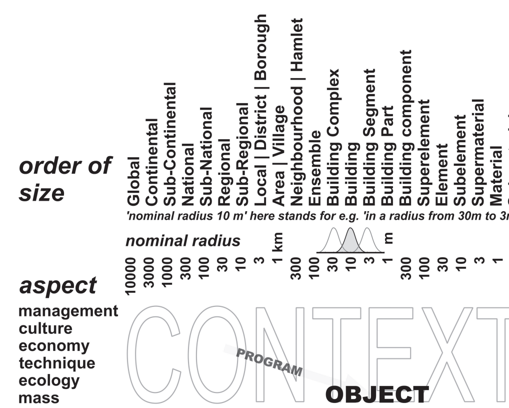
Perhaps the impression is created here that the study challenges the position of the Creator Himself. In the examples as practice generates them, much more is already determined or given. One just looks at a limited number of variables on a rather narrow time-horizon. As already mentioned in the start of paragraph 27.13, usually scenarios are not meant to be forecasts, but tools to facilitate and improve social and political discussion and decision making.

a Meulen, Van der; Cameron et al. (1996), quoted by Geels, F. (1997) *Met de blik vooruit - op weg naar socio-technische scenario's*.

PROGRAMMING AND OPTIMISING

E PROGRAMMING AND OPTIMISING

Making a programme of requirements for a building or urban plan pre-supposes a model of the future. With the help of models discussed in the previous section, discrepancies may be signalled between the present situation and the most likely situation in the future and the most desirable one. Starting from a future model like that, urban, architectural and constructive programmes of requirements may be drawn up in order to deal with problems signalled or predicted. The programme directs the design, even if it determines the spatial model in a limited way. A programme represents a need from the context of the object on a certain scale level (e.g. national, provincial, local) and of a certain nature (e.g. cultural, economical, technical). Positioning the need in a contextual scheme is an important part of programming design.



285 Context

Urban programming research and programming of buildings

In the contributions of Guyt and Hulsbergen (urban level) and Van der Voordt and Van Wegen (building level) the method of programming study is worked out further; not only for re-programming existing situations, but also for programming new architectural objects. Both approaches show a careful inventory of wishes, needs and activities to house. Study among present and future users, functional analyses, norms and characteristic values, lessons learned from evaluative study and statistical prognoses are important sources for formulating a programme of requirements. The use of scenario methods is a good tool to picture the spatial consequences of different possible futures.

Programming building construction

Eekhout and Cuperus discuss programming on lower levels of scale (<100 m. radius), but in the same time in a wide range (until 1 mm.) and within a more strict technical context of performance requirements.

Designing a city hall

The Chapter by Weeber, Van Eldijk and Van Kan is an example of a design process where the programme of requirements functioned explicitly as guidance for the design.

Design by optimisation

In a programme of requirements wishes and requirements related to an architectural object are often contradictory. In that case choices and priorities must be made. Decision theory has made a lot of progress in weighing conflicting requirements transparently and democratically. Van Loon shows what mathematical optimisation models can contribute. His contribution is focused on use of linear programming.

Optimising performance requirements

Houben describes a more verbal approach. In his view not only factual arguments matter, but – as least as important – also the way in which actors in the process communicate. An important distinction is the one between norms, laws and results from scientific study on one hand, and collective and individual preferences on the other. Rational and emotional arguments often conflict. Consensus under an umbrella concept and a phased development of the plan are important ingredients for taking decisions acceptable to all parties.

The environmental maximisation method

The contribution of Duijvestein argues not for optimisation, but for maximisation of dominant values, in this case: a safe, healthy and sustainable environment. With maximisation of an interest like that the importance of weighing interests of separate parties shows again.

28 URBAN PROGRAMMING RESEARCH

PIET GUYT
EDWARD HULSBERGEN

Urban programming research aims to generate knowledge and data as input for the urban programme of requirements. Usually the urban brief focuses on the functions and measures in the urban plan. The quantitative programme of requirements determines what the design must realise. Qualitative aspects may concern liveability, sphere, safety, sustainability and so on. An urban planning programme can be written with or without research. Here, we assume that research plays a part. A research based programme of requirements does not come out of the blue, nor is it solely based on a normative idea of city form and function, but the contents are based on careful studies or well sustained argumentation. The next two paragraphs discuss characteristics of the brief and the focus of programming research. Next, two examples are described: the programming of amenities and of businesses. We end with concluding remarks.

28.1 ASPECTS OF THE PROGRAMME OF REQUIREMENTS

The programme of requirements depends on the actual context of a plan or design. Four aspects are useful as criteria for the discussion about the contents of the programme.

a. Type of assignment

A programme can be determined for a newly to-be-built area, but also for an existing built situation. The programme for a 'new' area may benefit from the results and information of ex post research in other, comparable situations concerning the functions and measures the urban plan has to meet. For an existing area the situation is different. There, the built environment can be described in terms of the realised, existing programme and the developments afterwards. Research of its effects may clarify the formal and functional defects and positive points. This existing programme forms the start of the re-programming. The new programme can be based on the effects of spatial interventions elsewhere, and contains necessary adaptations, improvements and modernisations.

b. Programme elements

The elements of the urban programme are derived from the desired functional-spatial organisation. They can be expressed in a quantitative and qualitative way. Reference images can be used as illustration or guideline. Programme elements concern structure of the area, functions and form:

The *structure* includes infrastructure and the structure of amenities, green and water. The structural part of the design is the well-considered composition of these component structures.

The *functions*, like housing, amenities (shops, restaurants, schools, hospitals, theatres) and workplaces, can be classified in several ways. With respect to amenities one can discern for example free and compulsory, mono- and multi-functional, competing and complementary amenities. The functional part of the design concerns the well thought out tuning to each other. The functions in a plan area can be on one hand the ('autonomous') starting point, for instance the amount of houses; on the other the 'derived' functions (e.g. amenities) based on the population in the given amount of houses. This relationship can be expressed in indicators (rules and numbers of thumbs) for instance: x m^2 per inhabitant. It must be emphasised that one should be very careful in handling these rules of thumb. There can be great differences between actual situations (see below: programming of amenities).

The programme must also express the demands about the actual number and *form* of the buildings and outdoor spaces, leaving space, however, to the creativity of the designer.

c. Functions and questions

The functions mentioned can be divided into categories, for instance according to the CIAM-classification. With respect to them several questions need to be answered:

Housing: How many houses and which types are needed and for whom? Which density shall be used, and why?

Employment: Which type of activities can be included in the planned area? Where? What are the advantages and disadvantages? What are the requirements of the businesses themselves, and the wishes of inhabitants with respect to companies? Aspects that can play a rôle are diversity, identifying marks, liveliness and the presence of facilities.

Amenities: Which amenities (shopping centres, schools, sports centres, playgrounds, churches, social and cultural amenities, recreation areas, hotels, restaurants, hospitals, entertainment centres) are needed, and how many? Just for the people in the area itself, or also for people living in the surrounding neighbourhood, visitors, and tourists?

Traffic: Which road structure, parking, type of public transport and so on will be required? How can the modal split be influenced?

d. Dealing with uncertainty

If the outlines of the plan are clear and the programme ready, it can be worked out in a design, for example a certain density of houses, and an amount of amenities. However, one problem might be how to deal with uncertainties about the specific organisation or the future developments. In the case of uncertainties the solution is to reserve space for a specific function.

28.2 FOCUS OF PROGRAMMING RESEARCH

The focus of programming research depends on the need for information and the decisions to be taken.

a. Demand or supply

The programme can be determined from the demand side. Generally, the preliminary magnitude of the demand is determined with the help of index numbers(rule of thumb(planning)): simplified rules and relations between variables, based on general research.[a] However, general index numbers do not take into account the specific information of a particular local situation. So one should be very careful in handling these index numbers. If one does not take into account from what situation the rule of thumb is derived, great planning misfits may occur. An example: a ratio between space for parking and space for shops in a shopping centre was used for a centre planned in a new town in The Netherlands. Later on, it turned out that the ratio was derived from a situation of a different type of shopping centre in the United States, where the modal split is totally different, and where cars are larger than in the Netherlands. Also the type of shopping centre plays a rôle, because of a possible difference in average duration of the visit. The longer the visit, the more space for parking is needed. Another example: one cannot use a fixed ratio between number of inhabitants and the number of m^2 shopping space. The ratio depends on what the influx or outflux of purchasing power is. Rules of thumb can only give indications of what is needed to some extent.

With respect to the actual programme in a particular planning situation, information can be obtained by research in that area, by observations, interviews with key persons and discussions with clients. Nevertheless, uncertainty will remain to some extent. It is important to handle this uncertainty by scenarios[b], monitoring and flexibility in the design (see Hulsbergen and Van der Schaaf on ex ante research on page 159).

Programming research can also start from the supply side. In the inter-action between programme and design the programme possibilities can be explored. One must bear in mind that

a NIROV (1988) *Planologische Kengetallen 1988-2001* (regularly revised).

b Draak, J. den (1993) *Van blauwdruk naar draaiboek, scenario's in de ruimtelijke planning en volkshuisvesting.*

for certain elements a “critical mass” must be part of the evaluation of the outcomes. This is a kind of research with the help of design (design study / study by design), where designing is interpreted as hypothesis. An example of a plan in which the design was determining the programme is the well-known Kop van Zuid in Rotterdam. In this context we can point out the difference between programmes that are following existing trends and task setting programmes. The task setting programmes relate to programmes, that are greater than the estimated need for a certain location, for instance based on considerations on a higher scalelevel. The design can be a means to show the potentials of an area, and be used to approach or even reach the chosen goals.

b. Present or future situation

Programming research not only concerns estimation of future developments, for instance population growth and income growth, but also analysis of the way certain amenities, for instance a shopping centre, function now and in the future. Synergy between several kinds of amenities, financial feasibility and location play important rôles. It is also possible that an amenity is placed not only because of the need for this amenity as such, but because of other purposes: e.g. fighting deterioration, vandalism and criminality.

c. General or specific plan orientated research

Programming research can focus on general questions and general knowledge. For instance: how is the development of the demand for offices? What are important factors determining the location of businesses? On the other hand, programming can focus on a specific plan. What are the needs of prospective tenants (see also paragraph 1c)? An interesting question for ex post evaluation is for instance: which similarities and dissimilarities turn out between expectations, ambitions and planning tools (like index numbers) in advance, and actual use and perception of a certain area? How did the design function? This knowledge may be used to improve the area itself, but also to add knowledge to the existing ‘body of knowledge’, as input for a particular urban brief or to include in the decision-making process.

d. Financial aspects

The rent to be paid is one of the factors influencing the choice of businesses and amenities for a specific location. Industries needing a lot of space especially will pay much attention to the price of the land. Businesses and offices that can afford to pay high rents push away weaker functions from preferred locations (displacement). In areas preferred by functions that can afford to pay high prices, the ground exploitation is no problem generally. In case of ground exploitation problems in a certain plan area, the local government can decide to absorb functions (offices, amenities) that can pay higher prices.

e. Methodological aspects

Firstly it should be taken into account that the results of research may be rough or detailed depending on the phase of the planning process. This means that the research outcomes may differ in desired precision, reliability and range of the results. However, the information must always be collected and analysed properly. The conclusions must be based on the information used. The approach can be empirical (statistics, inquiries, interviews and observations) or with the help of models, for instance mathematical formulae describing reality in simple terms. Examples of models are gravity models or models that describe the division of purchasing power in a region or city. Whatever the method, one should be very critical with respect to the reliability of the used information (for instance based on inquiries, interviews), and the application of outcomes.

28.3 PROGRAMMING OF AMENITIES[a]

Programming research with respect to amenities needs understanding the phenomenon in question. The concept of the supply structure: the network of the amenities in relation to the consumers is important. This structure has several levels (the quantitative and qualitative composition of the set of amenities), and a range for each level. The structure is determined by factors like: population structure (age, households, religion), social and economic situation, and spatial situation. The scale and quality of the amenities in an area are determined by the amount of people using the amenity and its frequency. In this respect the relation between the level of the amenities and the reach is important. The higher the level the wider the reach. On the other hand, the higher the frequency of use, the smaller the reach must be. The maximum distance a consumer considers acceptable to reach an amenity depends of the type of amenity, frequency, transport possibilities and subjective perception. The reach of an amenity influences the chosen means of transport. In case the amenity is very near, it can be reached on foot or by bicycle. Further away car or train are needed. This is also related to the category of visitors (old or young) and availability of the means of transport. On the supply side the minimum turnover, necessary for the amenity (for instance a shop) to be profitable is important.

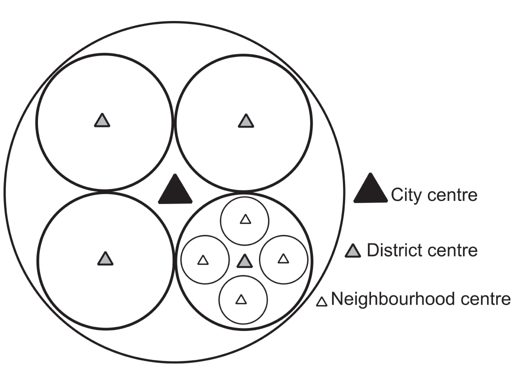
As mentioned before amenities can be divided into 'compulsory' and 'free' amenities. In case of 'compulsory' amenities (schools, medical care) the need for them can be estimated fairly easy. In the case of "free" amenities visiting is without obligation, so that estimating the need is more difficult and uncertain. Factors like distance, quality and alternatives play their rôle.

28.4 EXAMPLE: PROGRAMMING OF SHOPPING CENTRES

The retail structure has two characteristics:

a) shops are concentrated in shopping centres;
b) centres are ranked in a hierarchy.

a) Concentration takes place in order to achieve a certain attraction to the shopping centre. The consumer can buy several articles in one trip (one stop shopping) and can compare goods and prices. By combining shops with amenities like restaurants, pubs, post offices, etc., and by designing a promenade with terraces, fountains, an attractive atmosphere can be created. Concentration makes it possible to connect the centre with public transport.



286 Hierarchy and dispersal of shopping centres

b) The shopping centres form a hierarchy (see figure 286) based on classification of goods in several types. This functional hierarchy is an application on structures *within* a city or town of Christallers[b] 'central place theory' that explained an *inter*local hierarchy of communities. The functional hierarchy means that each type of shopping centre is specialised in certain types of articles, and has her own market area. In the city centre, with a function for the whole town, durable goods can be bought, and in the smaller centres in the neighbourhoods the frequently purchased articles (by people who live in that neighbourhood). In recent years the hierarchy is adapted by small selling points in fuelling stations (related to traffic) on the level of the neigbourhood, and megastores on the periphery of the town.

The size of the shopping area depends on the number of inhabitants, income level and what part of the income is spent in shops. It also depends on the loss of expenditure from inhabitants who shop in other areas or, on the other hand, the influx of purchasing power from outside town. The orientation of the local purchasing power to the own shopping centres is greater for daily needed articles than for durable goods. A general expectation is that the more amenities there are in an area, the higher the orientation of the purchasing power to that area will be. The orientation of purchasing power depends on the scale used. For example: 20% of

a Guyt, P. (2000) *Voorzieningen, Ruimtelijke Planning Monografie 4*.
b Christaller, W. (1933) *Die zentralen Orte in Süddeutschland: eine ökonomisch-geografische Untersuchung über die Gesetzmässigkeit der Verbreitung und Entwicklung der Siedlungen mit städtischen Funktionen*. English translation: (1966) *Central places in southern Germany.*

the total expenditure of the inhabitants of a neighbourhood is spent in the neighbourhood, 50% in the district and 90% in the town.

The scope of the shopping area is determined by dividing the turnover in a shopping centre by the required turnover per m^2. In order to estimate the turnover of a shopping centre one can use empirical approaches like consumer inquiries, visitors inquiries and retailer inquiries. Each approach has its advantages and disadvantages. It is also possible to use models, like individual choice models (predicting consumer behaviour) and spatial inter-action models by which it is possible to estimate the effect for existing shopping centres when a new shopping centre will be built. Models used in the planning of shopping centres are based on the gravitation model of Newton, in which the reach of a shopping centre is the result of the attraction of that centre and the distance to that centre.

287 Large-Scale Retail Establishment Alexandrium II in Rotterdam North East

This formula gives the division of expenditure from j to i and k:

Kji / Kjk = Bi / Bk x (djk / dji)²,

In which:

Kji = amount of expenditure from j orientated on i
Kjk = amount of expenditure from j orientated on k
Bi = population of i
Bk = population of k
Dji = distance between town j and i
Djk = distance between town j and k

With respect to shopping centres, the question is how they should be organised and designed. Programming research should give the information needed. Items like acceptable distance between parking place and shopping centre, a good mix of branches, and effective routing, are important for designing a well-organised shopping centre. There is a relationship between the size and type of the shopping centre. Small centres have the form of a strip or a court, big shopping centres are clustered in malls.

Because of some developments, for instance, the diminishing size of a household and changing shopping behaviour (caused by increasing mobility, other preferences, technical developments, teleshopping), the position of the neighbourhood centres changes. Some centres will vanish. It is expected that the shopping structure will become less dense.[a] On the other hand, we see small shops linked to fuelling stations and train stations, related to traffic flows. Because of lack of space in city centres, new types of shopping centres (Large-Scale Retail Establishment) arise at the edge of town (see figure 287). As a result of a more efficient purchasing policy of the shopkeeper, the turnover per m^2 will increase.

BOX 1: Example of determining the amount of parking place for a shopping centre

The required number of parking places depends mainly on the type and area of the shopping centre. The greater the shopping centre, the greater the reach and the greater the number of visitors that travel by car. This example refers to a city centre on Saturday, because then the maximum number is needed.

Area of the shopping centre is 100.000 m^2 floor space (accessible for the visitors) exclusive 50.000 m^2 storage and office space.

The estimated number of visitors on a Saturday is 150.000

Assumption: 1/3 travels by car = 50.000 people.

Assumption: average two persons per car, so 25.000 cars are expected on a Saturday.

The parking time is depending on how long visitors are staying in the shopping centre. This determines the circulation factor, i.e. the average number of cars on a parking place. If this factor is 5, than the number of parking spaces is 5.000.

The visitors are not equally divided over the day, so that an axtra amount of e.g. 1750 places is needed for the period between 13.00 and 16.00, so in total 6.750 places have to be available.

For people working in the shopping centre 1500 places (1 parking place per 100 m^2 space) are needed.

Parking area needed for visitors is

6.750 x 25 m^2 = 168.500 m^2

and for employees 1.500 x 25 m^2 = 37.500 m^2

so that in total 206.000 m^2

parking lot have to be planned for the shopping centre.

(The amount of parking spaces per 100 m^2 shopping area can differ with the type of shopping centre).

28.5 EXAMPLE: PROGRAMMING OF BUSINESSES

The employment in a region or town is strongly influenced by the current economic situation. The structure and composition of the employment changes with economic and technological developments. In contrast to amenities, the programme for businesses in a planned area is not dependent in the first place on the size of the local population, but on the attractiveness of the local area for businesses. It is based on several factors influencing settlement of firms and offices: quality of the location, reputation, acquaintance with the location by businesses, social climate, co-operation of local government and many other factors.[b] In determining the programme not only the preferences of the firms themselves play a rôle but also the wishes of inhabitants (who do not like the hindrance of the adjacent businesses) and local government policy. Because of the variety in potentially relevant factors that may be important for the various types of firms, different types of locations (industrial areas, business parks, office concentrations, small business areas in residential quarters) are discerned

a Toorn Vrijthoff, W. van der, H. de Jonge et al. (1998) *Werk aan de winkel. De toekomst van de winkelmarkt 1995-2015*.
b Guyt, P. (2000) *Bedrijvigheid, Ruimtelijke planning Monografie 3*.

and developed in cities and towns. Attempts are made to match different types of locations with types of businesses that are possible or desired in the various locations. It can be used in the development of a spatial policy local government wants to pursue. Municipalities also make use of estimations of the future employment, using instruments like models, inquiries, extrapolations and planned goals. The number of workers has to be divided by the number of workers per m^2 to calculate the space needed.

For offices the floor space needed depends particularly on the type of employment in offices and space per employee. The size of the employment in offices depends partly on the size of the local population. But, offices can also be established there because of specific advantages. Important factors are accessibility by car and public transport, parking space, and prestige of location and building. The ground space needed depends on the number of floors, and the ratio of the built and total area (ground-space-index). Example: 5000 employees have to be accommodated. Every person needs 30 m^2, in total 150.000 m^2 floor space. If the number of floors is 10, the built area is 15.000 m^2. If the ground-space-index is 20-100, the ground area is 75.000 m^2. The floor-space-index is 2,0 (150.000 / 75.000).

	Building form	Density	Image	Nearness amenities	Public transport	Attainability by car
1 Office boulevards	h / m	z	++	++	++	+
2 Other centre	m	i		++	++	+
3 Junction locations	l / m	i	+	+	+ / ++	++
4 Offices in neighboorhoods	l	e			+	
5 Offices on industry and harbour sites	l	e				++

h high rise — z very high density — ++ very good
m middle high — i high density — + good
l low — e low density

288 Office locations and characteristics[b]

The relationship between the employment in offices and the floor space needed is variable. When the growth of employment in an office building is absorbed in the existing building, the average space per worker decreases. On the other hand, in case of moving to a larger office building (anticipating future growth of employment) the space per employee will be very high. The interests of the institute that made the prognosis may influence the prognosis of the need for office buildings. Building consultancy agencies are interested in an optimistic view: because they earn more when many buildings are built. On the other hand, real estate consultancy agencies are interested in a pessimistic view: in that case there is more need for their services. Local government stimulates offices in their municipality because offices offer workplaces without pollution, and because certain exploitation problems can be solved, because it is expected that office organisations can pay a high rent. Moreover it is possible to influence the modal split by establishing the offices near public transport stops.[a]

As is the case for businesses in general, offices can also be located on a variety of types of locations. Alongside is an example of distinguished office locations is shown.

28.6 CONCLUDING REMARKS

Programme research can be related to several objects, themes and points of view. These determine which different research activities are relevant. It is recommended to be very critical with respect to the used information as inquiries, statistics and interviews. Uncertainties should not be neglected, but should be met by a flexible design. After execution it is desirable to monitor developments in order to be able to evaluate the programme. Programme research is a continuing activity.

a Guyt, P. (2000) *Kantoren in kort bestek*.
b Gemeente Rotterdam (1999) *Kantorenbeleid 1999-2003*.

29 PROGRAMMING OF BUILDINGS

THEO VAN DER VOORDT
HERMAN VAN WEGEN

A vital function of a building is spatial organisation of activity. Designing must have a sound insight into points of departure objectives and wishes of users: their activities, organisational structure and ensuing spatial consequences. When a new organisation is looking for an adress; or when an existing organisation has decided that present premises are no longer suitable, a lot of thought should be spent on possible and desirable variants of solution. Instances are: remodelling, expansion, disposing of (a part of) the building, joining, moving into another building, or (commissioning the) designing of a new building. In order to ensure that the building supports activities in an adequate way with respect to cultural, aesthetic, economic, climatical, technical and judicial considerations, the requirements must be carefully charted.

This is also mandatory for weighing alternatives against one another and for ascertaining whether wishes and potentials match. It is extremely rare, that what is deemed desirable is completely feasible in terms of time and money as well. Present laws and rules delimit possibilities as well. This necessitates formulating priorities and making choices. Charting requirements, wishes and boundary conditions is termed in the building process 'programming'; or 'briefing'.

In this contribution we discuss how programming of buildings is effectuated and identify the means available to trace and record wishes and requirements in a document: the programme of requirements, or brief. These requirements must get the form of a description of the performance to be delivered. They may be of a quantitative or qualitative nature and have regard to location, building, spaces, building parts and facilities.

29.1 PROGRAMMING IN THE BUILDING PROCESS

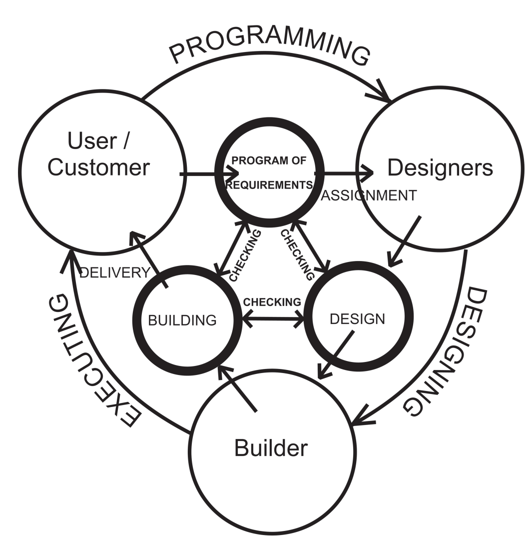
Programming and recording the results in a brief is an essential step towards a well-considered plan development. It will preclude that solutions are embraced too readily who have shown themselves to be adequate elsewhere, but are not tailored to the specific requirements and wishes of the organisation calling the shots. By thinking too early in terms of solutions, this stage of the programming often becomes a weak link in the building process. This sometimes causes that in a later stage, when the solutions proposed have already been discussed, it is nevertheless decided to formulate explicitly the requirements and conditions. Additional work and loss of time goes hand in hand with it. Other objections *vis-à-vis* the slipshod passing of the programming stage and preliminary brief are:

- profitting too little from usage experience;
- the designer must spend a lot of time on collecting and analysing the information;
- the feasibility of the project can only be checked much later; on the basis of the first sketched design;
- the design must be altered more often; and more extensively. This costs time and money; and often irritation for the parties concerned;
- a lack of time and attentiveness for alternative solutions;
- one has to settle for a building more expensive and less appropriate than the one opted for.

29.2 PROGRAMMING, DESIGNING AND BUILDING

Programming, designing and building are three main activities in the building process. The diagram to go with this here gives a systematic view of the place of programming in a traditional building process.[a]

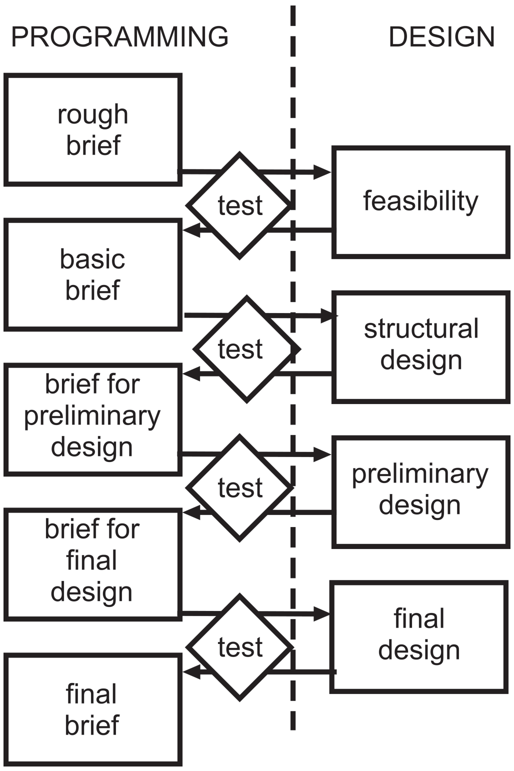
In order to keep the scheme simple, it is pre-supposed that the principal co-incides with the owner and is acting also on behalf of future users of the building. The three parties mentioned are often supported by advisors, sub-contractors and providers; that have been disregarded. The arrows between the products (brief, design, building) indicate that there is



289 Place of programming in a traditional building process

a Derived from Vrielink, D. (1991) *Hoe verder met het prestatieconcept? Kwaliteit maken, meten en vergelijken*.

always – or should be – a reciprocal checking, giving the process a cyclical character. When, for instance, the design does not accommodate the programme, this may be ground on which the design or programme may be adapted. This does not take away from the fact that in traditional building the programming stage is, in principle, closed off by a final brief. Next, the designer picks it up. This approach makes the brief a rather static document. Subsequent detailing concerns primarily technical matters and hardly anymore spatial-functional aspects. Also, in building processes with modern organisational forms like Design and Build, General Contracting, Build Operate Transfer (BOT) and contracting on the basis of a performance contract, the programme of requirements is a rather static document. First, the brief is developed. Next, one party or one building team is responsible for design and realisation. BOT implies that this party also sees (temporarily) to maintenance.



290 Brief developed from global to detailed

An advantage of a distinct programming stage, is separated up to a degree, from the designing stage, so that time and attentiveness is spent explicitly on clear formulation of the requirements, without thinking immediately in terms of solutions. When the result is recorded in a brief, all parties concerned know what they are doing. This is opposed by the fact that translation in images and sketched designs often leads to new forms of insight; and, together with that, to different wishes. A designer can envisage solutions not called for in the programme of requirement, or even opposing it, but which may imply an essential improvement of the plan; for instance by using in the design properties of the environment. The brief may also contain contradictory requirements, or those of a type that can not be accommodated; emerging during the designing process. In this, it is up to the principal to assess differences between programme and design and to accept or reject. It should be added, that delivering information 'just in time' is meeting with increasing demand: more information should not be provided than is needed on that specific moment. That is the reason why the *'Stichting Bouwresearch Rotterdam'* (SBR; *Foundation for Building Research Rotterdam*) makes a plea for a gradual development of requirements, from global to detailed; in combination with plan development.

29.3 CONTENT OF THE BRIEF

In order to give the designer and other parties a sufficient grip on the building process, the programme should be as complete as possible *vis-à-vis* requirements and wishes of the principal and other conditions the building must comply with. As a function of the size of the building and complexity of the task, the number of requirements can grow considerably. It is important, therefore, to order the requirements for surveying purposes. Different ways of categorising are used. We restrict ourselves to categories of the Netherlands Normalisation Institute (NEN 2658, the current 'norm') and the categorising of SBR 258 (often applied in building practice).

29.4 NEN 2658

According to NEN 2658, *'Programmes of requirements for building and matching project procedure'*, a programme of requirements should comprise the parts of boundary conditions, of characteristics of the target group to be housed, and of requirements put to the object. The boundary conditions are relating to the laws and rules applying, technical aspects and financial aspects. The characteristic of the target group(s) to be housed should give an insight, among others, into the objectives of the organisation, the users and their activities and expectations for the future. With regard to the requirements relating to the object, NEN 2658 distinguishes requirements for location, the building as a whole, building parts and facilities on the premises. In addition the project procedure should be recorded. It involves two parts:

- Identification of the project (type of the building, purpose, situating, main sizes and building volume, costs and financing, relevant documents and participants etc.).
- Task description (tasks and responsibilities of the agents concerned), process description and temporal planning.

Various practical guidelines have been developed for filling-in the programme.[a] The lists for controlling and checking provided here are giving a good picture of the subjects on which the programme should shed light. NEN 2658 is less clear on the content of the requirements, the conceptual framework and the phased emerging of requirements.

29.5 SBR 258

Additional study of the conceptual framework and the phased approach was conducted by *Stichting Bouwresearch Rotterdam*. The third edition of SBR 258 *'Programme of requirements. Instrument for quality control'* was published in 1996. Next to a clear explanation of the conceptual framework this publication contains a manual for drawing up the project orientated programmes of requirements. SBR 258 is following a compartmentalisation in 5 blocks:

- Usage requirements
- Functions and performances
- Image expectations
- Internal conditions
- External requirements and conditions.

Ad a. Usage requirements

These are the requirements and wishes regarding (parts of) the housing, resulting from the foreseen usage. A picture should be given of the organisation to be housed in terms of nature, size, organisational structure and patterns of activities, now and in the future.

Ad b. Functions and performances

The characteristics of the organisation to be housed should be translated into spatial-constructive requirements and wishes with regard to the location (ease of access, facilities in the surroundings, possibilities for expansion, etc.) and requirements and wishes with regard to the building. Relevant items are – amongst others – the spatial need for the building as a whole and per room, physical building conditions envisaged (temperature, light, humidity, sound, view), safety and flexibility.

Ad c. Image expectations

Although the creation of visual quality is belonging to the competence of the designer, the principal is well-advised to formulate his own wishes in this respect as clearly as possible. Does he want to have an atmosphere of luxury or one of soberness and effectiveness? Is a traditional style of building assumed, or rather something rubbing shoulders with high tech? Should the building express something of the function or the corporate identity; or exactly the opposite?

Ad d. Internal conditions

This concerns financial-economical conditions (possibilities and limitations with regard to costs of investment and exploitation charges) and conditions relating to time (date of completion, time-frame of the housing process). Other internal conditions are, for instance, specific requirements with respect to sustainability.

Ad e. External requirements and conditions

This concerns requirements as seen from the perspective of spatial ordering and other laws and rules. Examples are functional zone planning, requirements ensuing from a protected urban

a NNI, Nederlands Normalisatie Instituut (1992) *NPR 3405, Programma's van eisen voor gebouwen. Indeling en aspecten van gebouwdelen en voorzieningen op het terrein;* – (1993) *NPR 3401, Programma's van eisen voor gebouwen en bijbehorende projectprocedure, Algemene naloop-lijst.*

view, the Building Decree, security standards, alcohol and food industry law, consumer's law, environmental maintenance, general police ordinance etc.

29.6 KINDS OF REQUIREMENTS

The requirements should really have something to say. Platitudes like "The building should not leak" are to be avoided. In addition the requirements should be formulated clearly in a maximal verifiable manner. An important distinction is the one between functional requirements (or usage requirements) and performance requirements.

Functional requirements describe the intended functioning of the building. They are formulated in a qualitative way; for instance: "the building should be integrally accessible." A variant is the description of the activities to be housed; for instance: "there should be space for placing 12.000 books in an open shelf arrangement, taking in and giving out of books, the reading of books and magazines and consulting reference books."

Performance requirements record the performances that are asked for. It concerns requirements that can be checked objectively. With that in mind the desired quality level needs to be quantified as much as possible. Examples are: "a gross floor surface of 12.500 square metres", or "free width of passing of doors minimally 850 mm." In the example of the library: "a lending room of 180 m^2 with 12.000 books, an in-take and lending desk of 20 m^2 and a reading room with 30 seats of 90 m^2 in total." Performance requirements literally point to what the building should perform.

One should be cautious in formulating descriptive requirements in the form of solutions, like: "the floor should be made of white marble." This formulation is leaving hardly any room for alternative solutions. On the other side it does not make sense to give a description in performance requirements when the commissioner is saying explicitly to accept this specific solution only. However, in many cases a demanded solution is referring to underlying wishes, for instance: "can be cleaned simply and has a luxurious atmosphere." By making the underlying wishes explicit and including them in the brief, a space comes into being for alternative solutions obeying the requirements just as well.

Clients' requirements may relate to different scales, e.g. the total building performance and requirements for different spaces. The latter can be documented per room using so-called activity sheets and performance criteria, including:

- user characteristics: number of users, their functions and personal characteristics (only when these have spatial implications);
- activities (type of activities, time schedule);
- facilities and furniture, temporary or permanent;
- spatial requirements with reference to accessibility, efficiency, ergonomics, spatial orientation and finding your way, privacy, flexibility etc.;
- technical and physical requirements regarding floor load bearing, thermal comfort, acoustics, lighting and fire safety;
- wall finishes, floors and ceiling, regarding aesthetic preferences, ecological issues, maintenance;
- dimensions and square metres, if relevant, both minima and optima;
- number of required areas of this particular type;
- a brief explanation, if required.

29.7 METHODS FOR PROGRAMMING

The most important materials for preparation of a brief are:

a. Accurate documentation and analysis of the organisation and activities for which housing is needed. The necessary information can be collected by interviews with the client, questionnaires, analysis of documents, behavioural mapping, counting occupancy rates, and workshops with prospective users. Scenario techniques can be used to comprehend spatial implications of future developments.

b. 'Translation' of organisational characteristics and functional requirements into performance criteria. This functional analysis is normally based on clients' experiences and the programmer's professional expertise (often a specialised consultant or architect). Additional research is frequently required, especially when new functions are involved. Testing design variants in a computer model, scale model, or full-scale mock-up are techniques often used
c. Site visits to similar projects (reference projects or 'precedents').
d. Analysis and Post-Occupancy Evaluation of similar projects (see the Chapter on ex post evaluation of buildings).
e. Review of literature, searching for data, experiences with particular design solutions, standards, guidelines for programming and design, etc. It is particularly worthwhile to review references of similar building types. Furthermore, general studies on anthropometrics and ergonomics or functional aspects like safety, sustainability and cost-effective design may be extremely useful, both for programming and design

The activities named first are known as 'functional analysis' or 'function analysis'. The translation from function analysis to a functional design is sometimes called functional designing. The methodical approach of this inter-connects with the ergonomic analyses of the American Frederick Taylor. In the sixties and seventies his approach was worked out for architecture by Zweers and De Bruijn and Polak.[a] For a more recent treatment of functional designing we refer to Van Duin *et al.*, Sanoff and Blyth & Worthington.[b] Here we restrict ourselves to a summary of how function analyses are taking place, which literature is especially relevant and how use may be made of reference projects.

Function analysis

Programming starts with analysing the organisation and activities needing housing. The analysis entails determining the nature of the activities and the required spatial condition, like the floor surface needed, possibly minimal sizes for width and depth, physical conditions (lighting, acoustics and such) and spatial-psychological requirements (view, privacy, territoriality). Careful thought should be given to which activities are needing their own, specific space, and which activities may be housed in a common space. Should copying and fax equipment be installed in the space of the secretariat, in a separate space, or in an (open) intermediary room? Is each office getting its own place for discussion, or are there meeting rooms for common use and informal corners for sitting together? When it has been settled which activities need their own space and which activities may be put together, spatial conditions per room can be formulated. This determines to a high degree the spatial need in terms of separate rooms and conditions. By the way: not every activity requires a specific spatial solution. From the perspective of flexibility and future value it is important to design the spaces in such a way, that they can not only serve the activities intended, but other activities as well. A narrowly 'tailored suit' in the form of an unequivocal 1:1 relationship between function and form restricts the possibilities for adapting to changing circumstances.

Activities and spaces with a strong mutual relation should be positioned close to one another, if the situation admits this. Other considerations for spatial proximity or of clustering spaces (zoning) are common characteristics in terms of public / private, hot / cold, silent / noisy, view / inner space, etc. The analysis of spatial relations can be done easily by hand, in the case of simple buildings. For more complex structures using the computer is advisable.

Box 1: Example of a functional analysis of an office restaurant

The required number of square metres depends on the number of people using the restaurant at the same time. Professional literature includes the following guidelines:

- Restaurant: number of seats x 1.4 m^2
- Counter, kitchen, storage space: number of seats x 0.7 m^2
- Staff rooms (cloakroom, informal meeting place during breaks, office space): number of seats x 0.4 m^2.

Data based on client's information and assumptions based on consultant's experience:

- Number of employees: 400
- Number of people actually present: 90% (10% absent for reasons of sick leave, vacation, training etc.)
- People have staggered lunch breaks: from 12.00-12.45 and from 12.45-13.30.
- Assumption: 60% of all employees use the restaurant.
- Assumption: even in peak hours not all seats are loccupied (e.g. 3 persons using a 4-person table). For this reason 15% extra space is required.

These data and assumptions lead to a calculation of the number of seats as

$$\frac{400 \times 0.90 \times 0.60 \times 1.15}{2} = 125$$

and required floor space of:

-	Public space	125 x 1.4 m^2 =	175	m^2
-	Counter/kitchen	125 x 0.7 m^2 =	87,5	m^2
-	Staff	125 x 0.4 m^2 =	50	m^2
-	*Total*		*313*	*m^2*

a Zweers, B.H.H. and W.N. de Bruin (1958) *Een analytische methode voor het ontwerpen van bedrijfsgebouwen;* Polak, B. M. (1973) *Functioneel ontwerpen*.

b Duin, L van, W. Wilms Floet et al. (1989) *Functioneel ontwerpen, ontwikkeling en toepassingen van het doelmatigheidsbeginsel in de architectuur;* Sanoff, H. (1992) *Integrating programming, evaluation and participation in design;* Blyth, A. and J. Worthington (2001) *Managing the brief for better design*.

Relevant tools and literature

Obviously, principal and programme advisor will use their experience(s) with their own organisation and with drawing up programmes of requirements. Programme consultants are often making use of a brief used before, for a comparable task; while going through it with the client, or without him, and adapt it to the present task. For auditing the organisation use is made of interviews, workshops with (representatives of) users, ratios of usage, scenario techniques, and sometimes also space planning studies in a 1 : 1 model. Many things do not need new thought. During the years many publications have appeared that may support a function analysis and that may be useful for formulating internal and external conditions. Without trying to be comprehensive, we mention just a few important publications:

- Studies specifically aiming at the development of a brief; among them SBR 258 and the booklet 'Bouwstenen voor het PVE (Wijk and Spekking) and the publications of Preiser *et al.*, Preiser, Sanoff and Blyth & Worthington.[a]
- Space planning studies translating the activities in spatial measures, like *'Architects' Data'*, the English translation of Ernst Neufert's *'Bauentwurfslehre'*.[b]
- Studies of buildings for a specific kind of function(s), e.g. books focussing on office buildings, libraries, schools or hospitals.
- Studies of specific aspects like:
  - Integral accessibility, social security
  - Flexibility
  - Sick Building Syndrome, sustainability
- Norms and directives, such as NEN 1824, Ergonomic recommendations for sizing office rooms.
- Branch-specific building norms and design directives. Hospitals, for instance, must comply with the building norms of the College for Hospital Facilities. For schools, homes for children and libraries norms and directives have been developed as well.
- Surveys of law and rule giving.

Reference projects ('precedents')

Buildings with identical or comparable function(s) may teach a lot. It is wise, therefore, to visit kindred buildings to get *'in situ'* new ideas by observing and discussing for one's own housing. Documentation on buildings and especially evaluations of buildings in stages of use and maintenance are extremely valuable as well. This kind of evaluation is sometimes termed 'Post-Occupancy Evaluation' (POE). When the evaluation is also extending to other aspects than just use and experiencing – for instance to costs, technology, aesthetics – the term may be (Total) Building Performance Evaluation (BPE). For a working out of that notion see the contribution by Van der Voordt and Van Wegen on evaluating study ex post.

Evaluative studies are gaining power when characteristics and experiences from a sequence of kindred building are compared.[c] Comparative building analysis has the advantage over traditional methods of study like observation and interviews, that the information is linked to spatial variants of solution. Each building is the result of a complicated decision forming process, in which points of departure and objectives are translated into an organisational structure and activities and are receiving form in blueprints, floor plans, cross-sections, materials and facilities. Analysis ex post is enabling that thoughts, ideas and points of departure can be rediscovered after the various choices. Obviously, problems of interpretation may result from this; for the design realised has always been influenced by interpretation of the designer and by internal and external boundary conditions; as there are the available budget, and characteristics of the location (functional destination plan, size and shape of the plot, surrounding functions e.t.q.). By the same token, it is desirable to complement the analyses with study of the realisation process, interviews with the commissioner (at the time) and other parties involved in the building process; for instance the architect and advisors. The combination of a com-

a Sanoff, H. (1977) *Methods of architectural programming;* Preiser, W.F.E., J.C. Vischer et al. (1991) *Design intervention, toward a more humane architecture;* Sanoff, H. (1991) *Visual research methods in design;* Preiser, W.F.E. (1993) *Professional practice in facility programming;* Wijk, M. and D. Spekkink (1998) *Bouwstenen voor het PVE, SBR 421;* Blyth, A. and J. Worthington (2001) *Managing the brief for better design*.

b Neufert, E. (2000) *Architects' data*.

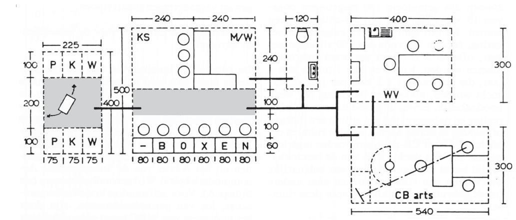
c Voordt, D.J.M. van der, D. Vrielink et al. (1998) *Comparative floorplan-analysis in programming and design*.

parative analysis of buildings with evaluative study may lead to a reasoned typology of solution variants; together with pros and cons for costs and quality.

An example of programming study using evaluative study, is the one concerning health centres by Van Hoogdalem *et al.*[a] These are co-operative organisations, in which one or more general medical practitioners, neighbourhood nursing, social workers and often also physiotherapists have been housed under a single roof. The study aimed at the development of directives for programming and design to be employed in the case of new initiatives. In addition the study was conducted to check the Accommodation Policy Neighbourhood Health Centres at the time and adjust them; especially with an eye on the floor surface needed per discipline, and in total. Beside four case studies, some fifty purpose-built health centres were inspected and subjected to a comparative floor-plan analysis. The analyses were supported by means of one or two interviews and a short questionnaire in writing among daily users (both staff and patients). By way of illustration, we give an example of the programmatic data for an infant welfare centre, respectively a flow-chart for the course of the activities and an picture of the supports of the space.

29.8 CONCLUDING REMARKS

Nowadays a large number of references are available in order to support the briefing process. Apart from the Dutch NEN-standards and the SBR 258 report, English references are mentioned in this Chapter. It should be understood that a brief must not be too restrictive regarding the form of the building. Besides functional requirements, many other aspects will affect the form, e.g. personal preferences of designer and client, contextual aspects like physical, cultural and historical characteristics of the environment, flexibility with reference to changing functions in the future, economic aspects and legislation. It is still the task of the designer to work on a synthesis of function, form and construction, according to the old Vitruvian triad. Modern multi-media techniques and virtual reality will also improve opportunities to discuss formal aspects with prospective users. It is a challenge for designers and their clients to include such new information and communication techniques both in briefing and in design processes.



291 Supports of space for a child health assessment new style

Legend: P K W = storage of prams
CB = doctor
WV = nurse
MW = measuring of length and weight
Boxen = boxes to (un)dress babies

Activity	Time / duration	Room
Parent arrives with child in pram	According to appointment, e.g. 1 child / 20 min.	Via entrance of the health centre or entrance of the nursing service
Parent parks pram	pm	Collective waiting room of the health centre, waiting room of the nursing service, or changing room.
Waiting (if changing room is full)	pm	Idem
Parent takes child out of the pram, undresses it and waits	10 min	Changing room with playpen or prams
Measuring and weighing child + keeping accounts	5 min	Changing room or room district nurse
Consult district nurse	20 min	Room district nurse
Possibly: consult doctor child health centre	20 min	Room doctor child health centre
Parent dresses child	10 min	Changing room
Parent lays child in pram	pm	Waiting room
Parent leaves	pm	Via exit of the health centre or the exit of the nursing service

292 Example of a flow-chart for a child health centre

a Hoogdalem, H, D.J.M. van der Voordt et al. (1985) *Bouwen aan gezondheidscentra. Functionele grondslagen voor programma en ontwerp.*

30 PROGRAMMING BUILDING CONSTRUCTION

MICK EEKHOUT
YPE CUPERUS

Planning the construction of a building includes specification of its technical performance. In the perspective of preceding Chapters on urban planning and planning of buildings, a conceptual range based on sizes from large to small is suggested for the benefit of the overall picture in this book. This will not occur in reality, however, as the time cycles of these scales are quite different. Although the scale range from urban design, architecture to interior design may be suitable in terms of scale and dimension from the point of view of the architect, the range urban design, architecture, and building construction is more suitable in terms of technical function. It defines the phases in terms of time rather than of significance: after the functional and spatial design concept the construction concept is made and developed towards a mature composition which is the construction of the building, as a totality of systems, sub-systems and building parts, components and elements. Materialising a design concept is as significant as the previous conceptual design activities. Building technical design is the subject of this Chapter. Hence, it does not include areas of urban technology like civil engineering: road and water works and infrastructure: like pipes and cabling that make a city function.

30.1 CONSTRUCTION PLANNING ON FOUR DIFFERENT SCALES

Construction planning can occur on four major levels. In the case of specifications for a highway it can be required that a bridge has to be realised crossing a waterway. The specifications will describe the frequency and loads of the traffic, the free spans and the free height underneath for nautical traffic. In case of the second level of a building the planning description will depart from the spatial design concept and the zones in which the construction has to be fitted in in order to form the materialised concept of the building. On the third level, the construction components, of which a lot of different versions have to be developed within one single building, are planned, departing from the function of the desired component within the whole of the building or one of the composing building parts. On the fourth level, the choice of material and production method is made in order to form, out of material or half products, new elements with distinct desired characteristics.

Imagine a building where the load bearing structure has the form of a skeleton and the façade is planned to be produced independently in an off-site factory. In order to keep options open to cater for future decisions; the façade construction could be connected to the supporting main construction with steel angle brackets. Once the façade design is ready and the weight and loadings on the façade are known, the dimensions of the elements of the façade can be developed and engineered and the optimum connection fixed, keeping in mind the mode of elevations and installation. This connection detail might contain steel clad plates and sliding provisions and fixing elements as M16 bolts, which have to be detailed at a scale of 1:1.

30.2 HIERARCHY

These examples illustrate that construction planning is not related to one particular scale. Rather the subject, in the order of given function and 3D form from the previous higher level, like the form of the building has been derived from the town planning design, the form of the construction design of the building is derived from the architectural design of the building. It involves analysis of the technical functions of the higher entity as the higher level into its composing parts. After analysis the appropriate structural scheme has to be chosen, the proper materials, the form of components and elements in conjunction with production and the final detailing fit for installation, each at its own level. The complexity of the building is usually greater than that of infrastructural works. The speciality of bridge design usually refers to civil technology designers and engineers. Infrastructure design, building design, component design and material design are the four basic levels of construction design a planning can be made for.

Decisions about infrastructure belong to a level, different from decisions about the load-bearing construction of a building. However, while there is a separate relationship between the two, it is a relationship of hierarchy. The position of the building depends on infrastructure; not the other way around. The load-bearing construction, in turn, creates the condition for possible claddings. In addition, the cladding component determines the parameters for developing a new material in order to cope with new requirements. This hierarchy of entity and parts co-incides in general with corresponding levels of decision making.

There is also a relationship with life-span. The position of the street, part of the infra-structure and town planning, is fixed for hundreds of years. The building is written off in an economical life of some thirty years and has an average technical life span of fifty to hundred years. The cladding has a technical life span of twenty to thirty years and a market lifespan possibly shorter. Dwellers move every 7 to 10 years and office buildings are re-furbished every 5 to 10 years; shop interiors every 3 years.

The hierarchy of building parts reflects the ease with which elements can be moved. A user can move furniture immediately, since it can be lifted, not being connected to other parts. However, designing furniture is not regarded as belonging to the architecture domain. Doors and windows can be swayed instantly; internal partitions as well, if necessary. This is technically more complicated, but a professional craftsman can remount an internal wall within one single day. Alterations to the load bearing structure are technically major changes that are hardly done within a period of one generation of habitation (10-20 years for offices and 30 years for housing). Altering the position of a street is beyond consideration; planning new roads takes decades. Understanding different levels of building parts, and their consequent levels of decision making (reflected in life spans and mobility) is important in determining the technical performance specification.[a]

30.3 DISCIPLINES

If we look at a building as a system, 'a group or combination of inter-related, inter-dependent, or inter-acting elements, forming a collective entity'[b], we can also define the sub-systems. The load bearing structure is a sub-system to the building that received external loadings and sustains dead weight and directs them as internal forces to the foundation and the soil. The plumbing sub-system takes care of distribution of water throughout the building. The building façade sub-system provides the climate barrier between inside and outside. Many more sub-systems can be identified this way. These sub-systems are called building parts. These technical sub-systems may co-incide with one level of decision-making. The sub-system 'furniture' co-incides with the authority of the space user while the sub-system 'internal-partitions' with the authority of the tenant. In contrast, the plumbing sub-system depends on decision-making at all levels. This requires an integrated and coherent chain of decision making from source to tap.

A much more strongly relationship is seen between sub-systems/building parts and the building disciplines concerned. The main contractor sub-contracts laying the foundation to a third party, specialising in driving piles. Another sub-contractor builds the ground floor, while yet another party builds the steel or pre-fabricated reinforced concrete load-bearing structure. When planning the construction process, all specialised producers working off-site and all disciplines on the site need to be considered. They should not interfere with one another, nor should they damage each other's work and they should be able to finish their job, if possible, in one un-interrupted working period. A building built and completed on the site through a

a Habraken, N.J. (1982) *Transformations of the site*.
b Hanks, P. (1988) *The Collins concise dictionary of the English language*.

well co-ordinated building process has the potential to be built and maintained by independent disciplines and to adapt to new demands. Consequently knowledge of the construction process is essential when writing the technical brief.

30.4 BUILDING AND MANUFACTURING

Building is an on-site assembly and installation process as productions and manufacturing are factory-based pre-processes. On-site building processes exposed to the outdoor climate, are usually unique and quality can be controlled mainly on-site during construction. The elements and components produced off-site an be controlled in quality as end products in the respective factories, or as a result of a continuous and total quality assurance process. On site only the installation aspect is controlled. Building elements and components of diverse natures and their mutual (i.e. external) and their internal sub-system connections are subject to ever increasing quality demands. The two contemporary examples of a traditional timber window frame in a dual brick wall in a rural type building with a triple-glazed, climate-controlled façade integrated with an air-conditioning system in a high-tech office building illustrates the way in which an increasing part of the building energy is transferred into production environments. The development costs of high-tech systems for the said triple glazed façades cannot be justified for a single building. Manufacturers who intend to recover their investment over a period of time incur such costs. The shift from 'building' to 'production' and 'manufacturing' creates an appropriate environment for development of project-independent designed, but project-pre-fabricated sub-system elements and components. At one extreme the whole building could be pre-fabricated in different factories of co-makers and finally assembled and completed in a single end-line factory. The leading example of this is the Japanese Sekisui Heim house.

293 Sekisui Heim, housing factory in Japan

From a limited catalogue range of components, the client can design his house, as he would purchase a modern kitchen. All parts are assembled in the end-line factory into three-dimensional elements designed to fit onto the back of a truck. These are then transported in the right order to the building site, where they are post-assembled to form the final house.[a] An on-site assembly process replaces the traditional construction process, however, since building is by its nature always site related – unlike cars and other consumer products – it will keep to some extent the properties of an on-site 'building' process. (In the fourties one of Jean Prouvé's very mobile and light-weight houses was stolen from the site!) Understanding the turning point in balance between building and productions & manufacturing is a very important factor in planning construction.

30.5 BUILDING CONSTRUCTION PLANNING

The specifications of the technical composition of a building are described by the architect in the project specifications. These specifications contain:

- an administrative part;
- a technical description part;
- and a building execution part.

This type of project specification stems from the traditional habit in the building industry to describe and understand traditional methods of building using traditional materials. Both designer, the architect, as well as building contractor mastered these techniques and materials. Communication was simple; quality assurance based on the fact that many influences on quality could be managed and checked on the site itself.

However, with the introduction of pre-fabrication and industrialisation in the building process, with their inherent specialised production techniques by the producer, not to be influenced by consumers, it has no sense to prescribe to the specialist, who knows better than the consumer how to make his products. There are only two ways out: to prescribe in global

a Cuperus, Y.J. (2000) *Industrialisatie van de Japanse woningbouw.*

terms the requirements posed to the specific building products, building system; to opt for special components, so that the proposing sub-contractor / producer can detail his proposition and price it. The second possibility is to use the product description of the specialised producer directly in specifications. This is a pure case of ignorance of the prescribing parties compared with the tendering parties; and will happen as long as producers are ahead of architects. In fact, these producers are treated as co-designers and co-producers; and just to fit them in the conventional building and contracting process these specialised specifications are used to enlarge the project specifications.

The project specifications are usually described in the old fashioned manner of collections of materials. It goes far beyond the goal of the site contractor to divide the total job of productions off-site and building on-site and its respective technical description into workable parts, i.e. building parts that are clusters of coherent products, with its own administative, production and site assembly conditions. Sub-division of the main contractor's job into 20 to 60 sub-contractors per project contract is a tedious job, with many risks of non-description of the mutual border zones between contractors and mis-understanding of the specialities of these sub-contractors / specialised installing producers. With an increasing amount of specialised contractors in contemporary projects, specialised sub-contracts have to be drafted in order to maintain the quality of the offered sub-contracts. The other *modus operandi* is to pick the brains of these specialists and to describe the specifications from the perspective of the prescribing architect.

30.6 THREE MAJOR TYPES OF BUILDING PRODUCTS

For manufactured products a scale of project independence can be identified in three major types of building products:

- Special building components, are designed and produced for one specific project (designed and produced project–dependent);
- System products or building systems (semi- dependent: designed project independent, yet produced project- related);
- Standard building products (designed and produced project–independent).

30.7 SPECIAL BUILDING COMPONENTS

These are products specially developed for a single building. The building designer or architect designs the global conditions of function, size and spacing and writes their specifications. These have to fit within the entire technical composition of the building and have to give the building that extra flavour or dimension that makes all the special effort necessary. The architect can select a component developer in his own office to work out the special product or select a producer with an experienced precomponent designer/developer in his service. Usually the architect acts as principal, within the budget limits of his client, towards the component designer to fully develop the design of the speciual components, to have a prototype made and after satisfactorally development to have them produced. The entire development process of special building components knows three major phases:

- concept design
- protoytype & testing
- production and installation

30.8 SYSTEM PRODUCTS OR BUILDING SYSTEMS

The brief is not limited to one component; rather it covers a family of related elements and components of a building system or sub-system. This can be developed from a special commission related to one specific building originating from the specific requirements of an architect, desiring a project-related sub-system. But, it can also be developed project- independent by a producer as the largest common denominator of a great many different applications with similar or slightly different requirements, which cannot be fulfilled by an existing system, unless the development is started because of a 'me too' attitude. In the latter case of a market (sub)system it makes sense to start with market research in order to determine the gross list of demand requirements and market opportunities corresponding with them. From this analysis a development brief can be drafted and the desired performance of the new (sub-)system specified. The preliminary design of the new system can then be checked against this initial specified performance.

Project-dependent systems are developed between an architect and a producer or system developer for use in one project only. Project-independent systems need to be marketed and sold as applications to the clients: the set of all architect / contractor combinations of the different application projects.

Once a detailed and final brief has been developed by the architect, the system developing and producing manufacturer can price his special sub-system for the project at hand. The phasing of the development of system products happens esentially on two different levels: initially, on the system level, afterwards on the application level:

- system design concept
- preliminary marketing investigation
- prototype and testing of system

and

- application design
- prototype & testing of application
- production of application.

30.9 STANDARD BUILDING PRODUCTS

In this case the producer takes the initiative to develop a standard product, totally project independent. It is made for the market, not for specific building projects. Five main phases of development activities can be identified after the initiative or basis for a product idea, initiated either by the marketing department of the producer or by the board:

- concept design
- preliminary market investigation
- prototype and testing
- final marketing investigation
- market introduction & production.

Between, or better still, parallel to the technical phases, the market demand for the developing product is monitored. During the preliminary market research the product concept is presented, the feedback evaluated, and used to modify the design of the final product. During the final market investigation the same is done with the real size prototype. The reactions of the chosen clients (representing the entire market in all of its expected facets) will influence the final composition and appearance of this standard product. One of their characteristics as compared to system products is that they are developed and produced before sales.[a]

30.10 NEW MATERIAL PLANNING: ZAPPI

Zappi represents the ultimate in the new and unknown. The term Zappi was invented by the former town architect of Haarlem, Thijs Asselbergs, at a forum discussion in January 1992. We were asked to describe an ideal building material as yet unknown to either of us. After discussion the term Zappi lived on as special epithet. Originally launched as a term for a new building material with superior qualities yet to be developed, it symbolises the adventurous quest. It represents what is unknown, mysterious, challenging! It is both a material and an

a Eekhout, A.C.J.M. (1997) *POPO of ontwerpen voor bouwproducten en bouwcomponenten*.

idea, simultaneously tangible and abstract. It is a mental construct that cares little about the apparent senselessness of ideas, or practicality of invention.

Firstly: Zappi as it began: a long-term fundamental research project with the objective of the development of a strong, stiff and tough glass-like engineering material that does not fail suddenly on overloading; being carried out in conjunction with the Faculties of Aerospace Engineering and Applied Sciences (materials science programme).

Secondly: Zappi represents not only objectives, but also a mentality. Zappi is a friendly and rather comical bulldog, with a character combining intelligence and perseverance. This mentality is needed to generate the motivation needed to maintain the process of design research, evaluation and development. And who is best suited to the research for this new product? An individual has as many disadvantages as a team. An individual needs a soundboard and subservient assistence; a team can choke creativity of its members.

Looking for Zappi may take a lifetime. The process of design, manufacture and construction usually gives more satisfaction than the void experienced after a building has been completed or a new product has been manufactured and launched. The ultimate goal represented by Zappi may, like the horizon, always remain just one day ahead; but it is, nonetheless, just as noble a goal as the Holy Grail to King Arthur's Knights of the Round Table.

Thirdly: Zappi is always near by. Each step towards Zappi is also Zappi itself, simply because of the pleasure one can derive from achieving a definitive step on the road towards Zappi. An example of such a step forward is the frameless glazing of the early nineties. Each further development towards a perfect structural glass material is also part of Zappi. Each result is achieved because Zappi takes immediate advantage of every new opportunity, although at the same time it never forgets that achievement of the ultimate objectives involves a number of discrete steps. That is the reason why this paragraph contains Zappi in its title: its publication marks one step that has been taken, to be followed, hopefully, by many other equally successful steps.

Fourthly: Zappi represents the infectiousness inherent to development of new products for the building industry. Zappi wants to see the entire audience laughing with it at its jokes, to win applause with its clever feats, and to stimulate the larger circle of parties actually involved – all those who, in one way or another, are engaged in product development for the building industry. This is achieved by disseminating new ideas and products among professionals with the motivation to upgrade the technology of materials and products for architecture and the builing industry. Zappi's answer to the question *"Would you ever do it again?"* would always be *"Yes!"*.

A proposal has been drawn up now for the fundamental materials research required for Zappi, one of Zappi's objectives. However, information about the initiative has already been published – and the pull effect of marketing has resulted in the first collaborations.

Zappi, designing a material

The concept of designed materials is new to materials science. Traditionally, a new material was developed, and then it was up to designers and engineers to find ways to use it. The modern discipline of materials science has made it possible to design materials that are tailored to the demands of designers and engineers. The materials science research constituent of Zappi is an experiment in the design of a material that satisfies the requirements of the architect needing a combination of the mechanical properties of steel and the transparancy of glass.

Glass in architecture

For centuries glass has been used as a transparent barrier to preserve the interior climate of a building whilst allowing daylight in its interior. Experience has shown that it is the most stable transparent façade material available. However, glass has poor mechanical properties. This has resulted in a material conflict. The glass window, essential for the inhabitation of interior spaces, is, in structural terms, just a hole in a wall. From the beginning of this century onwards large glazed openings played a major rôle in the development of Modern Architecture. Glass was used in the construction of tall buildings as a façade cladding for steel or concrete framework structures. Increasingly stringent requirements from the sixties onwards created a need for the enhanced performance provided by the use of coatings and advanced double-glazing systems. In the last decade the use of ultra-transparent glass façades and roofs to contrast with closed walls has become an accepted architectural practice. Yet, glass remains mechanically unreliable. In modern applications glass panels are fully pre-stressed to allow them to bear greater stresses. Although special laminates are available, they do not offer significant improvement on glass as a structural material.

The design of the Zappi material

In essence Zappi should combine the following properties:

- The mechanical properties of steel
- The transparency of glass

In physical terms, an impossible combination in one single material; the first property requires the dense metallic crystalline structure of a metal, whilst the second property requires the microstructure of an amorphous solid mutually exclusive structures.

Some answers to the problem can be obtained by combining existing materials and techniques in novel ways. What we have at our disposal are transparent materials like glass and polymers. Pre-stressed glass possesses the required strength and E-modulus, whilst polymers like polycarbonates have the required ductility. The combination of these materials in a composite should provide us with a structural material with enhanced properties in comparison with its components. Obstacles remain:

- Pre-stressed glass fails as a result of extensive unstable crack growth with multi-directional crack branching, leading to total de-cohesion of the material after global or local overloading.
- Amorphous polymers like polycarbonates have very low surface energy values, rendering them highly unsuitable for conventional laminating processes.

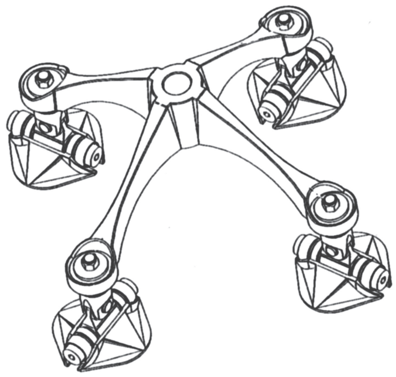
If we are to make a suitable composite then, the cracking behaviour of glass will first need to be modified in such a way that the glass will fail in a controlled manner. Next, we have to bond this modified glass to a suitable polymer.

There are several possible approaches that can be used to modify glass. The most logical approach would be to develop a new glass ‘alloy’ with the required properties. However, development of a new type of glass is a complicated process, requiring extensive technical facilities. Another approach is to modify the fracture behaviour of existing types of glass, to be achieved with exisiting surface modification techniques. The further development of these techniques for standard glass may not provide an optimum solution, but will result in a demonstration of the technology. Two years of preliminary research have resulted in a scientifically-verified concept for a material that combines transparancy of glass with mechanical properties of aluminium.

Although Zappi is still a long way off, the research and development programme is an exciting and convincing process. What is so stimulating is that the various projects make it possible to achieve *incremental* results. Factors of major importance for each incremental result are its orientation to constructional value and its practical application. Zappi prefers its high-tech product to be used in good buildings – which makes it even better. This means that the significance of the development of a new product cannot be assessed on its own. As always in research and development, real satisfaction is derived from victories you win by the skin of your teeth. Perhaps, the best remedy for the disease of sterile architecture is joy in design, joy in performance, vigour and wit.

The nodal bond, Barbara van Gelder

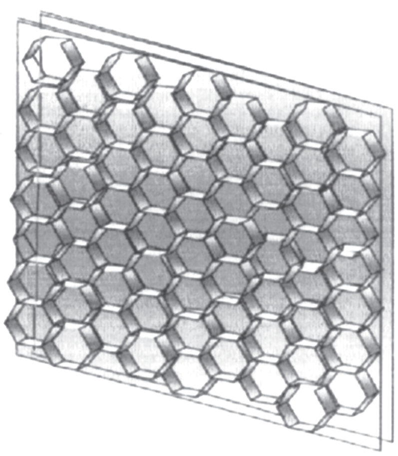
Connections between glass and metal have always been a problem. One possibility is to drill holes in the glass, then harden it. Subsequently, bolts are passed through the holes to attach the glass. However, this is not always desirable with modern double glazing panels as it may cause leakages in the air cavity, with all the concomitant problems. One alternative is to bond the double glazing panels to the metal: a new technology, about which relatively little is known at present. Barbara van Gelder carried out research into glass-metal bonded joints, and came to the conclusion that one of the greatest problems involved is the rigidity of the joint, that caused substantial localised forces in the glass and ultimately fractures adjacent to the bond. In order to solve the problem she designed a hinged nodal bond preventing the build-up of excessive forces in the glass. That results in a safer construction. A patent application has been submitted.



294 Hinged nodal bond

The sound-absorbent panel, Kees van Kranenburg

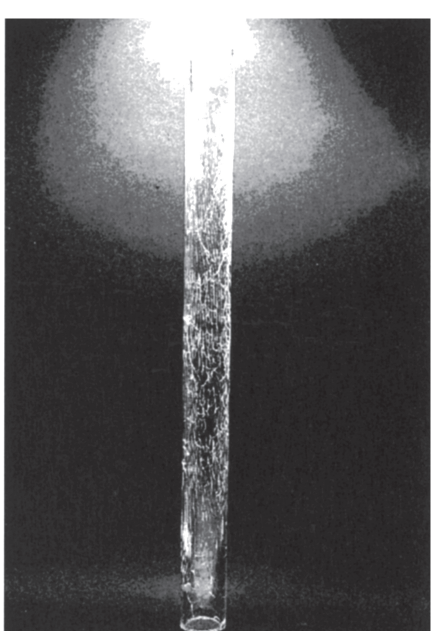
Existing glass structures often exhibit major deficiencies in terms of building physics. The glass construction increases the architectural expression of the building at the expense of the comfort it provides. One problem is noise. A large glass façade possesses only limited sound-absorbent properties which is not beneficial for the comfort in the rooms behind it. Kees van Kranenburg accepted the challenge to design a panel that had good structural properties and was transparent, but possessed much improved sound-absorbent properties. A long period of research into the acoustic poperties of the Zappi panel was required, followed by a series of designs and construction and testing of the prototypes.



295 Design of material with a high acoustic impedance

The transparent column, Joost Pastunink

The column is a basic element in framework structures. In the past, glass columns were used only extremely rarely, as their inherent brittleness makes them unsuitable for construction purposes. A transparent column capable of transferring invisible vertical forces would offer unprecedented opportunities. Joost Pastunink laid the foundations for this type of column: by designing a process to make a laminate using two concentric glass cylinders he was able to manufacture a prototype that did not fail spontaneously when subjected to an overload, but gradually crumbled in safety under the load imposed. Even after a considerable amount of fracturing the column still exhibited a substantial residual load-bearing capacity. The total load-bearing capacity of a column 40 mm in diametre and with a wall thickness of 3 mm is 10 tonnes – equivalent to a roof surface of 100 m^2, including its own weight and the useful load. A patent application has been submitted.



296 The transparent column after the trial

30.11 BUILDING TECHNICAL PROGRAMMING

Planning the production of building components may be characterised as an ex ante activity; it precedes the conception of a building design. However, even while a component is being planned, performance and market assessments are continuously evaluated, independent of construction activity. This is very much ex post, measuring product performance in its designed environment.

In the final analysis, construction of buildings can only be planned with full appreciation of construction processes and details.

31 DESIGNING A CITY HALL

CAREL WEEBER
JOB VAN ELDIJK
LENNEKE VAN KAN

31.1 INTRODUCTION

This is the report of a design process of Carel Weeber for a new City Hall in the town of Berkel en Rodenrijs. Each illustration indicates an important step in the design process.

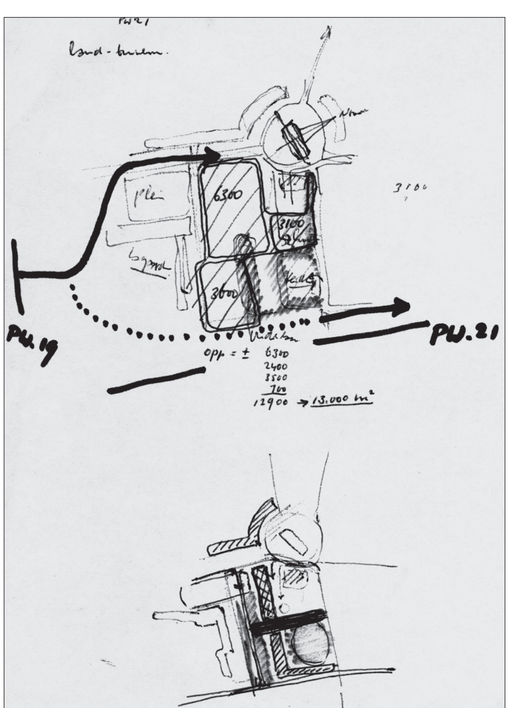
In my design process, the working out of associations and design ideas is taking place in my head, in my memory. This may be done everywhere, at any time. I investigate an idea like that in small sketches. As I grow older, I need fewer sketches. Now that I am working exclusively on the computer, these sketches are at the same time the start of a process of elaboration. Previously, I started with a drawing in ink in the top-left corner; a few days later I would finish in the corner right-below. If that did not come off very well, I started anew. I was taught to do so at Delft University of Technology and, basically, this is still the way I work.

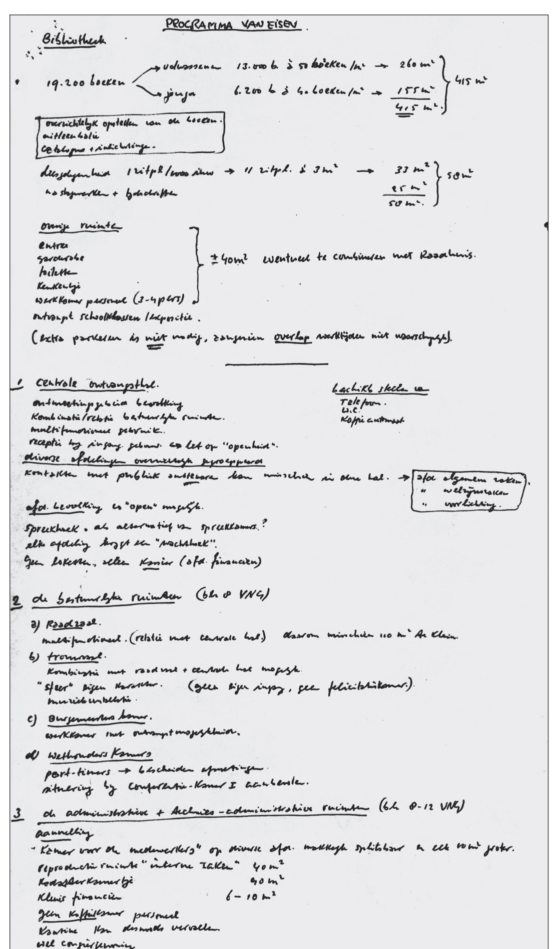
The commission described consisted in a Prize Competition on the basis of invitation for a new city hall in Berkel en Rodenrijs. My design process started with an extensive study of the location and the programme of requirements. Next I tend to ponder the possible and required spatial relations between functions, while trying to develop a total concept. I am studying scale relations, placing the whole in the context in terms of urban architecture, starting with floor plans, cross-sections and the front. I am making spatial sketches while studying new design ideas. In the end I make the final design drawings. Visually the deployment of my design process looks as follows.

31.2 DESIGN PROCESS

297 Study of context

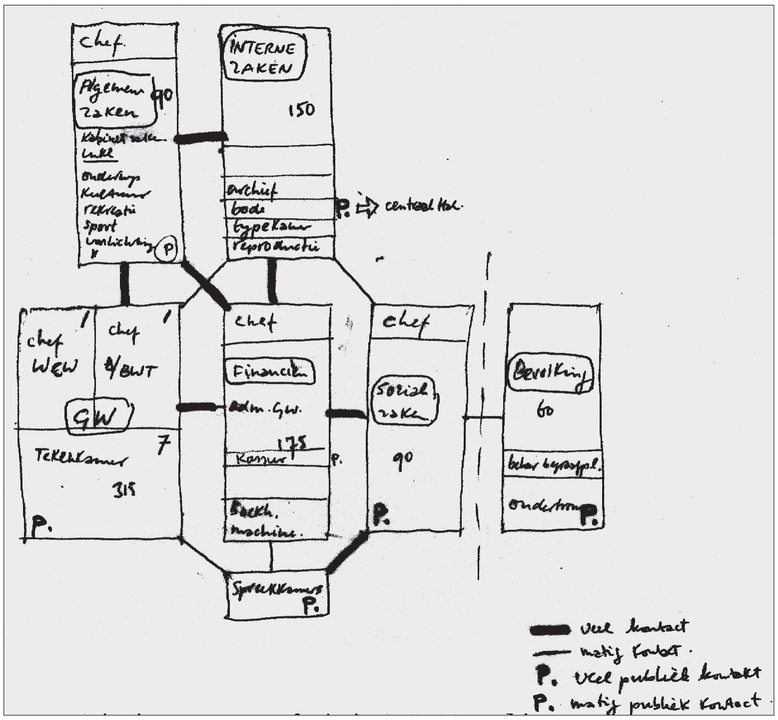
As the first study the context in terms of urban architecture





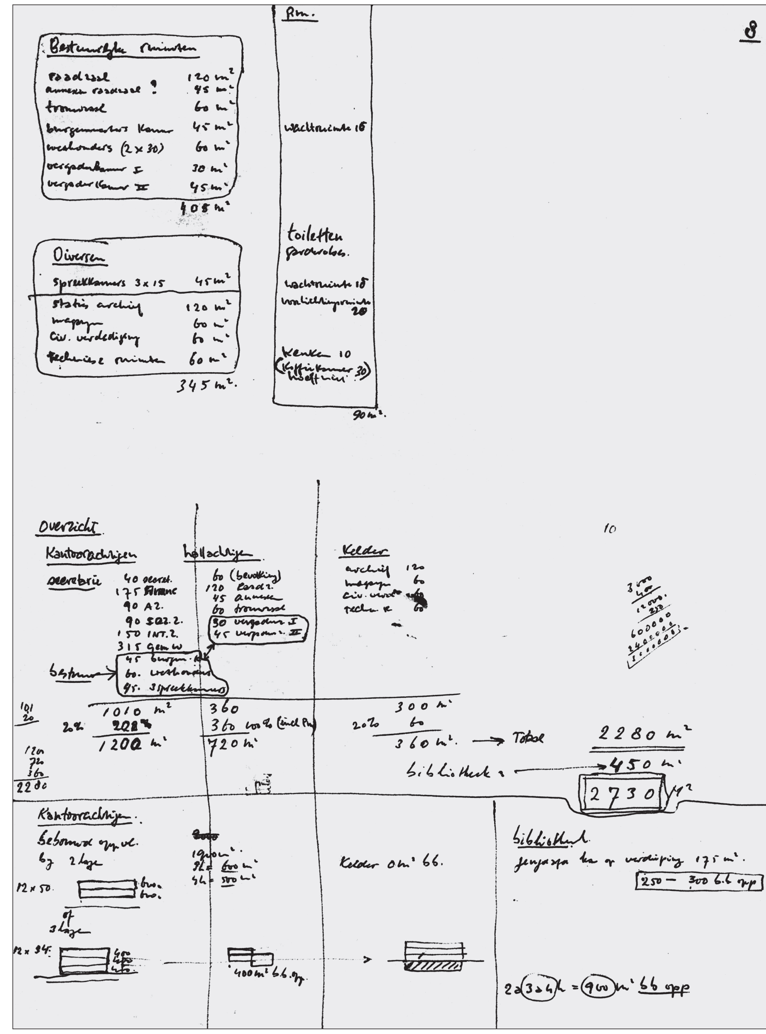
298 Summary programme of requirements

Along with the situation I study the programme of requirements extensively. I always make a summary of it; I am already learning it by heart.



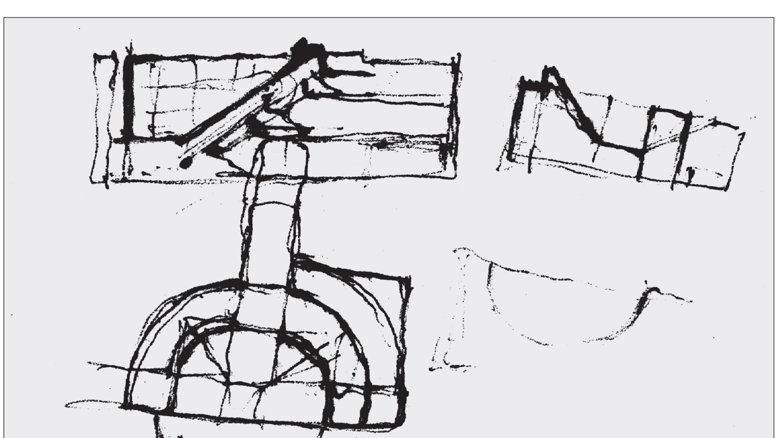
299 Relation schema + valuation

A next step consists in determining the relations between parts and characterising them.



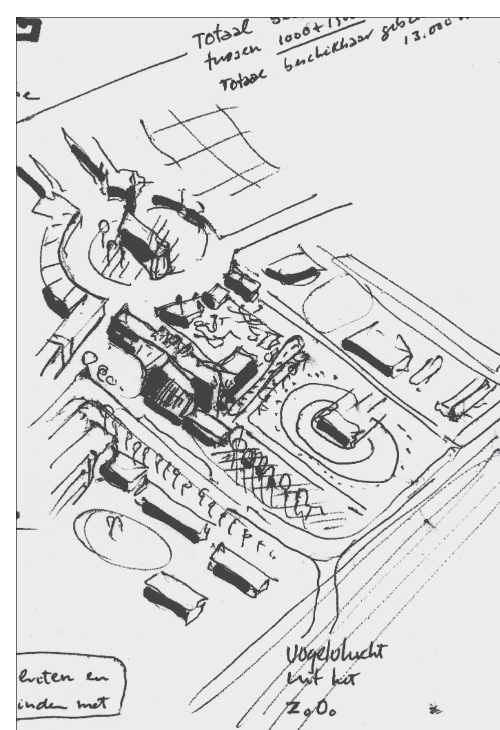
300 Typing

Guided by the programme of requirements and the relational schema I determine the total concept. I am looking first to what I have got in hand. How much office surface is required? Is it an office with additional functions or a hall with offices?



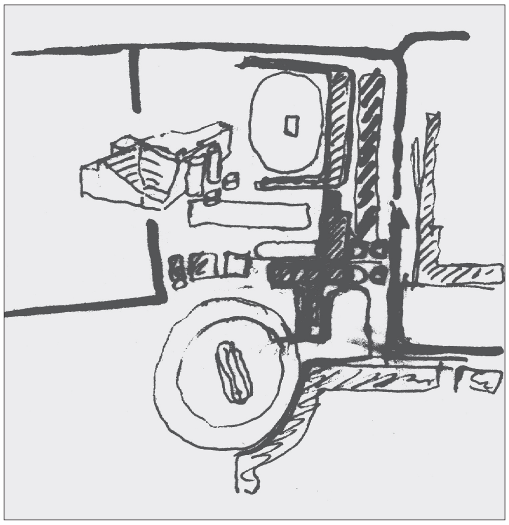
301 Scale relation study

I study possible organisations for the building and proportions of the parts of the building.

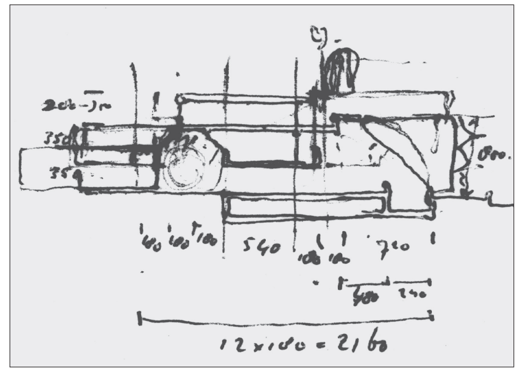


302 Urban context

What the study of the programme of requirements has yielded as a whole is placed in context in terms of urban architecture. This will result in morphological requirements for the surroundings. In a small sketch in perspective I look at whether something can be made of this.

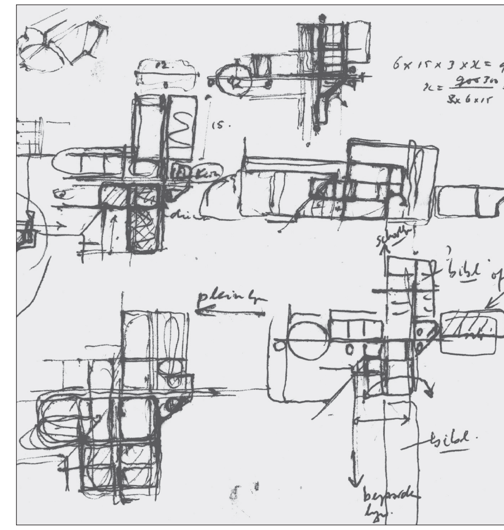


303 Test of form

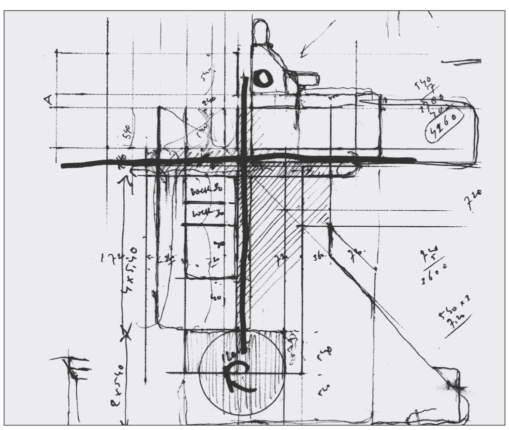


304 Cross-section

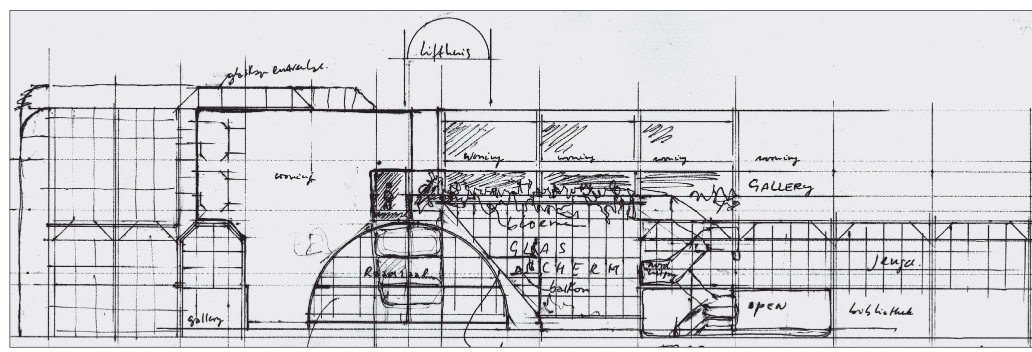
Following this, the elaboration in floor plans and cross-sections starts. I consider it to be very important, that this is done directly in the right proportion and scaling. These small sketches are acting as further elaboration of the design ideas in my head.



305 Loose sketch

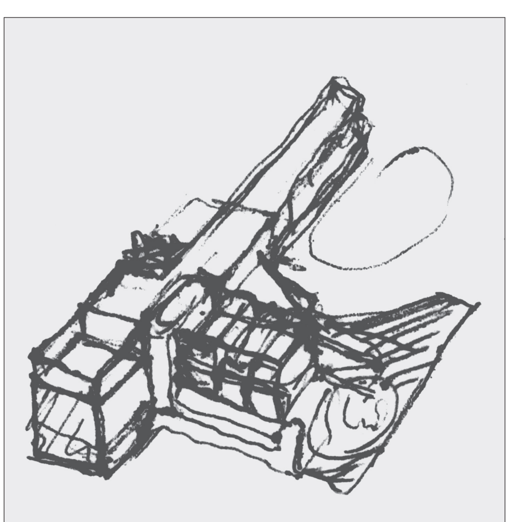


306 Sketch with a ruler



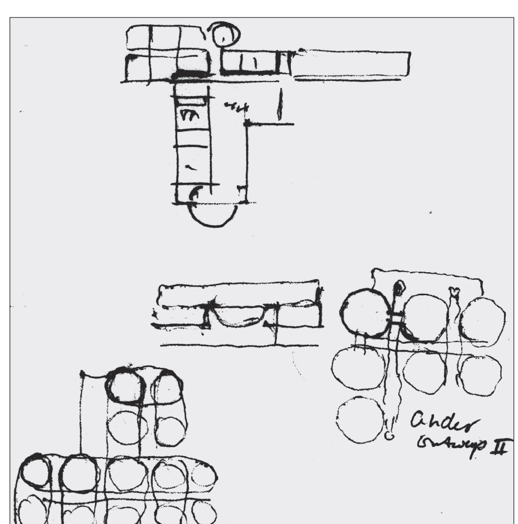
307 Study of the front

Next, I study colour and texture of the front. Any number of these modest studies is being made. If I run into something of importance, I just make a note.



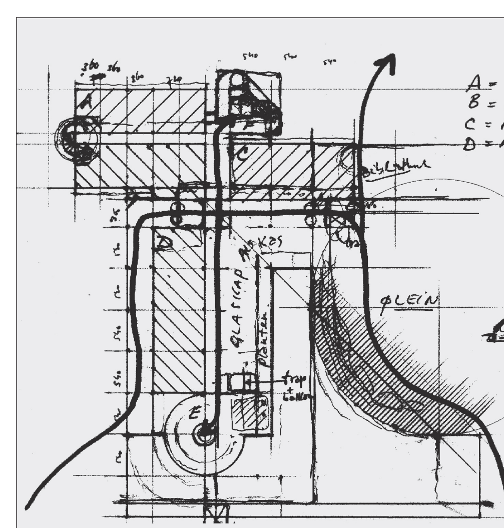
308 Spatial sketch

A spatial sketch, to look again whether it is any good.



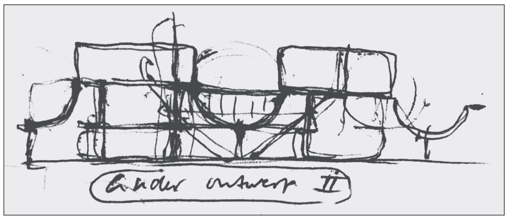
309 Different design ideas

While studying a detail of the building, a different design idea emerged: some upturned halved spheres forming corridors through the space they are leaving open. A nice idea, a kind of fascination: something for a following design.



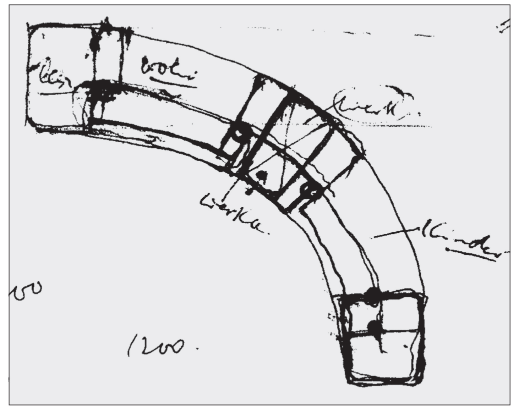
310 Context

Then, study of the adaptation in the urban context, as far as entrance and accessibility are concerned.



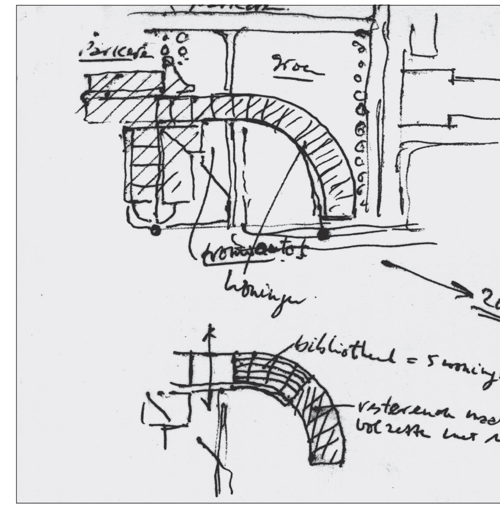
311 Come-back of an idea

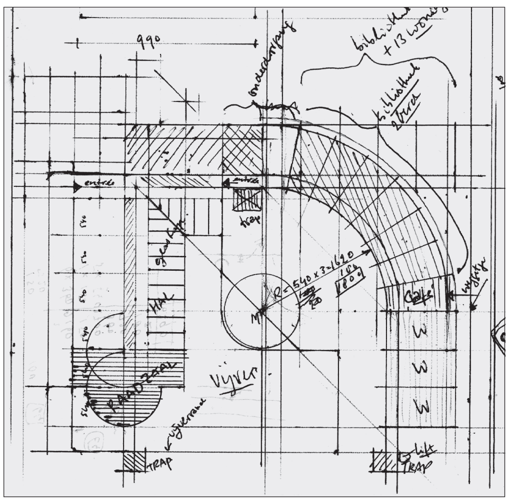
On the corner of the page the other design theme is returning. Maybe I also saw in this a solution; or maybe I was uncertain about the solution on which I was working; or maybe I just had fallen in love with this idea.



312 Adding functions

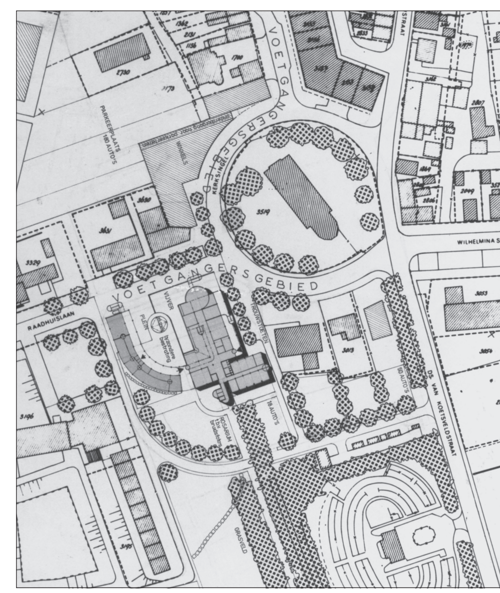
It was permitted to add a few programmatic components. I added some homes and a library. Obviously, no further study of a programme of requirements for the homes was necessary: a house is a house.

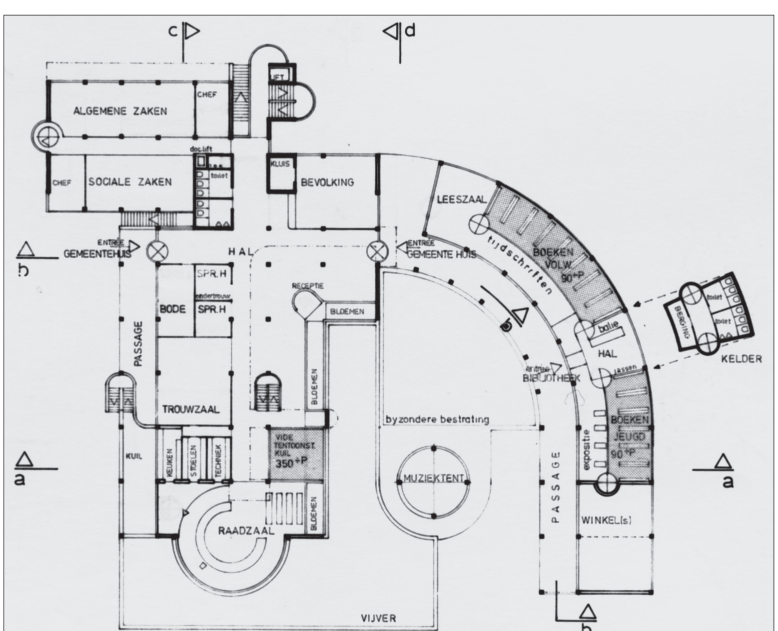


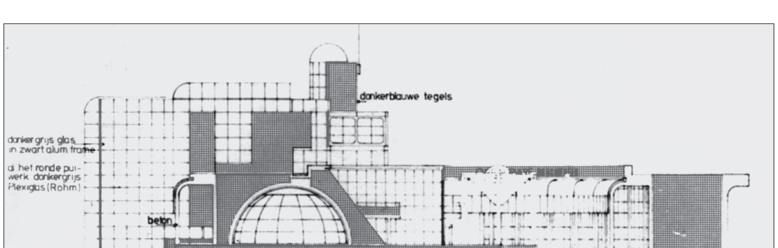


313 Library study

A simple design study for the library. The envelope for it hailed back to the design of the City Hall. For the rest, it was matter of connecting with the programme here. I have partitioned it in segments preceding fitting it in with the programme.







314 Final drawings

During the production of the presentation drawings, I work with a pencil and a pen in hand. In the way I work, I calculate before I draw; so there is not much going wrong. In addition you already see, before you start with ink, and while drawing the auxiliary lines, whether something is going right or wrong. My sketches are illegible and introverted. Designing this way is individual.

31.3 LOOKING BACK

Is this report of sketching happening in your head?

This is not a report of sketching but an elaborate programme of requirements study; I am doing this for each design.

You are unleashing your design idea on the urban context. Is this a characteristic approach?

Yes, the programme of requirements is providing a box of building blocks reacting to the location.

What is making for the initial inspiration?

My most important source of inspiration lies in a deadline. The approaching moment of presentation co-erces the making of choices. A deadline is forcing the idea; for that I do not need flowers or things like that. It is just hard work. While your designing experience is growing, you are putting greater confidence in your intuition. I panicked only once in relation to the enduring absence of a design idea in my time as a student. That also proved to be the last time. I have learned to trust the circumstance that design inspirations are coming by themselves. In addition, I have learned that designing is just hard work.

What are you doing with a dead end?

I am experiencing them regularly. But, this is compensated by my systematic way of working. If I have arrived at a dead end, I can just turn the pages back to the moment when it still went alright. It is important to me that my study is written down and dated rigorously.

At the moment I do not need this any more. For the residential project for students 'De Struyck' in The Hague a study of one A4 page was sufficient. Everything that happens, is happening directly on the computer. With a lot of designing experience, you are not in need of sketches any more; you can add the measuring mentally. Students can not do that as yet; they are lacking a sense of scale: what is 1.8 metre, what is a toilet?

What was a decisive constraint?

In practice, the programme of requirements, the budget and the method of building are decisive. And the image you have. What are you after? The shift from the programme of requirements to the image is a matter of feeling: it does not yield an image. In India I was fascinated by a red building. I made the decision my next building should become a red one. That was 'De Struyck' in The Hague.

After all, initial inspiration?

Of course one is influenced by the environment. Are not all young architects doing the same thing? One is afraid to step out of convention; it is a kind of fashion. Form convention is a more powerful constraint than the programme of requirements.

The residential project for students in The Hague had to be an unconventional building, it had to be disturbing. It is also for students. The municipality went along with this.

Are you not this way part of that convention yourself?

Of course, but with the addition, that I am conscious of that myself. An architect cannot function without convention. Peutz, for instance, designed in one year in all domestic Dutch styles. One did not take that gladly. In the Faculty of Architecture form is associated too tightly with ideology. There should emerge an exercise in convention, so that students would become conscious of these conventions. As a commission, for instance: "Design in the style of the thirties, or the style of Gehry". When you are asking students during the beginning of their study what they consider to be beautiful they tend to suggest 'farmerettes' and their ilk;

when you ask the same question after six months you get as an answer the Van Nelle factory or something like that.

Is your design process methodical?

Certainly; the study of the programme of requirements and the measuring can be ascertained and may be followed up. The form is not developed systematically, the form is a found object, like the colour in India. Sometimes there is a form fascination, like in the design of the city hall. The form arrives suddenly; like in the design for the prison in Schiedam. During the study of the programme of requirements, in one fell sweep, a form idea occurred; and ultimately it was realised. It is a intuitive process surrounding the question: under which form may the programme be housed?

In our profession there is a lot of flexibility in allocating functions; the relation form-function is very relative in architecture.

Can study in architecture be compared to that in industrial design?

In architecture the relation between the programme of requirements (the properties of the product) and the form are not fixed. Man is a flexible animal. Usage of architecture is determined by behaviour, not by ergonomics like in industrial designing. Behaviour is less readily predictable and open to study. Guidelines for a ramp for a normal human being are, for example, impossible to give. The relationship between form and function can only be given in a reduced form, for humans only in convention. From The Netherlands I can not design a house for an Indian in South-America, although I can design a rifle or a needle; then he even knows its purpose. That is the reason why architectonic study is so difficult; it does allow verification. The failure of a building can always be compensated. And if it collapses, it is not a building anymore.

The programme of requirements is playing an important rôle in architecture, but in spite of that it is only of secondary importance.

Why then so much attention for the programme of requirements?

I am a functionalist; buildings are also being judged according to functionality. The (spatial) form of function is the convention. A lord mayor can also function in an office of 10 m^2, instead of one of 40 m^2. Form convention is important; without it we could not design. The description of sleeping is not leading to the form of a bedroom, nor even to the form of a bed.

32 DESIGN BY OPTIMISATION
AN OPEN DECISION-MAKING APPROACH

PETER PAUL VAN LOON

In this contribution it is assumed that designers in architecture and urban planning constantly strive to improve their design. In doing so, they act as rational actors who, as soon as they see opportunities to improve proposals, will no longer be satisfied with their existing ones. Designers will continually strive to achieve the best result possible. In other words, they optimise outcome of their work. This process is referred to as design by optimisation, and the outcome as the optimum design, the definitions of which I shall build into this Chapter.

Some 25 years ago, the design process in architecture and urban planning was almost always headed by one, perhaps several architects, or in the case of large-scale projects, several urban designers. Today, however, a comprehensive design team consisting of all organisations involved is responsible for the process and its results. In consequence, nowadays designers other than architects also have direct and strong influence on the design: structural engineers, costing experts, traffic engineers, building contractors, governmental planners, also users, investors and local residents.

For co-operation between all these experts, specialists and decision-makers a new methodology, called 'Open Design' has been developed by the author. This methodology reflects the necessarily 'multi-actor' or 'multi-party' negotiation and decision-making in current architectural and urban design.[a]

In Open Design, the terms 'designer', 'group', and 'optimum design' are interpreted more broadly than is common in established design methodology. A designer is anyone who has an impact on a design, whether professional or not. The group of designers, therefore, also includes non-professional designers. Which design result is considered optimal is decided jointly.

The Open Design methodology consciously distances itself from the position adopted by many professional designers, who believe that professional group optimisation must be regarded as distinct from, and a necessary pre-requisite for, social group optimisation. In other words, the study sees the optimum social design not as deriviation from optimum professional design. Professional designers often refer to the social optimum as a political compromise. Such a distinction can not be drawn, and the order in which these two optima come about can not be dictated. A professional design also incorporates social views of the professionals and therefore implicitly includes their social group optimum. And a social design incorporates technical views of the non-professionals, thus implicitly including their technical group optimum. They are therefore two aspects of the same design.

32.1 THE DESIGNER AS HOMO ECONOMICUS

Optimisation is, within the context of rational action, goal-orientated. Rational, goal-orientated action differs from traditional action determined by custom. It also differs from affective action, which involves unrestricted response to external stimuli and from idealistic action, whereby the individual does what he considers to be his duty, irrespective of results.[b]

As far as rational goal-orientated action is concerned, one distinguishes between economic and non-economic goals. Economic goals are those which require use of scarce resources that could be used alternatively. All other goals are non-economic. It is possible for economic and non-economic goals to conflict. For instance, if a private individual seeks to meet his accommodation needs rationally and economically by having an affordable (cheap) house designed and built, this might conflict with his non-economic goals regarding the (expensive) aesthetic quality and status of the house.

a Loon, P.P. van (1998) *Interorganisational design, a new approach to team design in architecture and urban planning;* Gunsteren, L.A. van and P.P. van Loon (2000) *Open design, a collaborative approch to architecture*.

b M. Weber, 1922 in: Doel, J. van den (1978) *Demokratie en Welvaartstheorie*.

In the seventies it was assumed that, in order to be rational, an actor acts as a Homo Economicus who[a]:

- is fully informed about the various economic options;
- operates completely rationally;
- aims to optimise the expected economic value;
- and is influenced by measurable results only.

These assumptions later came under heavy criticism. Complete information is never available, no one behaves in a completely rational way, people do not always strive to achieve the best result, and results, also not to be measured, play an important rôle. As more insight was gained into the actual state of affairs, it was concluded that an actor is not always consistent and focused. Human action also involves intuition, tradition, trust and impulse. Goals are often determined after choices have been made. Decisions are, therefore, often made in an unpredictable order.[b]

32.2 GOAL ORIENTATED DESIGN IS NOT DOOMED TO FAILURE

This is not to say that every method in design and decision-making, which assumes that an actor tackles his problems in a targeted and focused way is doomed to failure.[c] One can regard many, if not most, activities as focused. Nevertheless, one should be aware of the fact that there are, in reality, situations in which designs and decisions come about without explicit goals. In these cases appropriate goals are set both during and after the design/decision-making process. In such situations it is still possible to reconstruct the relationship between goal and solution.

In decision-making theory, such situations are said to involve 'limited rationality', indicating the limitations of people as decision-makers.[d] These limitations are connected to: the image of a decision-making problem (lack of knowledge means that the problem is not always a 'given fact' and is therefore difficult to define and the image is limited and subjective); the availability of solutions (alternative solutions are not usually provided, but have to be sought or devised); the awareness of the effects of solutions (It is often not known what can be achieved with a particular solution).

32.3 DESIGN AT A SATISFACTORY LEVEL

Herbert Simon[e] postulated that it is not always possible to maximise profits, and introduced the idea of the 'satisfying' principle (minimising complications and risks).[f] This holds that actors strive only to achieve a limited, usually concrete level of aspiration, because their image of a problem is limited by incomplete knowledge and shortage of time to spent on the problem solving process and because solutions still have to be devised and the effects of the solutions are not entirely known. The criterion is then not 'the house must be as big as possible' but 'the house must have 200 m^2 of floor space'.

Describing decision criteria as specific levels of aspiration offers important practical and theoretical advantages, even if those involved have only a vague notion how their situation could be improved. It is an unambiguous means of measuring whether the goal has been achieved.

Van den Doel (1978, p. 40) states that the fact that formulating decision criteria as 'levels of aspiration' offers advantages must not automatically lead to the conclusion that individuals do not seek to achieve a maximum. The inaccuracy of this conclusion can be demonstrated by distinguishing between subjective and objective rationality. A decision is subjectively rational, if a decision-maker attempts to maximise his goal function. It is objectively rational, if this maximum is actually achieved. The gap between subjective and objective rationality arises partly because of lack of information about alternatives and their implications, and partly

a Davis, G.B. and M.H. Olson (1985) *Management information systems*. p.231

b Boersma, S.K.T. (1989) *Beslissingsondersteunende systemen; een praktijkgerichte ontwikkelingsmethode*, p. 39

c Doel, J. van den (1978) *Demokratie en Welvaartstheorie*, p. 39

d Boersma, S.K.T. (1989) p.23.

e Simon, H. (1957) *Administrative behavior;* – (1969) *The sciences of the artificial*.

f Boersma, S.K.T. (1989) p. 20-22.

because of the impossibility of taking all information into account. The actor optimises: he looks for the best solution from given, offered or known solutions.

In terms of design this means that the designer attempts to achieve a satisfactory level of design result. Achieving this does not necessarily mean he will always be entirely content. For instance, as soon as he receives more information, his level of aspiration will rise and he will attempt to reach that level.

32.4 THE COMBINATIONAL EXPLOSION OF SUB-DESIGNS

These ideas about optimisation on the part of the individual designer are often also applied to whole design teams. In a team, all members' ideas and proposals are collected, arranged in order of preference and combined with alternative solutions. The team then chooses the best. This represents the basis of what we might call 'classic' (or 'systematic') design methods, most frequently used in practice. These methods developed from a succession of techniques, allowing teams to combine and select more effectively, more efficiently, more rapidly.

However, once design commissions became more complex and teams more inter-disciplinary and larger, the design process began to run aground more frequently. The enormous number of sub-solutions produced in these large teams and the complexity of combining alternatives meant that it became impossible to find solutions satisfactory for everyone. The technical refinement of classic methods, refinements in terms of the calculation procedures for combination and selection, did not solve the problem. On the contrary: they allowed so many possibilities, that they caused a combinational 'explosion' (see page 208). In other words, the calculation time needed to find the best combinations from all possibilities had become so excessive that the process had become virtually unmanageable.

In practice, many professional designers therefore rejected the systematic design methods they had been taught, simply in order 'to make good plans', they then tried to sell using charisma and powers of persuasion. In so doing, they turned their backs to a large extent on team design.

32.5 THE DESIGNER AS HOMO SOCIOLOGICUS

In the shift from classic design methods, based on the individual situation, to the group situation, design methodology overlooked the fact that these methods were based on an excessively narrow definition of rationality: the rationality of Homo economicus of the 1970s. The idea that a decision-maker, or designer, in the process of optimising, rationally compares conflicting preferences and arranges them in a fixed order before choosing the best one and that the designers in a team, in the process of optimising, also make a rational comparison and determine a fixed order, then for all preferences together, before choosing, is too limited for team design.

Later, in the 1980s, rational choice theory showed that rational decision-making in groups could also be structured using a broader definition of rationality. The image of Homo Economicus was replaced by Homo Sociologicus, thus replacing economic rationality with sociological rationality.

Pellikaan and Aarts summarised this by distinguishing between the thick theory of rationality and the thin version.[a] Thick theory assumes maximisation of the outcome and specifies the goals, objectives and preference orderings of actors. Thin theory assumes some sort of maximisation and specifies conditions for the preference orderings of actors, but does not specify any particular goal, objective or preference ordering.

This difference can be illustrated using the well-known Prisoner's Dilemma from decision-making theory (a theoretical formulation of a human dilemma that had already been described by philosophers like Hobbes and Hume).

a Pellikaan, H. and K. Aarts (1996) *Potential and actual social dilemmas, rational choice in survey research.*

Row – Player		Column – Player	
		Co-operate / do not Confess	Defect / confess
	Co-operate / do not confess	Outcome Q (1 year, 1 year) Neither player confesses the major crime; they are tried for minor crimes and get one year each.	Outcome S (20 years, 0 year) The column player turns state's evidence and is freed. The row player is convicted and gets twenty years.
	Defect / confess	Outcome P (0 years, 20 years) The row player turns State's evidence and is freed. The column player is convicted and gets twenty years.	Outcome R (10 years, 10 years) Both players confess, are tried for the major crime and get ten years each.

315 The outcome matrix of the original Prisoner's Dilemma (after: Pellikaan and Aarts, 1996)

		Column – Player	
		Co-operate	Defect
	Co-operate	Outcome Q (3,3).	Outcome S (4,1) a
	Defect	Outcome P (4,1)	Outcome R (2,2)

316 The payoff matrix of the original Prisoner's Dilemma (after: Pellikaan and Aarts, 1996)

In the original Prisoner's Dilemma two players have a choice between two strategies: co-operate (do not confess) or defect (confess). The combination of two players with two possible strategies yields a matrix with four possible cells. Figure 315 is the outcome matrix of this game, describing the physical consequences for every possible combination of choice by both players. The outcomes in figure 315, however, do not imply the dilemma. The dilemma only arises after the players have established their utilities or payoffs for the four outcomes.

The problem in figure 315 is one-dimensional because the players are assumed to consider only the self-regarding motive indicated by the number of years they personally will spend in jail. The self-regarding motive 'prefer a shorter term for yourself to a longer term' leads to the following preference ordering: 0 years > 1 year > 10 years > 20 years. This preference ordering corresponds with P > Q > R > S or, for short, PQRS.

The preference ordering PQRS is the so-called Prisoner's Dilemma or PD-ordering. The PD-ordering is a plausible ordering for every individual placed as a (row-) player in the outcome matrix of figure 315. If both players have a PD-ordering the game becomes a Prisoner's Dilemma. The payoffs in figure 316 define the Prisoner's Dilemma game. Both players have a dominant strategy (Defect), and the result of the game is mutual defection.

The Prisoner's Dilemma was often used to show that methodological individualism and, consequently, individual pursuit of maximisation of utility, leads to a less-than-optimum collective outcome. This justifies the enforcement, from outside the group, of co-operative behaviour that would be beneficial for both players - enforcement by government or management.

These bodies do not decide what the best outcome is; they have no goals or preferences of their own, but enforce co-operation so that the individuals achieve a group optimum.

The PD model is often extrapolated to the N-individuals situation. The number of combinations of strategies then grows exponentially. Without co-operation enforced by some central authority, the collective optimum could never be achieved in an N-individuals group.

However, enforcement of mutual co-operation in groups has led to many drawbacks. Not everyone can be forced to co-operate always. Power to enforce the optimum will be limited in an open, democratic, community. There will be no consensus that people must be forced to co-operate on all collective dilemmas. An alternative for central enforcement was then sought in co-operation on the basis of commitment to others and social norms. But, because people did not always choose to contribute to collective matters, it was not possible to achieve the group optimum in some cases. The search then turned to co-operation based on the notion that iterated choices can generate co-operative behaviour. The rational actor will choose a conditional voluntary co-operative strategy. But, in a large group of actors a common knowledge of each other's behaviour was not feasible. Individual actors still preferred unilateral defection to mutual co-operation.[a]

One common feature of these three types of 'enforced' co-operation is the assumption that each individual is selfish and that this can only be held in check by central authority, commitment to others and social norms. Pellikaan introduced an alternative to this assumption: the actor's viewpoint (based on the thin theory of rationality).

The actor's viewpoint assumes that even given force, commitment to others and social norms, actors can adopt a co-operative attitude. This possibility arises because the individual's efforts to maximise utility do not mean that he seeks to achieve selfish aims. People are not selfish by definition.[b] This implies, that individuals have their own subjective preferences, their own view of the best outcome, and that in a group there will always be several preference orderings for one and the same group dilemma. Only in practice will it become clear whether a specific collective issue that is a dilemma on paper will actually appear so in

a Pellikaan, H. and K. Aarts (1996) *Potential and actual social dilemmas, rational choice in survey research*.
b Pellikaan, H. (1994) *Anarchie, staat en het Prisoner's Dilemma*.

reality. And, conversely, an issue that on paper seems uncontroversial might turn out to be a dilemma in practice.

In short, one cannot say in advance how preferences and goals will be weighted. This can only be established on the basis of concrete actions. I shall look at the optimum inter-organisational design from the actor's viewpoint below. In terms of my study as a whole, this viewpoint means that actors (designers) must, above all, have the opportunity, as they work together, to weigh up their preferences and goals during the design process. The design method they use must cater for this.

32.6 FOUR DEFINITIONS OF THE OPTIMUM DESIGN

No conceptual framework exists within which the term 'optimum design' can be unambiguously defined. Widely varying interpretations and definitions can be found in the literature. I shall divide these interpretations into four categories of conception of the optimum and the optimum design solution:

a. design conception, concerning the optimum form;
b. planning conception, concerning the optimum choice;
c. mathematical conception, concerning the arithmetical optimum;
d. welfare economics conception concerning the optimum distribution.

a. The optimum form

The design conception of optimality and the optimum design can be found in architectural design theory and also in general design methodology. Here, one is concerned with 'good' design, the 'best' design and 'high-quality' design. Architects often use the term 'optimum form'. The differing theoretical and methodological bases are found mainly in design and design method manuals.[a]

The design conception can be characterised by three aspects of the optimality of a design. The first concerns optimum quality; mainly the architect's concern. Architects believe that their most important task is to create a design of the highest possible architectural quality. In their view, this quality is defined in the debate among architects themselves and between architects and their critics. This determines the different movements, what style is acceptable, and what is regarded as good and bad quality (see legislation governing the architectural profession).[b] The best designs are those, which the architectural profession and its critics regard as the best. A similar process is found in the arts (visual, music, dance, etc.). It is often said that the process has to work in this way because outsiders (principals and users) do not know what 'architectural quality' is. Only the professionals can decide this.

The second aspect concerns the optimum selection and combination of sub-solutions, defined by design theorists. They hold that an optimum design can be achieved only through an optimum design process. The design process is optimum only, if all sub-solutions are first systematically and explicitly collected and selected, after which the selected sub-solutions are gradually combined. It is recognised that the choices made during the selection and combination process are determined not only by the requirements the new product will have to meet (never clear and comprehensive), but also by the inventiveness of the designer and the generally accepted wisdom at that moment about what is best, or what is normal and *en vogue*.

The third aspect involves meeting the requirements the optimum way, the most practical of the three. It is assumed here that the requirements of a principal have been formulated in such a way that the designer knows exactly to what extent his design meets them. They need not be comprehensive and explicit right from the outset; they can be finalised during the process. However, principal and designer must stick to their rôles: the principal formulates requirements, designer finds the solutions.

a Jones, J.C. (1970) *Design methods: seeds of human futures;* Broadbent, G. (1973) *Design in architecture: architecture and the human sciences;* Foqué, R. (1975) *Ontwerpsystemen, een inleiding tot de ontwerptheorie;* Lawson, B.R. (1990) *How designers think, the design process demystified.*

b VROM, Ministerie van (1987) *Wet op de Architectentitel*.

In the past many attempts were made to link the three aspects methodologically. The systems approach, particularly its mathematical side, and operations research were usually taken as a basis. The idea was not to create mathematical models for the design process but to analyse it systematically, almost mathematically, and divide it into a large number of sub-processes. Methods for structuring the individual sub-processes were developed, so that optimum partial results could be achieved. A whole generation of design methods emerged this way in the 1960s. Jones (1970) managed to bring some order to the chaos created by this proliferation of new design methods.

However, after many studies and experiments, it became clear that this was no way to determine the conditions required for an optimum design. It was found that an optimum design is not simply the sum of optimum sub-designs. Foqué maintains that the attempts at integration were too technocratic, based on an exclusive belief in the logical analytical thought process, in total rationalisation of action and in 'scientific method'.[a] This negative conclusion dogged the development of design theory and design methodology for many years. In the 1980s, with the advent of computer aided design techniques (CAD), it was given new life. However, renewed study of optimum design has yet to get off the ground.[b]

b. The optimum choice

The planning conception of optimality and the optimum design can be found in planning theory. This conception is an elaboration of one aspect of the design conception: optimum combination of sub-solutions. Planners refer to the 'optimum choice from alternative possibilities'.

Planning theory assumes that the problems planners are called upon to solve are ill defined. There is uncertainty both as to the environment within which the problems arise and as to the values and objectives one must attempt to achieve. This means the problems cannot be fully quantified and, consequently, quantitative planning techniques cannot be used. In order to achieve an optimum outcome nevertheless, a 'rational planning process' must be followed: *"enumerate the finite number of alternative programmes, evaluate them and select one, thereby invoking a decision rule like (mathematical, PPvL) optimisation"*.[c]

Several authors developed prescriptive models for the planning process along these lines.[d] They see it not as a strict timetable of activities which is determined in advance, but as a learning process: the more problems come to light, and the more alternative solutions are devised, the better one will understand the problem and the better solutions one will find. If this process is structured systematically and rationally, the best (optimum) plan comes about 'automatically'.

c. The arithmetical optimum

The mathematical conception of optimality and the optimum design can be found, inter alia, in operations research (OR), where the term arithmetical optimum is most commonly used.[e] Operations research is *"the application of scientific methods, techniques and tools to problems involving the operations of a system such as to provide those in control of the system with optimal solutions to the problem"*.[f] Mathematical decision-making models are central. Operations research is concerned with 'the scientific method', i.e. 'a scientific (typically mathematical) model' which reflects the essence of how a real decision-making problem is constructed, and can then be used to calculate the optimum outcome. It is assumed that it is possible to create a mathematical representation of reality allowing mathematically optimum solutions to be derived valid in terms of that reality.

In operations research a number of models have been devised for various types of decision-making problems.[g] Although these models are complicated from a mathematical point of view (practical problems are always complex), their basic structure is simple.[h] This structure can best be illustrated using the linear programming model (LP model).

a Foqué, R. (1975) *Ontwerpsystemen, een inleiding tot de ontwerptheorie,* p.63.
b Loon, P.P. van (1998) *Interorganisational design, a new approach to team design in architecture and urban planning.*
c Faludi, A. (1973) *Planning Theory.*
d Friend, J.K. and W.N. Jessop (1969) *Local government and strategic choice, an operational research approach to the process of public planning;* McLoughlin, J.B. (1969) *Urban and regional planning, a systems approach;* Chadwick, G. (1971) *A systems view of planning, towards a theory of the urban and regional planning process.*
e Ackoff, R.L. and M.W. Sasieni (1968) *Fundamentals of operations research.*
f Boersma, S.K.T. (1989) *Beslissingsondersteunende systemen; een praktijkgerichte ontwikkelingsmethode*, p. 18
g Ackoff, R.L. and M.W. Sasieni (1968); Wagner, H. (1972) *Principles of operations research.*
h Boersma, S.K.T. (1989) p. 52-54.

The LP model consists of a set of linear equations (equalities and inequalities) (see page 221). This model can be solved mathematically using the simplex algorithm (see page 223). Its application is known as linear programming: the determination (systematic calculation) of the minimum or maximum value of a linear function (objective function) in the area defined by the linear equations (constraints). The problem faced by the housing association at the end of this Chapter is an example.

In OR, the mathematical definition of the optimum design is fairly simple: the outcome of the mathematical model whose value for the objective function is best, i.e. highest in the case of maximisation, or lowest in the case of minimisation.

Mathematical optimisation is used for many economic and commercial problems. In such cases, mainly financial and organisational goals are optimised: maximum profit, most efficient allocation of responsibilities, fastest production flow. It has also been used in building and urban development, and again in financial and technical objectives (like the maximum number of houses in area B, optimum division of floor space and land use, minimisation of energy consumption, etc.).[a] Goals concerning things like quality of the living environment, equitable distribution of space and preservation of existing culture or environment do not figure. 'Soft' social interests have always been put off by the technical nature of mathematical optimisation. This is not justifiable, since quality, equity and the like also lend themselves to mathematical optimisation.[b]

d. The optimum distribution

The last conception of optimality and the optimum design is derived from 'welfare theory'. As far as I am aware, welfare theory is not concerned with design - unfortunately, since this theory could have important implications for decentralised design, especially design projects that have to be completed in a dynamic decision-making environment. Welfare theory allows a link between democratic decision-making on one hand, and design within a team on the other.

Welfare theory is part of economics. Its exponents concern themselves with group welfare, by which they mean not the material wealth in itself of a particular group but the group's welfare to the extent that it is dependent on scarce (economic) resources. Welfare theory studies the allocation of resources, usually in the form of public goods, within a group (a society), including both costs and benefits associated with a particular allocation.[c]

Pareto's criterion provides a scale for measuring increase in the collective welfare of a group.[d] It is deemed to have increased if the welfare of one or more members of the group increases, without diminishing the welfare of other members. The criterion not only comprises a measure of the direction of change, but also its end point. According to it, collective welfare is optimal as soon as it is no longer possible to increase the welfare of one or more individuals without decreasing that of one or more of the others.

Pareto's criterion does not imply a value judgement.[e] It does not dictate that collective welfare must increase, but merely offers a means of measuring increase. It must be known which groups are enjoying the increase. *"If, for instance, it is only individuals with a relatively high income who profit from an increase in welfare, the change merely accentuates the unequal distribution of wealth and can be rejected on these grounds, despite the fact that Pareto's criterion has been met"*.[f]

If a design is regarded as a plan for distribution of costs and benefits among parties involved, Pareto's criterion can be applied. The design is then optimum, when it can no longer be improved to the benefit of one or more of those involved without diminishing the benefits enjoyed by one or more of the others, benefits they would enjoy if one of the earlier versions of the plan were implemented.

a Catanese, A.J. (1972) *Scientific methods of urban analysis;* Lee, C. (1973) *Models in planning, an introduction to the use of quantitative models in planning;* Lee, C. (1973) *Requiem for large scale models;* Radford, A.D. and J. Gero (1988) *Design by optimization in architecture, building and construction*.

b See: Gunsteren, L.A. van and P.P. van Loon (2000) *Open design, a collaborative approch to architecture;* Loon, P.P. van (2000) *Design by optimization*.

c Doel, J. van den (1978) *Demokratie en Welvaartstheorie*, p. 22.

d Pareto (1906), in Doel, J. van den (1978) p. 59.

e Doel, J. van den (1978) p. 60.

f Idem.

Practical objections to Pareto's criterion arise from the fact that changes in welfare seldom meet the criterion, since almost every gain for some entails loss for others. Van den Doel mentions the 'compensation principle' formulated to overcome these objections.[a] This principle involves assessing whether the 'winners' are able to compensate the loss suffered by the 'losers'. *"If the winners enjoy such a large profit that, after the losers have been compensated for their loss, a net profit still remains, it may be said that the change in welfare is potentially an improvement in terms of Pareto's criterion"*.

32.7 THE OPTIMUM DISTRIBUTION INTEGRATED WITH THE ARITHMETIC OPTIMUM

The four conceptions can be integrated into one definition by expanding the welfare conception to encompass the others.

The welfare conception and Pareto's criterion are used in practice only to discuss actual changes in collective welfare. But, the theory can also be used to analyse welfare changes in a 'designed', not yet effected, distribution of costs and benefits, as indicated above. The theory is then applied during the process in which a group (society) makes and discusses proposals for allocating the finite resources available. The final proposal accepted by the group can then be put into effect and separately evaluated in terms of welfare theory.

In this context, there is a major difference between the design and the implementation stage. At the design stage, the group can freely put forward and discuss proposals. Positive and negative impacts on collective welfare exist only on paper and are therefore intangible. This freedom no longer exists at the implementation stage, since each action has a tangible effect.

If Pareto's criterion is used at the design stage to measure changes, the group can explore all kinds of alternative welfare effects and is still free to compare them. At the implementation stage, the existing level of welfare is the benchmark for Pareto's criterion. At the design stage, the group can decide on its own benchmark, what it will take as minimum constraint. Pareto's criterion can therefore be expanded for the design stage, with the following result:

Collective welfare might increase in response to the implementation of a particular design, if the level of welfare of one or more members of the group increases without causing that of one or more other members to fall below a minimum which these members have set themselves.

This implies that part of the group might enjoy a lower level of welfare than at the outset, since the lower limit they have set might be below present level. It might, however, be higher, if the members concerned feel that there should be a certain minimum increase in actual welfare. The optimum design can then be defined as follows:

The optimum design is achieved when the level of welfare of one or more members of the group can no longer be raised without causing that of one or more other members to fall below the new minimum.

The mathematical conception can be brought in at this juncture, although with an altered view of the rôle of mathematical models in finding solutions (or creating designs).

Normally, a tried and tested model will be used to solve a particular problem. The mathematical method, the main structure and most of the model equations have already been determined. Often, many of the inputs are delivered along with the model as fixed data. Users can generate alternative outcomes only by using variations in the free data of the model. The calculation technique assures that these outcomes represent the mathematical optimum. It is therefore virtually impossible for users not sufficiently versed in construction of mathematical models to use the model to find the optimum according to Pareto. The fixed structure and fixed data make it difficult for them to perform the necessary exercises within the upper and lower constraints of the solution space. This is, however, possible if mathematical methods and techniques are used in such a way, that the design team in principle determines and con-

a Doel, J. van den (1978) *Demokratie en Welvaartstheorie*, p. 61

trols everything in the mathematical description of solution space and constraints. The team must have at all times the opportunity to make changes to the mathematical model (equations, structure and data). The mathematical methods and techniques form no obstacle in themselves. A problem arises when a model has many fixed components incorporated by the individual who devised the model, on his own authority, on the grounds that this was the only - mathematically sound - way.

A mathematical description of the optimum group design, which is in line with the welfare definition, might read as follows:

The design is optimal if the value of the objective function cannot be raised (in the case of maximisation) or lowered (in the case of minimisation) without breaching the limits set by those involved.

One example of this is the solution to the problem faced by the housing association in the following.

32.8 THE HOUSING ASSOCIATION'S DECISION MAKING PROBLEM

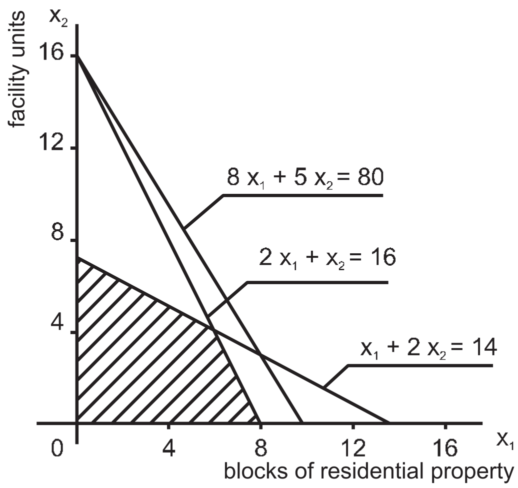
We briefly repeat the exercise of page 221. A housing association wants to build a number of blocks of residential property and facility units (shops, school, social and cultural centre, etc.) on a particular site. The site covers 14,000 m^2. The association hopes to complete the project within 16 months. A block (construction time 2 months) covers 1,000 m^2, while a facility unit (construction time 1 month) covers 2,000 m^2. A residential block costs 8.10^6 guilders, and a facility unit costs 5.10^6 guilders; the overall budget is 80.10^6 guilders. It is not necessary to cover the entire site. A survey has been conducted among future residents. This revealed that they value housing blocks and facilities at a ratio of 5:3. The aim is to ensure that the future residents are as pleased with their neighbourhood as possible.[a]

This problem can be represented mathematically in an LP model. X_1 is the number of blocks of residential property and X_2 the number of facility units. Two decision-makers are involved in this problem: the housing association and the future residents. The housing association decides what site area is to be built on, how long the building work will take how much it will cost and sets out the timetable for the project. The future residents decide on their opinion of the houses and facilities. These give the decision variables. The input variables are the total budget (80.10^6 guilders maximum) and the land available (14,000 m^2 maximum). They have been determined by the local authority within the constraints of its overall urban plan and the regulations governing its housing budget. The future residents want to see their views taken into account to the greatest possible extent, so $5\ X_1 + 3\ X_2$ must be maximised. The housing association wants to complete the project within 16 months and sticks to its decisions regarding construction costs, construction time and site area. These are the goals; they can be represented as follows:

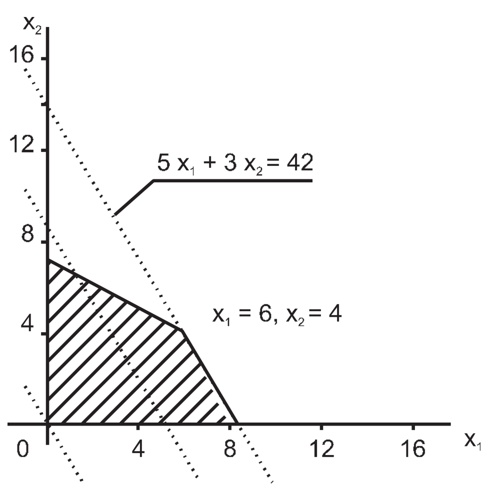
maximise:	$5\ X_1$	+	$3\ X_2$			(appreciation)
constraints:	$1{,}000\ X_1$	+	$2{,}000\ X_2$	$\leq$	14,000	(site area)
	$2\ X_1$	+	X_2	$\leq$	16	(construction time)
	$8.10^6\ X_1$	+	$5.10^6\ X_2$	$\leq$	80.10^6	(budget)
			X_1	$\geq$	0	
			X_2	$\geq$	0	

The simplex algorithm (a mathematical procedure which allows an LP model to be solved with 2 or more unknown variables) can be used to find the mathematical solution. Since the example has only two unknown variables, it can be solved using a simple drawing. This can be explained simply and allows the mathematical solution to be presented graphically. The problem facing the housing association is represented in figure 318.

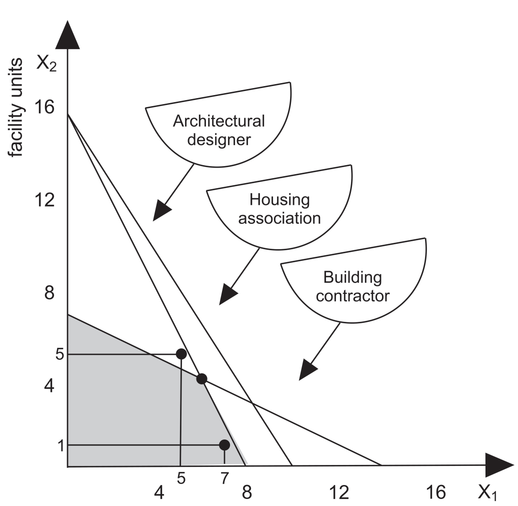
a This example is given by Berkhout and de Graaf, published in Horssen, W.T. van and A.H.P. van der Burgh (1985) *Inleiding Matrixrekening en Lineaire Optimalisering*, p. 57-59.



318 The solution space (shaded)



319 The objective function



320 Position of qualitatively optimum designs in relation to the mathematically optimum design

The maximum value of the linear equation $5X_1 + 3X_2$ (the objective function) must be found within the shaded area. Consider the group of parallel lines $5X_1 + 3X_2 = c$. The highest possible value of c has to be obtained, within the constraints. This can be achieved when $X_1 = 6$ and $X_2 = 4$, because $c = 42$. The best outcome is achieved with 6 housing blocks and 4 facility units (figure 319).

The housing association and the future residents will undoubtedly continue negotiating their decisions and goals after this 'initial' solution has been found. Such negotiation is useful in order, to establish for instance, whether a change in the construction costs might better suit preferences of the residents. Other, cheaper building materials could lower the costs, which might lead to a better distribution of houses and facilities.

32.9 THE OPTIMUM FORM INTEGRATED WITH THE OPTIMUM CHOICE

The design conception can easily be integrated with the foregoing. The first aspect of this conception - meeting the requirements the optimum way - has already been incorporated into the mathematical definition of the optimum design, since these requirements are represented in the mathematical constraints. The second aspect - optimum selection of sub-solutions - is addressed below, when the planning conception is incorporated. The third aspect - optimum quality - can be integrated as follows. The best alternative designs approved by architects as good, in terms of quality, can be divided into designs which fall within and outside the constraints of the best Pareto solution. This can even be determined unequivocally using a mathematical model. This also applies to designs which lie exactly on the point representing the mathematical optimum: the best designs. However, if there is no design at this point, a choice will have to be made from the designs within the solution space.

In the mathematical solution to the housing association's problem, the position of a design within, or outside, the solution space can be illustrated as follows (figure 320):

a. The quality plan within the solution space

If an architectural design has been made for a residential block that covers 1,400 m^2 of land and a facility unit that covers 2,500 m^2, the new optimum lies at the point $X_1 = 7.2$, $X_2 = 1.6$ (the new site area constraint: $1{,}400\ X_1 + 2{,}500\ X_2 < 14{,}000$). If the figures are rounded off, the architect is actually proposing to build 7 residential blocks and 1 facility unit.

b. The quality plan outside the solution space

If the architectural design requires 900 m^2 for a residential block and 1,800 m^2 for a facility unit, the new optimum solution lies at the point $X_1 = 5.1$, $X_2 = 5.2$ (the new site area constraint is $900\ X_1 + 1{,}500\ X_2 < 14{,}000$). In this case, 5 residential blocks and 5 facility units can be built.

Finally, the planning conception. This plays a rôle in the rational choice of alternatives falling within the constraints. The design team must agree on how to choose between these alternatives: whether to decide by vote, leave it to principal or designer, or to try to reach consensus as a team. The optimum design is the design selected according to the agreed procedure from the alternatives falling within the constraints.

Integration of all these conceptions produces the following definition of the optimum design:

The optimum design is the design selected by an explicitly defined procedure from alternatives falling within mathematically defined constraints accepted by those involved.

This definition is consistent with the Open Design viewpoint from which I looked in this Chapter at multi-actor design optimisation. After all, it includes all key features of 'multi-actor' or ‘multi-party’ negotiation and decision-making in current architectural and urban planning: the organisations involved in the design team determine each independently a part of the solution space; everyone has a say when it comes to selecting alternatives; and the organisations consult about the choices they make.

32.10 ACCEPTANCE OF AN OPEN ENDED OUTCOME

The collaboration between various designers often gets stuck. Solutions to get the ball rolling tend to be characterised by compromise rather than synthesis, as a result of the autocratic way of decision-making by a limited number of expert designers.

Some causes of this rather disappointing state of affairs:

- Combinatory explosion: there are more possibilities, opinions, alternatives than any one player can handle.
- Power games: players try to dominate.
- Unilaterally sticking to certain concepts: architects tend to nourish solutions originating from themselves rather than from others.
- Conflicts of interest: parties try to defend their own interests so vigorously that a solution for the project as a whole becomes impossible.
- Stubbornness: sticking to conventional and familiar concepts.

The process leading to an open design, i.e. a design in which the interests of all stakeholders are reflected in an optimal manner, is complex. To communicate outcomes, to gain acceptance for these outcomes, to avoid stalemate situations, to maintain momentum, etc. – the management of the entire open design process – is in practice even more crucial to success than the methods and computer tools involved.

When the interests of all designers must be incorporated in the design, no one can predict beforehand how the design will ultimately look. Since the end product is unpredictable, the management of open design must focus on process rather than content. The outcome of that process remains open-ended.

33 OPTIMISING PERFORMANCE REQUIREMENTS

PIET HOUBEN

Western societies are changing into knowledge societies. Architectural engineers are expected to change with them as well. Characteristic for a knowledge-based society is inter-action and communication between people with different backgrounds in terms of professional discipline, culture and life-style. It calls for people getting out of the shell of personal professional discipline, of reassuring norms and values, of personal life-style and aesthetic taste; while communicating openly and creatively. The sociologist Jürgen Habermas talks about 'acting communicatively'. The term 'acting' is indicating, that people are conscious about the context in which they meet, prepared to recognise that there are several ways of looking, and that this multiplicity should be catered for in solutions to be designed.

Developing a programme of requirements is a fine opportunity for acting communicatively; since the development of performance requirements for a building is taking place during a process in which several agents discuss and negotiate with one another on the content of these requirements. Sequentially: in the commission, the statement of points of departure, the sketched design, the programme of requirements, and in further documents the performances to be delivered by the building have been made increasingly more explicit; differentiated further and more specified. Certain requirements may well be getting more weight during the process; or may be rather weakened. Particular requirements may end up higher, equal or lower than on the usual moment to assess a certain performance. It is also possible that, ex post performances may be read in the design that were not topics of discussion at all. In such cases it may concern, for instance, routine, prevailing norms or performance requirements based on official prescriptions beyond discussion.

33.1 METHODICAL APPROACH

The present Chapter is dealing with methodical points of departure for acting communicatively in order to formulate performance requirements, from which parties concerned are expecting that they are leading to optimal results.[a] In this context, 'optimising' means to make actors conscious of the fact that they are playing in the concrete situation a rôle in creating the best possibilities for that situation and the near future. The emphasis on 'best possibilities' is related to the fact that by all kinds of modernising trends changes in science and society have come to the fore strongly. If people, professionals, and therefore agents in the design process do not want to be swept away themselves by the present, post-modern stream of changes, it is a necessity to make choices in order to follow that stream as responsibly as possible. In this context optimising is implying that people want to facilitate in the design the development they consider to be desirable.

When agents in a design process want to strive for optimising their choices like that, they should found their considerations well, while inviting criticism; where needed, they are 'criticising' statements on the performances of the building to be realised. In this, criticism means to say: an argued effort to 'improve upon' the statement of someone on a performance, deemed probable or desirable.

These developments show that from the stand-point of methodology allowance should be made for the increasing variety of visions for the performance requirements of the building within a technological and social context, in which a strong pressure heading upwards for quality is prevailing. How to deal with the ensuing proliferation and development of performance requirements? How can there be balanced attention for aspects between content and relation? How can right be done to the fact that the agents in this post-modern era are 'learning' professionals?

a Houben, P.P.J.A.M. (1992) *Methodisch innoveren in de ouderenhuisvesting*.

In order to have the process of critique run well, the following three methodical aspects are of importance:

- Balanced attention for aspects of the process in terms of content and relation
- Critique articulated according to the specific domain of reality
- Phased plan development and crucial rôle of the encompassing concept.

33.2 BALANCED ATTENTION FOR ASPECTS OF CONTENT AND RELATION

Since in all segments of society households of 'command' are making place for 'negotiating' households, communication in the designing process has changed in character. The historical central position of the architect gave way to a situation in which responsibilities for the design were shared by other disciplines. The relationship with the modern commissioner towards a dialogue has evolved as well; while he can formulate – assisted by experts; or not – a clearer picture of the desirable programme of requirements and type of architecture. More than ever before, representatives of the users of the building are voicing what needs and desires live with them in terms of performance requirements.

As in all processes of co-operation, within a team of designing agents communication not only entails exchange in terms of content, but also in those regarding relation. How people relate to one another proves to be at least as important for realising a good design as the quality of the input of content. By the way of communicating a 'platform' must be created, so that all, or at least the most important agents, should be backing the design to be realised. That may be difficult, when certain distributions of power, or forms of dominant behaviour stand in the way of a sound discussion of content. It is not for nothing, that occasionally a process consultant is hired to ensure that aspects of content and process come to the fore in a balanced way.

In today's post-modern times it is striking that performance requirements are changing at a more rapid rate. In the arenas of building technology, architecture and society are causing a sweeping stream in terms of improvement and innovation in buildings. It is characteristic for innovations that they – in contrast with a more gradual increase of the quality in improving – are performing a 'Quality Jump'. This is expressed in a new mix of quality requirements and a more than gradual improvement of quality levels. In order to be able to innovate, agents concerned in the designing process must be open to the most recent knowledge and insight; and to an approach rather more experimental than before. Since the actors are usually only aware of the newest developments in their own field of expertise and social niche, the communication process needs reserve space for discussion. In analogy with the contemporary principle of the 'learning organisation', agents in a designing process will develop themselves mutually, in order to reach better results. So its is desirable, that the designing process should be phased in a certain way.

33.3 TOWARDS A CRITICISM BASED ON A SECTIONALISATION OF REALITY

During the process, discussions are held regarding quite varied performance requirements, some of which will be new to some of the actors involved. Developments and standards within every concerned discipline, changes in norms and notions of quality in relevant social sectors, and increasing variation in forms of lifestyle all lead to dynamics in, and increasing pressure on, the results to be achieved. Based on the developmental perspective on optimisation outlined, a well-balanced way of looking at reality is desirable. An important aspect is that one distinguishes between three different fields of reality in which performance requirements can be developed, to wit:

a. empirical science and technology
b. social values and norms
c. individual preferences and needs, and aesthetic criteria.

Employing this sectionalisation in the criticism process is essential if optimisation is to occur. It is also important that statements about performance requirements in each of these fields be tested against qualification criteria that apply specifically to the field in which they are made. Development in each of the fields becomes hampered, as soon as evaluation criteria from other fields are employed during the criticism process. Developments in society (and the buildings designed for it) benefit from an equality in how these fields are used during the processes of communication and criticism. Before addressing the dangers of using these unequally, let us first identify the most important types of assessment criteria, per field:

a. Empirical science and technology

In the field of empirical sciences and technology, the criteria that apply are derived from description and explanation of phenomena as true to reality as possible; these criteria involve efficiency and suitability of a certain measure. In the design process, the state of science and technology determines the best solution for a problem at that point in time, as well as the performance requirements that can be generated from this solution in the building to be designed.

The field of insulation, for example, deals with statements within this field that exclusively address the insulation value of a certain kind of windowpane, or thickness of the glass.

These kinds of objective statements in the field of empirical science and technology must not be confused with statements about the two other fields. Towards this end, statements about perceivable or expected insulation values must not be confused with society's or an individual's desire for insulation.

b. Social values and norms

In the field of social norms, statements in the design process must be tested against the currently prevailing notions about quality, and the customary norms regarding presentation requirements.

Arguments for criticism can then initially be tested on the basis of how, in the social debate and in the political decision-making process, norms and performance requirements considered desirable by a society are thought of and decided upon. This field has been set in motion, on one hand, by economic and technological developments and individualisation, and on the other by increased information about these things as a result of television and electronic tools. The modern phenomenon of "social debate" facilitates these dynamics. Critical, contemplative science contributes to the clarification of opportunities in these kinds of debates.

On the topic of insulation, for example, the debate revolves around insulation norms that address considerations of a clean environment and durability on one hand, and around affordability and economical feasibility on the other. Again, these kinds of considerations must not be confused with the preferences and tastes of, future users, for example.

c. Preferences and needs of individuals; aesthetic criteria

The third field concerns the one of 'Taste'. It is comprising preferences and needs of would-be future users as well aesthetic criteria regarding designing. Neither the sciences – see the first domain – nor society – see the second domain – can command from an environment in which both domains of reality are equitable, prescribe and ordain what someone needs to experience and think consciously; or to what demands an architectural vision on designing should comply.

It is up to the individual to open up in terms of his/ her feelings and conceptions. Someone else can help that person in the creation of favourable conditions whereby someone can circumscribe and motivate authentic experiences and conceptions. This is particularly important for realising a personal style of living, working and housing. Market studies of the last decades demonstrate that preferences of consumers are becoming increasingly volatile.

Opinions of individual persons, for instance, on heating and isolation may be varying; because of differences in somatic-sensorial experience; in aesthetic preferences regarding noise-isolating measures taken for buildings and in awareness on the use of care for the environment; and thermal isolation balanced against personal financial possibilities.

The same applies to architectural vision on designing. Obviously, discussions about aesthetic perspectives and points of departure are viable, but arguments in the matter do need to restrict themselves to this domain; and should not be entangled with discussions on the functionality of the building to be realised – first domain – or social norms, - second domain.

33.4 PHASED PLAN DEVELOPMENT AND CRUCIAL RÔLE OF ENCOMPASSING CONCEPT

The designing process is in need of a phasing in which the input of each agent is warranted, as well as his/ her potential to learn, and to think along with what other agents are bringing to the fore. Given restrictions in time, this collective process of communicating and learning must get to results in a short period of time that can be surveyed. This is the reason that phasing is desirable during the trajectory of the development of a programme of requirements. Before the design team has formulated the final design requirements, there are two previous stages. The very first is termed 'shaping of image'; the second 'shaping of judgement'. The first and second stages are hinging around an encompassing concept of the design. Given the dynamics of technology and society, the first is gaining in importance; however, since it is considered, given its reflective and procedural character as time-consuming, it is often passed-by. In descriptions of design processes the stage of image creation is often resembling a black box. Nevertheless, it is crucial; since the foundation for the design is laid in it.

Stage 1: Creating the image

The first stage departs from clarification of the analysis. Information possibly lacking in the commission is supplemented. During it representatives of the principal and the users of the facilities to be housed in the building are becoming involved with providing input to the discussion. This imagining stage is pre-supposing a 'free' exchange between agents on the developments they deem relevant for the design and which may be recognised in various disciplines and social sectors. The agents are wording to what extent they consider to be themselves at home in a given development, and which points of departure and objectives should found the design. They are not to be pinned down on these statements, but should be available to be questioned by other agents critically. The aim is to elicit from each agent increasingly clear statements; not to negotiate with him/ her.

It is essential in this stage of imagining that each agent is at liberty to give his/ her vision on the design to be made. During this stage feasibility should not be held in too high esteem. This would dampen creativity, innovative potential and initiating power of the agents. In it, a maximally large space should be given to learning and developing shared support.

In a process developing well, the statement of a shared concept is crystalised; to which 2 or 3 main variants may be coupled. It is the responsibility of the facilitator of the process to make an effort, at the right time, to name the concept and variants. A useful technique in this regard is the meta-plan method. The prefix *'meta'* is referring to a higher level of abstraction. Here, concept and variants are worded in their kernel by way of a mission statement; and eventually represented in symbolical drawings. Their meta-level is so high in words as well in images, that each agent is recognising himself in it. This means that a well-formulated, encompassing concept is furthering the supporting forces of the effort; a source of inspiration for subsequent stages.

Stage 2: Forming of judgement

During the second stage, 'forming of judgement', the concept and possible variants are further developed into a programme of requirements, sketched designs and costing projections. With regard to his/ her discipline an agent, or a group of agents, further develops an aspect or part within the framework of the concept and possible main variants. Regularly, the results of the work of all (groups of) agents will be discussed and weighed, in order to see whether the separate detailing is fitting together in the concept and main variants. In principle, this servo-mechanism is just leading to adjustment of the detailing. During this stage all kinds of feasibility checks will take place at given times. During this checking the agents can contribute constructively – on behalf of the principal and the target group that also participated during the first stage and know, by the same token, the 'spirit' of the concept - in commenting on better performance requirements; and thinking along with them. Obviously, it should be ascertained that in these checks the principle of articulated criticism is followed.

Particularly if the pressure on feasibility is increasing greatly, it will show whether the mission statement character of the concept and the initiating and sustaining power of the agents is 'strong' enough for realising the original ideas as much as possible, without relinquishing essential points of departure and objectives. Nevertheless, it cannot be excluded that the concept is in need of adaptation during the judgement forming stage. That is an important moment for enhancing the process in order to see to it that it is happening in a well-considered way. Actually, a new imagining stage must be started in a shortened form. Particularly during the second stage it is important that during the development the feed-back of the development to the concept and in case of feasibility checks the discussion on performance requirements is differentiated according to the domain of reality to which they are relating. The second stage finishes with a preliminary programme of requirements.

Stage 3: Decision making

The third stage, 'decision making', starts with the preliminary programme. The aim of this stage is to get final approval. Adjustment is just possible on minor points. Instituting this stage is desirable, since those holding themselves responsible for realising the programme are comprising a more narrow circle of agents than those active during the first two stages. However it is desirable that the agents that participated during the first stages should be retained; because of their insight in backgrounds and choices underlying the preliminary programme of requirements.

33.5 SOCIAL RELATIONS AND POSSIBILITIES FOR ACTING COMMUNICATIVELY

The possibilities for communicative acting depend on social conditions. It may be stated, looking at the ways in which western societies have been organised, that performance requirements formulated on the first two domains of reality seem to strengthen one another mutually; and dominate the third domain. New discoveries in science and technology, in combination with welfare states and organisations operating globally, striving for modernisation of social institutions, respectively of economic activity, do establish a favourable breeding ground for developing new, and increased demands in these domains. The odds are, that this is happening in disregard of preferences and needs of individuals and aesthetic aspects. In that case a disproportion of statements on the three domains of reality is applying.

It should be kept in mind that during recent years such an individualisation has been going on in society, that the possibility of the individual to design his, or her, life according to personal insights and to steer it in that vein seem to show a nett gain. However, the social-economical position of someone as a principal is depending on his/ her capability to deal independently and satisfactory with technological and welfare innovations. Luckily, during the last decades emphasis on functionality has also been reduced in architecture; and room gained for a larger variety in form and colouring of buildings.

33.6 PRACTICAL EXAMPLE: HOUSING FOR THE ELDERLY

Over the past 15 years, a wave of innovation has become visible in the housing of elderly people. This resulted in new construction regulations, new types of buildings, and new logistics of care and service provision. The innovations are a result of increasing criticism of the traditional approach. Critical questions regarding the three fields of reality:

Sub a: Is it actually effective and efficient to have people moved, as soon as they become less mobile and needy of care, first to special intermediary homes for older people with a mild need for care, and then, as their need for help increases, to a full-time care centre or convalescent home?

Sub b: With an eye towards the greying of the population and the high costs involved, can building and utilisation of care centres and convalescent homes be slowed down? Are there cheaper alternatives?

Sub c: Why do older people have to move when they become in need of care, leaving behind their trusted home and environment so as to move to a special home, or even to a convalescent home? Why are seniors "stored away" in a small sitting room/bedroom (care centre) or in a multi-person room (convalescent home)? Why are intra-mural facilities so large-scale, and why do they have the character of "hospital-like institutions"?

In developing and achieving innovative approaches, a number of discoveries were made now resulting in approaches towards validation:

Sub. a

Adaptable building or renovating of apartments and intermediary forms of residences, specifically aimed at achieving better accessibility to the kitchen and the sanitary unit, helps seniors to take care of themselves, and promotes efficiency of home care. This also applies to the development of various delivery services, specifically in so-called "home care zones" such as those in IJburg, as well as to computer and communication technologies increasing ease-of-use, comfort, and security of the residence. By expanding and intensifying home care, people with a moderate need for help can stay at home longer, and can continue to live in an intermediary form of housing.

Sub. b

These alternative solutions have lead to a reduction in the number of expensive care centres and convalescent homes. It is easier to ask the seniors themselves to contribute and invest, since this allows them to live independently for longer periods of time. This also contributes to savings.

Sub. c

The alternative solutions better fulfil the residential and caring needs of older people. By continuing to live independently for longer periods of time, they feel less discarded, remain active longer, and maintain an interest in the world around them. More small-scale residential possibilities also become available. In design, there is an increasing tendency for architects to warm to the idea of the "apartment" which can also be inhabited by non-elderly residents.

These new basic approaches can be seen in all kinds of innovative projects.[a] Applying them on a large scale, however, is a slow process. Established interests, engrained routines, and viscous bureaucratic procedures all stand in the way of rapid change. Thus it seems that many architects are not well informed about the principles of accessibility, and too little involved in the development of innovative concepts. This results in unnecessary or incorrect solutions. The recently published "*Woonkeur*" consumer approval mark is a good example of practically applicable guidelines based on ergonomic and safety research (Field A), the readiness to build social housing with higher quality requirements and increased value for the future (Field B), and active participation on the part of older people, people with a handicap, and creative architects (Field C).[b] The plans for IJburg are also based on intensive exchange of ideas between experts from many different disciplines and organisations. This has led to an interesting schedule of demands for the district in general, and for care zones in particular.[c]

33.7 EXTRADUCTION: PROGRAMMING STUDY WITH AN EYE ON OPTIMISING

In this Chapter vital aspects of methodical optimising of performance requirements have been sketched for social development. One characteristic of this methodical approach is the search for a balance between analytical and synthetic ways of working.

The analytical aspect shows in clarifying the commission and free association during the stage of image forming, differentiation of performance requirements according to the three domains of reality and testing proposals to improve on them according to the appropriate domain of reality.

The synthetic aspect shows in the balance between content and process, judicious dealing with the domains of reality, 'finding' an adequate concept; while developing and criticising within the framework of the concept the performance requirements. The synthetic aspect is demonstrated by the staged approach, starting with a broad stage of forming the image, proceeding into activities concentrated around a 'concept' during the judgmental stage; and around a preliminary stage of deciding involving the programme of requirements.

This methodical approach demonstrates that starting from empirical study a contribution is viable with regard to probable effects of certain performance requirements; to what the wishes are in society and among users of buildings *vis-à-vis* performance requirements. The methodical steerage of the communication between agents during the development of performance requirements indicated is aiming at making this process transparent and, by that, scientifically verifiable. It has been especially developed for the present, post-modern society, after underlying trends and dynamics were first studied. Experiments with applying it have demonstrated that this methodical approach is working well generally, if some conditions have been fulfilled. A very important one: sufficient time and willingness of agents to invest in the first stage of image forming, was already mentioned. Just as in other designing processes, there are but a few systematic descriptions of experiments like that. Producing these descriptions needs quite a lot of energy; while it should be kept in mind that in publications on these projects the attention of most readers is rather focused on the final result than on the way in which the programme of requirements came into being. On top of that, expectations raised by the programme of requirements and assessment of the building realised eventually do not need to agree. Thus, in those cases the question emerges why one has to go through such a lot of trouble for the description of the process, with a result that, compared to it, is somewhat disappointing. Nevertheless, this disappointing experience can never legitimise denying transparency to designing processes. On the contrary: the importance of transparency – and therefore methodical developing and designing – is increasing; since increasingly better educated, but also specialised professionals and organisations, as well as more assertive consumers are being involved in realising the built environment.

a Houben, P.P.J.A.M. (1997) *Reflexieve modernisering ouderenzorg.*
b Woonkeur, Almere: SKW Certificatie bv, 2000; VROM (2000) *Nota wonen (ontwerp).*
c Lammers, B. and A. Reyndorp (2001) *Buitengewoon, nieuwe vormen van wonen, zorg en service op IJburg.*

34 THE ENVIRONMENTAL MAXIMISATION METHOD

KEES DUIJVESTEIN

The environmental maximisation method is a design method used by town planners in which an attempt is made to clarify the long-term, ecological approach in such a way, that it is possible to recognise how decisions were made in the final design.

34.1 BLUEPRINT FOR A CITY

The original idea for the environmental maximisation method came into being in the mid-seventies. A research programme, *'Blueprint for a City'*, was started in what was then the multidisciplinary Centre for Environmental Science and Technology. The title was inspired by the manifesto *'Blueprint for survival'*, written by Friends of the Earth. The research programme had two main aims. Firstly, to encourage inter-disciplinary co-operation. Secondly, to clarify pre-conditions and requirements set by the professions involved in advising the building industry as a whole. What was required was an indication of the ideal extent, density and system of land division for a city or urban area as seen by a particular profession. The question was put to specialists in fields like district heating, use of solar energy, and avoidance of wind problems, public transport and sewage treatment. This kind of approach turned out to be impractical. The advisors were not accustomed even to give an outline answer to such questions.

34.2 URBAN DESIGN AND THE ENVIRONMENT ('SOM')

When the attempt to use staff-members failed, a further attempt was made in 1978 using final-year students in the various professional fields brought together in the Inter-faculty Study Group for Planning, Urban Design and the Environment. Between 1978 and 1980, eight different groups worked, half a year each, on environmental awareness plans for cities like Delft, Rotterdam, Almere and Wageningen. One result was formation of the SOM Group currently acting as the source for co-ordination of regular environmental education. The concept of maximisation is currently used in the design tasks in the second-year block IMAGO (Integration of Environmental Aspects in the Built Environment) and in the fourth-year environmental module *'Integrated Design'* and in the Delft Interfaculty Research Centre: *'The Ecological City'*.

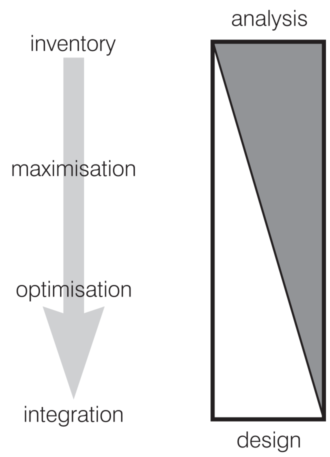
34.3 CONTACT WITH ACTUAL PRACTICE

The SOM Group has many contacts with actual practice; ex-SOM students are involved in the majority of Sustainable Building projects in the Netherlands. One important contact is with *BOOM*, *Buro voor Onderzoek & Ontwerp voor het Milieu* (Office for Research & Design for the Environment) in Delft. In 1995 BOOM completed the manual *'Materials for Sustainable Urban Design'* commissioned by SEV (Steering Committee for Experiments in Housing) and Novem (The Netherlands Agency for the Environment and Energy). This manual and the maximisation concept are being used in the planning of DE Wijk, a 2.800 houses development area in the western part of Tilburg.[a]

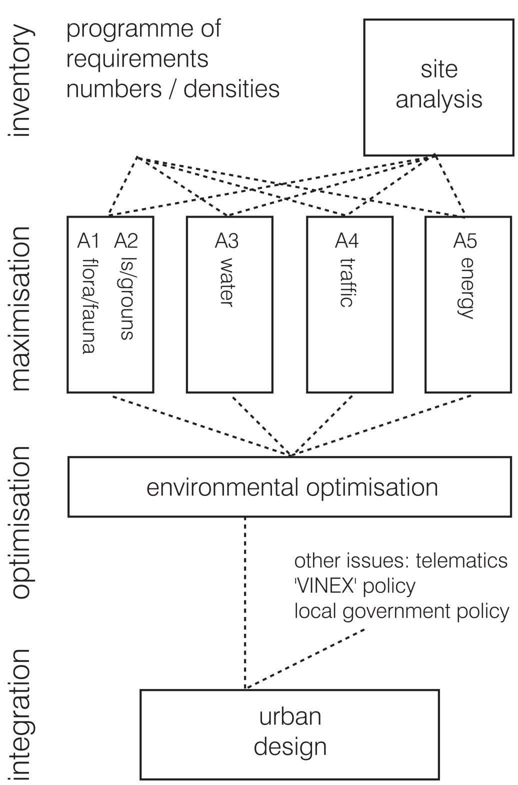
34.4 THE THREE-WAY APPROACH

After brainstorming sessions, the local government departments developing DE Wijk in Tilburg decided to take a three-way approach. Besides design quality and environmental quality research study would be carried out into what influence the application of computer techniques might have on the master plan for the new area. Prof. Wytze Patijn was asked to supervise design quality, Prof. Theo Beckers of Tilburg University was asked to handle informatics and the author of this Chapter was given the task of ensuring that environmental thinking had proper influence on the master plan. In the first instance the local project co-ordinator only

a Boom-Duijvestein (1998) *De mileu maximalisatie methode.*



321 How environmental issues affect the master plan during the gradual progression from analysis to design



322 Maximisations give insight into environmental issues affecting the master plan. Sketch maps are given for the subjects and issues in the boxes. A1, A2 etc. refer to the manual 'Materials for Sustainable Urban Planning'

involved local government departments in the planning process indirectly. This meant that the team that had been put together had the task of developing not only a product (DE Wijk), but also a process.

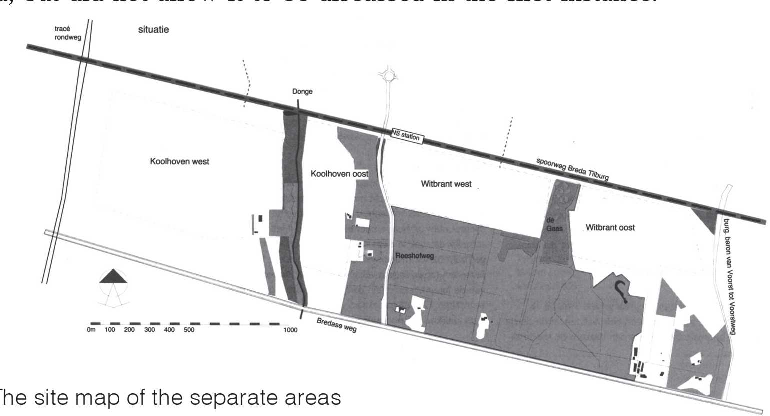
34.5 DESIGN PROCESS

Design processes are often carried out in a highly individual way, which makes it difficult afterwards to find out exactly what happened. The process, from analysis of the location and the programme of requirements through to design, takes place largely inside the heads of those involved. If all goes well, this ensures a constant interplay between analysis and design.

The first draft (design) is often put forward quite early on, and refers back to continuation of the analysis that will be necessary for quite a while. Figure 321 represents the gradual progression from analysis to design as a two-way process. The maximisation concept is used to give some insight into the influence of the environment on the master plan. For each environmental issue a plan is drawn that would be most beneficial to the environment if all requirements relating to that issue, and of course to location and requirements, are taken into account (see figure 322).

34.6 THE SITE

The method used certainly allowed the choice of location and programme of requirements to be analysed, but did not allow it to be discussed in the first instance.

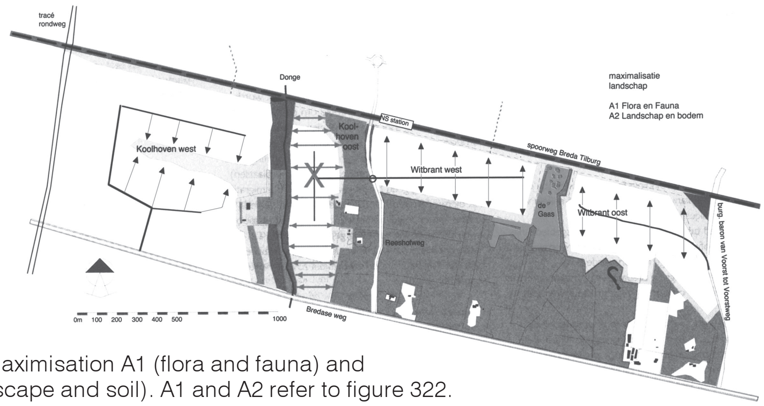


323 Map 1 The site map of the separate areas

The location is due west of Tilburg, south of the 10,000 house district of Reeshof, between the railway line running from Tilburg to Breda and the old Breda road, about eight kilometres from the centre. The programme includes at least 2,650 houses for which the necessary services are to be in Reeshof on the other side of the railway track. The Witbrant district was reserved for the Floriade, but when the choice for Floriade 2000 went to Haarlemmermeer the area came free for residential development. It consists of fields and grazing land where buildings can be put up without trespassing on an area of pine trees within which, in principle, no building is permitted. A number of estates are located in this area along the Breda road. On the east the boundary is formed by the Burgemeester Baron van Voorst tot Voorst road, and on the west by the future western ring road. The area is divided in four sections by a stream (the Donge), the Reeshof road and a piece of heath land (De Gaas). There is a plan for a railway station along the Reeshof road. The area comprising Koolhoven west and Witbrant west is to be connected to the Reeshof by a tunnel for cyclists and pedestrians. All this is shown in map 1.

Landscape

The maximisations A1 (flora and fauna) and A2 (landscape and soil) used the countryside inventory prepared by the local department responsible for the provision of green space. This inventory divides Tilburg into separate regions and gives for each region present an ecological quality and a description of the target to be aimed at.

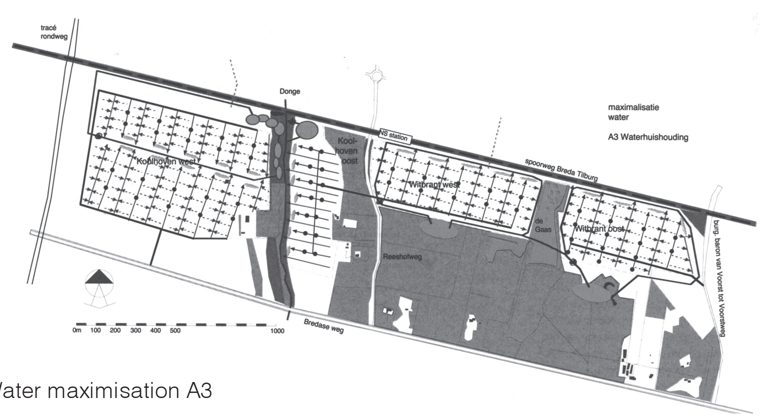


324 Map 2. Maximisation A1 (flora and fauna) and
A2 (landscape and soil). A1 and A2 refer to figure 322.

The regions with the highest present and future ecological quality are in DE Wijk the strip along the railway, the heath land (De Gaas) and the area between the Donge and the Woodland along the Reeshof road. This Area, Koolhoven east, is scheduled for building, but should really remain unbuilt, forming an important connection between the Donge and the Wood. The strip along the railway largely co-incides with the noise-pollution zone, so the pressure to build is to be expected mainly in the neighbourhood of the station. Access is to be provided to the edges of Koolhoven west, with an extra strip of green planned for the middle; access to Witbrant east and west is thought to go via the middle. Map 2 shows how these data are translated into a sketch of the master plan.

Water

An important guideline in the water maximisation is that rainwater infiltration should be allowed to the greatest extent possible, topping up the ground water level. This combats drying out and minimises reduction in water quality. So the surrounding natural areas and the quality of the immediate environment will benefit from this maximisation.



325 Map 3. Water maximisation A3

Rainwater from roofs and the surfaces of road not intensively used by motor traffic is either allowed to flow directly into the ground, or led to ditches via surface drainage. Water in the ditches is then pumped back; up to higher sandy areas in the pinewoods. Water still left is discharged in the Donge. Map 3 indicates how this is done.

Traffic

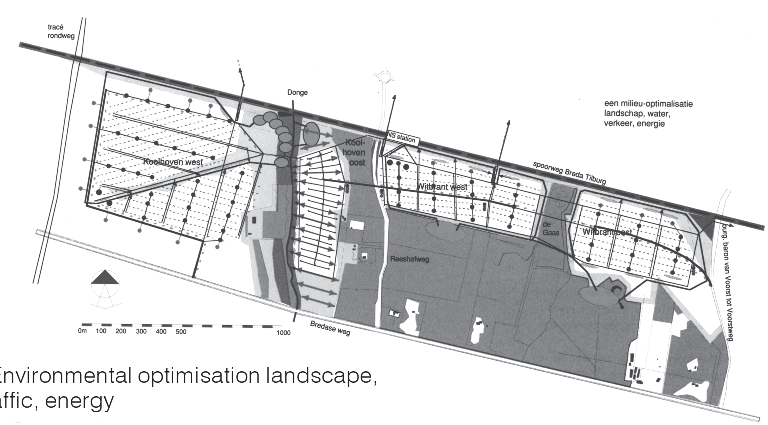
This maximisation looks at cyclists and pedestrians ('slow traffic'), public transport and motor vehicles. Issues relating to cyclists and pedestrians include road safety, connections, immediacy (including access to the railway station, schools, the Reeshof Centre and the centre of Tilburg), speed, attractiveness and the alternatives available at times when the prevailing circumstances create a feeling of social insecurity.

Direct connection with the station means a diagonal running across Koolhaven west. There are connections under and over the track in Koolhoven west and Witbrant west. For public transport the location of the planned station is taken as fixed; further consideration being directed at provision of a fast direct bus route and maximal distance between houses and bus stops. Koolhoven west is to be opened up for motor traffic from the Breda road, Koolhoven east and Witbrant west from the Reeshof road and Witbrant east from Burgemeester Baron van Voorst tot Voorst road. This means that the Donge and the heath land area are not crossed by motor vehicles in any way, though crossing will be possible for the other two types of traffic. Slow traffic and public transport are the key factors in this maximisation.

Energy

Energy maximisation looks primarily at the influence of orientation towards the sun. According to specialists, district heating imposes no pre-conditions that need affect the master plan. Uses of solar energy considered were passive: windows or conservatories, and active: solar collectors or solar cells. In all cases a deviation of no more than 20° from due South appeared to be acceptable. The long straight lines running through the location – the railway line and the old Breda road – which gave the town-planners' outline master plan its name, deviate approximately 15 from East-West. This makes the area outstandingly suitable for East-West land division for the residential blocks.

34.7 AN ENVIRONMENTAL OPTIMISATION

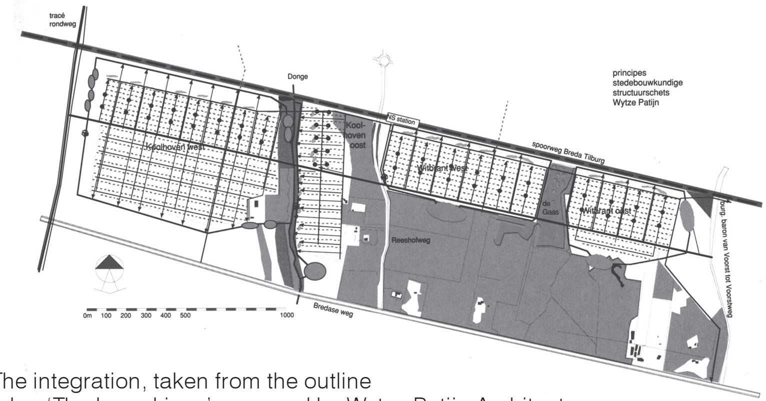


326 Map 4. Environmental optimisation landscape, water traffic, energy

The individual maximisations appear for the most part to fit together well, like pieces of a jigsaw. There are a few points at which choices must be made. The landscape maximisation indicated that Koolhoven east should be left unbuilt, to preserve the connection between the Donge and the higher wooded area. But this area is situated close to the station, and for that very reason should have a high building density. The choice was made to build in the area, but to have green connective zones. The landscape maximisation opened up Witbrant to traffic form the middle of the districts, while the water system and the traffic system provided access along the edge of the wood. The existing landscape has been taken as basis; the other maximisation models have been adjusted to fit. Fortunately, they are sufficiently flexible to allow this.

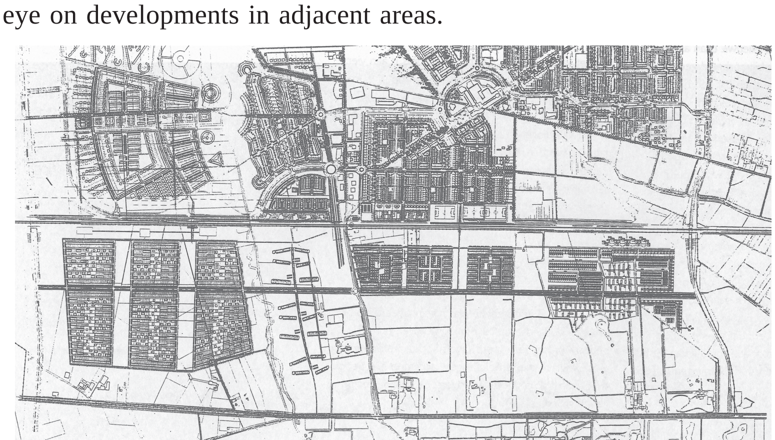
34.8 THE INTEGRATION

Map 5, taken from the outline master plan 'The long lines', shows how everything has been integrated.



327 Map 5. The integration, taken from the outline master plan 'The Long Lines' prepared by Wytze Patijn Architecten

A large number of points can be recognised as derived from the individual maximisations and the final optimisation. It seems that the different players were in agreement (or reached it) on a large number of matters affecting the master plan. Disagreement remained on two issues. In the outline master plan, the choice was made to introduce a long third line, the '*Nieuwe Laan*', to accompany the two existing lines (the railway and the Breda road). This *Nieuwe Laan*, a significant visual element, important for the design, connects the various neighbourhoods and also provides access for buses and cycles. How to avoid traffic, using it as a short cut or driving too fast along it, is to be looked at in the detail planning stage. Consideration is to be given to experimental electronic speed regulation systems and perhaps blocking the traffic flow by the Donge and by the De Gaas heath-land. Another immediately recognisable difference between the environmental optimisation and the way everything is integrated into the plan is the absence of a diagonal green strip and a route for slow traffic in Koolhoven west. This is a case where the image of a peaceful piece of urban design took precedence over a short connection for slow traffic. The outline plan does provide a close-knit network for slow traffic that will be almost entirely free of motor vehicles. What will happen next? After the outline master plan was prepared, four designers were asked to give their ideas on how the development of DE Wijk might be taken further. After discussing different opinions, they were asked to concentrate particularly on the individual component areas, while at the same time keeping an eye on developments in adjacent areas.



328 Map 6. One of the variations from the design study carried out by Lafour en Wijk for the consultation with designers in November 1996

Map 6 shows a variation that came out of one of these studies, from which it is possible, to some extent, to see how each individual component area is to be developed in its individual way. It also shows how an attempt is to be made to keep the area between the Donge and the wood as open as possible, both visually and as an ecological connection, despite building. The environmental maximisation method appears to be an outstanding tool for systematic integration of environmental issues into the process of urban design.

TECHNICAL STUDY

F TECHNICAL STUDY

Construction technique serves spatial design. It is also a subject of education, study and development. Designing includes construction-technical design; linked with all other subjects of this book.

Re-design and renovation

Presently the largest part of the built environment already exists; as soon as it is completed, a new building is added to the stock. An important dimension of the challenge of building for the future includes renovation, maintenance, re-adjustment and improvement of existing buildings (Verhoef, page 323).

Study of building services and installations

Schalkoort discusses the study of technical facilities in buildings most close to man: climate control, installations for transport, electricity, sanitary, communications, cleaning and risk prevention. The more space they require, the earlier its concern has to be involved in the process.

Methodical design of load-bearing constructions in buildings

Kamerling discusses the study of technical facilities more remote from man, sometimes even invisible. This kind of study covers a limited range of scale levels and limited context variables. The resulting clear-cut considerations could serve as a prototype of more complex design study.

Classification and combination

In this Chapter Cuperus argues that there are several ways to order building technique, each of them with a specific objective. Architectural transformations do not occur spontaneously. They result from human decisions, ultimately linked to the way components of the building are connected. One approach may be to order building along the lines of the 'building node'. The interface of the building node defines not only an ordering for the levels where decisions will be made, but also one with respect to sub-systems.

Methodology and component development

Components ('constituent parts of a whole') may be part of architectural (sub-)systems and separately developed. Eekhout argues how, in which case and context.

Industrial design methods

Designing components resembles industrial design of loose products as done on the Faculty of Industrial Design Engineering. De Jager refers to this branch of design methodology and discusses similarities and dissimilarities in context and methodology of product development, industrial design and architectural design.

Future ICT developments

Sariyildiz *et al.* indicate that both 'hard' and 'soft' computing techniques such as artificial neural networks, fuzzy logic and generic algorythms are helpful in complex design processes and architectural education. They discuss four application domains of ICT: creative-design, materialisation, realisation, and process and management.

Conclusion

Technical design is an interface between hard knowledge as discussed in the previous sections, and soft growing concepts. They are subject of the next sections.

35 RE-DESIGN AND RENOVATION

LEO VERHOEF

35.1 INTRODUCTION

Buildings ultimately reach the end of their life-span. Various notions may be implied by 'life-span', like:

- Economic life-span; after which it is not attractive any more to maintain a material, building component or building.
- Functional life-span; the degree in which the building is satisfactory for carrying out the function for which it was designed is an important part of the economic life-span.
- Technical life-span literally means the end. The material from which the building is constructed is giving up, or materials seeing to the coherence of the building. For important parts of the building, like the skeleton, this may take a much longer time than the economic life-span.[a]

Reaching the end of one of these stages of life-span may cause terminating the life of the building, by demolishing it. In what is following here that option, and others, are discussed. When buildings have arrived at the end of their functional-economic life-span, the technical life-span has not been reached by far, generally speaking. At this point a number of decisions are possible:

- Demolition and building anew. Increasingly, the environmental costs of processing the debris of the demolition can not be waved; to this the use of energy for manufacturing new products should be added, actually. On the social level there is increasing pressure against demolishing buildings with a sound potential for renovation. The quality of the overall structure is important;
- Continuation of usage. Given the fact that the building has ceased to function properly, the user will only be prepared to lengthen his use at significantly lower costs. From an economic viewpoint the building is valued lower.
- Re-design with renovation activities. Buildings are increasingly adapted to a (re)new(ed) use. The aim of this is to see to it that the building is functioning properly; in this, innovative energy concepts are taken explicitly into account: for instance active – and passive – solar energy, or the application of façade variants, like a second façade skin, or a climate façade.

35.2 DEALING WITH THE PRELIMINARY STAGE AND THE STAGE OF THE PROJECT STUDY

Dealing with re-design and renovation of buildings may distinguish a preliminary stage and the stage of the project study itself. The preliminary stage serves to reach a decision for recycling and renovation.[b] Topics like a market study are coming to the fore in order to tune locations, buildings and functions; global analysis of the building in which situation, possibilities of usage and general properties are addressed; and an investigation into special aspects with regard to the building and the location, like environmental and other requirements, rights and obligations associated with the building and possibilities for subsidy. Conclusions regarding possibilities for re-design and renovation as well as an estimate of costs, usually on the basis of characteristic numbers compared to building from scratch; or demolition and building from scratch finalise this stage and indicate the financial framework for the project study.

During the stage of the project study a number of steps may be discerned as well. It starts with the in-take, followed by a stage in which the location, the building and the function are analysed, after which the development of concepts for usage is conducted. This is leading to selection of one of the concepts (possibly with variants), followed by materialising the concept in its relationship to the budget.

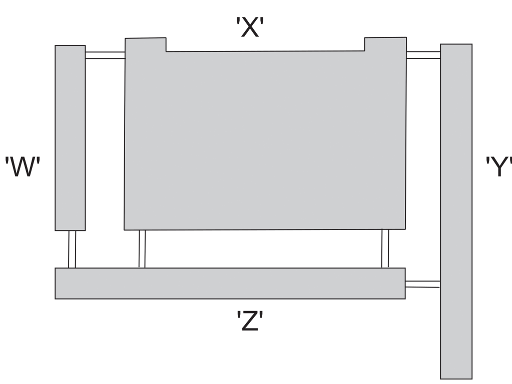
a Kristinsson, J. (2000) *Lecture-text*.
b Rongen, C.T.H. van (1988) *Hergebruik van gebouwen, een verkennend onderzoek*.

The stage of the project study starts with an accurate survey of current conditions. These may be itemised according to location, building and usage; with the purpose to find out what is valuable in the existing situation. It may be that the value of an ensemble, building or setting is already protected, for instance in the case of a monument, creating restrictions and other possibilities for re-design and renovation. Generally speaking, such a protection does not apply.

Collecting or producing material that should be recorded by drawings, photographs and maps is an element of this stage. In order to clarify matters by way of an example, a study of Delft University is described globally, in which the task was undertaken to study how usage of a specific built ensemble could be improved upon. Since the preliminary stage or project stage did not apply, the conceptual project study could start immediately.

35.3 EXAMPLE *'CONCEPTUAL STUDY OF RENEWED USE OF BUILDINGS'*[a]

The approach of such a project study is illustrated by an example taken from practice. It concerned four buildings functioning as offices with its associated functions as well as laboratory functions. Management wanted to find out how many people could be housed in the built ensemble, if the laboratory part could be allocated to a building created separately. The underlying thought was strong reduction in use of space by the laboratory caused by IC technology.



329 Ensemble

General points of departure for the study included:

- Interventions for adaptation of the existing buildings 'w', 'x', 'y' and 'z', for new functions are applying to office housing with associated functions, like conferencing rooms, meeting rooms, office restaurant.
- Separation of functions; and, if possible, per part of the building. Mixing functions, like those of offices with laboratory ones, is no longer desirable. Laboratory functions should be housed in a separate building;
- Concentrating the functions associated with housing offices as much as possible.
- Solving the problems related to fire security and the view from the low building 'x';
- Modernising the buildings in such a way that it gives a 'corporate identity' feeling.

In the general approach to this stage of the project study the following was mentioned already:

- In-take;
- Stage of analysis of building and function;
- Development of concepts of usage.

After this, the selection is following one of the concepts with possible variants, then materialising the concept as related to the budget.

330 Façade

The building in-take regarded architecture, usage, technical possibilities of adapting on the basis of construction/ detailing and quality of maintenance, particularly of the façades.

During the analysis stage of the building and functions a number of conclusions was drawn based on the in-take that should lead to improvement. The most important ones:

In an architectural sense:

- The buildings are not displaying a lower and upper side;
- The columns, placed out of the façade by more than one metre, are not functioning as such, in order to interrupt the horizontal character of the 170 metres long buildings. The length is staying dominant and the building remains anonymous;
- The buildings have a strongly defensive character, since the walls reach 1,1 m. above the floors;

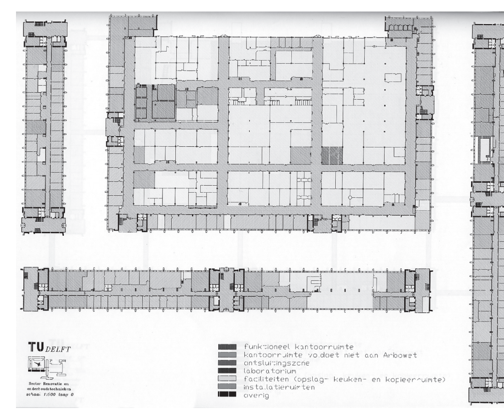
a Verhoef, L.G.W. and A.J. van Stigt (1994) *Conceptueel onderzoek naar het hergebruik van de gebouwen*.

- The detailing of the stairs system in brick is not in harmony with the heavy columns in the façade;
- The nine aerial bridges are too many for giving clarity to the structure of access.

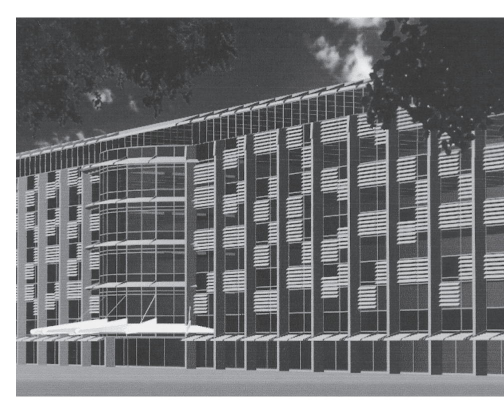
From a viewpoint of usage:
- The drawings show that many spaces are not used as an office. The buildings can be used more intensively than up to now;
- Building ‘x’ with its dimensions of 80 by 120 m. is not obeying legal requirements with regard to lighting and view. Separate study concerning adaptability of building ‘x’ is called for;
- The bottom glass line on 1,2 m. above floor level is clashing with the legal requirement of 0,9 m.;
- Parts of building ‘x’ must be removed in order to comply with legal requirements for daylight and view;
- Analysis shows that raising the floors housing the ducts for new usage is preferred to lowering the beams of the façade, and with it the glass line.

In a technical sense:
- The façade features a very special construction. The columns outside of the building have been linked to the monolith concrete façade beams by pre-fabricated concrete linkages. The link has been realised by hanging staves and short concrete elements. In this case the technical detailing is so important, that long-term and controlled protection is deemed necessary. The conclusion drawn from the analysis caused selection of skin sheltering from rain around the inner directed side of buildings ‘w’, ‘y’ and ‘z’ and to cover the streets between these buildings and ‘x’ with a hood from glass. This selection is also enabling the appropriate ‘corporate identity’ and the creation of an inner world;
- The foundations and the construction are demonstrating after repeated calculation so much reserve, that an additional floor can be constructed on the building;
- The beam on the ground floor breast-high has no significance for the construction. By removing it and adding a floor, the building is getting, by the changes proposed, in addition a lower and an upper side in an architectural sense.

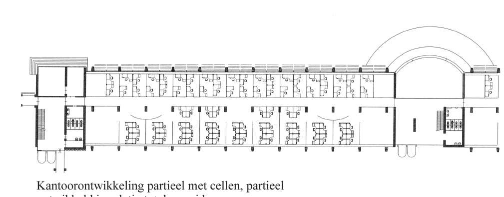
331 Bridges



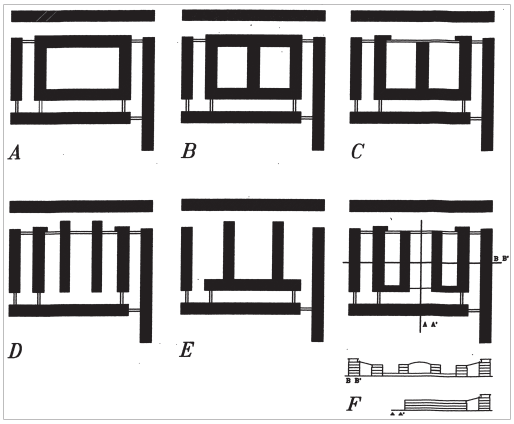
332 Floor plan



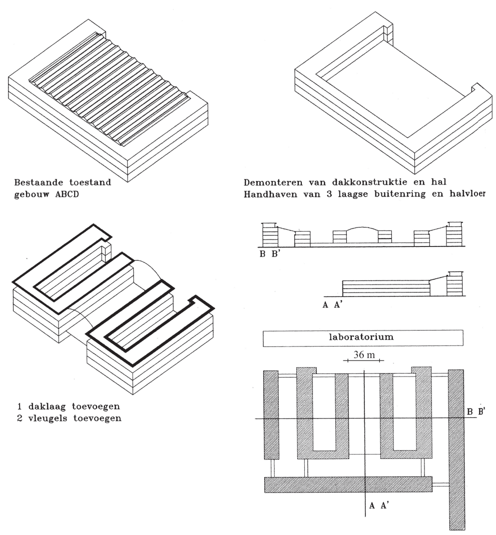
333 Façade

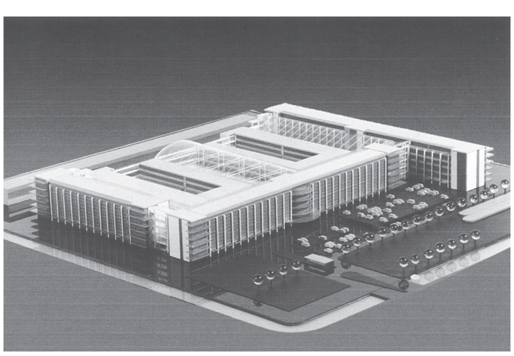


334 Floor plan



335 Six shape variants





336 Selection

35.4 DEVELOPING USAGE CONCEPTS FOR BUILDING 'X'

Building 'x' has a U-shaped skin with a rather office-like look, with in-between a space with the structure resembling a hall. The point of departure of the study concerns maximising the number of office working places. Legal requirements concerning light and view are making the present form unacceptable and are necessitating partial demolition. On this basis six variants were developed: three on the basis of large atrium shapes and three on more linear ones.

A one single atrium building;
B a double atrium building;
C an E-structure;
D a structure in lines (| | | |);
E a ∏ structure;
F a mixed structure (U U).

After an analysis of all concepts variant F, with a (U U) structure proves to be the most satisfactory one. It has a central area immediately behind the central entrance in building 'z'.

This leads to a continuous language of forms in the covered inner streets parallel to the buildings 'w', 'z' en 'y'. By the intervention the areas at the roofed central hall and at the atria get a language of forms differing from the façades, but one that is consistent and continuous.

In this concept all buildings must be accessed by a double ring structure including the aerial bridges. Since the inner areas have been covered, the glass enclosures of the existing aerial bridges have become redundant: free elements in space, demonstrating their primary function. Each area and building with covered streets protecting the existing façades gets a character of its own. The inner world created this way stands in open connection with the spacious central area with a roof 36 metres wide.

When conceptual selections for usage and architecture have been made, materialising and detailing as related to the budget is called for. With regard to the objective of the present book, *'Ways to Study and Research'*, the process has been described in large strides in terms of what is needed when it comes to re-design and what the most important factors are.

For smaller components within the whole – for instance in the case of the new outer façades – the same procedure is followed. Then also the 'in-take' is the basis; and then, specifically:

- Data and dimensions of the existing façade;
- Stage of analysis of the façade and its function. This causes the new outer façades, second ones, while the solar energy generated is used during winter and disposed of in summer;
- Developing the usage concepts
- Selection of one of the concepts with possibly variants for the outer façade and then materialising the concept as it is related to the budget for the façade.

35.5 CONCLUSION

In the case that there are weighty arguments for extending the life-span of a building, redesign and renovation are called for. In the above the various stages of study have been discussed on the basis of an example taken from practice. The constructive part of the building was emphasised, and checked on quantifiable life-spans, like economical, functional and technical ones.

The type, size and state of the technical installations of a building are at least as important for judging the architectural state; since that is not only made on measurable properties, but predominantly on emotional results. A climate is up to a large degree a feeling and is therefor not to be measured objectively. One should use the work of behavioural sciences. The next Chapter will discuss this in more detail and provide examples.

36 STUDY OF BUILDING SERVICES AND INSTALLATIONS

BOB SCHALKOORT

36.1 INTRODUCTION

36.1.1 Building services: objective and means

The purpose of building services and installations is to support the building functions, so that buildings can fulfil their functional demands. They can also be a means to ensure that buildings answer economic or societal purposes. Finally, technical installations can be a formative factor in determining the shape of the building. In that case, contrasts between styling and functionality can come into being and should be balanced against each other: a subject of research.

36.1.2. Scope of the research

Examination of building services and installations entails a wide range of purposes, subjects, applications and methods, from technical studies focused on development of equipment and systems to investigations relying on specific methods to measure the effects of such installations on people. One aspect of the application study relates to the design of installations as part of the design process of buildings. 'Technical' studies with aspects of social sciences focus on problem solving in the case of complaints and on development of diagnostic methods. Study centring in methods from social sciences is the exploring and hypothesis formulating study needed in order to know installations as they relate to the building and building occupants as a risk factor. Ultimately study also serves improvement of building installations and their application and to improvement of the design process.

36.1.3. Problem-solving studies

Such studies normally take place in response to specific complaints from building occupants. If it is suspected that the cause may lie in technical installations, it is customary for investigation to be carried out by maintenance technicians. Such first line surveys are often performed in response to an 'explanatory complaint', in which people do not say what is bothering them, but what they think is causing the problem.[a] First-line investigators normally do not know what to do with complaints about headaches, dry skin, contact lens problems and such. In order to change their situation, affected people tend to mention a cause, like "the air conditioning does not work properly", because technicians will respond to that. If these complaints are taken literally, it is likely that the wrong track will be followed and the real cause will never be found, also because the appropriate experts may not be employed. Complaints on head-aches and such-like can have many causes; as do causes hailing from the building, type of work and the complainers themselves. When a situation has developed with a great many unexplained complaints the idiom 'Sick Building Syndrome' may well be used. In order to prevent originating that syndrome and to lower the number of unexplained complaints, diagnostic methods have been developed for first-line investigations.[b] This teaches researchers to take complaints seriously, but not literally.

Questionnaires are used in order to ascertain what is ailing complainers and what they experience. The conditions prevailing in the building pass muster systematically with the help of a checklist to make an inventory of possible causes of complaints. The investigator must try to find a likely solution by matching the list of complaints with the list of possible causes.[c]

If the first-line investigation does not yield results, specially trained second-line investigators can be called in. They frequently work as described above, but are more knowledgeable and experienced, and can carry out measurements. In case this inspection also does not yield results, the survey can be extended and the building investigated in its entirety, taking into account risk factors in the surrounding area, the work place and the organisation. This type of inves-

a Schalkoort, T.A.J. (1987) *Sick Building Syndrome, bewonersklachten, mogelijke oorzaken en oplossingen*.

b Schalkoort, T.A.J. (1988) *Wat wordt verstaan onder 'Sick Building Syndrome' en hoe moet met het daarbij behorende klachtenprobleem worden omgegaan?;* Schalkoort, T.A.J. (1991) *Ontwikkeling en behoud van gezonde kantoorgebouwen - Studie naar het 'Sick Building Syndrome' en de mogelijkheden van het terugdringen van bewonersklachten in kantoorgebouwen*.

c Kurvers, S.R. (1994) *Handleiding voor de aanpak van gebouw- en werkplekgerelateerde klachten*.

tigation is similar to 'Building in Use' evaluation and methodologically comparable to 'Post Occupancy Evaluation', see also paragraph 36.2.5.

36.1.4 Hypothesis-forming

Hypothesis-forming is carried out on the assumption that there is a relation between certain aspects of buildings and specific health complaints. This type of examination is often carried out as an epidemiological study. Many of these studies have been executed in order to gain insight in the causes of the 'Sick Building Syndrome'.[a]

The most important conclusion was that the more influence the inhabitants of a building have on their situation, the less they complain.They should be in a position to operate the climate control and shading installations themselves, as well as to open windows.

Characteristic for study in epidemics is the large scale with which data is being assembled. For study as considered here, usually dozens of buildings are investigated. Next to the properties and characteristics of the buildings themselves, data is collected on environment, installations, furnishing, type of work done in the building and the inhabitants. Key instruments of study are a questionnaire presented to the inhabitants, a building checklist and a measurement protocol. Development of these instruments has received a lot of attention internationally; with the objective to lessen the ambiguity of the results in order to make them better mutually comparable.

A certain size of the population to be studied (buildings and people) is necessary for reaching reliable statements on possible relations. Statistical considerations determine the size through the number of relations that should be demonstrated and through the statistical distribution of properties and characteristics. These relations and distributions must be known for determining the population size, and consequently for performing the study. At the same time, the study is precisely undertaken to get to know them: a well-known methodological problem and subject of discussion; as in 'objective orientated' and 'means orientated' study.[b] For meaningful study there should be an idea about possible relations, however vague it may be. Usually, ideas come into being during problem solving studies. Furthermore epidemiological study is not more than a hint that, possibly, causal relations exist. Causality and the question whether one factor influences the other, or vice versa, may be demonstrated by intervention study.

36.1.5 Intervention-study

Intervention study entails changing one factor under controlled conditions; that is to say that all others remain constant. The effect of that one change is then measured. This way a causal relation can be demonstrated. Intervention study can be conducted in normally functioning buildings as well as in laboratories. The most convincing kind is a 'double-blind' study. Then not only the persons studied, but also the people conducting the study are not aware of the fact of whether something has changed; and what has changed. The conditions prevailing when nothing has changed serve as 'control' population.

The study of an effect of a factor on people, for instance a factor of the internal environment, may be needed to get insight into the 'dose/effect relation'. Such a relation provides a basis for developing norms for an acceptable dose (and with that an acceptable effect). This study may be conducted in normally functioning buildings as well as in laboratories. In many cases the study is performed by universities or scientific institutions.

Intervention study may also relate to a factor in a process. The usefulness of the diagnostic method, described in paragraph 36.1.3, for better dealing with complaints, for instance, can be studied. For performing the study a number of buildings should be considered, let us say twenty. The buildings should be largely comparable in terms of size, usage and inhabitants composition. Before the intervention the situation should be measured by presenting a questionnaire to the inhabitants. That may be a sample, for instance one of 10% of the inhabitants.

a Finnegan, M.J. , A.C. Pickering et al. (1984) *The Sick Building Syndrome: prevalence studies;* Burge, P.S., A. Hedge et al. (1987) *Sick Building Syndrome: a study of 4373 office workers;* Kröling, P. (1988) *Health and well-being disorders in air-conditioned buildings:comparative investigations of the building illness syndrome;* Preller, L., T. Zweers et al. (1990) *Gezondheidsklachten en klachten over het binnenklimaat in kantoorgebouwen.*

b Bergh, W.H.J. van den, A.C.J.M. Eekhout et al. (1999) *Methodologie is elkaars methoden begrijpen;* Eekhout, A.C.J.M. (2000) *Over de dialoog tussen doel- en middelengericht ontwerpen.*

It should also be ascertained how complaints are being taken care of in the buildings concerned. Management of, say ten, buildings may be provided with the diagnostic method employed, for instance in the form of an expert system. The management of ten other buildings (the control group) just get general information. After six months, and again after a year all buildings are measured and conclusions may be drawn from the differences.

An intervention study of the effect of a particular design method may be imagined as well. A study like that could be performed in architectural education.

36.1.6 Development-orientated research

The development of equipment and systems entails more technical research. In this connection, one can think of investigations into cooling capacity of a chilled ceiling, the energy yield of an absorption-cooling process, the airflow pattern of an air supply grating, and similar issues. The purpose of this research is to attain (more) insight into how these systems work and / or how to improve their functioning. The analysis may also be related to energy use, life span and production methods. Manufacturers or large users of building installations (e.g. utilities companies) usually carry out this type of work. In a limited number of cases, study of this type is conducted at universities, like at the Faculty of Mechanical Engineering and Maritime Technology in Delft.

Developers seldom publish their study or study methods because they do not profit by that; for reasons of competition. Because of this, the study does not achieve scientific status. That does not imply that the study could not stand scrutiny of scientific criticism. Development study executed by universities is often published. In commissioned studies one is more secretive.

Research reports have to include the subject of investigation, description of the experiment set-up, methods and instruments; measurement results; analysis methodology and results (often graphs or mathematical models). Typical of this type of investigation is use of a model for the subject under investigation.

For example: in the case of the cooling capacity of a chilled ceiling it is known approximately how things work. On the basis of data from the literature it is possible to describe a theoretical model; like the heat transfer between the cooling water and the indoor space that can be described with empirical relations and ‘non-dimensional’ numbers like those of Nusselt, Prandl, Grashof and Reynolds.[a] A trial installation and measurements are needed in order to be able to determine the co-efficients in those relations, since they depend on characteristics of the airflow along the ceiling. The behaviour of the air current varies between a laminar stream and turbulence and also has the characteristics of a mixture of both natural and forced convection. The description of the theoretical model is one initial step in the development study.

36.1.7 Application-related investigation

Application-related studies may concern the effects of heating, ventilation and airconditioning (HVAC) installations on indoor environmental conditions, or on people. These studies can be conducted in normally functioning buildings or a laboratory. Indoor climate conditions are charted using checklists and measurements. People’s reactions are measured by having them answer questions with a questionnaire. During study in a laboratory it is possible to objectify human responses by measuring physiological functions: heart beat, oxygen uptake, skin temperature.

The conclusions of the study are usually formulated quite carefully, since they are also based on statistical analyses of subjective data collected by means of questionnaires. With this type of analysis several techniques are used in order to be able to demonstrate relations.[b] Although execution of the study and the manner of reporting usually obey scientific standards, the results are seldom published in refereed scientific journals; rather during interna-

a Knoll, W.H. and E.J. Wagenaar (1994) *Handboek Installatietechniek*.

b Orlebeke, J.F. , P.J.D. Drenth et al. (1983) *Compendium van de psychologie. Dl. 8. Methoden van psychologisch onderzoek, het verzamelen en scoren van data, statistiek*.

tional congresses like ‘Healthy Buildings’, ‘Indoor Air’ and ‘Clima 2000’. Also congresses of the American ASHRAE and the ‘ASHRAE Transactions’, published as a scientific journal next to the professional ‘ASHRAE Journal’, are highly esteemed.

36.1.8 Design-orientated studies

Design study is a form of application study. Such investigations are used to work out which technical or architectural facilities are necessary for meeting the functional requirements of a building with given characteristics and intended use. In addition to selection of the system, design study is aiming for the dimensioning of facilities. The study of the functional requirements based on the function of the building, is an essential part of this study.

Various installations are needed to make buildings fit for their function:

- climate control (heating, cooling and ventilation)
- transportation (elevators, escalators and similar)
- sanitary facilities (hot and cold water supply, sewage)
- electricity (lighting, power supply for machines and equipment)
- communication (telephone, data, security and similar)
- maintenance of building envelope.

In the paragraphs to follow, the design process of these functions and the type of research necessary will be worked out.

36.1.9 Evaluation

Design of building services and installations can be assessed beforehand (evaluation ‘ex ante’) and afterwards (evaluation ‘ex post’). ‘Ex-ante’ evaluations are increasingly being carried out as part of the design process, because their use leads to better insight into the effects of the dynamic properties of the building than the usual static design methods. In such a case the aim of the evaluations is optimising the properties of the building; for instance to make mechanical cooling superfluous. The evaluation may also be needed to forecast the effect of specific installations under conditions not applied previously. See paragraph 36.2.4 on page 333 for a more detailed description of this study.

‘Ex- post’ evaluation is needed to judge whether the functional goals of a design have been reached. This is the final stage of the design process that makes the design into a scientific feat, if the process is regarded as an empirical cycle (see page 249). A study like that is seldom conducted in practice if an architectonic design is concerned. This does not derive from the fact that there are methods known for conducting ex post evaluations. See paragraph 36.2.5 on page 334 for a description of the study concerning climate installations.

36.2 CLIMATE CONTROL

36.2.1 Functionality

The building functions determine the requirements in terms of comfort and usage that should be honoured by the indoor climate. The study of these requirements is the first part of the design study. Climate control may be realised by installations, constructional facilities or both. The shape and thermal properties of the building determine whether mechanical systems must be used or whether architectural provisions can be made. Comfort requirements and demands of use can be met by installations, provided they have sufficient capacity and are spatially positioned so that they do not cause annoyance. This demands something of the building: a sufficient amount of built-in space at an appropriate spot.

In order to be able to meet the requirements always, the installations must be accessible for maintenance and replacement. If the building should be flexible in terms of function or use, then the installations should also be flexible or at least adaptable. Insufficient built-in space leads to the use of installations that are too small; these do not have the required capacity, so it becomes too cold or too warm in the building, or stuffy. Or, these installations must do more than they are designed to do, without creating noise or draught problems. If terminal devices are wrongly located, it may cause draughts or unpleasant temperature gradients. These design mistakes can be prevented by ensuring that the architectural design and the design of the load-bearing, partition, and finishing constructions are in tune with each other and are being carried out synchronously.

It seems logical that the functions of the building determine which demands the indoor climate must meet, and that is indeed true. It seems less logical, that it may not be clear during the architectural design process what the function is of a particular space, and thus, that it is also unclear which demands this spatial area must meet. Often it concerns spaces that originated as a consequence of the architectural design and not because of their being mentioned in the programme of requirements. Glass spaces and atria are well-known examples. It is also possible that spatial areas are created as required by the specifications, but for which it is predictable that they will not be able to meet the normal demands related to their function, regardless of the installations or architectural measures taken. It may be attractive, for other than functional reasons, to build such spatial areas as they were designed. In that case the function of the space or the permanent character of that function should be re-examined. Often, such re-examination is not - or not openly - carried out, which leads to a lack of clarity about the possible use of these spaces. This is not a design error, but a mistake in the design process. This could be prevented by a project organisation in which all parties concerned, including client and future users, communicate openly about what is possible and what is impossible.

36.2.2 Requirements

Utility buildings usually owe their level of facilities to the requirements organisations put to them in their rôle of user. Inhabitants (people working in the building) have often different wishes. Not everything users or inhabitants expect of a building is made explicit as a requirement. For instance: a programme of requirements will never mention the quality of the water that should come out of the taps. Only if users or inhabitants have experienced an aspect as a problem, it gets attention and will there be conscious requirements formulated. It is the task of architects and advisers to establish a balanced schedule and to communicate about it with those involved. Functional requirements to be reckoned with in an installation design have been formulated largely in laws, standards and other rules. They relate to the thermal climate (temperature, velocity and humidity of the air), airpurity (ventilation), lighting (luminosity, contrasts and colouring) and acoustics (amongst others sound levels and reverberation times). Collecting this data is the first step in the design study.

36.2.3 Design process

Building and installation design

The indoor climate depends much of the time on the HVAC installations. This dependence is directly proportional to external loads (meteorological conditions, traffic and industry) and to internal loads (number of persons, artificial lighting, apparatus, production processes, building materials): the heavier the loads, the greater the dependence. The architect can influence this situation, primarily by reducing external and internal loads, and, secondarily, by reducing their effects.

A proper thermal insulation of the façade and use of sunblinds, keeping the solar heat out while allowing optimal daylighting, can reduce external heat load. An optimum is usually found by using adjustable (outside) sunshades. Tinted glazing and awnings also reduce heat at times when sun and daylight are needed. External load from emissions of annoying or harmful particles by traffic or industry can be reduced by not building in an area with traffic or industry.

If this is not possible, the façade must be constructed in such a way that it can be properly closed off, and the building must be equipped with mechanical ventilation including a proper air-filtering system (see paragraph 36.8, page 337).

Internal heat load is strongly dependent on the use of a space. The power of artificial lighting can be reduced by using high / shallow spaces and by making the façade less transparent. To clarify: in order to attain comfortable relative brightness, artificial lighting is required in proportion to the transparency of the façade. The optimum lies at about 30% light openings in the façade (as seen from the inside). Extracting air through the lighting fixtures can halve the heatload from the artificial lighting. Advising the client to use energy-efficient equipment and computers can reduce heatload from appliances. In this context one can think of computer screens turning off automatically when not in use. Further, it is possible to directly extract heat and contaminants from apparatus, for instance, by using furniture with a built-in extraction system. Thus, 70% to 80% of the heat and contaminants of apparatus can be discharged and does not enter the room.

The effect of heat load on the indoor climate can be reduced by a high capacity of heat accumulating mass. The mass absorbs heat during the day, emits it during the night. The mass of floors and partition walls is especially important. Preferably, the mass should not be shielded by false ceilings, panelling, raised floors, etc. Often, for reasons of flexibility, light movable partition walls are chosen. In practice, it turns out that many of these walls are never relocated. Here also are opportunities, if the designer can discuss this with the client. These opportunities are much reduced if the development is aimed at 'the market' and the location of partition walls is not fixed and changes per tenant.

Design process characteristics

Designing building services and installations is an iterative process, working from generic to specific and from rough to fine. There are various descriptions of the processes. They have in common that the design process is divided into phases. A well-known example comes from the Dutch *'Stichting Bouw Research'* (SBR) and *'Instituut voor Studie en Stimulering van Onderzoek op het gebied van gebouwinstallaties'* (ISSO).[a] This description is summarised below and indicates for each phase of the design process which decisions must be taken with regard to technical and architectural aspects of building-design.

Phase	Design decision on
FEASIBILITY STUDY	objectives / functions spatial needs financing
PROJECT DEFINITION	schedule of requirements - thermal comfort - lighting and - air tightness and insulation
GENERAL LAYOUT (spatial design)	building structure outline spatial layout & basic dimensions building shape zoning & compartmentation duct layout
PRELIMINARY DESIGN	building construction (=mass) façade construction sunshade, glazing and U-values HVAC system selection HVAC build-in space
FINAL DESIGN	façade details glazing & sunshade systems roof & floor details interior & ceiling details HVAC system sizing control systems

337 Design process according to SBR/ISSO[a]

Characteristic of the design process is that decisions continually have to be made on the basis of data not yet available. For instance: in the General Layout (at the Faculty of Architecture in Delft usually referred to as Spatial Design), the overall layout and main dimensions of the air ducts have to be determined. To be able to do that, it must be known which HVAC system will be used. That, however, is not yet clear at the stage of the Spatial Design. Moreover, at a later stage it may become clear that air ducts are not required at all, for instance, because natural ventilation will be all that is required. According to the scheme (figure 337), the choice of system must be made at the Preliminary Design stage. In practice, this is only possible when form and characteristics of the façade (glazing percentage, type of sunshading, etc.) and of partition-walls and finishings (heat accumulating mass, false ceiling, and such) are known. However, these aspects are only considered at the Final Design stage, not earlier.

The scheme shows that design decisions often have to be made on the basis of assumptions and that it has to be checked afterwards whether these assumptions were correct and whether earlier decisions perhaps have to be amended. In this lies the weakness of the design process, because the further the design has gone ahead, the more difficult it is to incorporate changes. On the one hand, this has to do with the fact that practical possibilities to incorporate changes reduce with the progress of the design, while, on the other hand, partners in the design proc-

a ISSO and SBR (1990) *Ontwerpen van energie-efficiënte kantoorgebouwen*.

ess are increasingly less prepared to accept changes. Further, one wants to keep to the agreements so as not to endanger progress of the design process. The assumptions must, therefore, always be as realistic as possible and, during the whole course of the design process, the focus should be on reaching coherence between the various design aspects.

This may be achieved by selecting a design method guaranteeing this coherence – and thus optimal integration. The design of HVAC installations from the perspective of installation designers is described in *'Concepten voor klimaatinstallaties'*.[a] Figure 338 schematically renders how a well-founded system selection can be realised. That does not mean to say that each and every installation designer does it that way.

Installation designers do have their own methods; whilst rarely communicating about them among themselves. They often prefer certain systems while they have good experiences with them. An installation shows almost who designed it. The system selection process described in *'Concepten voor klimaatinstallaties'* chooses the architectural sketch design for point of departure. Next to realising the programme of requirements an important objective is to conform to laws and rules, like those relating to energy conservation. Installation designers do feel themselves responsible for them and want to be held accountable.

The result of the process described is a pre-selection of viable installation concepts and variants. The final selection has just been described globally in *'Concepten voor klimaatinstallaties'*. It is a study orientated on requirements of comfort and creation of sufficient built-in space, possibilities of maintenance and management, aiming at flexibility, cost control (investment, energy, maintenance, exploitation), restricting environmental effects and a sufficient performance in terms of energy. It has not been indicated how various aims and costs associated with attaining them are weighed against one another. It is most remarkable that the installation design is described as a free-standing process; not as a part of the architectonic/constructional design process.

Design method

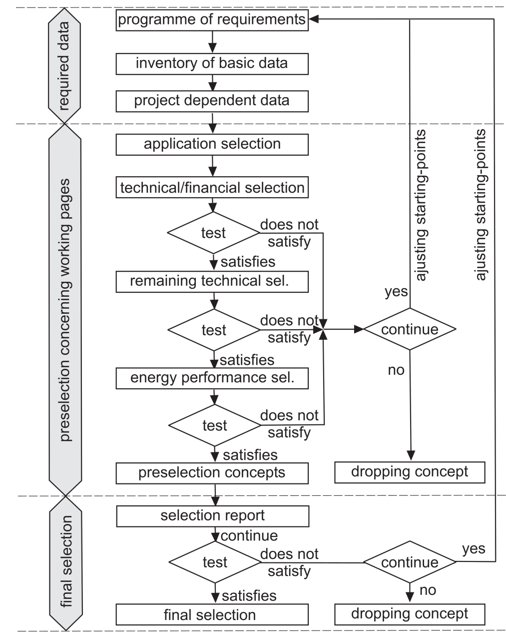
Departing from the given situation that with a design the road goes from generic to specific and from rough to fine, the installation design and the building design can be tuned increasingly better to one another during subsequent stages. The result of tuning always depends on the available data and on detailing those data. It concerns on one side constructional and physical data; on the other – as a consequence – data on the necessary installations and the built-in space needed.

The figure *'Integration building and climate control systems'* indicates which data are required at each stage in order to achieve optimal integration. The use of this method leads to an efficient design process, because the chance that in a following stage the building design may have to be changed substantially in order to accommodate the installations is reduced.

It is typical of this method is that the architect directs the installation design by designing the installations in their form and function. Installation designers may provide support in the way described in the previous paragraph, but the architect remains responsible. The task and responsibilities of the installation designers are detailing and carrying out the calculations for what is chosen by the architect. The detailing concerns the choice of the installation components, dimensioning, cost control, energy consumption and other environmental effects, preparing the specifications and contract documents, quality assurance during construction, etc.

36.2.4 Evaluation ex ante

Evaluation ex ante of the design is possible by means of mock-up investigations or by using computer models. In the case of a mock-up study a space is built, life-size or on scale, with in it the HVAC and lighting installation designed; and in a stable situation measurements of temperature and air velocity are conducted on several point in that space. Summer and winter conditions are simulated by using warm and cold walls; the internal heat load from



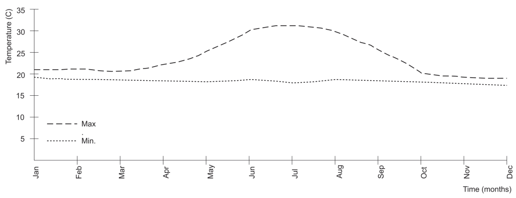
338 Design process HVAC installations

DESIGN STAGE →	GENERAL LAYOUT	PRELIMI-NARY DESIGN	FINAL DESIGN
DIMEN-SIONING →	'ROUGH'	'GLOBAL'	'FINE'
INTEGRA-TION STEP:	*based on:*	*based on:*	*based on:*
DETERMINATION REQUIREMENTS			
- indoor climate - indoor air quality - usage	schedule “ “	schedule “ “	schedule “ “
SYSTEM SELECTION	room typology	global calculation heat & cooling load	specific calculation heat & cooling load
HEAT STATION			
- location - dimensions	building volume	load estimation	load calculation, apparatus choice and room layout
COOLING EQUIPMENT			
- location - dimensions * central station * cooling towers * decentral units	building volume “ room volume	load estimation “ “	load calculation “ “
AIR HANDLING			
- zoning	<-room functions & building dimensions ->		
- central stations * locations * dimensions	zone volume	estimation m^3/h	apparatus choice calculation m^3/h and room layout
DUCTS, PIPES AND TERMINAL UNITS			
- locations - build-in space	system type	estimation (load & m^3)	calculation and apparatus choice

339 Integration building and climate control

b ISSO (1998) *Concepten voor klimaatinstallaties*.

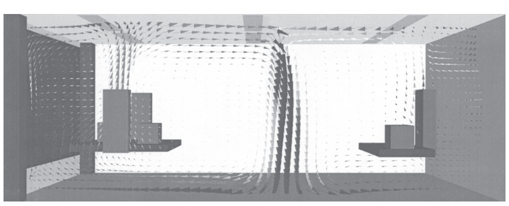
people and apparatus are reproduced by heating elements. This type of evaluation study is increasingly replaced by model testing using computer programs. For evaluation by computer, there are programs available that calculate changes in temperature with time, and programs that predict variations in temperature and airflow through a room. The first type of programs (TO), perform heat load calculations to predict variations in air and radiant temperature for a whole year, including the number of hours certain temperature limits are exceeded. See Figure 340.



340 Prediction of variations in air and radiant temperature by TO program.

In order to include adaptive behaviour of people in the evaluation, there are programs simulating the influence of acclimatisation and clothing. These programs require input of room dimensions, composition and material properties of walls, windows, and sunshade systems, as well as the rate of use and the load from people, and (lighting)apparatus. Cooling and heating capacity plus the control strategy for air supply and temperature also have to be entered. In these calculations, meteorological data from various weather stations and from different years can be used. The programs can calculate energy consumption for heating, cooling and ventilation, and the energy performance of HVAC systems.

Although such programs have been intended to evaluate installation designs, they are also used to test variants in order to optimise the installation design.



341 Calculation of temperature and air flows by CFD program.

With current Computational Fluid Dynamics (CFD) programs, the temperature and air flows (direction and velocity) can be calculated for a space in a two- or three-dimensional grid. By these programs, one can determine the best location for end-apparatus, for instance, in order to prevent drafts occurring in the living area. In order to limit the input it is studied presently how TO and CFD programs may be linked to a graphic CAD system.[a]

Knowledge of the physics of the interior environment and of HVAC technology is needed for conducting this evaluation study aided by the computer programmes described here. In addition one should be able to use these programmes routinely. That is the reason that they are not in use – as yet – in regular architectural education. Presently it is being studied how to increase the practicability and accessibility of these programs to such a degree that they could be employed in design education and by architects as a design tool.[b]

36.2.5 Evaluation ex post

To finalise the design process, an investigation can be carried out to see whether the designed building meets the design requirements; on that basis the effectiveness of the design process can be judged. In order to be able to determine whether the HVAC system has been designed effectively, it has to be determined whether the indoor climate requirements have been realised. These demands, however, are not sufficient to determine how occupants experience the indoor climate.[c] That is why occupant reactions also have to be analysed. For this investigation, 'Post-occupancy' and 'Post-project' evaluation methods have been developed.

A pre-cursor of the 'post-occupancy' evaluation is the 'Building in Use' evaluation, specifically intended to find explanations for complaints of building occupants.[d]

It is characteristic of these ex post evaluations that surveys have to be conducted and the occupants, or groups of them, have to be questioned with a questionnaire. The results are compared with the results of earlier building investigations. This procedure has provided extensive databases, from which increasingly reliable conclusions can be drawn.

Still larger collections come into being if the data of several researchers are linked. This has been done in the area of indoor climate study and resulted in increased insight in the human capability to adapt to the climate and in mechanisms influencing it.[e] This study shows that the preferred temperature in buildings with windows that may be opened is depending on the temperature outside more strongly than in buildings where that cannot be done. This means that buildings with openable windows need less cooling then the other type. This study con-

a Hartog, J.P. den, A. Koutamanis et al. (2000) *Possibilities and limitations of CFD simulations for indoor climate analysis.*
b Hartog, J.P. den, P.G. Luscuere et al. (2002) *A tool for thermal analysis of conceptual design.*
c Kurvers, S.R. and J.L. Leijten (2000) *A comparison of a pre construction judgement of the design and a post occupancy evaluation in a large Dutch office building.*
d Vischer, J.C. (1989) *Environmental quality in offices.*
e Dear, N. and G. Schiller-Brager (1998) *Developing an adaptive model of thermal comfort and preference.*

firms the idea existing for a longer time that buildings of the first type need less rigorous temperature requirements.[a]

International congresses have given a lot of attention to 'Building in Use' study, particularly to the development of questionnaires with minimal length. It has been shown that the original lists of more than 100 questions could be reduced to less than 20 questions. It is imaginable that 'post-occupancy' and 'post-project' evaluations, meant for ascertaining whether realised buildings reach their functional objectives reasonably, may be shortened similarly in length compared to current practice.[b]

36.3 TRANSPORT INSTALLATIONS

The study of internal transport of people by means of installations (elevators, escalators e.t.q.) relates to an analysis of the demand for movement and to the performance requirements put to the transport system. This performance is determined by the impression users are getting of the ease with which the demand for movement is handled. For an objective assessment the interval time, as well as handling capacity, amongst others, are used as indicator. The interval time is the time passing between the departure of two cabins following one another from the reception lobby. For the handling capacity the percentage of the occupancy is taken that may be transported in five minutes. By 'occupancy' is meant the number of persons maximally present on the floors served by the elevator in question.

The demand for movement depends on usage and partitioning of the building and the location of the building with regard to public transport. Buildings close to a train or metro station have to cope with higher peaks in the demand for movement than buildings relying on private transportation. Horizontal distribution of the traffic flow from the entrance to the building may serve in first instance the lowering of the peaks at the elevators. Escalators are also used for this purpose. In the case of buildings for one organisation peaks are higher than in buildings housing several organisations with varying or 'gliding' shifts. In department stores, hospitals and their ilk opening times, visiting hours etc. are responsible for peaks. With varying shifts and the spreading of opening hours, peaks will be lowered and the performance of the transport systems improved.

In the case of a spatial design a global analysis of the traffic flow in the building usually suffices; location and number of elevators (and possibly escalators) is determined on the basis of tables and rules of thumb. For the preliminary design number, sizes, type of motor, steerage and elevator speed are often determined with the aid of simple calculation rules and statistics-based computer programs supplied by elevator manufacturers.[c] In the case of very high buildings – where vertical transport may be of great influence on the shape of the building – this study should be conducted during the spatial design stage. For the final design simulation programmes are available enabling study of the traffic; also between floors. For the study aided by simulation programs specific knowledge of transport systems is needed as well as routine in working with them. Elevator manufacturers and a limited number of consulting companies possess this knowledge and routine. In architectural education until now only use is made of simple calculation rules and of programmes based on statistical data.

36.4 ELECTRICAL INSTALLATIONS

36.4.1 Lighting

The demand for artificial light within buildings depends on the presence of daylight. By tuning daylight and artificial light, a considerable amount of energy saving may be realised, particularly in utility buildings. As mentioned earlier, a lot of daylight does not mean that less artificial light is needed. Often it is just the other way round. More important than the amount of light (measured in the illuminance) is evenness of lighting. That is certainly applicable for spaces where work is done relying strongly on the visual function, when precise perception of small details is important, of slight differences in colour, or tiny contrasts. In the case of tuning the lighting on this limiting too large contrasts between work-surface (the task put to

a Schalkoort, T.A.J. (1994) *Normen voor een acceptabel binnenklimaat.*
b Leaman, A. (1989) *Building use studies, Post-occupancy and post-project evaluation.*
c Schalkoort, T.A.J. (2000) *Handleiding liftenprogramma.*

the eye) and surroundings is crucial, next to limiting reflections and blinding. However, it may happen that reflections and direct light are needed; for instance in order to perceive small faults in shapes or in properties of a surface. Optimal tuning is possible with regulating the amount of daylight as well as of artificial light. During the past two decades scientific study has been conducted of this combined control (also at the Technical University of Eindhoven).

Because of the development of artificial lighting, particularly fluorescent lamps ('TL'), the interest in daylight as a light source was waning for a while. Windows got much more attention in their function of visual connection between inside and outside and as architectonic elements in order to create contrasts in the appearance. Precisely these contrasts may work out unpleasantly in rooms where specific visual tasks should be executed; or may be even too stark. This may then be corrected by artificial light, shading against the sun, curtains and their ilk; at the cost of the architectonic contrast intended, of course. This implies that there exists tension between functional requirements and architectonic design. Consequently, the two should be balanced.

For the stage of the spatial design a study of the type of lighting, placing the lights and spacing cables usually suffices. During the stage of the preliminary design the placing of the light-spots and detailing of the space are tuned to one another (compartmentalisation, lowered ceilings etc.). At the final design it is studied which specific lighting fixtures are precisely needed in order to realise the requirements put to lighting in the project definition. The lighting requirements relate to strength, evenness, contrasts, colour rendering and colour temperature. Computer programs are available for studying type and positioning of the lighting fixtures that may be used; the size of the rooms and the reflection co-efficients of ceiling, walls and floors are input to these programs. They contain lighting technical data of a range of products. That is also the reason that these programs are usually made by manufacturers or providers of the equipment needed.

36.4.2 Power supply

For the design of the remaining electrical installations, like electrical power supply to equipment and machines, study is only conducted for the total needed and for the positioning and the space needed for transforming and housing electrical power and such like. For this, use is made of safety requirements – often formulated in national standards (e.g. NEN 1010) – of rules of thumb, and experiential data.[a] The physical hierarchy of electrical groups and switches is determined on the basis of constructional drawings. Knowledge and experience based on the lore of the craft is used. As far as known, scientific study is exclusively conducted in the areas of producing, transporting and distributing electrical energy.

36.5 SANITARY INSTALLATIONS

Sanitary installations comprise sanitary apparatus and facilities for producing and distributing hot and cold water. Facilities for sewage and discharge of rainwater often is included. For the design of these installations as a whole, knowledge and experience based on the lore of the craft is used. The probability that this knowledge and experience is not used is large, since the importance of this 'plumber's work' is often recognised insufficiently. This importance concerns particularly the built-in part of the sanitary installations that is in the building construction. If an insufficient amount of attention is given to this, cumbersome side-effects may emerge:water hammer, noise of flowing water, stench, sewage to the outside. When the building is ready, the possibility of correcting for them is usually slight. Trouble can be prevented by dimensioning pipes for hot and cold water, sewage and rainwater generously (but not too generously) with minimal curvature and – of course – by allowing for this timely in the architectural design, so that a sufficient amount of built-in space has been reserved. For sewage the horizontal pipes should have a slope not too slight; long horizontal pipes – certainly if they are realised within concrete floors – should be avoided as much as possible.

22 An. (1998) *Elektrische installaties, ontwerp en dimensionering: hoofdlijnen*.

During the spatial design a study of the number, the most logical placing of sanitary equipment and of the horizontal and vertical built-in spaces is usually considered to suffice. The pipes are dimensioned during the preliminary design.[a] At the final design stage, the selection of the material and the connecting technique is determined.

Increasingly, attention is being paid in the case of sanitary installations to environmental effects. In particular it is attempted to restrict the use of energy in the production of hot tap water, for instance by solar energy. Unfortunately water heated this way may provide 'ideal' circumstances for storage and growth of pathogenic micro-organisms like legionella pneumophila. Outbreak of legionellosis can be prevented by heating water from solar energy always to 60 degrees Celsius minimally (electrically or with a heating furnace). See also paragraph 36.8.

36.6 COMMUNICATION INSTALLATIONS

In order to be able to keep pace with the stormy developments in communication, utility building should have access to a flexible and adaptable infrastructure and built-in space to install such a structure and to expand it, if need be. Consider cabling, network servers, patch-panels and their like. The development is so highly paced that vested insight in this field may change within a very short time; sometimes months. The time needed to realise buildings runs a lot slower. This means that (optimising) study for data communication installations as they relate to design of the building is relatively senseless. A vision of the future provides a better basis for selecting and choosing. Up to now, raised floors, above a space that may be simply accessed (so-called 'computer -floors') have proven to be the most flexible option. That does not prevent buildings with such floors from demonstrating similar Gordian knots of cabling as the buildings where ducts for cables (on walls or in floors) have been applied. Obviously one does not take the time to move furniture to provide access to the space under the floor. In both cases (computer-floors or floor-ducts) ducts integrated in the furniture could provide a solution to reduce the mass of cables on the floor. Independent of this, data communication equipment and cables require less and less space; and instead of cables increasingly use is being made of infra-red transmission for communication between the pieces of equipment and between equipment and networks.

36.7 FAÇADE MAINTENANCE EQUIPMENT

Architects should indicate how maintenance of the skin of the building can be done safely. It should be accessible safely in its entirety for cleaning windows, paint-work, inspection, replacement etc. Ladders are allowed up to a height of 10 metres for washing windows. Higher than that, a 'cherry picker' may be used up to a maximum of 25 metres, if it is placed sufficiently close to the wall and safely secured on the ground. At greater heights – and in the case of walls bordering on ponds and inner gardens – they cannot be used and special facilities have to be implemented. During the spatial design the possibility of this type of maintenance should be studied, since it might cause adaptation of the shape of the building, certainly if slanting or protruding walls are considered. Large surfaces of panes under an angle, like those of conservatories and atria, should be studied for accessibility; in these cases also on the inside. At the preliminary design stage it should be checked how special facilities, like suspended access-equipment, can be implemented and what that entails for the detailing the wall and the construction of the building. During this design stage it should be studied, amongst others, how the suspended platform or chair can glide along the surface of the wall. During the final design stage the construction of the façade cleaning installation is dimensioned.

36.8 PREVENTING RISKS OF COMPLAINTS

Presently more than half of the occupants of office buildings is dis-satisfied with the internal climate. In other utility buildings as well (schools, hospitals and their likes) considerable dissatisfaction is rampant. National and international studies show that a large part of this is caused

a Schalkoort, T.A.J. and P.G. Luscuere (1996) *Binnenriolering en hemelwaterafvoer, ontwerp en dimensionering.*

by other aspects of the building than the HVAC installations.[a] Dis-satisfaction and complaints may be pre-empted by applying in each design stage a strategy that restricts or reduces risks of complaining. This strategy, often alluded to as 'Healthy Building'[b] is best used by the designers of the building themselves. When other parties are being made responsible for reducing the risks of its study, the risk as described in paragraph 36.9.3 comes into being.

36.9 DIFFERENCE BETWEEN CLASSROOM AND PRACTICE

36.9.1 Research in learning situation

There is a difference between the study as conducted in the learning situation at the Faculty of Architecture and the study in practice. In architectural education fewer design stages are being gone through. Teaching restricts itself usually to the Project Definition, Spatial Design and Preliminary Design. In a small number of exercises a Final Design is made.

The learning situation at the Faculty is aiming at the emergence of an attitude where the building designer in the making feels him/herself responsible for the installations of the building and for the functional goals that should be realised. In order to reach this aim in the learning context, study is also conducted that does not belong typically to the task of, for instance, architects, but to the one of installation designers and advisers. These exercises should give the experience what consequences certain constructional and architectonic design decisions entail for the type of installations and for the built-in space needed to house them.

36.9.2 Research in practice

Practice comprises more stages of the design process than have been trained in the learning situation. In addition, some tasks trained for are executed in practice by advisers or installation providers. The study focusing on design and integration of the whole comprises in practice the stages of the programme, design, development, realisation and maintenance stages. As far as advisers and providers play a rôle there, the process for HVAC installations has been described in Publication 43 of ISSO.[c] It describes an ideal; practice is often different. ISSO casts the installation designer for a rôle within which the architectonic design is being followed. The architect has the initiative; regularly reporting and linking back is the name of the game. This pre-supposes that in each stage of the design information is exchanged consistently. In practice this works often quite differently, since advisers or providers are getting more responsibilities and have to develop by themselves solutions for problems; even if these solutions can be found in the architectonic design.

36.9.3 Installation designers

Installation designers are aware of the fact that in the case of complaints on the indoor climate the accusing finger is readily pointed at the HVAC installations. They deem this to be understandable. Nevertheless, quite often the cause of these complaints must be allocated somewhere else. The phenomenon has been studied extensively; many congresses have been devoted to it. The solution is clear: installation designers should prevent during the design process the risks of complaints by warning commissioners and architects if they are forced to take risky design decisions. In reality most installation designers do like not to bother their clients and architects with this kind of problems. They are of the opinion – just like architects, by the way – that they have not been hired to warn for problems, but to solve them. In *'Concepten voor klimaatinstallaties'* this is also shown.[d] By the same token installation advisers are sensing a dilemma. They must earn an income, but also the confidence sitting on their shoulders. Usually they opt for short-term success and decide to make the best of it and hope – often against knowing better – that the final result will just work out. Client and architect can prevent this type of behaviour – risky to them – by means of a project organisation in which open communication is encouraged and realisation of a perfect result is seen as a common responsibility.

a Schalkoort, T.A.J. (1991) *Ontwikkeling en behoud van gezonde kantoorgebouwen - Studie naar het 'Sick Building Syndrome' en de mogelijkheden van het terugdringen van bewonersklachten in kantoorgebouwen.*
b SZW (1992) *Gezonde kantoorgebouwen, aandachtspunten bij ontwikkeling en beheer;* Schalkoort, T.A.J. and P. Luscuere (1997) *Gezonde gebouwen.*
c ISSO (1998) *Concepten voor klimaatinstallaties.*
d Idem.

37 METHODICAL DESIGN OF LOAD-BEARING CONSTRUCTIONS

WIM KAMERLING

37.1 PROBLEM DEFINITION

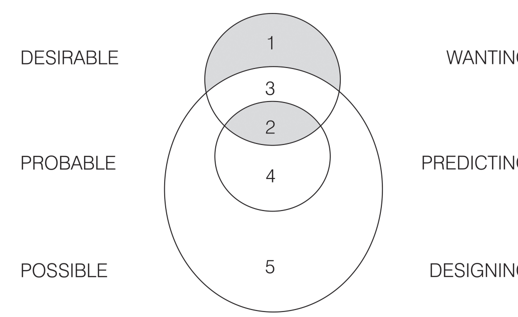
Throughout the last decades the building industry has changed considerably with regard to, for example, the use of construction equipment, logistics, products and management. These changes also affect the design process and the design methods for the design of buildings and for the design of parts of buildings like the load-bearing construction. Thus, because of increased complexity, buildings are more often designed by multi-disciplinary teams. Multi-disciplinary design is far from simple: part-products not independent of each other are designed separately and at a later stage part-designs often have to be tuned to each other (see page 345).

In order to ensure that the multi-disciplinary design process proceeds smoothly, design methods are required that permit concurrent and integral design of the whole building and the various parts. In order to attain optimal inter-action between the disciplines, methods which permit the design of the whole as well as part-products are preferred. The development of a method for the design of the support construction is based on a top-down approach. First, a general method for multi-disciplinary design is described and, next, this method is worked out for the design of support structures.

Figure 342 shows the influence of the participants of the design team, the authorities, and the client on a design. The number of designers and the influence of the designers on the whole varies per project. An inter-disciplinary design only comes about when the designers go beyond the boundaries of respective disciplines and design the whole together.

Authorities	
Client	Cost consultant
	Construction consultant
Architect	Installations consultant

342 The influence of the participants



343 Views of the future

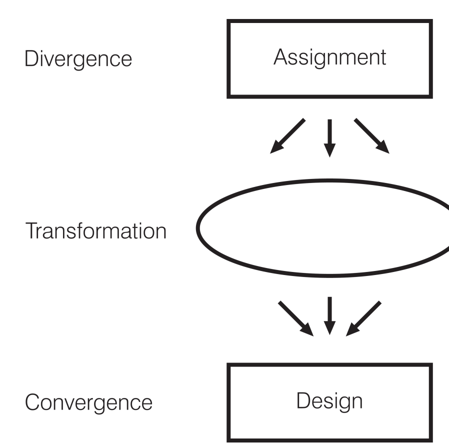
37.2 METHODICAL DESIGN

What is designing? Foqué presents the proposition: *“Designing is a concept with a very polyvalent content”*.[a] Eekhout, in the lecture notes for Design Methodology, gives an overview of the definitions used by lecturers at the different faculties of the Delft University of Technology, the Netherlands.[b] They show that the following facets are essential in designing: fulfilment of wishes and needs, taking decisions, shaping a product and originality. Based on these facets we can define the designing of the structure of a building as: to devise a system of building elements that can transfer the loads on a building to the foundations, while taking into account the limiting conditions dictated by the concept of the building.

Figure 343 shows the view of the future in politics, science and technology.[c] Like the politician, the designer tries to make the improbable possible. De Jong writes: *“The designer has the task of exploring improbable possibilities, especially when the most probable development is not the one preferred. Because of their improbability, these possibilities are not predictable, one has to design them”*.[d]

There are different schools of thought on design methods and designing. Often, a distinction is made between the intuitive and the explicit method. In essence, these two categories overlap. An explicit method always has moments in the process when intuition governs, and an intuitive method also has phases in which analyses and selections take place.

In the divergence phase there is a marked increase in the number of possible variations and data. In the transformation phase concepts and solutions for part-designs are conceived. In the convergence phase the part-solutions are combined in alternatives and the preferred solution is chosen.[e]



344 Schematic representation of the design process

a Foqué, R. (1975) *Ontwerpsystemen, een inleiding tot de ontwerptheorie*, p. 13.
b Ridder, H. de and A.C.J.M. Eekhout (1996) *Lecture notes design methodology*.
c Jong, T.M. de (1995) *Systematische transformaties in het getekende ontwerp en hun effect*. p.14, fig. 9.
d Idem, p.15.
e Foqué, R. (1975) p. 59

A design method for multi-disciplinary design must be able to be applied independently of disciplines and must foster inter-action between disciplines; further, the method should not interfere with creativity. What needs to be determined is whether the analysis phase - creative phase – and execution phase model[a] would be suitable, perhaps after some adaptation, for multi-disciplinary and interdisciplinary design.

The analysis phase - creative phase – execution phase model is as follows:

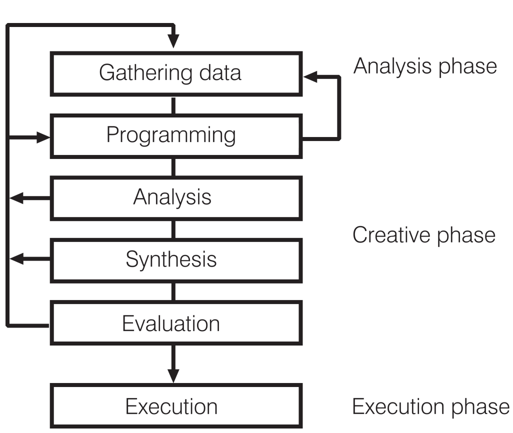
- The analysis phase: the problem is identified;
- The creative phase, with three sub-phases:
  - analysis phase: information collection, definition of the design criteria, classification of the design criteria;
  - synthesis phase: devising part-solutions, combining part-solutions in alternatives;
  - evaluation phase: testing the alternatives, selecting the preferred solution;
- The execution phase:the solution is presented in one form or another.

In the model, the creative part of the design process takes place mainly in the synthesis phase, when the solutions for the part-problems have been thought through and sub-solutions are combined in alternatives. Several methods have been invented to facilitate creative solutions, like:

- associative methods, for instance brainstorming;
- creative confrontational methods, using analogies;
- analytic systematic methods, like the morphological method, in which the problem is split into part-problems and solutions for part-problems are combined to yield alternatives.[b]

The first two methods are used, by preference, to come to a new concept of solving the problem. The morphological method fits in well with the model described, because, also in this model, the design problem is split up into part-problems, the solutions of which are then combined in alternatives.

The presentation of part-solutions and alternatives during the course of the design process is essential for multi-disciplinary designing. In the original model the presentation takes place mainly in the last phase. Because the members of the design team must tune their part-designs to the overall design, a continuous visualisation of part-solutions is essential for multi-disciplinary designing. For the sake of communication, the model must be extended in each phase with a visualisation of solutions and designs. During the last phase the chosen solution is further refined.



345 The Condensed model

37.3 CONSTRUCTION DESIGN OF A BUILDING

The design of the support structure is based on the architect's spatial outline plan. In this plan, the volumes and sizes of the areas are indicated globally. This spatial plan, together with the programme of requirements, defines the part-assignment for the design of the load-bearing structure. The design of a part-product is based on the detailed requirements which follow from the overall requirements. As the problem definition for the design of the part-product has already been defined in the analytical phase, a separate phase for the problem definition of the part-product is not necessary.

The design of the support structure is worked out simultaneously with the other part-designs. Thus, the implementation phase of the part-design can co-incide with the implementation phase of the overall design, so that no separate implementation phase need be included in the part-design process.

In view of the above, one may postulate that for the design of a part-product like the construction of a building, the method can be condensed to the three sub-phases of the creative phase, i.e., analysis phase - synthesis phase - evaluation phase. Figure 345 shows the condensed model for the design of a part-product like the construction of a building.

a Foqué, R. (1975) *Ontwerpsystemen, een inleiding tot de ontwerptheorie*, p.58.
b Tiemessen, N.T.M., Methodisch ontwerpen, p.15.

37.4 DESCRIPTION OF THE METHOD

Part-assignment

The architect's outline design is the basis for the design of the support structure. In this plan, a part-assignment, the volumes and the sizes of the various spaces are globally indicated.

Analysis

The problem definition and the data are analysed, differentiating between the problems and the data related to the location and those related to the function of the building.

Analysis of the location:

Investigation of the location and building site, adjoining buildings, cables and ducts, accessibility, site contours and elevation, soil profile, bearing capacity of the subsoil, drainage characteristics, climate and availability of personnel, materials and equipment. Determination of the variable loads on roofs and façades for the given site with regard to wind, snow, rain, earthquakes and similar.

Analysis of the object:

The making of an inventory of the requirements with regard to safety, for instance, in case of a calamity like fire, and preferences with regard to construction time, costs, deflections, position of the support points and of the stability provisions. Determining the variable loads resulting from the actual use, like floor loads.

Synthesis

In this phase, solutions for part-problems are devised and sub-solutions combined in alternatives.

Creation of sub-solutions

Generating part-solutions for the construction of foundation, roofs and floors, which are essentially different with regard to shape and construction material. Investigate which stability provisions are feasible. For easy communication with other members of the design team, visualise the part-solutions with the aid of sketches which clearly show position and shape of the construction aspects.

Combining the sub-solutions

Next, using a relationship matrix, the investigation focuses on which part-solutions for roofs, floors, and foundation can be combined in construction designs. Eliminating non-feasible alternatives at an early stage saves much time in combining the sub-solution. Making a display of the alternatives using sketches clearly showing form, position and dimensions. At this stage, the dimensions are determined globally only; for instance by rule of thumb and simple calculations. In the relationship matrix, at the intersection points of the horizontal and vertical axis, 1 indicates that the sub-solutions can be combined, 0 that they cannot.[a] There are in principle 3*2*2=12 combinations possible for the sub-solutions. After evaluation just four combinations remain: D1V1F1, D1V2F2, D2V1F1 and D3V1F1.

Evaluation

For evaluation of the alternatives, the criteria and their weightings are determined. Selection criteria may be, for instance, costs, aesthetics, feasibility, usefulness and load on the environment. Next, alternatives are compared with each other using the evaluation matrix.

Finalisation

In the finalisation phase, the dimensions of the building elements are checked, cost estimates made, and design and construction drawings prepared for the selected alternative design.

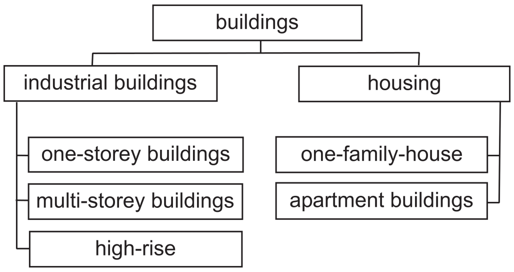
Function	subsolution	D1	D2	D3	V1	V2	F1	F2
Roof	D1				1	1	1	1
	D2				1	0	1	1
	D3				1	0	1	1
Floors	V1						1	0
	V2						0	1
Foundation	F1							
	F2							

346 Relationship matrix

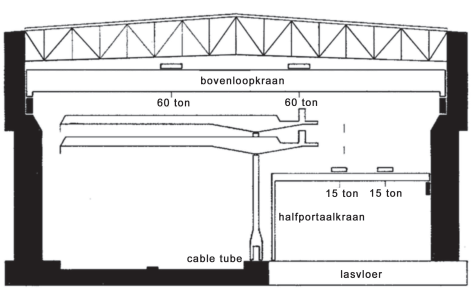
	Weight	A1	A2	A3	A4	A5	A6
Criterion 1							
Criterion 2							
Criterion 3							
Criterion 4							
Total							

347 The selection matrix with the alternatives in the rows and the selection criteria in the columns.

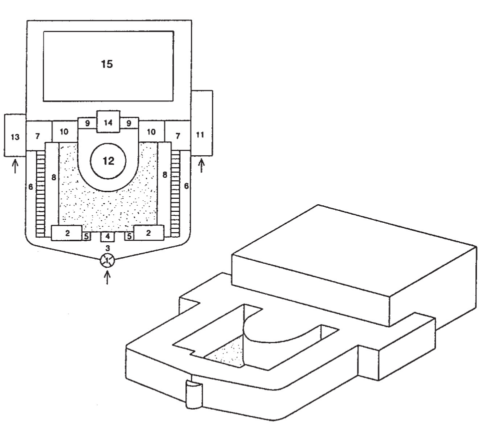
a Tiemessen, N.T.M., Methodisch ontwerpen, p.18.



348 The classification of buildings



349 Low-rise building



350 Outline design

37.5 FINALISATION OF THE METHOD

The method described can be applied to any type of building regardless of its intended use. Because many buildings are very similar from the point of view of their construction, buildings can be classified, and for each class a design method can be specified. In line with established practice, we distinguish, as an initial division, between building dwellings and industrial plants. In building houses we distinguish between one-family housing and apartment buildings. In industrial buildings we differentiate between one-storey, multi-storey and high-rise. These different categories differ both in the loads they are exposed to and in the design solutions.[a] For instance, the roof construction and the ground floor construction are essential for the design of a one-storey building, while for a multi-storey building the floor construction at the different levels is important and for a high-rise building not only the floors at the different elevations, but also the bracing structures are of great importance.

For further clarification, the method is worked out for the design of a unit of the classification, i.e., the design of the construction for one-storey buildings.

Figure 349. A one-storey building is a building with one main building layer, with possibly locally a mezzanine or landing.[b] The height of the building is not essential to the classification. The shipbuilding yard for Van der Giesen – de Noord, for instance, is 52 m high, 97 m wide and 264 m long. The design of the support construction of a one-storey building is based on the outline design of the building with the volumes and sizes of the spaces indicated. We discern the following steps:

Analysis

The problem definition and the data are analysed. Apart from the aspects mentioned in the general description, we specify the following aspects for one-storey buildings:

Analysis of the location

Investigating whether the one-storey building can be placed on footings, if necessary after soil improvement, or whether a pile foundation is necessary. Determining the variable loads on roofs and façades at the given location with respect to wind, snow, rain, earthquakes etc.

Analysis of the object

Making an inventory of the preferences with regard to construction time, costs, deflections, position of support points, shape of the roof and position of the provisions for stability. Determining the variable loads on the ground floor and the horizontal loads from building cranes. Listing the preferences with regard to settlements. Investigate the possibilities with regard to locations for support points and provisions for stability, and the possibilities with regard to the shape of the roof: flat, sloping, curved or double curved.

Figure 350 is an outline design of a swimming pool. This layout makes the position and size of the building elements visible, and the spaces located within.[c]

Synthesis

The generation of sub-solutions and the analysis of the sub-solutions.

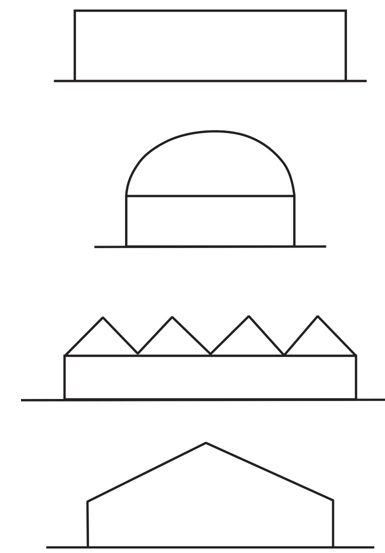
- Analysing which construction solutions are feasible for the roof construction, starting with the position of the support points, possible roof shapes and the position of the possibly necessary stability provisions.
- Devising types of construction that fit the roof shapes, which differ from each other in shape and construction material, and draw the roof plans.

a Kamerling, J.W., M. Bonebakker et al. (1997) *Hogere bouwkunde Jellema. Dl. 9. Utiliteitsbouw; bouwmethoden*, p.7.
b Idem, p.144.
c Tol, A. van and R. Jellema (1983) *Bouwkunde voor het hoger technisch onderwijs. Dl. 11*, p.1

Possible roofshapes:

- Flat roofs with a linear support structure like beams, trusses, pre-stressed beams, cable-stayed beams and portals;
- Flat roofs with a neutral structure like space frames and beam rasters
- Sloping roofs: three-hinged frames and folded roofs
- Curved roofs: arches and barrel vaults
- Double curved roofs: domes, conoide shells and hyppar shells.

- Analysing the possible types of floor construction; investigate for instance whether a reinforced concrete floor, a steel-fibre concrete floor or a prefab floor on a raster of beams is feasible. Analysing the possibilities with regard to the foundation, investigate whether a foundation on footings is possible, (if necessary after soil improvement) or whether the building will have to be supported on piles; and investigating whether the top layers of the soil are strong enough to carry the loads during construction from, for instance, building cranes, storage of construction materials and the pouring of concrete.
- Devising part-solutions for the floor construction and the foundation, and visualising them.



351 Possible roof shapes

Combining the sub-solutions

Next, the relation matrix is used to investigate which part-solutions for the roof, the ground floor and the foundation can be combined in construction designs. The different part-solutions for the construction of roof, floor and foundation are placed in the relationship matrix. Then, the investigation focuses on which part-solutions for the roof construction, the floor construction and the foundation fit together with regard to load transfer, and can be combined in designs for the whole building. Making the alternatives visual in sketches of the plan layout and cross-sections in which shape, position and dimensions of the various construction elements are brought out. At this stage, the dimensions can be generally determined by rule of thumb and simple calculations.

Evaluation

For evaluation of the alternatives, the criteria and their weights are determined and ordered. Next, alternatives are compared to each other using the evaluation matrix. The alternative that meets the requirements best is selected and further worked out.

The design method for the construction of a one-storey building can be developed for other types of buildings.

The preceding displayed a scheme with combinatorial possibilities between variants of foundations, floors and roofs (see figure 347). The variants of the foundation may be combined with some floor-systems, not with others. The combinatorial possibilities with foundation variants x1…xm and floor-systems y1…yn may be rendered by a m x n matrix (figure 352)

The readings are limited to 1 and 0, possible and impossible. However, the elements in the matrix may also indicate the price at which a contractor is prepared to connect the foundation to the floor-system. An extremely high price is economically equivalent to ‘impossible’, but we should keep the possibility in mind, for everything here is possible technically speaking.

A matrix like this can now also be made for the combination of n floor-systems Y and o roof-systems Z and for the combination of m foundation-systems X and o roof-systems Z. The total number of technical possibilities is then n times m times o. The connection between foundation, floors and roof is formed in this case by a system of columns and/ or walls between them and the design of that system is depending on the combination selected from the possibilities mentioned.

	y1	…	yn
x1			
…			
xm			

352 Combinatorial possibilities

This example should make clear that three aspects are of importance on this level: the *components* (here: foundation, floors and roof), the *connections* between these components and their *size-co-ordination*. The last one is, for instance, of great importance for the economical feasibility of a foundation-system with a floor-system. When the size-system of the foundation is differing from the one of the pre-supposed points of support of the floors, the connection may become expensive and perhaps even ‘impossible’ economically.

Obviously, the number of combinatorial possibilities is determined in the first place by what is considered a ‘component’ (*classification*). In order to be able to combine these components, several connections are required: between foundation and ground floor, between columns and floors, and between columns and roofs.

Therefore, a study of designing methodically carrying constructions leads by the same token from combination via classification to the ‘building node’.

38 CLASSIFICATION AND COMBINATION

YPE CUPERUS

Different ways exist for classifying components. Each classification serves its own purpose. This Chapter discusses several classifications. In a design for a building, components are combined into an ordered whole. The ordering of the positioning and size of the components constitutes the essence of the design, execution and usage of buildings. In order to be able to classify, the components should first be brought under the same nomer. Classification is the condition for combination.

Every classification of components generates problems of definition: should a floor be regarded as a load carrying component? For a floor is featuring a separating function as well. And should the walls always be regarded as separating components? Some walls are displaying a carrying function after all. By the same token, a global distinction between carrying and separating does not suffice: the classification should be worked out further; and this leads readily to complicated classifications of components and their definitions. In addition, the number of kinds of connections between all these components is growing. Perhaps these should be distinguished further in connections with the forms of points, lines, planes or three-dimensional structures; each of them with carrying and/ or separating functions; or both. But is it not better in that case to regard the connections as starting point, while defining the components between them? The focus shifts then to the 'building node'.

First, different classifications are described as seen from the practice of education, building and research. Next, an ordering of the combinations of components is explained as related to the history of the origination of modular co-ordination for building in The Netherlands. The shift from building to fabrication and assembly caused an inquiry into another, new classification of the components. The state-of-the-art of the most recent building node study is described. This is the foundation for consumer-orientated, industrial, flexible, decomposable and thereby sustainable building.

All the classifications demonstrate a range of scale overlapping with the semi-logarithmic range of nominal radii and their nomenclature earlier mentioned in the present book.

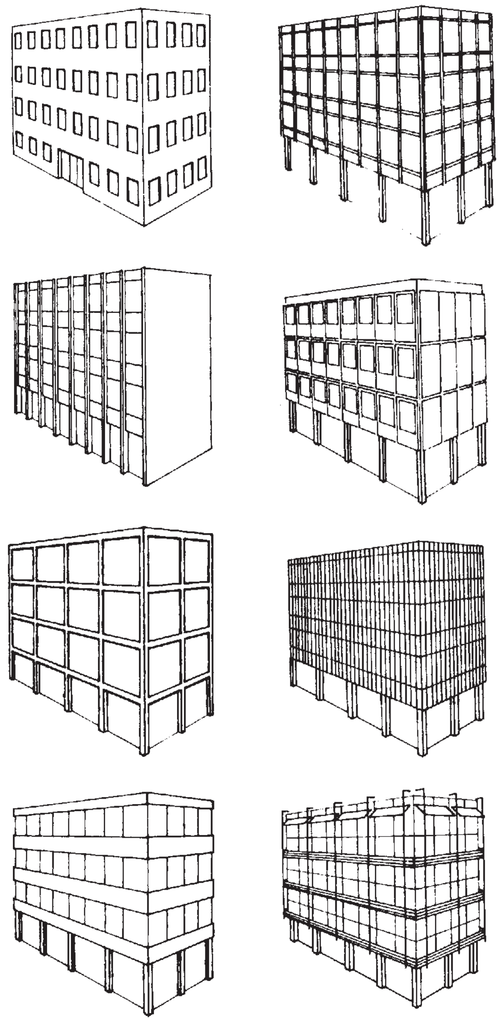
Nominal radius	Name
30m	Building complex
10m	Building
3m	Building segment
1m	Building part
300mm	Building component
100mm	Superelement
30mm	Element
10mm	Subelement
3mm	Trade material
1mm	Composition material
$<$1mm	Material

Both within the Faculty of Architecture of Delft University and outside it, different classifications of components have been used in education over the years. Building practice employs its own. These classifications will be described here; starting with those of a book dearly beloved at the Faculty of Architecture.

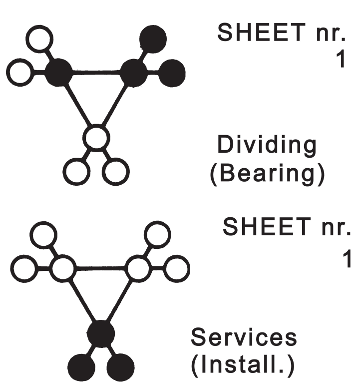
38.1 ACKERMANN'S CLASSIFICATION

The book '*Grundlagen für das Entwerfen und Konstruieren*' (Basic Principles of Design and Construction) by Kurt Ackermann deserves sincere appreciation because it defines, in 150 pages, very many aspects of the technical design of buildings. The author discriminates between spatial structuring (planning, design, dimension control systems), function (placing the different functions in relation to each other, and their connection to corridors, stairs and elevators), load-bearing constructions, divided according to their composition principle (column versus load-bearing wall), type of building (high-rise, single storey), but also main building elements (foundation, roof, façade, etc.) and material (timber, steel, concrete, etc.). Further, he treats physics as applicable to buildings, construction connections and technical installations. He concludes with the subject 'form'. The book, the product of one person only, takes a didactic approach to architecture and construction, starting out with technical issues which lead finally to the definition of form.[a]

a Ackermann, K. (1983) *Grundlagen fur das Entwerfen und Konstruieren*.



353 Structure according to Ackermann



354 Subject coding according to Gout

At Delft University, every subject in the structuring by Ackermann has its own specialists who, as a team, teach and carry out research on technical aspects of design and building. Until 1975, the Faculty of Architecture comprised five sections dealing with building-technical matters: three for 'Building Constructions' which followed the yearly curriculum (first and second year; third year; forth and fifth year), the Section Industrial Building, sub-divided according to construction material (concrete, steel, timber), and the Section Applied Mechanics. These last two sections were more orientated towards design and were part of the annual curriculum.

38.2 EDUCATIONAL CLASSIFICATIONS

To bring some order into the growing volume of building-trade data, In the seventies, Gout, a Professor of building technique, used a system that differentiated between 'partitioning', load-bearing', and 'facilities', crossed with a division according to 'function', 'materials' and 'construction'.[a] After 1979, this system was no longer used and lecture notes again became more traditional, addressing principles and particular solutions in architecture and building design.

In 1977, Dijkstra defined 'integration levels': the first integration level is that of basic knowledge (like applied mechanics, physics as related to buildings), the second integration level deals with the knowledge and practice to integrate various building-construction disciplines on the level of an actual building design. Dijkstra taught the second level of integration in his legendary project lectures, in which, for eight consecutive weeks, the project design and the implementation were explained by people with hands-on experience.[b]

During the eighties, a simpler structure for the department was put into place, related to graduating specialities, in which technical installations and physics as applied to buildings (and, temporarily, building economics) formed the sub-department group Architecture and Urban Technology (AST). This structuring, based on the way teaching was organised, was provided by successive professors and staff members who often had earned their spurs in practice, not in research or teaching.

In the course of time Chairs were modified, like the change of the Chair 'Materials and Creative Design'[c] to 'Product Development' (Eekhout). Teaching activities always followed the structuring according to integration levels, whilst changing the definition of tasks and fields of activity of the chairs made it possible to stay in touch with real-life.[d]

Brouwer, Professor in Building Technology from 1991 to 2000, pleads for integration. Then it will be possible, by clever design, to combine functions, for instance in a façade panel. By providing the parapet of a façade with a combined heating / cooling / sun-shade system, which works independently from the rest of the building, it is possible to save money on large installations and related space requirements of air ducts, where additional expenditure follows from thinking in separate systems.[e]

In design, an almost endless series of decisions is required before the built environment actually comes into being. Trotz, Professor of building technique from 1994 till 1999, ordered these decisions by category and translated them into a checklist, which the various parties, under the direction of the architect, can go through. Because the check list, in first instance, is written on the process and not on the end product, the list is long, regardless of the size of the result.[f]

The architectural field can be structured in many more ways, for instance according to type of production (once-only or industrial), discipline (foundation, façade, roof, etc.), scale, sequence, economics, culture, time, environment. All systems of structuring serve their own purpose and, because the building industry serves many purposes, no particular system of structuring is optimal.

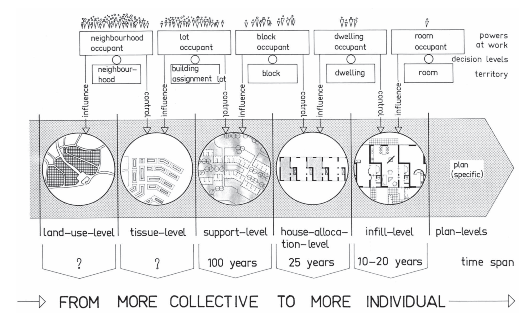
a Gout, M. (1973) *Bouwmethodiek I. 2e bundel*.
b Dijkstra, T. (1970) *Gebouw Afdeling Bouwkunde TH, Berlageweg, Delft, bouwkundig ontwerp.*
c Zwarts, M.E. (1983) *Bouwmethodiek 1*.
d Woord, J. van der (1994) *Een kleine historie van het vak op de faculteit*.
e Haartsen, J., J Brouwer et al. (1999) *De intelligente gevel*.
f Trotz, A.J. (1999) *Lamme hand achter blinde vlek?*

38.3 BUILDING-TRADE CLASSIFICATIONS

The Netherlands Building-trade Documentation (NBD) is a loose-leaf system of product information. It uses the SfB classification system. The NDB describes it as follows: *"It is a classification system for all information relevant to the building industry. This system was developed in Sweden in 1950 and has been accepted internationally"*. The system divides the building process into: substructure, superstructure, completion, finishing, provisions for installations, standard layouts, variable fittings and building site. All data 'relevant to the building process' is placed in one of these groups. The system uses an extensive letter / numbering code.[a]

The Standard Specification for Housing and Industrial Buildings (STABU) uses its own system for the classification of products. This system is geared towards writing specifications.

Typical for the classification of products is that, by rigidly staying with the system, the 'General' section keeps on growing, because very many items either do not fit one particular section or belong in more than one section. For instance: should data on sun-shades be placed in the category 'sun-shades', because they are sun-shades, or in the category 'façade systems', because sun-shades are procured and installed by the supplier of the façade, or under 'aluminium', because the sun-shade contains aluminium parts for which the specifications contain general conditions?[b]



355 Levels of decision making

38.4 CLASSIFICATION FOR DECISION-MAKING

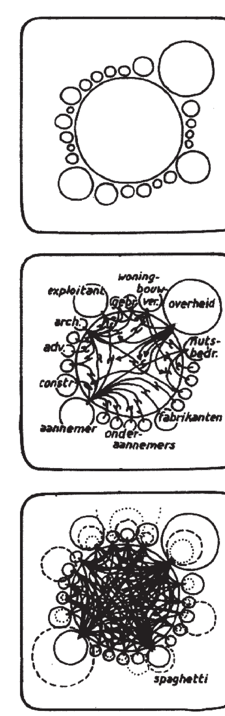
Instead of dividing the building trade according to 'things', there is much to be said for making a division based on the parties that decide over these 'things'. This idea was worked out for the first time in the beginning of the sixties by Habraken and the Foundation for Architectural Research (SAR), Eindhoven, at which time 'support' and 'infill' were defined. The support is that part of the building about which the inhabitant has no say and the infill is the part about which the inhabitant has full say.[c] Later, other decision making levels were identified, like 'tissue', refering to town planning.

Van Randen, Professor for building technique from 1973 till 1991, further detailed the sub-division of the decision-making process. He described the building process as the 'spaghetti-effect': pull one strand and everything starts to move in an arbitrary way.

Because decisions by the parties involved result, in the end, in decisions about materials, it was proposed to 'un-couple' building elements by proposing rules for location and size of the building elements.[d] This led to extensive research into modular co-ordination in house building, resulting in yet another classification of components. The basis was division of a building into 'building parts'. The groups of building parts defined were: load-bearing walls, floors, roofs, façades, inner-partitioning and wall lining, equipment, ducts and services and spatial areas. By agreeing, for each building part group, on certain rules about dimensions (multiples and parts of 30 cm) and locations (on an imaginary grid), the freedom of choice for the various parties involved would be exactly known, and this would make the building industry more efficient.[e]

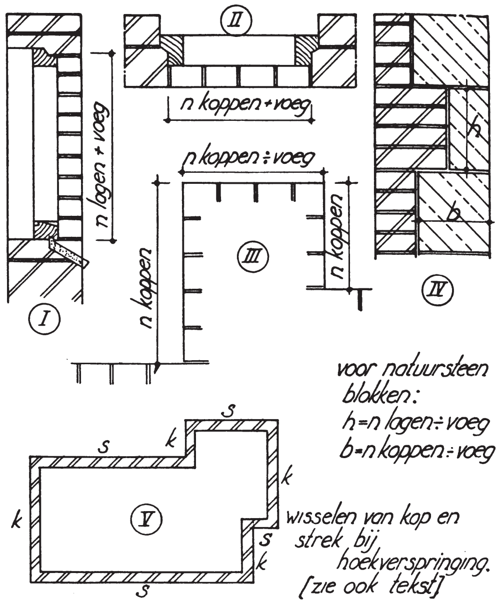
The division into building part groups, intended for structuring the building process, was also used in teaching. The building technique was explained using 'double pages' with, on the left page, the general considerations and, on the right-hand page, the specific solutions.[f]

When the components to be used are known, they must be combined within a plan for the building. This could be achieved by using mathematical models. In architecture this usually happens by a design process. During building the components are connected to one another. Connecting, joining, linking, coupling, fitting or interface determine whether a combination works. Sizing and positioning of the components establish the complement of the connection. Since the beginning of the sixties elaborate study into this has been undertaken; under the umbrella 'modular co-ordination'.



356 Van Randen characterised the power game in the building process as 'the spaghetti– effect'

a NCA Vakdocumentatie (1999) *Nederlandse bouwdocumentatie*.
b STABU, Stichting (1999) *Standaardbestek Burger en Utiliteitsbouw*.
c Habraken, N.J. (1961) *De dragers en de mensen, het einde van de massawoningbouw*.
d Randen, A. van and L. Hulsbos (1976) *De bouw in de knoop*.
e NNI, Nederlands Normalisatie Instituut (1981) *NEN2883, Regels voor gecontracteerde experimenten met modulaire coördinatie voor de woningbouw*.
f Randen, A van (1979) *Dakdiktaat*.



357 Koppenmaat

38.5 SYSTEMS OF COUNTING AND MODULAR SYSTEMS

Systems of scale and measure are significant for building in two ways. In the first place, they are a system for counting. All sizes may be expressed in the system of units chosen. But, even since early days a second application demonstrated itself: a modular system. Then, the rôle of the measuring system does not stay limited to counting. It has consequences for the positioning and sizes of the building element itself. The brick with its derived measures for length, width and height provides a classical example.

Modular systems entail great advantages for communication, since they allow standardisation. Not only the brick itself, but different building elements could be expressed in an earlier stage in these measures.

This standardisation enabled pre-fabrication. A carpenter could make sliding windows with a reasonable certainty that they could be applied in projects. A commission for a window-frame could be formulated simply in a number of heads and layers. This enhanced communication enormously.

In the early days the measure of heads and layers were just regionally significant, since the shape of the brick varied per region. Then, following the Building Law of 1901 that caused the emergence of a national building market, the 'Waal' format proved to be triumphant with a layer thickness of 6,25 cm. Sixteen layers make one metre: the modular system (brick module) and the counting system (the metre) were coupled.[a]

38.6 MODULAR CO-ORDINATION AS AN INTERNATIONAL NORM

After the Second World War modular co-ordination was getting new impetus, also a new basis. During the industrial effort connected with the war a vast body of experience with mass-production came into being. The merits of standardisation were discovered. These achievements should also be employed in building: not only for rapid re-construction, but also to build a counter-weight in Western Europe against threats from behind the Iron Curtain.

The ISO, the International Organisation for Standardisation, was called into being with for its aim world-encompassing uniformity of normalisation. The NNI, the Netherlands Normalisation Institute, is member of ISO.

The new basis for modular co-ordination in building was fixed by ISO on a basis module M of 100 mm and a preferential module of 3M, 300 mm. In this way a synthesis of the metric system and the anthropomorphic system of inch, foot and yard came into being. This way, 100 mm is roughly 4 inches and the preferential module of 300 mm is rounded off to 1 foot. That industry influenced modular developments greatly can be explained from the history of the rise of ISO. The options were determined by producing, rather than by those prevailing while building. Industrial considerations, like assortment restriction were rampant. Architectural conditions, like simple joining and inter-weaving – and the forming of spaces as well – was subservient to it.

Almost all industrialised countries prescribed a norm for modular co-ordination in building on the basis of the ISO guide-lines. The version of the Netherlands was published in 1964. It is a two-page document, NEN 5700, wherein just the basic module M of 10 cm is fixed and a system of reference, 'a three-dimensional grid of planes perpendicular to one another on a mutual distance equal to the basic module M. This system serves as a point of departure for the positioning of all building elements'. One year later, a norm was published, entitled 'Modular Co-ordination for Building. Tolerance System'. In it, the concepts related to tolerances were defined, like placing a modular building element in the grid, tolerance of manufacture, positioning tolerance, maximal and minimal impact of joining.[b]

38.7 THE IMPORTANCE OF CO-ORDINATION OF POSITIONING

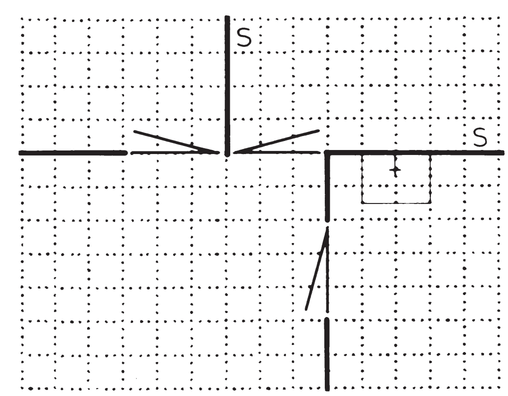
Modular co-ordination in building in the Netherlands took a turn differing from those in other countries. Architects were feeling ill-at-ease with norm NEN 5700, given its undefined deter-

a Carp, J.C. (1983) *Modulaire coördinatie, een hele geschiedenis*.
b Idem.

mination of position. The architect is not developing products, but designing buildings. By the same token he is not dealing with parts, but the whole. Joining, inter-weaving and forming of spaces are essential problems to him. All solutions should be studied for three-dimensional consequences; also on positions very distant in the building. Therefore, it is important that the elements do have a fixed position. Differences in size should not lead immediately to adjustments, having an inclination to reproduce themselves well into the remotest fringes of the building. In addition, a second characteristic of the work of the architect is important. Each and every design is always developing in steps. The interest of the architect is entailing that each subsequent step does not undo the previous one. This adds to the importance that the elements are staying in place. Further detailing to be considered may not trespass on positioning of building elements.

Then, a variant on the ISO proposals was generated among architects in which positioning was called for. It departed from an alternative modular grid with a one-to-one relationship between modules M and 3M: the M was positioned at the heart of the 3M grid-lines. These were the proposals of SAR, *Stichting Architecten Research*, a group of architects interested in furthering industrial ways of production in residential building; amongst other aims. The modular proposals had to enable separation between 'carrier' and 'appurtenance'. The emancipation of the appurtenance and equipment was seen as a way to create a space where the resident may decide for himself.

The SAR proposals were well received domestically; and outside the country. They also caused dis-enchantment. The positioning leap of 3M was experienced by architects as huge, particularly in residential building. Producers were of the opinion, that the SAR proposals were veering too much into the direction of positional fixing. The fixing of measuring was deemed to be left in jeopardy.[a]



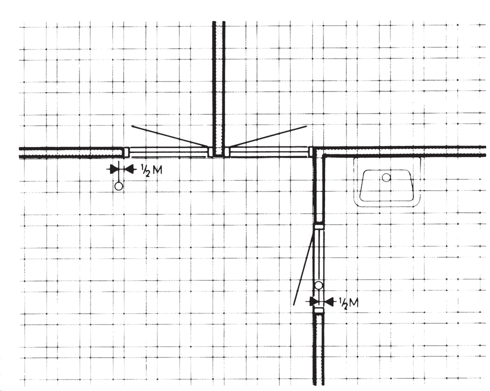
358 Spatial floor plan according to NEN2883

38.8 SYNTHESIS OF POSITIONING AND MEASURING CO-ORDINATION

The new interest as well as criticism caused the NNI to re-install the Norm Committee. Norm NEN 2880, *'Modular Co-ordination in Building'* was published in 1977. The positioning systemising of the SAR was endorsed and a lot of attention spent on the determination of measurement. A *'modus operandi'* was proposed, how sizes could be deduced. As far as the determination of sizing is concerned, NEN 2880, however, was rather a methodology than a norm.

By the massive production in residential building in series, the need emerged for a norm regulating the determination of proportioning in residential building more precisely; this became NEN 2883, *'Modular Co-ordination for Residential Building'*. It may be regarded as a synthesis of the developments described above. The norm regulated positioning as well as sizing prescriptions and was furthering as such the interests of builders as well as producers. It did enable the architect to work from what is global to what is detail, and to change building material in a later stage, since the co-ordination of positioning prevented that changes in size were transferred, 'radiated' to elements elsewhere in the building.[b]

The norm disconnected carrier and equipment; so that separate parties could decide independently within their own range of influence. The tuning of sizing and positioning also allowed that different disciplines could work next to one another during construction.



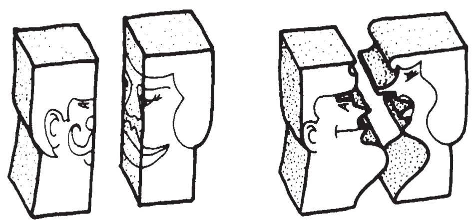
359 Material floor plan according to NEN2883

The consequences for products and ways of producing have been studied carefully in extensive consultation with industry. The norm distinguished between different 'partial building groups', like carrying construction, roof, façade inner walls, etc., all suggested by different disciplines with their own conditions and requirements. The spatial norms to be attained in residential building were included in the considerations as well, since minimal sizes of spaces are often dominant over the sizes of materials. 'Space' was one of the partial building groups.

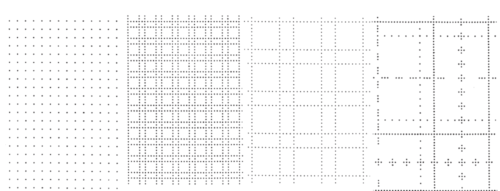
In spite of all these advantages, NEN 2883 had to face resistance in building practice. The rulings determining measure and position were rather abstract and kept themselves aloof

b Carp, J.C. (1983) *Modulaire coördinatie, een hele geschiedenis*.
c Idem.

from the practice of drawing boards and building site. At the time the norm should start to apply, the building industry was faced by serious recession, so that it could impossibly invest sufficiently in the apparatus of production. By increasing automation in production due to CAD / CAM and the logistics of Just-in-Time Delivery, the urgency of restriction of assortment was smaller than during the initial period of modular co-ordination. NEN 2883 was replaced in 1986 by NEN 6000, *'Modular Co-ordination for Buildings'*. Once again, this one was written in the spirit of the time-honoured ISO guide-lines. This particular norm was never made obligatory and is not applied in practice.[a]

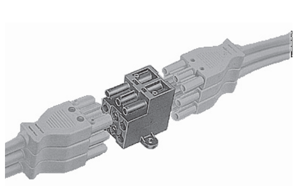


360 Adjoining and penetrating connections



361 Four different grids, illustration from the handbook.

362 Building on the site



363 If it clicks, it is alright

38.9 FROM DE-LINKING TO INTERFACE

The synthesis of size and place co-ordination served design and execution because changes in size on one place were not transferred to places elsewhere in the building. For the fitting of the parts suggestions were given: do not make penetrating connections, prevent 'boys meet girls'. This hint also contributed to prevention of the 'ripple effect'.[b]

Without adhering and closure no building can emerge. For that purpose an elaborate handbook has been developed, explaining how the spatial plan could be drawn subsequently on a 3M line grid (design grid 1:100), how, on that basis, the material plan could be drawn on a 1M-2M bandwidth grid (notation grid 1:50) and subsequently the details on a grid with a granular size of 1 mm (detail grid 1:5).[c]

The rules of sizing and positioning co-ordinate the elements and to a lower degree the connections between the elements. These were solved in first instance in the drawings ('to be decided on'), in second instance during construction ('saw off').

Government is de-regulating and has withdrawn itself from residential building. The Building Decree does not prescribe norms for details, but for types of performance of the building. The requirements put to the building in terms of safety, comfort and endurance are high. The quality desired of the components to be applied can be reached better under the controlled conditions prevailing in the industrial plant than in the wind and weather of the building site. The component has ceased to be the weakest link; now it is the interlocking of the components. The attention has shifted from position and size to inter-connection or interface.

Rulings for the interface are implicating an important condition for independent product development and building with sub-systems, like an entire roof delivered on site, or a façade system. In order to be able to use a computer for designing products and connections and to select from the database of existing products, an abstract description is needed allowing the computer to search and select. Next, inter-dependencies between the building parts can be named. Then, making the building parts independent can be a condition for more efficient production.

Manufacturing and building are two ways to make a product. Manufacturing happens in the industrial plant, building on the site. If manufacturing leads to an improved price-quality ratio than building, why do we not stop building and are we not making buildings just in the plant? The answer is obvious. Buildings are bound to sites. At best, we can shift the balance between building and manufacturing (pre-fabricating). The part of the building to be connected to the site (the foundation) may be comprising pre-fabricated parts like poles and beams, but the instalment happens on site. Many constituent parts just need installation. Building is becoming assembling. In order to be able to assemble, there should exist pre-fabricated products as well as the certainty that they will fit on their position. Improvising on the site does not provide that certainty; plugging- in and interlocking does.

In addition a well-designed interface renders the service of a built-in quality control: if it clicks, it is alright; and a plug-connection not well-made may be recognised and improved upon. This way the hiding of shortcomings is made impossible.

a NNI, Nederlands Normalisatie Instituut (1986) *NEN 6000, Modulaire coordinatie voor gebouwen*.
b Randen, A. van and L. Hulsbos (1976) *De bouw in de knoop*.
c Project Group MC+B (1980) *Modulaire coördinatie: plannen & details volgens NEN 2883*.

As long as there is no consensus on the interface no good products can be developed: that was the subject of the *'Building Node Study'* conducted during the nineties.

38.10 BUILDING NODE AS AN INTERFACE

In a design process from global to detail, general decisions may be formulated during an early stage in a spatial plan, with, in it, material boxes, spatial reservations for components with a certain performance. The performance, for instance thermal isolation, does not only extend to the components, but also to the joining between the components. In order to be able to classify the connection, the components should also have the potential to be named. For this, existing classifications proved to be inadequate. A new classification was needed that can name the components according to their position and size, the x, y and z co-ordinates of their spatial boxes, the performance required and the inter-connections.

This classification is establishing the basis for description of the interface in terms of performance. Furthermore, it allows searching in the database of available components on the basis of performance description, while matching the best possible performance to the spatial box for which the performance was specified.[a]

38.11 CLASSIFICATION ACCORDING TO POSITIONING

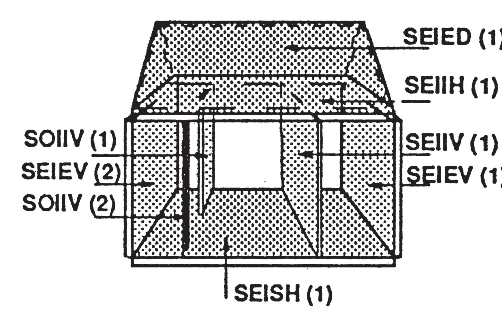
Parts and connections make a building. It may be described by points, lines and planes (x, y and z) as a concatenation of volumes. Some volumes are spaces, other volumes contain material. Such an abstract description enables description of a building without referring to specific products or connections. Based on its position, a unique code may be given to each part of the building, like S-EI-EV-(1). This code comprises a combinations of letters: in sequence prefix (S), first position (EI), second position (EV) and postfix (1). In this context one may distinguish between space-separating and non-space-separating parts. The first type, for instance an outside wall, inner wall or floor, is termed SE (space enclosure), the second, for instance a column or a kitchen cupboard a SO (space occupier).

A space separating part may separate an inner space from outside (IE), two inner spaces from one another (II), an inner space from the soil (IS) or from water (IW). A space separating part may then be placed horizontally (H), vertically (V) or at an angle (D):

Separating	Outside	Horizontal	SEIEH
		Vertical	SEIEV
		Angle	SEIED
	Inside	Horizontal	SEIIH
		Vertical	SEIIV
		Angle	SEIID
	Soil	Horizontal	SEIBH
		Vertical	SEIBV
		Angle	SEIBD
	Water	Horizontal	SEIWH
		Vertical	SEIWV
		Angle	SEIWD
Other			SO

364 Separating

The collection of materials within a volume is termed a 'group'. An example of a group is an inner wall. Its parts are not always homogeneous; a window or a door may be located in it. A group may comprise several sectors. A sector is a 'sub-group'. To indicate that the code does not refer to the group as a whole, but to a part, the prefix (sector) is used. Many groups and sectors demonstrate a tiered structure. These tiers can become part of the code.



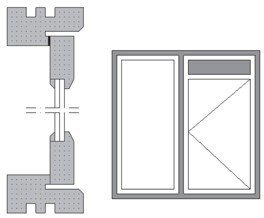
365 Group level

Computer programs may be developed, on the basis of a building drawn on a computer, coding automatically all parts. It is clear that this does not lead to user-friendly codes. However, they are unambiguous; and the computer knows how to deal with them. Just as a bar-code reader may tell us what information is hidden in the bar-code, an alias may be associated to a code, not readily recognised by the human eye.

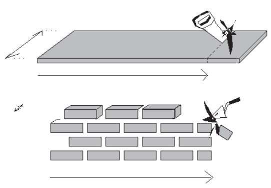
Spatial information in the form of x, y and z co-ordinates may be added to the coded parts together with additional performance requirements, such as desirable strength, fire proof, isolation in terms of heat and noise, colour, maximal price, and their likes. On the basis of this information the database of available products may be searched for optimal products, that may be drawn then as desired in the appropriate material box. Alternatives may then be drawn and compared, and the total price calculated. Ordering lists may be generated and on-line sent to providers, who then on demand and just in time.[b]

The abstract description can also be the basis for defining the interface. Materials are also differing in the degree in which they can adapt themselves to their environment. That is why a product description is also needed.

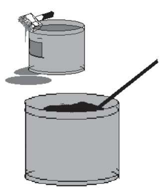
a Kapteijns, J.H.M. (1992) *Het informatiseren van het ontwerpen van bouwknopen;* Kapteijns, J.H.M. (1997) *Systematische productontwikkeling voor de bouw*.
b Hartog, P. den (1996) *NodeIT*.



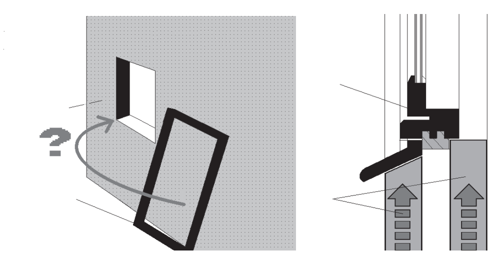
366 Part



367 Form



368 Material



369 Fitting problem and no fitting problem

38.12 CLASSIFICATION ACCORDING TO ADAPTABILITY

Many pre-fabricated products can not be adapted without damaging them unacceptably; think of pre-fabricated concrete or posts of doors and windows. These products are given the code P (part). Other products, like brick, wooden parts and planar materials are precisely used since they allow cutting or sawing on the building site, in order to make a measured fit. The products are given the code F (form). And then there are products delivered to the site as a material that will get final form only following processing; like concrete poured on-site, cement, paint, foam and their likes. These products are given the code M (material).

Earlier it was explained why it is that fabricating is better than building. In realising a building it is always necessary to build. A large share of pre-fabrication requires a lot of co-ordination, becoming more complicated with increasing numbers of suppliers. In the assembly of automobiles many suppliers are employed, but the location of production and the final product remain constant. In the assembly of buildings the site of production differs per building in terms of accessibility, and therefore of the providers. That is why the final product is different each time. In addition, different products demonstrate different sizing tolerances. For instance:

- a frame (P) in a pre-fabricated wall of concrete (P) must fit well; or it does not fit at all;
- the brick work (F) surrounding a positioned frame is adapting itself readily and, therefore, requires less tuning in advance;
- a wall decorated by carpentry must be sawn to size (F); - stucco and paint (M) always fit.

38.13 POSITION AND ADAPTABILITY COMBINED

The abstract description has a bearing on the space reservation for the material in a building. A distinction is made between the building (B), the space reservation for material: group (G), a subgroup; sector (S) and a tier, or layer in a group or sector (L).

The product description concerns the degree of adaptability of a product and is expressed in part (P), form (F) and material (M). We can now assess the building according to the degree of building and fabricating, by confronting both descriptions in a matrix:

	P	F	M
B			
G			
S			
L			

A traditionally built residence leads to the following distribution: Only the frames (sector level) have been pre-fabricated, made in the carpenter shop (P), the rest of the residence is on a low level (L) made on the building site (F, M).

	P	F	M
B			
G			
S	x		
L		x	x

A mobile home leads to the following distribution:
The entire building (B) is pre-fabricated (P) and is positioned on a pre-fabricated (P) foundation (G).

	P	F	M
B	x		
G	x		
S			
L			

A traditionally produced building is focusing on the right bottom part of the matrix, a pre-fabricated building on the top left.

The abstract description enables us to link the space reservation for the materials to the performance requirements and to find the optimal product substitutes. When appropriate products have been found for the empty fields, this is as yet no guarantee for a sound building. In the case of building, as well as in the one of assembly, there are certain dependencies between the products found that should be examined further.

38.14 DEPENDENCY DIAGRAMS

A building is a connected whole of building materials and building products. The connection transforms a collection of products and materials into a building that works. At the same time, the connection restricts the flexibility of the building, during construction as well as usage. A computer programme has been developed allowing analysis of the dependencies between various parts of the building. It can be provided in a dual way with building parts relating to one another, for instance: floor – door frame; frame door.[a] The dependencies of a part of a residence have been pictured, by naming the building parts relating to one another dually. The building parts (equipped with their Part-, Form-, or Material quality) are represented alongside, in the sequence of applying.

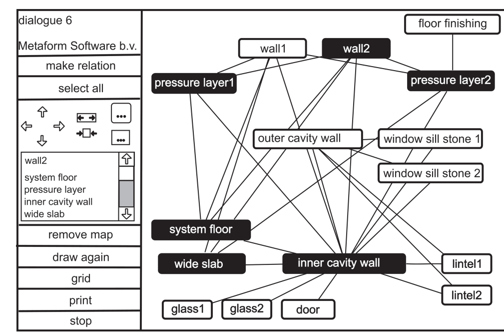
	Building part	P/F/M-code
1	System floor(first)	P
2	Pressure layer (first floor)	M
3	Wall(dwelling separating) 1	M
4	Wall(dwelling separating) 2	M
5	Wide slab storey floor	P
6	Pressure layer storey floor	M
7	Prefab inner cavity wall	P
8	Outer cavity wall	F
9	Lintel 1	P
10	Lintel 2	P
11	Window sill stone 1	F
12	Window sill stone 2	F
13	Glass 1	P
14	Glass 2	P
15	Door	P
16	Floor finishing (first floor)	M

Now the relations may be ordered in different ways. In relation diagram 1 the building parts have been ordered in such a way, that the building part with the largest number of relations is on top, the one with the lowest at the bottom. This indicates the most critical part. This diagram gives a first impression of the various dependencies; a good point of departure for further analysis.

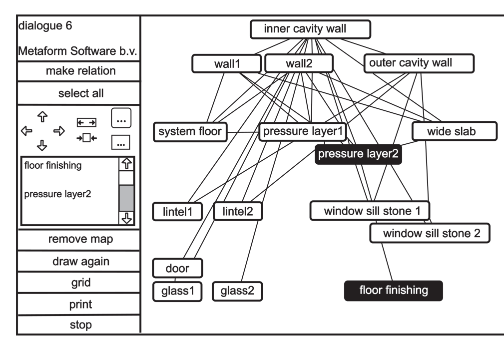
Relation diagram 2 classifies the building parts according to their P/F/M quality. It shows all P-P relations. If long chains of Part – Part relations are occurring, this is sign of many prefabricated building parts, all of them with a dependency relation. Any change has consequences for all other building parts, since the change can not be transferred to any other part. If the chain would be interrupted regularly with building parts with a Form- or Material quality, the ripple effect would be restricted significantly.

Relation diagram 3 shows a hierarchical ordering: the same relations, now in clusters of connection. It demonstrates that the critical component forms the connection between two clusters, displaying per cluster just internal relations. Spotting these clusters may indicate independent product development. It could also be a reason for adjustment of the architectural design, in order to lower the number of connections of one cluster with the critical component; for instance from three dependencies to one. It will simplify co-ordination during execution. On top of that, it is an indication for simple replacement in the future. In the context it should be remarked that complicated relations restrict flexibility, while straight relations are not proving the opposite automatically. When the relation, for instance, is one of gravity, like in 'floor resting on foundation', this is an indication for the foundation as a subject for independent product development. This also means that during the design stage it is possible to change the foundation principle. It does not mean that the foundation may be readily changed by a different one following the transfer of the building to its owner.

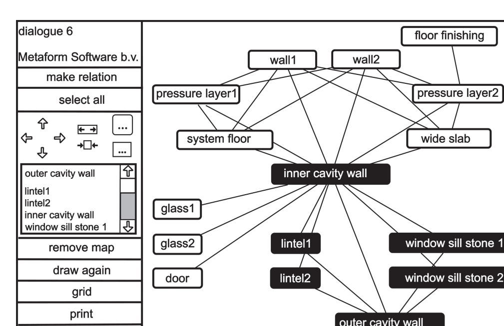
Analysing dependencies is an important tool for assuring the flexibility called for: during the design, execution, as well as usage stage of a building. If we see a building as a system, a co-operating whole, then the building node analysis is evoking the image of a building to be put together from various sub-systems, with a large amount of independence.



370 Relation diagram 1



371 Relation diagram 2



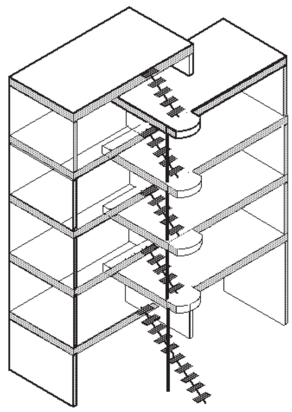
372 Relation diagram 3

38.15 CLASSIFICATION AS TO PRODUCTION

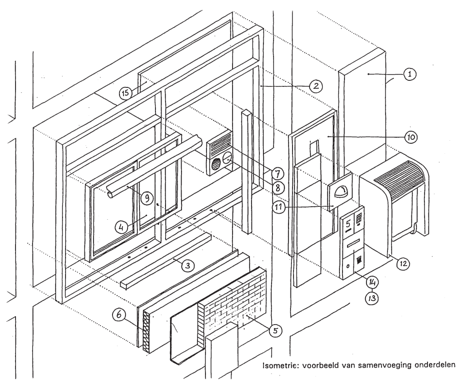
The dependency diagrams allow us to study and analyse the complexity of the connection of the parts. It is giving indications for clusters of components that may be developed as independent sub-systems, like carrying construction, façade, roof and interior facilities. This emancipation follows building practice, in which total sub-systems are pre-fabricated by a provider and applied in the works, with separate financial and guarantee arrangements.

Next, within each sub-system a further sub-division can be made of fixed and variable elements, between frames and substitutes. In this way a roof panel may become a frame for a sequence of roof windows, extensions and ducts. Frame and substitutes are classifications of component ordering; possibly co-inciding with carrier and facilities, classifications of decision forming. The consumer buys or rents a home with a standard roof, but an extension to it of his personal choice.

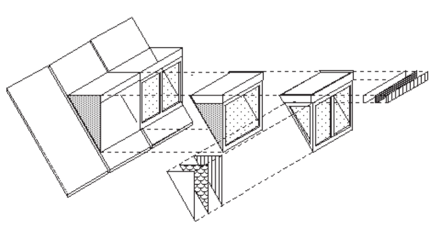
a Kapteijns, J.H.M. (1997) *Systematische productontwikkeling voor de bouw.*



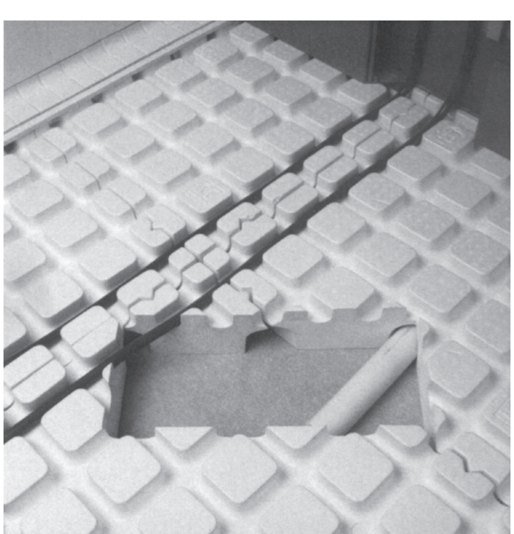
373 Skeleton



374 Optional window



375 Roof extension



376 Matura system

Carrying structure

The carrying structure is the sub-system of the building maximally connected to the location. Residential building in The Netherlands is mainly made of concrete, blocks of limestone and brick. The nature of these materials sees to it that larger size tolerances can be reckoned with than for other sub-systems. In addition the carrying construction provides the context, the 'frame' for the other sub-systems.

Façade

The façade has always been an sub-system, for which components (posts, windows, doors, bow-windows) were made in the carpenters' shop, then carried to the site, ready to install. Within the sub-system frame a substitution may be distinguished. The substitutions may be of an architectural nature, like windows and doors, but also constructional, like motorised shading, shutters, mailboxes, electric doorbells with inter-com and security cameras.

Roof

The laying of roofs has always been a separate profession. Roofs of thatch, slate, tiles and flat roof were provided by specialised sub-contractors. With the introduction of more extensive roof panels – the hinged roof being the largest among them – the manufacturing and applying of the sub-package is sub-contracted increasingly more often to suppliers. The roof is the framework for substitutes like windows, lighting surfaces, roof extensions and ducts for chimneys and ventilation.

Appliances

Appliances demonstrate the largest number of sub-contractors: plasterers, painters, tiling, plumbers, electricians. The main contractor always had an important co-ordinating task in this. The situation is slowly changing. Kitchen equipment, for instance, has vanished completed from building package and is sold now directly to consumers in the kitchen business, installing its wares without any interference from the main contractor. Appliances for bathrooms are being installed increasingly less often by traditional building partners; but ever more by specialists, approaching consumers directly. There is a clear trend that the whole area of appliances is becoming a constructional sub-system, installed by one agent in the glazed residence, without the interference of the contractor, and with bills directly charged to the consumer.

The building node study demonstrated that the building part groups mentioned allow independence towards sub-systems. That this trend can already be discerned in building is not the consequence of the building node study, but of mutual competition, the economic necessity to make a profit and of study following it.

The building industry finds itself on the eve of vast change. The residential shortage following WW II has been solved, the consumer has options as well as money. This means that the residential market is not determined any more by supply, but by demand. The consumer has power to buy; the building industry focusing on this has the best chance to make a profit and to survive. Building with frames, substitutes and independent sub-systems may provide an answer. In addition it is an important condition for independent development of building products; presently so advanced, that they cannot be developed any more for individual projects.

Lengthening the life-span of buildings, dis-assembly for renewed use and ultimately separate processing for waste are three other reasons for building with sub-systems.

Building node study is necessary, since it is not focusing primarily on improvement of the position of the building partners, but on flexibility of the building; finally on the built environment. The building industry understanding that is changing its bearings and will prevail.

39 METHODOLOGY OF COMPONENT DEVELOPMENT

MICK EEKHOUT

This Chapter focusses on the methodology of component development, originating from 20 years experience in designing, researching and developing spatial structures and claddings for architecture by the author. Component development is the name of the entire process, which contains a continuous flow of designing activities, embedded in process management activities. Core designing is the main activity, reinforced and supported by researching activities. The process is bordered by commercial influences from the market, directed from and towards the client(s) on the one (demand) side and bordered by production-technical influences from and towards the producing industries on the other (supply) side. The process itself is directed towards the final material product. Marketing considerations are seen as a continuous reflection for the process leader: is the product in the making still the desired product? The entire development process is steered by strategic process management, ending in design quality assurance.[a]

39.1 PRODUCTS, SYSTEMS AND COMPONENTS

The total process of component development is occupied by catering to the demand for new or renovated products. Three main groups can be discerned:

- standard building products
- building systems or sub-systems
- special building components.

The initiative to the development process is found in the producer who wants to extend his product range with a new standard product (glass producer St. Gobain could develop, for instance, square, transparent double glass panels with the graphical effect of glass building blocks). Or, take the producer who wants to improve a building system for the construction market (like Trespa an over-cladding façade system for old office buildings); or an architect who wants to have developed, for his building especially, a set of components or even a project system (as Kees Spanjers did with a filigrain and hanging glass roof construction as an acoustic reflecting screen for the 'New Church' in The Hague).

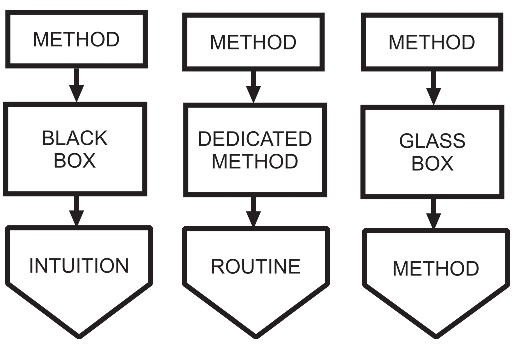
The standard product, building system or special building component must be designed and developed in order to fit well in the larger whole of a product range, building system or building. From this technical application environment of building components, the boundary conditions are usually rather clearly determined by the totality of the building within which the product should function. That is why the process of product, system or component development can have a clear structure, certainly compared to an architectural design process. Examples of these process organisations are given on page 282. Further in the text specific component development is referred to as the most interesting of the three main categories of products.

39.2 DEVELOPING IS DESIGNING, STUDYING AND MANAGING IN BUILDING

Within the development process as a whole the design activities, in their inter-changing modes of analysis and synthesis, are relating to an increasing contraction of answers to the question, while research is used as an activity to fill in the gaps in knowledge. Research starts by finding out whether the knowledge lacking is accessible elsewhere (research and retrieval). If that is not the case, a quest must be undertaken to describe the unknown field effectively, in its characteristics and systematically, in order to discover general rules and laws to distill this way finally that specific part of the generally orientated new knowledge and insight into the application required.

a Eekhout, A.C.J.M. (1998) *Ontwerpmethodologie*.

Technical development should result in the development of the appropriate final product, via a trajectory in which a solution is found for all sub-problems: either by designing or studying. In this, technical designing is the widely ranging and continuing composing of elements and components with known and unknown characteristics. Technical study is busying itself thoroughly with one, or few, technical aspects at the same time; in principle a finite activity. Process management is the continuing care for progress of the total development process.



377 Schematic Process

39.3 INTUITION, ROUTINE AND METHOD

The development process as a whole is, all things considered, extremely complex. The entire scholarly development process is developed in all parts critically and consciously. In comparison the practical development process (in the practice of design studios) will fall back in many points on routine knowledge & insight or intuitive decisions, carrying the process some distance further on the basis of a well developed feeling; or just good luck. This applies, while usually the novelty is only designed and studied on a select number of striking aspects. It is not necessary to re-invent the wheel all the time. The building technical designer will do his best to tackle each new design challenge with the originality and the ingenuity needed (from which novelty emerges), given his knowledge, insight & experience. Because of marketing influences, special component development as a total process is always application orientated; since a useful standard product, a building system, or a special building component should result.
In the design flow (design nucleus) considerations without a technical or application nature may also play a rôle; for instance social and cultural considerations.

39.4 FUNDAMENTAL AND APPLIED STUDIES

The partial studies needed for the development process may be fundamental or applied. For the Quattro frameless double glazes panes, Octactube developed in 1995 a chemical glue connection which does not enter the space between the layers. In co-operation with the Faculty of Aircraft Building this study of glueing was conducted as fundamental study; since a visible UV resistant glue had never been realised before. At the same time an application study was undertaken in the form of shortened long duration experiments in order to be able to give the conventional life-span guarantee. The development process as a whole, of which both types of study were parts, resulted in taking out a patent and dozens of applications per annum world-wide.

However, the timing and the rhythm of applied and fundamental activities in a process of development are quite different; as gears with different tooth-wheels. For the new office building of Zwitserleven Headquarters, designed by Pi de Bruin in 1996, 5 glass ‘louvre’ beams were foreseen above the main entry of the building spanning 23 and 27 metres with a height of 25 m. More than 80% of the building budget was spent on this study. Project constructor ABT and producer Octatube were strongly divided in their opinions on the built-in security of the design, resulting in a long series of prototypes and tests. This was fundamental study: nowhere else in the world had a 27 m long, free, spanning beam made from glass been realised that could carry its own weight through the glass alone. The project was terminated one year following the opening of the building, with for an attained performance of a breaking strength of some 60% of the stress aimed at in the glass construction. Measured in intensity as well as in time, this fundamental process of component development did not match the ongoing building process.

39.5 TYPES OF DESIGNERS

Just as this book as a whole, the present Chapter addresses three types of designers. Each of them will read it in a different way, for only after some (negative) experiences will the necessity be felt:

- Young designers (students), in need of a lot of knowledge, insight and experience. The methodological aspect should be emphasised in design education more strongly than presently. Many students think that the block and module manuals are their methods. During the graduation stage – when they have to function completely independently for the first time – many students demonstrate total absence of methodological insight.
- Professionals in design studios with knowledge, experience and insight who are tackling each design task from routine, often with an intuition nourished by experience. The efficiency required and the time-pressure usually characteristic for the design process is leading to leaps in the decision process of the designing guided by experience. Professionals should break with their routine & intuition and make them transparent, in order to give students a scholarly and educational design insight. For students the author wrote the book *'POPO or design methods for building products and components'*.[a]
- Scholarly developers, designers and students, monitoring a development process in order to come for a new task to a new solution by means of new materials and systems, thus increasing the state-of-the-art of the technology. In the Faculty of Architecture Dr. Ir. Karel Vollers is a striking example of these scholarly component designers. February 6, 2001 he received *cum laude* his doctorate for his dissertation *'Twist & Build'* on façades demonstrating torsion. Its subject encompassed urban architecture, architecture, building technology production technology and material science; and back again: Design study and study by design (see also Chapter 54 on page 483).

39.6 CONSUMING AND PRODUCING DESIGNERS

In the praxis of architectural designing novelty is often found exclusively in the composition of building components into a new spatial whole: 'designing as composing'. Well-known architects like Jan Benthem and Mels Crouwel act mainly as building consumers on the building market and are composing their buildings from elements and components offered on the market. Their studio is hardly active in product development, if at all; in component development in the construction parts of their buildings. Completely opposite in the spectrum, Jan Brouwer always devoted a lot of attention in his work to development of new and original components. He is behaving as a designer-producer in the preparatory stage of building. The rough polyester 'Brouwer' façades of the eighties are an example. He seduced the producing industry into co-operating with him. These components and their combination with components of a different type endowed the buildings of Brouwer of that period with a strong identity.

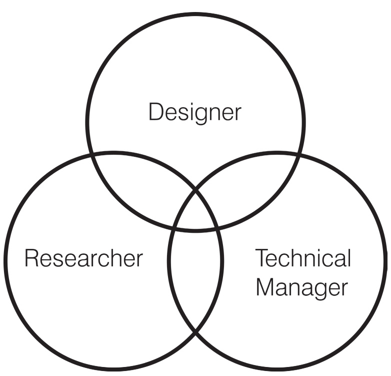
If the architect is unable to produce a new or original composition with well-know components – or is not allowed to; as is often the case in residential building with its low budgets – the degree of originality of the designing is almost lowered to the level of engineering. That does not require (scholarly trained) designers, but engineers. The Faculty of Architecture does not choose to educate its designers in that domain. Architectural designers should produce original and sophisticated work. The degree of originality of a design determines its quality greatly. It also happens that deliberate eccentricity of architects to produce compositions in an opposite way than the usual one is responsible for the quality of their designs; like the 'ruffled' buildings of Ben van Berkel during the nineties, and the new generation of 'Blob' architects (later in this Chapter).

a Eekhout, A.C.J.M. (1997) *POPO of ontwerpen voor bouwproducten en bouwcomponenten*.

In the praxis of design studios study, making the unknown known, is usually conducted from a personal shortage of knowledge and insight. This often amounts to acquisition of lacking knowledge and insight that is known elsewhere; or supposed to be. Rather, finding out and retrieving along these lines involves investigation (things unknown to the student only). It has nothing to do with 'scholarly study' increasing world-wide the state-of-the-art of technology that is the subject of this book.

39.7 PROFESSION PROFILES

So, within the whole process of component development, many designers in the building construction industry excercise a combination of activities in the field of development, design, research, engineering and management. Engineering is understood as the full elaboration of a building component once all design and research decisions have been taken. Engineering of components is often very critical as mistakes may cause dis-efficiencies or even failures. However, inseparable from the design and research activities, engineering in essence is not a core activity in the eyes of the scientific designer. In most technical development processes design, research, engineering and management are integrated to a certain degree, however the emphasis may differ between different component development processes. Emphasising one type of activity does not exclude another. Nevertheless, they are distinct enough to form the basis for three separate profession profiles of the Delft University Master of Science (at this moment still called 'technical engineer').[a]



378 Three profiles overlapping

the Master of Science as a designer;
the Master of Science as a researcher;
the Master of Science as a technical manager.

In the praxis of building the three profiles will always overlap. The student should have mastered the three profiles as fundamental qualifications. The professional designer should be able to deal with the three profiles as a partner; and when he has but a small office, he should integrate them in his own functioning. The scholarly designer knows how to separate the three profiles clearly and get them into dialogue.

39.8 DESIGN DOMAINS LACKING R&D

In architecture three principally different design domains may be distinguished: city-building, architecture and building technology. On each level, but certainly in building technology, building is distinct from other engineering disciplines by:

- Extensive dependency on context;
- Multi-disciplinary complexity of the design task;
- Cultural sensitivity of the result;
- Providing for one of the basic human needs;
- Well-known and generally used, often simple methods of execution;
- Relatively low-valued or traditional materials;
- Low entrance level for players;
- Small-scale of the enterprises concerned;
- Fierce competitiveness between designers and producers as well as builders; low prices for components;
- Relatively low final product costs;
- Strong focus on straight applications and absence of a feeling for long-term developments;
- Lack of a profound tradition and attitude in studying.

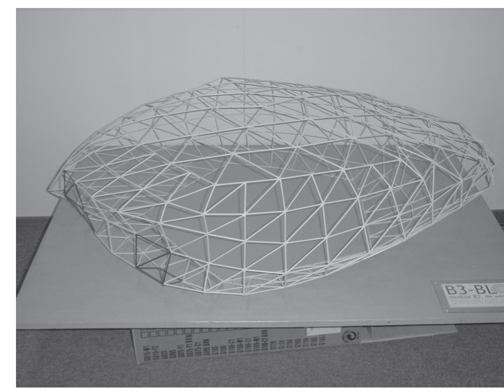
These properties are resulting in a shallowness of fundamental as well as of applied study. Generally, design activities are not regarded as study. Generally, the energy put into the development of the design during the preparatory process of buildings – in the form of designing, study and engineering – is not seen as 'Research & Development'. The engineering is almost

a Adviesraad Technologiebeleid TU Delft, (1995) *Op weg naar de 21e eeuw.*

completely application orientated. The bulk of the activities mentioned is charged directly to the projects. However, from the project-driven activity of building the experience & insight from the developmental processes is remaining. The study of SMO indicates that in building (= civil engineering + architecture) a meagre 0,5% of gross income is spent on R & D.[a] Water engineering is taking the largest part of that pie. However, in the case of buildings 10 to 20 % of the execution value is spent on development, design, research and engineering; being the total sum of the wages of the architect, advisors and engineering departments of the producers. With the total sum for R & D in building there can not be too much amiss. But, the long-term fundamental R & D is missing; usually it is application orientated on the very-short-term.

39.9 PRE-FABRICATION AND CO-ORDINATION

With the increasing complexity of buildings enabled by the more constructional character of the components and by the freedom *vis-à-vis* the Cartesian grid, in which architects can indulge through computers (see the 'Blobs' later); the process of preparation itself is also becoming very complex. It is requiring a process management based on thorough insight into all aspects of the development of a building design. Until two decades ago the architect was, traditionally and technically, the hub in the developmental process of building. This position is being eroded since then. However, computer-orientated preparatory processes could result in a watershed. In the new developmental processes for 'Blobs' the process is dominated by agreements between the chief designer and part-designers (engineers or co-makers) on the basis of the spatial 3D model, produced, certified and guarded by the architect. Out of this he can distil a position of power, as long as he shoulders the burden of the associated responsibilities for correctness of the geometry of the whole building as well as its parts.



379 Part 3D model of the Floriade design by Kas Oosterhuis

The realisation of building in open air with heavy materials and large components has very few, or no similarities with the increasingly virtual world in other branches of enterprise. Young people are clearly becoming more hesitant to start working in the building industry. The labour conditions prevailing at the building location are improving more slowly than the inclination of youngsters to become subjected to the slings and arrows of the outdoor climate. Quality control on the site is also leaving a lot to be desired. Components manufactured in a well-equipped production environment are featuring a better quality. The character of building will be determined increasingly by industrially fabricated standard building components and building components and building systems requiring much more co-ordination and integration for the various engineering disciplines, the productions of components of dozens of producers and the final assemblage/ execution in each building project. The preparatory process is becoming much more technical. In the past this task of co-ordination had to be executed by the chief constructor. Presently the number of constructors well aware of technical specialities is very limited. That is why specialised building managers are coming to the fore increasingly in order to take over that function. On the long-term they can only be successful in this, if they are having sufficient technical insight and willing to take a proportional part of the risk for their co-ordination.

39.10 SPECIALISATION AND CO-OPERATION

The environment of the technical designer is determined to a great extent by the one of the architect. The competition among architects operating independent from production & execution is fierce, because of the large number of relatively small studios. More than 75% of Dutch architectural studios employ less than three people, with a modest turn-over per person. A completed education, a position in the register of Dutch architects, a number of relatives in the building industry or winning a design competition prize, and one or more design computers are providing a starting architect already with the wherewithal to compete. Next, architects are inclined to develop and work out further all kinds of, and increasingly differing

a Jacobs, D., J. Kuijper et al. (1992) *De economische kracht van de bouw, noodzaak van een culturele trendbreuk.*

types of, design tasks. Shared sub-contracting to specialised colleagues is almost non-existent. Specialities in a segment of the building market are occurring mainly in larger studios; for instance with EGM, with many hospitals in its design portfolio, and NACO, developing many airports.

As a buying market building is usually local and the players are national; some engineering agencies and starring architects are operating internationally as an exception. Ambitious authorities on the city-level tend to profile themselves occasionally by proposing international design competitions. Some major international building companies and producers operate in several countries as well; however, again, according to national rules and with national networks. The regulation is still not very internationalised, due to informal national protective constructions; although there is a striving towards a clear European or international standard.

In building, technical designing is orientated towards application. In the easily accessed building industry it is customary to work with ingredients well known, understood and manageable by designers, as well as producers and constructors. A musical composer designing for each part in the score for his concert new notations and musical instruments will not perform many concerts. Too much attention for application and engineering, however, can cause in its turn undervaluing fundamentally new possibilities. Fundamental (applied) study is in that case insufficiently conducted; and designs are chosen from well-known materials, techniques and components: putting together, rather than inventing. This picture tallies with the majority of present building. Scholarly designers should be able to change this with a higher ambition

39.11 A BRIDGE BETWEEN ARTIST AND ENGINEER

An architectural design requires so many design decisions with complex inter-actions, that most of them will be taken by routine or intuition. A methodical approach is only serving to make this intuition clear to young designers and to the professionals in order to bridle them in some design tasks. The design capability of the architect finds itself somewhere in between the extremes of the functional-technically developing engineer and the purely intuitively shaping artist. The engineer with his rational thought and the sensitive artist – that is technique and creating form – are constituting the extremes of the band-width within which the architect is looking for his place. It should be kept in mind that both extremes do not exist without their mutual influence; a work of art can not stand on its own feet without knowledge of materials and technique of construction. At the other side of the fence, in the development of bridges in the Netherlands designers are becoming increasingly involved, in order to give the concatenated techniques and sub-systems a face that may be recognised. Luckily, there are also heroes in the building praxis serving as beacons for combining art and technology. Renzo Piano is making gorgeous buildings, earning each time respect by their originality as architectonic concepts (the KPN building in Rotterdam was built for a normal square metre price) while his chosen materials, components and details are managing the same feat in the technical working-out. Next to this, Piano is the most striking example of the studying designer developing his buildings in an innovative and inspiring way.

39.12 ARCHITECT AND COMPONENT DESIGNER

The architect finds himself between the urban designer and the component designer. At one side, social and cultural considerations are usually of importance, at the other functional, technical and economical ones. In this he must maintain the creation of form as a characteristic of his position as an artist and of the building as a form of applied art. The position of project architect, on one side, and of component designer, on the other, are usually distinct in the design band-width, in spite of the inspiring example of Renzo Piano. The component designer, who might be employed by an architect as well as by a producer, will have a tendency to the rational engineering approach, but with a high architectonic ambition level. The book by

Roozenburg en Eekels: *'Product design, structure and methods'* is influential in this respect: not only used at the sub-faculty Industrial Design of Delft Technical University, but also frequently in the building technology curriculum of the Faculty of Architecture.[a]

The component designer serving the project architect is, as a consumer of building products offered on the construction market and respectively of building components developed previously by third parties, rather less restricted to existing techniques of production and materials than the producer bound component designer. He is aware of the luxury of choosing from many more possibilities: also from possibilities seldom used or those that have to be imported in the discipline. As a designer-consumer he is not obliged to employ certain ways of producing or executing. Firstly he will be trying to get his personal ideas for components realised. Secondly, if that proves to be too expensive, or impossible on other grounds, he may opt for a higher degree of individuality for the total design through an unconventional ordering in the space ('topology') of standard products and system components. He has more affinity with the approach of the aesthetic composer. Standard components may also be used in an improper, or new way. Rudy Uittenbroek designed on Eindhoven University campus buildings with non-rectangular bricks. The eccentricity of the project architect can result in an eccentric building, realised in spite of a small budget by relatively few economical means.

The difference in the approach of the engineer and the one of the designer is the continuing combining of analysis and synthesis and feed-back between the two, if intermediary results are not satisfactory. The engineering approach, related to the methodology of designing, is resulting not infrequently in a straightforward technical-functional motivation with the appropriate feed-back. Contrariwise the designer approach results in a one-of-a-kind creative-aesthetic motivation.

39.13 REGISTRATING TRAINS OF THOUGHT

The integration of functioning as engineer and designer is very suitable for the developmental process of the component designer; when combined with a periodical description in writing of trains of thought and results. The ease with which meticulously recorded design processes can give insight to outsiders is at the same time a good start for convincing the commissioner.

To the designer it makes a lot of sense to be able to verify his own reasoning and to weigh the mass and validity of the arguments once more, especially for feed-back and evaluation ex post; but also to reserve room and to create expectations for creative explosions or implosions! During the development process creativity should stay well-protected. Still, working systematically and recording it often results in a better controlled design process. Fortunately, excellent examples of this way of working may be found among distinguished Dutch architects. In their publications on architecture both Herman Hertzberger and Hans Ruyssenaars demonstrate this transparent, but inquisitive approach. Especially in case several processes must be going on simultaneously within the head of one designer – something often happening in a major design studio – chronological reporting and accounting is an excellent tool to maintain insight into the design process. All too often a talented designer is faced by dozens of projects on his desk. That requires adequate ordering. 'Simultaneous designing' may be compared to playing simultaneous chess.

a Roozenburg, N.F.M. and J. Eekels (1991) *Produktontwerpen, structuur en methoden*. English translation: (1995) *Product design, fundamentals and methods*.

39.14 FREEING METHODOLOGY

For building technology developers applies the dictum: *designing is an efficient process in making decisions towards an original, ingenious, functional, material and spatial solution for a construction problem, from initiative to realisation*.[a]

- *Methodology is the science of methods* used in a process; component design methodology applies to the theory of methods for component design.
- *Methodics is a set of methods* somebody or a group of professionals operates with; in this case the set of methods used by a building engineer or a group of professionals during the component design process.
- *A method is a fixed and well-described procedure*. A component design method is used during component development and designing. Some methods cover the complete process: 'overall' or complete methods. However, most methods are partial methods, only applicable to specific parts of the design process. An overall method can contain several partial methods.

The word 'method' is derived from the Greek and means *'the way between'*, between the beginning and the end of a reasoning, between starting-point and objective. In linguistic usage it became understood as: *the* way, an absolute datum. That is somewhat inherent to the fact that a method seems a fixed, well-described procedure. Therefore, an individual method also has to be well-described, in order to avoid the predicate 'arbitrary'.

So, a personal interpretation of a design method always remains possible. There is the restriction, that it must meet the general demands of methodology; that the different steps or activities must be explicitly formulated and that they are open to communication, control and verification by outsiders, by tutors for students and by building team members for clients.

Although methods are generally used in practicing research science, in designing, on the other hand, opinions on the sense of using methods are divided. There are two extremes: the *intuitive* and the *methodical* approach. The *routine* approach is unconsciously methodical and lies in-between. In general successful design processes occur with an approach that can lead to good design results.

39.15 METHODICAL DESIGN APPROACH

The self-directedness or conceit of the designer does have to make space for directed, fixed and well-described methodics. The other way around, next to methodics there has to be kept a clear space in the design process for the individual creative ideas which make design results often so self-willed and attractive. *Methodics must never suffocate originality*. On the other hand, 'methodical' designers in their searching process of designing try to apply systematics and methodics which, from previous experiences, give them greater security for success. It is not so much the kernel of designing, the *brainwave*, where the looseness of thinking and creativity plays a grand part, which can be improved under the influence of a design method. But, to be treated methodically is the introduction up to the growing towards that creative moment (because with that, one is sure to be busy with the right design commission) and the following complete working-out (materialising, detailing and evaluation). Every human being has certain systematics built in his ways of thinking and acting, usually unconscious, but sometimes by force explicit and extrovert. Thanks to the fact that these systematics determine our actions unconsciously, we can spend more energy on outstanding and decisive moments.

For students, moreover, it goes that acquiring designing as a skill can give more insight when done systematically, in a discussible manner. Because of this, methodology will bring about a

a Eekhout, A.C.J.M. (1997) *POPO of ontwerpen voor bouwproducten en bouwcomponenten*.

faster learning process *for young designers.* That communicative function also belongs to methodical designing and written reaction on it later: it advances the identification of parties around the designer, with the interim and definite process result, and it makes a sensible and effective reaction possible. A designer beginning will be insecure whether (s)he is capable of accomplishing a design. Intuitive trying has the advantage of aim and shoot: it will miss often at first, and, hopefully, it will gradually score a hit. When an inexperienced designer has made a design strategy on his own, through methods and practice, gradually a relaxation in his head comes about, that there will always be a solution as long as he works methodically. But, at certain points in the methodical design there has to be room for the *spark*, the intuitive design idea.

39.16 WHEN IS THE METHODICAL APPROACH INEVITABLE?

The described view on designing and developing originates from experience with the designing of building components and of buildings. Small, *repetitive* or surveyable designs are often fed by unconscious knowledge and skill in an acquired *routine* of previous design processes, whether or not they were realised. Routine designing as a subject is not interesting, compared to the design process where the various steps and activities are done consciously and methodically. It takes place mainly in the same manner, only many times faster and undescribed. But, it cannot be denied that routine designing also has its origin in the methodically and extrovertly made design process, which by repetition and routine can be carried through at much higher speed. However, routine designing becomes a problem to the building engineer when the two qualities of the design ‘ingenious’ and ‘original’ disappear. The form of the design process, however, is isolated from the ingenious and original contents. For design orders with new challenges which rise above routine, the use of design methods is very sensible. Especially when one or more of the following *non-routine characteristics in the design problem* are valid. It is extremely sensible to use a method which can be controlled with a potential for communication on the design process and the design itself:

- New design problems
- Advanced design problems
- Complex design problems
- Experimental design problems
- Ultra-fast or fast-track design problems

With *new design problems* the newness can, indeed, be found in one of the following characteristics. But what is meant is a design order totally new to the designer, or *outside his experience* (for a building designer, for instance, a ship’s interior), or *before his experience* (to a *young designer*, who is yet inexperienced in the field of designing). Students have to learn methodical designing before they give it a place in their personal design approach: intuitive, routine-wise, methodical and yet typical, diversity, combined or integrated, whereby intuition and method chase each other to get better results.

With *advanced design problems* it is often sensible to divide the complete process systematically in different parts and to develop these parts simultaneously: ‘concurrent designing & engineering’, whereby the necessary methodical approach, resulting in drawings and reports, makes the mutual communication about the different interim results possible. The partial designs are afterwards integrated into a complete design.

In the case of *complex design problems* with mutual influence of aspects, these orders are often divided into smaller parts or aspects: each of them better surveyable and solvable, after which an integration is made of the part-designs into a complete design. The integration is more complex than the assembly. This working sequence is a method in itself. Methodical designing may take place completely in an all-enfolding schedule, as in the organogram, but it can also manifest itself very simply as an *ad hoc* agglomerate of smaller partial methods. This entails that in certain phases of the design process a scheme in abstraction is made of various activities to be undertaken, whereby especially the sequence and influence is graphically described: very often small scribbles, immediately understood by spatially and visually thinking designers. As a means of communication, visual schemes are very effective in the profession.

With *experimental design problems* there is a high degree of technical uncertainty. The designer must operate carefully in order not to overlook important matter and so reduce the chance that the final design does not meet all essential aspects. Experimental design orders are characterised by great contributions from research. In the experimental design process verification is important for communication and determination.

The *ultra-fast* or *fast-track design process* has to be worked through in an incomparably short time. The chances are big that the design will be done completely on the automatic pilot. There will be no time for studying extensive alternatives. A course of solution has to be chosen by feel or experience. It is then a challenge to choose a surprising course, not a well-known one which will lead to an expected result. The complete design process, which in other cases can be worked through step by step, has now to be worked through in 'less time'. Then the skill to make the right decisions is brought up from previous choices (experience) and not to work through an impoverished design process with less design variants and therefore a smaller chance on a good result (creativity). Often this type of design process leads to 'concurrent engineering'; with the danger that cause and effect do not connect anymore: sometimes there is already an effect while the cause has yet to be developed. Then the designers find themselves all mixed up. They confuse result with objective, while in the mean time the evaluation criteria are silently shifted. A high level of alertness and steering is required. The design method supplies the basic framework for internal communication.

39.17 BLOB DESIGNS

An illustrative example of design processes where methodical approaches are wanted, are 'Blob' designs: designs of buildings without straight lines and flat façades, except the floors (also called 'Fluid Architecture'). The most illustrative examble is the Bilbao Guggenheim Museum designed by Frank Gehry. The origin is older. Archigram designed fluid building envelopes in the sixties. Only after development of 3D designer computer programs able to prescribe the geometry of curved surfaces accurately, fluid architecture became more popular. In spring 2001 the Department of Building Technology formed a special 'Blob' design research group to bridge the gap between designing and computing architects and the desperate industry, confronted with the task of producing 3D curved surfaces in all sorts of materials architects think of these days. Apart from the inspiring, no doubt expensive building designs of Gehry in the USA, Spain and Germany, Dutch architects lead the trail, like Kas Oosterhuis, Lars Spuybroek and Erick van Egeraat. But, Norman Foster is also constructing in London two 'Blob' designs: the egg-shaped Greater London City Council building near Tower bridge and the corncob-formed Swiss Re high rise building, also in London; Ove Arup is occupied with a wild sculptural roof over the shopping area Chavasse Park in Liverpool; and so on. A high-profile building is the town hall of Alphen aan de Rijn, designed by van Egeraat, one year under construction. The 2002 *Floriade* exhibition will house several 'Blob' designs. One of these is the provincial pavilion, designed by Oosterhuis. Its form resembles a giant rock, made in a single layered triangulated space frame, covered with 3D curved aluminium panels in triangular form; all panels and space frame elements to be individual: 'Industrialisation in lots of one'.

Firstly, this building poses a new problem for the building technical designer. Secondly, the gap between the designer's computer programme and the producer's programmes is large and seems unbridgeable. Thirdly, the design is complex because of the extreme individualisation of the components. Fourthly, it is heavily experimental because all the triangulated panels have different bending radii and should form a flush surface, once mounted together. Fifthly, the opening of the pavilion is contracted, by the building technical way is uncertain. Yet it is an extreme challenge to perform an extensive process of development, which should increase the level of technology dramatically. At the moment of writing the process is still uncertain, but only with the utmost of carefulness and described in an methododical approach, can the target be achieved. De Delft 'Blob' design & research group is heavily involved on many levels and with many different specialisations to get this 'mission impossible' on the road.

39.18 PERMANENT QUALITY ASSURANCE

Parallel to experiences in the car industry, in building practice the notion also slowly dawned that to notice and remove already made mistakes only at the final check (= design assessment), is not very efficient. Especially when mistakes are immediately punished by the consumer. Avoiding mistakes is of the greatest importance. A car has to be, in principle, a 'zero-defect product', achieved by a continuous quality control in the entire production process, not just by probation periods after its final production. As a backing for intuitive building designers goes that the assessment criteria are not unanimous to the consumer. Moreover, defects in building practice are not so often critical and/or measurable (with the exceptions of leakage and draught, although they are looked upon as execution mistakes, not often as designing mistakes). Up to the usage phase one can always tinker with the design and technical applications to achieve a better performance. The relatively poor level of design and research and quality assurance of the prototyping building industry results in the questionable quality of the buildings realised.

A bold example is the sunshade and daylight regulation system to be applied after completion in the clear glass façades of the office building of the Netherlands Architecture Institute (NAI) in Rotterdam, designed by Jo Coenen. All parties involved knew about the 'greenhouse' problem of these façades, in practice it is actually in-operable, but even for this very important architectonical monument, there was no budget being made free during the building process. It is an example of the low-technological characteristic of the building industry, as opposed to a more industrial aspiration of the 'Blob' approach.

At the same time lack of clear assessment criteria leads to continuance of an essentially wrong procedure: by the grace of ignorance, minority or matchlessness, the design result is accepted as it is presented. It does not lead to a higher quality in the view of the consumer. How long can designers get away with this quality level of results?

The car industry formulated a first answer to this in the Sixties with the *TQA (Total Quality Assurance)* and points to the process being controlled continuously, as opposed to the only and too late final check of the assembled car during a test-run.

This process quality control is the basis of the notion 'quality guarantee' for the material realisation of buildings and building components by the industry. The design quality is achieved by, first of all, communicable development processes. In the routine of proper component and product development it could be followed by quality manuals, eventually possibly leading to certification. If the minimum criteria are determined, control is indeed also possible. But, what to do when the quality criteria are not, or hardly determined? It would be better to strive avoiding that the designer fools himself, as well as his client and the consumer by great uncertainty as framed in the notion '*black box design*' and to achieve that he looks upon his design methods as a ‘*glass box design*’. There has to be at the start of every design process, among other things, the fixing of the *evaluation criteria* of the design result. After this the quality of the product, system or component can be assessed or measured continuously. Then intervention is possible when insufficient interim results are noticed. This mechanism of feedback also proves to be a good help with attending to graduates during their design processes.

In the process of development of ‘Blob’ designs an overall quality assurance plan is the only one that ensures an overall quality. This means that all parties involved: client, architect, structural engineer, climate engineer, advisors, main contractor and specialist sub-contractors all have to play their part in the quality assurance plan, from the beginning preparation of the project up to the completion of the building. The omission of one party playing its rôle properly for himself and the others involved can cause considerable damage in the process. The results can be abortion of the entire project, overexpenditure by the client, bankruptcy of producers and contractor. All these results contribute to the premature demise of a highly exciting and promising new line of architecture.

Quality assurance is the ultimate expression of openness in performed activities, of a methodological approach, which is not a scientific topic any more, but a social necessity, if new and exciting trends in architecture like ‘Blobs’ are given a chance in balanced conditions.

40 INDUSTRIAL DESIGN METHODS

ALEX JAGER

Design methods for industrial products and methods for architectural designing do have similarities as well as dissimilarities. This Chapter is comparing the process and the players to one another on the basis of the differences between an industrial product and architecture.

40.1 INDUSTRIAL PRODUCT AND ARCHITECTURE

An industrial product is a commodity invented, made, exchanged and used by people because of the properties it features and the functions it may serve. Although the word ‘product’ can refer to everything brought forward, in the present Chapter it relates to objects for utilisation like razors, telephones, washing machines, and so forth. According to Roozenburg and Eekels[a] these products share a number of characteristics between themselves:

- They are material artefacts: they are visible and can be touched;
- they are fabricated: they are made from materials and half-fabricated components;
- they are discrete entities: the products intended function independently and when they are functioning the whole product is involved;
- they are end-products: their intention does not pre-suppose additional processing.

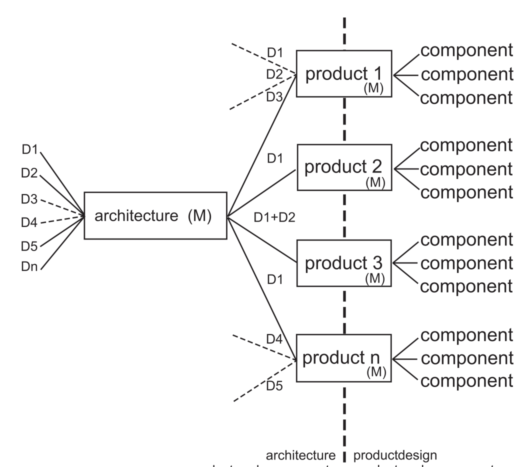
‘Architecture’ is, in the present Chapter, the result of an architectonic design process. Methodological differences between the design process of an industrial product and the design process of architecture may be better understood on the basis of differences between an industrial product and architecture. There are differences in:

- multi-functionality
- duration of life-cycle
- robustness
- dependence on location
- scale
- spatial experiencing
- personal ties

Multi-functionality

The first and most important difference between an industrial product and architecture is that a product is a mono-functional (or oligo-functional[b]) object of use, while architecture has a great many functions. The number of functions depends on the number of objectives to be accommodated by the result. Compared to the designing of products, architecture is taking a relatively long time for designing and must keep complying with new requirements. Therefore, it is more difficult to give a precise description of all objectives.

In the figure alongside a number of (sub-)components forms a certain product. That product serves one or more clearly described objectives. The case that certain objectives are not striven at may also apply. Together these products form the architectural product. Actually these products have become this way (sub-)components. Architecture originated this way strives, in its turn, at a large number of objectives. This number is larger than the sum of the objectives of the (sub-)components. Adaptability in the course of time might be an additional objective, as well as flexibility, comfort, experiencing aesthetics, etc.



380 Architecture designing and product designing

Duration of life-cycle

Neither industrial products, nor architecture share in eternal life. After a certain time a product disappears from the market: be it, while a better product catering for the same need has been introduced or be it that the need is vanishing. In the life-cycle of a product a moment

a Roozenburg, N.F.M. and J. Eekels (1998) *Productontwerpen, structuur en methoden, 2nd ed.* English translation of the 1st ed.: (1995) *Product design, fundamentals and methods*.

b ‘*Oligos*’ is Greek for ‘a little’: a product is oligo-functional when it has but a few functions.

may come that the product is successful. As from that moment on competition will raise its head. This competitive battle causes lowering of the price of the product. If the product can not be made cost-effectively, the end of its life-cycle will come. A need is spotted by scrutinising the market. It is even possible to create a need.

For architecture this is different. The need of the consumer on the real-estate market is clear: an affordable, spacious and, preferably, detached home with a garage. Three out of four people want to live 'in the country'. Contractors, architects, suppliers and project development would rather cater for that demand than do anything else, but the market is not exclusively dertermined by the consumers and those market parties: more than half of all homes is rented. The prime need in housing is timeless, enduring and continuous, but also more pluriform than in most other products. Simply put: almost every one wants a roof over his head.

The life-cycle of architecture is being shortened: where previously buildings were begin constructed for 'eternity' are now buildings rising in order to be ripe for demolition within forty years (or eighty in the case of housing). Because of the quick succession of social, economical and technological changes the secondary needs associated with the primary need will change as well.

Robustness

A consumer buys a product as it looks at that moment. The consumer does not expect that the product is adaptable in such a way that it will continue to serve new needs. Since most products are not adaptable, there is no necessity to include functional flexibility in designing considerations. This has to do with the relatively short life-cycle and low cost price of a product: at a given moment the product ceases to satisfy; a new product is purchased serving the same need better. In this, trends play a rôle: if a product is no longer 'in', some groups in the market will start to purchase a product catering for the same need, but shaped and formed according to more recent types of insight. In the case of an architecture product, users expect that it can continue to cater for individual and changing needs.

Real-estate consumers are demanding an individually tailored house at an affordable price. Because of this, architecture products should be designed in a flexible way, so that possible adaptations continue to be possible (robustness). The trend for construction is that the emphasis of building activities in 2010 will be on renovation. At the moment cities and villages are not growing slowly ('organically'): entire neighbourhoods are being planned in one fell swoop and built at the same time in large chunks. If the needs of the moment are too readily endorsed, the chance exists that the entire ensemble must be adapted concurrently.

Dependence on location

A product is location-independent. This does not mean that a product is context-independent as well: en electrical toothbrush is designed, for instance, for a bathroom: water resistant and in suitable colouring. Architecture is strongly dependent on context and location. Between the 'environment' and the architecture product many different relations, separations and connections will exist. An intended effect on one of the environmental aspects often causes many unintended effects on other environmental aspects. An architecture product is built in 'public space': not only eyed by the proprietors, but also by surrounding residents and passers-by.

Scale

Difference in scale results in aspects defying comparison. In the case of a product we often only see the exterior; with an architecture product the interior also has an important rôle.

Spatial experiencing

Space is experienced in its limitation in the case of an architectural product. In that regard the designing of architecture is giving measure to space.

Personal ties

Generally the – affective – personal ties with an architectural product are more strongly than the personal ties with a product.

40.2 PRODUCT DEVELOPMENT

As a guide for this Chapter I employ the book, previously mentioned, *'Product designing, structure and methods'* by Roozenburg and Eekels.[a] It is compulsory literature during the first two years of the curriculum in Industrial Design Engineering (IDE) at Delft University. During the entire programme the results of studying are weighed against the method described.[b]

When IDE became an independent faculty[c] in 1964, it did not feature a design tradition of its own; falling back on tradition in architecture was no option. Therefore, there was a good opportunity to develop in one fell swoop an explicit design method. The method described provided to the young faculty its own scholarly identity.

The first two parts of the book expose product designing in a broad sense, as a part of product development. First, an environment is created for (product) development methods. Its stages and concepts are defined, described and explained. Next, in part 3, a method of a more practicable nature is described. Finally, part 4 is providing some case histories.

Development

During the life-cycle of a product, a number of stages may be distinguished: pioneering stage, penetration stage, growing stage, saturation and the stage of exhaustion. Since no product features eternal life, enterprises face the pressing necessity of continuing to develop new products all the time. This process is called product development. A product development process starts with the product planning, in which an enterprise records its policy and strategies *vis-à-vis* an activity to be developed in a policy statement. Within this environment the enterprise starts studying what the market demands and what the strong and the weak points of the enterprise amount to. From these studies, ideas for a new activity may start to flow, of which the most promising one is recognised, selected and formulated.

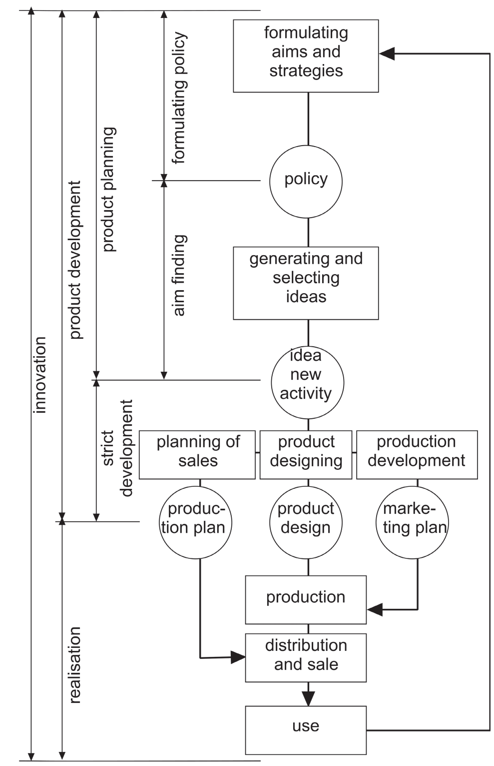
This idea is worked out during 'strict development' into detailed designs for the product, production and exploitation. Next to this 'technical development process' the enterprise should reflect on a marketing plan (the four P's according to Kotler[d]: Product, Price, Place and Promotion). This is called the 'commercial development process'.

Both processes (technical and commercial) will not run very smoothly in practice; an idea has to grow. It purports that the processes should be structured in a concentric way: first all partial designs should be worked out globally in mutual inter-dependence in order to be able to pass judgement on its entirety. Following that, judgements of all partial designs are examined one more time and adapted where needed. The designs are growing helix-wise (in iteration) from vague ideas into concrete plans.

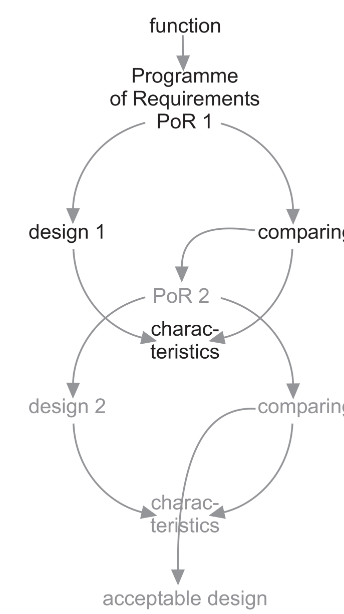
Designing

Product designing is a form of problem solving. While designing, reasoning proceeds from objective (function) to means (design). This reasoning is not a formal logical process in which by the deductive form 'If P then Q' from data (premises P) the result Q logically follows. In designing the result Q precedes in a certain sense the premises P, although the final design is in all other aspects (shape, composition, materialisation) still uncertain. The pattern of reasoning, termed 'innoduction' by Roozenburg and Eekels, proceeds as follows:

- Determining the functional behaviour envisaged (Q)
- And making a design (P), whilst…
- … ensuring that the functional behaviour is obeyed ($P \rightarrow Q$)



381 The stages of the innovation process



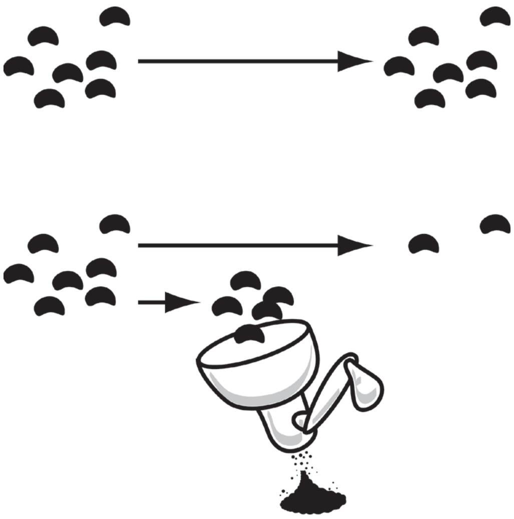
382 Iteration from vague to concrete

a Roozenburg, N.F.M. and J. Eekels (1998) *Productontwerpen, structuur en methoden, 2nd ed.* English translation of the 1st ed.: (1995) *Product design, fundamentals and methods*.

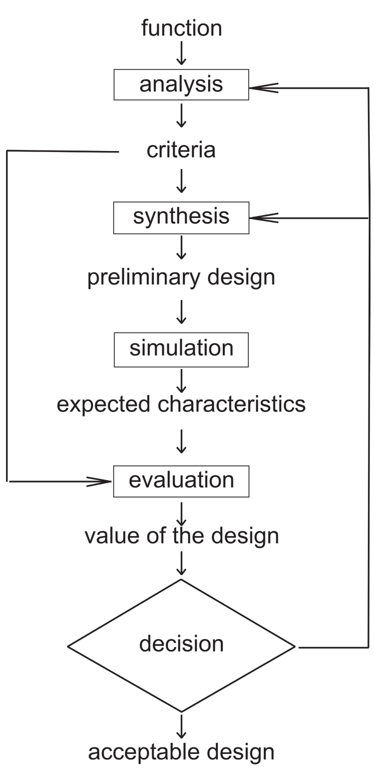
b For completeness sake it be mentioned that in recent years there has been experimentation with a different method: VIP, Vision In Product-development.

c The Faculty of Industrial Design Engineering emerged from the Faculty of Architecture en Mechanical Engineering and was called at the time '*Industriële Vormgeving*'. The discussion on starting the Faculty lasted fifteen years – "The other Faculties being very suspicious of a Faculty so involved in the arts" – but in 1964 the decision was made. However, 1969 is recorded as the first official year of the Faculty.

d Kotler, P. (1997) *Marketing management: analysis, planning, implementation and control*.



383 The autonomous natural process
Above: without human activity
Below: with human activity



384 The base cycle of designing

Further explanation is found in the Chapter on logic of the present book (see page 189).

During the design process, statements should be made on the shape of the design, the characteristics it should embody and the functions to be performed. The spatial form (geometrical) and physical-chemical form (material composition) a product should demonstrate after the manufacturing process is called the design of that product. The function of the product is the capability to realise a transformation in the material environment. This requires explanation.

Our material environment is subject to change on a continuous basis. In principle with our design we want to steer one or more of all the processes taking place around us. The figure alongside visualises some aspects.

Without the coffee grinder the coffee beans would remain coffee beans. The grinder comprises characteristics making a transformation of the material environment possible. For we may also decide not to grind coffee beans; then the beans stay as they are. The function of a product exists therefore only in a relation to human activity.

40.3 DESIGNING PRODUCTS

Generally the structure of distinct design processes proves to be rather similar.[a] In the design process a number of stages may be discerned. These stages are described in figure 384 as the base cycle of designing.

Naturally, the design process does not run as smoothly as the staged model may suggest: it is an idealised model. Iterations with a particular stage have been left out. Nevertheless, staged models are indispensable for planning and controlling of product development process and determining mile-stones and points of decision.

Staged models are based on the idea the a design-in-emergence can exist in three principally different ways:

- as function structure: a representation abstracting from concrete shape and material of the physical parts of the system[b]
- as solution in principle: an idealised (schematic) rendering of the structure of a system[c], in which properties of elements and relations essential for technical functioning are determined in a qualitative way
- as 'materialised' design; preliminary and / or final; in this, most characteristics of a product can be judged for the first time.

Analysis

First of all a problem statement must be defined:

- Who is owning the problem?
- What is the problem?
- What are the objectives?

Next the Programme of Requirements (PoR) must be made. A PoR may contain the following subject matter:

- Verbal criteria (for instance: "the colour should be red");
- Ordinal criteria (for instance: "the sales-price should be as low as possible");
- Norms;
- Specifications

A verbal criterion admits just two statements: the design is complying to the criterion; or not. A verbal criterion may be a demand as well as a wish. An ordinal criterion is always a wish. In the case of an ordinal criterion it is not possible to say bluntly that the design is satisfactory yes or no. Norms may be posed on a compulsory basis by an external agent and always have the status of a demand (for instance NEN norms). Specifications are statements on the geometry and/ or the material of the product. With this they fix the design partially; by the same

a Roozenburg and Eekels describe in their book various phase models: Pahl and Beitz (p. 114 figure 5.9), the Richtlijn VDI2221 (p. 119 figure 5.10) and the phasing according to Van den Kroonenberg en Siers (p. 120 figure 5.11) The structure is according to them in all three models almost identical, with differences just in details. Roozenburg, N.F.M. and J. Eekels (1998) *Productontwerpen, structuur en methoden, 2nd ed.*

b A system is a restricted conjunction of parts, termed the elements of the system.

c The structure of a system is a set of invariable relations between the elements of the system (Roozenburg and Eekels). Following de Jong, structure is a set of separations and connections.

token care should be exercised with including specifications in the Programme of Requirements. In order to arrive at a complete and consistent set of criteria exploring the objective-mean-relations may be a tool. Certain relations may exist between objectives. Consequentially the set of criteria is often displaying an hierarchical structure; for instance in a chain of objectives and means. An example:

Mean	Objective
Money	Vehicle
Vehicle	Transporting
Transporting	Work
Work	Money

A design is called 'good' if it is complying in a 'good' way to the PoR. Therefore, it is important that the PoR itself is already good and complete:

- Each separate criterion should be valid;
- All criteria together should cover the objective(s)
- The criteria should be maximally operational;
- The criteria must not be redundant;
- For transparency a Programme of Requirements should be as succinct as possible;
- The criteria should be accessible.

In case of an operational criterion it may be ascertained objectively to what extent the design is complying. However in practice it is often impossible to have a PoR with just operational criteria.

Synthesis

This is the generating of a preliminary design proposal. The result of this stage is called the 'preliminary design'. During it, various creativity enhancing methods may be used:

- Associative methods: brainstorming;
- Creative methods: serendipity and analogies: 'Synectics';[a]
- Analytical-systematic methods: function analysis, the morphological method[b], Analysis of Inter-connected Decision Areas.[c]

Simulation

Simulation is mimicking the behaviour of a system by means of another system. Simulation generates the factual information that is compared to the PoR during the processes of evaluation and decision. Simulation is a deductive sub-process: the designer wants to develop an idea of the behaviour and the characteristics by reasoning and/ or experimenting with models and of the inter-action with the product designed. This takes place before production in reality and actual use, so that possible mistakes may still be improved upon.

Evaluation and decision

'Evaluation' is here understood to be determining the value or quality of the preliminary design. The characteristics expected are compared to the characteristics considered desirable as they have been formulated in the Programme of Requirements. Then the decision follows: either continuing and detailing the design proposal further (if the proposal is the final design it can be taken in production following approval); or going back to the stage of synthesis and making a better design proposal.

After the design stage a number of stages follow (not discussed here):
- Production
- Distribution and sales
- Use
- Disposal

a Surprising ideas emerge from rather accidental confrontations of two situations: the problem situation and a situation seemingly not connected to it, or at a very significant distance. The 'synectics' procedure is trying to create an alienation through analogies *vis-à-vis* the problem.

b The morphological method tries to find all possible solution for a problem which are theoretically viable.

c AIDA (Analysis of Inter-connected Decision Areas) is a method for analysing problem situations where a number of mutually depending problems must be taken.

40.4 DESIGNING ARCHITECTURE

In the previous paragraph the stages of the base cycle of designing have been described. In this paragraph staging a building process is discussed and the position therein of the design process. This base cycle is found back, by and large, in staging the building process as below.[a]

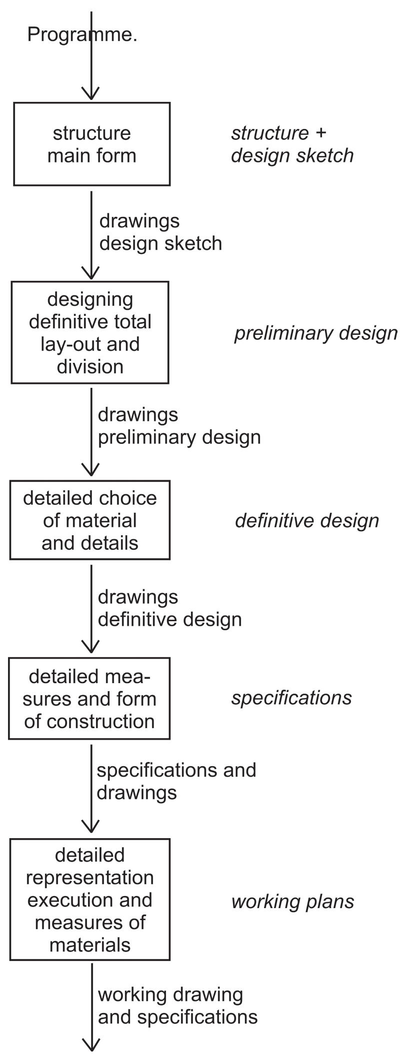
Programme

In contrast to product design the owner of the problem in architecture is often known. His demands is then worded in a staged Programme of Requirements (PoR):[b]

- a base programme
- a global PoR
- a detailed PoR

Usually a Programme of Requirements in architecture comprises the following items:

- a general characteristic of the organisation to be housed and of the requirements put to the building location
- an overview of the departments and their mutual relation
- a survey per department of the spaces needed, including size and interior facilities for those spaces
- a statement on the quality required and the finishing of the spaces
- a statement on the technical installations needed
- a statement on the technical and/ or economical life-cycle of the building that was determined.



385 Design process

Controlling the design process

In order to control the process the following cycle of control is used:

- recording the current state of things
- comparison of this recorded state of things to the norm
- possibly adaptation
- undertaking action in order to (continue to) meet that norm (the time schedule)

The most important aspects of control are: time, money (costs) and information.

Design

During the designing stage possibilities for solution are being looked for on the basis of the PoR. The demands and wishes are being made concrete in the form of designs. The description of the final result is translated into a building mass, blue-prints, spaces and use of materials. The Preliminary Design is a checking moment in the design process. Detailing and integration of the building and its installations are realised during the Final Design. Approval of authorities is asked on the basis of this design.

A global assessment of costs can also be made on the basis of the preliminary design. CAD systems enable simulations.

Manual

The manual entails:

- description of the work;
- drawings belonging to them;
- applicable conditions;
- noting of informations.

Since building is featuring separate responsibilities for design and execution, the manual is a good tool of communication between the commissioner, designer and parties involved in the construction. The manual also provides guidance during execution of the activities of the work

a Bondt, J.J. de, H.A. van Drunen et al. (1996) *Bedrijfskunde. De fasering van het bouwproces, 2nd ed.*

b See also Van der Voordt and Van Wegen on Programming of Buildings in the present book.

and a legal instrument in case of conflicting opinions. Following the stage of the manual additional stages are discerned[a], although they are beyond the horizon of the present Chapter:

- contracting
- determination of costing
- construction planning
- execution
- maintenance and control

40.5 THE PRODUCT DEVELOPER AS A PRODUCT ENTERPRISE

After having described some differences between a product and architecture as well as the design methodologies of both disciplines, it is now time to compare the rôle of a project developer and a product enterprise. The organisational environment of the two disciplines is rather different. If we restrict ourselves to the staging of the design process in both cases, it is obvious to compare an architectural office to a design studio in a product enterprise.

Since I think that a number of differences between product designing and architecture designing stem from the development path in a broader sense, I am comparing in this Chapter a 'product enterprise' to a 'project developer'. According to me the two are passing through similar trajectories and processes. A product enterprise can hire for the technical design process an external design studio; just as a project developer can hire for the technical design process an architectural office.

In the table belongside a lot is rather black and white, and has been put down very incompletely. For completeness' sake it should be mentioned that the product enterprise may of course also be an enterprise producing, for instance, mass-products for the construction market. In this vein a distinction may be made between a building product enterprise and a usage product enterprise.

	Commissions of private persons	Commissions of businesses	Developing products + Invent ideas	(have) Design(ed) + (have) execute(d)	for Mass production	Marketing for product
Architectural office	Yes	Yes	No	Yes	No	No
Design studio	Nee	Yes	No	No	Yes	No
Product enterprise	No	No	Yes	Yes	Yes	Yes
Project developer	No	Yes	Yes	Yes	Yes	Yes

386 Players in architecture and product design

40.6 DIFFERENCE IN POLICY AND STRATEGY

Product/ product enterprise

Defining a rather general direction the enterprise is striving to follow is predominant during this stage: what is the mission (objective of an enterprise in its direct and indirect field of competition for a period of ten to twenty years, the factual legitimising of the enterprise)? What is the vision (an imaginable view of the future of the enterprise, deemed feasible, in its market environment for a period of five to ten years)? What is the strategy (how to realise the vision) and what are the tactics (sequencing of actions with their corresponding results[b])? Distinction may be made between an internal and an external component: the external implies that a number of trends in the environment of the enterprise should be charted. The internal component concerns charting the core competence(s).

Architecture/ project developer

We are taking it for granted that the enterprise has a certain objective. This objective can be translated into motifs of the enterprise, economical, technical and social.

40.7 LOOKING FOR POSSIBILITIES

Since designing is regarded here as a form of problem solving, first of all there should be a 'problem'. A problem is always associated with a supposed dis-satisfaction of people on aspects of a situation in which they find themselves. Next, a real problem presents itself, if the 'problem owner' is intending to change something in the situation (and if it is not in principle impossible to solve the problem).

a The staging of the building process according to the Netherlands Normalisation Institute NNI: programme, initiative, feasibility study, project definition, design, structure design, preliminary design, final design, detailing, budget plan, pricing, realisation, work preparation, execution, transfer, maintenance, demolition.

b Smulders, F.E.H.M., M.H. Kiers et al. (1998) *Strategie en Organisatie: thema: productinnovatie*.

Product / product enterprise

Since a product does not live eternally, enterprises face an enforcing necessity to develop new products continuously. This means that an enterprise must (continue to) study its market well. Within its policy formulation[a], an enterprise is continuously trying to spot 'problems' in the market. One could say that enterprises have an active rôle in spotting and 'solving' problems (see page 253).

When looking for product ideas, it is first of all wise to delimit areas within which one is going to look: 'search areas'. A search area is a realistic depiction of a future area of activity for an organisation, based on knowledge of external opportunities and awareness of internal capability and will. For finding fertile areas one needs criteria derived from the policy (in the preceding stage). This results in ideas for new activities; and among these ideas the best are selected.

Architecture/ project developer

Project developers may play an active rôle in allocating 'problems' and looking for possibilities. Yet project developers are facing a less pressing necessity to realise solutions since an architecture product has a longer life-cycle than an industrial product. In addition an architecture product is preserving its value much longer: renting + exploiting + selling etc.

40.8 IDEA ANALYSIS

Product / product enterprise

There are a number of ideas. In this stage the specific possibilities should be studied further; deep insight into the needs of the potential purchasers should be acquired if possible. The result of this study is a product / market / technology combination (PMT-combination).

Next, the need of the market may be mapped further. In that context important subjects and tools include:

- insight in market need, getting a clear, detailed view of the target segment. This may be done by a qualitative consumer's study (panel discussions) or a quantitative one (usually on paper, quantifiable). The study can be conducted among a-select respondents (potential users picked at random), problem owners (populations experiencing the need or problems in reality) or leading users;
- opportunities for the enterprise: "Which product might cater for the problem spotted best?"
- analysis of potential competition: who are they, how big are they and how many, what are the products they are marketing or going to get to the market, what are the niches they are aiming for, are these niches their core business, how does this fit in their development?
- technology screening.

Architecture / project developer

Three activities are central to this stage[b]: specifying the housing problems, looking for solutions in principle and developing an action plan. This results in a 'go / no go' decision for the project. For the benefit of this decision the points of departure and the project result desired are recorded in a base programme. The plans for financing, boundary conditions and organisational form intended are also described in the action plan.

40.9 IDEA DEFINITION

By now, a lot of information has been collected and the whole of opportunities, potential market and possibilities for the enterprise has become clearer. Now it should be realistically described which activities should take place in order to transform the idea into a product, respectively into architecture.

a During product planning an enterprise records its policy and strategies concerning an activity to be developed in a policy formulation.

b Venemans, A. (1997) *Bouwwijs;* Huttinga, E., N. de Bont et al. (1999) *Reader Bouwmanagement t.b.v. blok Productie & Uitvoering, 1st ed.*

Product / product enterprise

The product to be developed must be integrated into the present organisation process. For this a detailed business-plan is written. It is important to distinguish four distinct processes and to plan and integrate them in parallel:

- Product development: design, prototypes, etc.
- Production development: development of the production process
- Market development: making a marketing plan etc.
- Organisation development: preparing for possible organisational changes.

40.10 CROSS-FERTILISATION

The student of Industrial Design Engineering is actually educated to the equivalent of the project developer in the building process. I mean to say that a student Industrial Design Engineering has a more extended notion of the process as a whole: of organisation, via product innovation to the market. What exactly must happen if we want to view the architecture product as an industrial product?

First of all, it is striking that a product enterprise puts out for itself very clearly a policy, together with strategies belonging to it. Generally, a product enterprise has a strong vision, also communicated to the world outside.

If we consider next the way both organisations look for possibilities, we see how a product enterprise is always busy with focusing on a more dynamic market: what kind of needs prevail, what are the opportunities to seize. In some cases this might apply to architectural design as well (for instance for a holiday park; 'mass' building, perhaps also for offices). We should spend more thought on the question which target group we envisage for architectural designing. Specific needs can be determined more readily for a specific target group. Cost reduction of 'mass' building results if an inventory of the needs has been made first. As mentioned earlier, usually architectural products can not hope to formulate all objectives. A part of the objectives might come into being by means of 'design study'.

Idea analysis is more elaborate in product development and the need is more thoroughly ascertained. Also in the area of architecture designing, one is becoming active on stage: one is going to specify the housing problem and to make an action plan.

The idea definition in architecture is partly given by the PoR, partly elaborated in the manual by design. In product development it is elaborated in a design and a business plan. The advantage provided by a business plan is that it is also already mentioning ideas for marketing, organisational change and production. The design extends into the development fluently; while architecture designing is showing a clear border-line between the making of a PoR, the concrete design and the building process.

For architectural designs, studies of usage should be exploited more often than is done now. Some realised projects have failed, because the needs of the target group were not studied well, whether they were taken into account or were being met. Studies of usage may enable adaptation of a number of items in an early stage.

Finally, it should be stated that in case of product development the product remains intellectual property of the enterprise. That enterprise will continue to earn money by it for a long time (patents, etc.). Perhaps a principle of that kind can also be thought out for architecture, by which a designer can continue to claim a right on his or her design for a longer period of time.

41 FUTURE ICT DEVELOPMENTS

SEVIL SARIYILDIZ, RUDI STOUFFS
ÖZER ÇIFTÇIOĞLU, BIGE TUNÇER

The building sector is entering a new era. Developments in information and communication technology (ICT) have an impact throughout the entire life-cycle of a building, not only from a process and technical point of view, but also from a creative one. As a result of developments of advanced modelling software for architectural design, the gap between what the architect can envision and what the building technician or product architect can materialise is enlarging. Internet technology has already started to provide a closer link between the participants in the building process, their activities, knowledge, and information. Concurrent and collaborative engineering will be the future of building practice with respect to efficiency and quality improvement of this sector. The nature of the building process is complex. Not only in terms of communication, but also of information of the number of participants, spatial organisation, infrastructure etc. In the near future, soft computing techniques like artificial neural networks, fuzzy logic, and genetic algorithms will make contributions to problem solving aspects of the complex design process. This Chapter provides an overview of these and other future developments of information and communication technology within the building sector.

41.1 INTRODUCTION

Looking back to historical developments in the building sector the development of technology has always had an impact how people designed, built and lived in a built environment. If cast iron was not invented there would not be a Eiffel Tower or if the car was not invented, we would still have the narrow streets of the middle ages. There are numerous examples that show the impact of the technological developments on the society itself, by changing habits and the way of living, and, therefore, the changes on the built environment.

As in other sciences, ICT also influences the building sector. We are entering a new era. This will cause innovations, improvements and new challenges in this sector. If we focus on the design process as a part of the building process, we can generally say that there are four main domains of applications of ICT in the design process.

- *Creative design* orientated ICT (applied in the conceptual design or inception phase)
- *Materialisation* orientated ICT (building physics and building technology aspects such as calculating bearing structures and detailing)
- *Realisation* orientated ICT
- *Process and management* orientated ICT (linking the first three categories or activities)

Within the on-going developments of ICT, the rôle and the daily work of the people involved in the design process are both changing. Until now this process was cut into a few periods. When the architect designed the concept, this goes to the constructor, to work out the materialisation step, and afterwards to the contractor to build. There is always the supervisor, the building manager steering this process. We are now entering into a new stage. This process is not sequential any more, but more a network type which we call *information, communication and collaboration networking* in the design process.

41.2 ICT IN BUILDING DESIGN PROCESS

Initially computers were put into practice as a *tool*, as an instrument for achieving a specific result; a final drawing, an animation, a simulation, an interactive visualisation. Nowadays, computers have a different rôle as a new *medium*; next to the existing media within the architectural design process. Especially the widespread use of Internet and the developments of the Web have pushed the computer into the rôle of a medium.

In the near future, we can expect another shift in the rôle of computers in the design and building process, namely, as a partner.[a] ICT allows now to develop new techniques and methodologies using the computer as a *partner* by means of knowledge integration, decision support, and artificial intelligence. Decision support systems allow the computer to support the user through knowledge provided by experts or by the user herself. The computer can also be a partner when we teach it things it can reason with. It can even be a valuable and reliable friend when we let it solve problems not clearly defined, fuzzy, or uncertain. It can also assist in generating forms by processing information that influences the shape, supported by self-learning techniques. Here, artificial intelligence techniques like fuzzy logic, genetic algorithm and neural networks play an important rôle.

The ICT as Tool, Medium and Partner has the following support in the entire design process:

- Tool
  - 3D modelling
  - CAD (Computer Aided Drafting)
  - Presentation (Animation, Simulation, Composition, Rendering etc.)
  - Analysis
- Medium
  - Interactive visualisations (VR-Virtual Reality, Cyber Space)
  - Information processing
  - Communication (Internet Technology)
  - Collaborative & Concurrent engineering, CSCW
  - CAD-CAM, CAE, EEM (Enterprise Engineering Management) etc.
- Partner
  - Knowledge Integration (ANN-Artificial neural Network, Fuzzy Logic, Intelligent Agents etc.
  - Decision Support Systems-DSS
  - Advanced Modelling (Genetic Algorithms, Grammars etc.)
  - Intelligent Management

Finally, the ICT means is meant to support the designer in the design process to achieve the intended goal. This goal can be differentiated for different users. The flexibility and the efficiency of these ICT means are an important item in the future.

41.3 COMPLEXITY IN THE DESIGN PROCESS

Buildings are becoming more and more complex nowadays, not only in form and functions, but also in their infrastructure: their techniques and communications. Naturally, the design process is also becoming more complex. It is complex in the sense that many, often conflicting, interests and criteria are involved, and that many different types of expertise are required to find an optimal solution. Additionally, there is the uncertainty of the future use of the building, requiring the meeting of new criteria not defined explicitly at the moment of design. That means that a designer must have the ability to meet a certain range of criteria in a flexible way so that future demands are also met to a certain degree. The outcome of the design process has to fulfill different requirements of functional, formal, and technical nature. These requirements concern aspects like usability, economics, quality of form and space, social aspects of architectural design, technical norms or laws, and technical and mechanical aspects of the design.

Building design is a multi-actor, multi-discipline, and multi-interest process. Design is teamwork among architects, designers, and consultants for various fields, e.g., building physics, construction, material science, electrical engineering, acoustics, geodetics, building economy, and environmental engineering. The process of decision-making is often intuitive and based

a McCullough, M. (1996) *Abstracting craft: the practised digital hand;* Sariyildiz, S., P. van der Veen et al. (1998) *Computers as reliable and valuable partner;* Schmitt, G. (1999) *Information architecture: basics of CAAD and its future.*

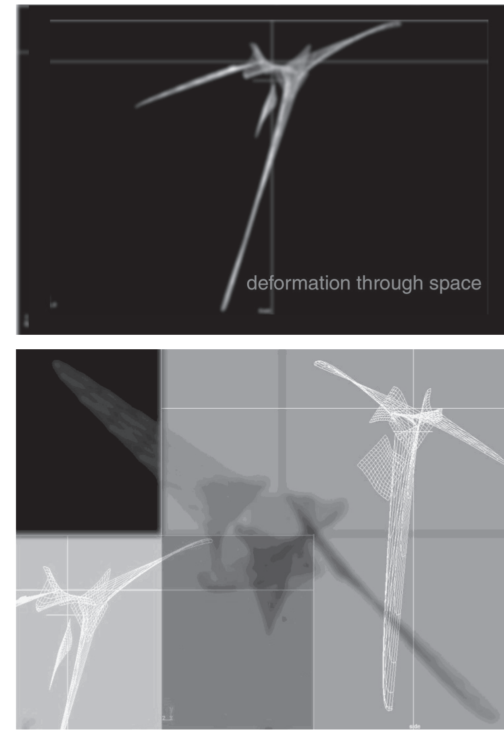
Next page:

a Forster, K.W. (1996) *Rising from the land, sinking into the ground.*

on experience. Tedious discussions may occur in committees where all or many of the criteria are represented. The resulting decision is obviously a compromise, but it is often unclear how the decision was reached and whether better solutions exist. In this respect, the ICT tools and their integration form an essential component in the knowledge integration process of the various disciplines. As such, they are increasingly becoming a valuable and, hopefully, reliable partner in the design process.

To reach better communication and information exchange during the design process there were some initiatives to try out concurrent engineering in Europe. It was not successful for many reasons. Because the building sector in Europe is fragmented and still a bit old-fashioned in thinking concerning the innovations and technological developments. Concurrent engineering is now turning into collaborative engineering especially by the influence of Internet. The work can be continued any time, anywhere in the world. By means of VR the participants can communicate visually with each other. Therefore, is it worth-while to put effort into the developments of the broad-band technology also in Europe.

As mentioned earlier, in the building process we deal with complexity. There are many partners and knowledge disciplines involved. Information must be ordered and communication realised between various disciplines and people involved. Management of Information, Communication and ICT means are, inevitably, tools in the future of the building sector. Collaborative engineering techniques can be a good start.



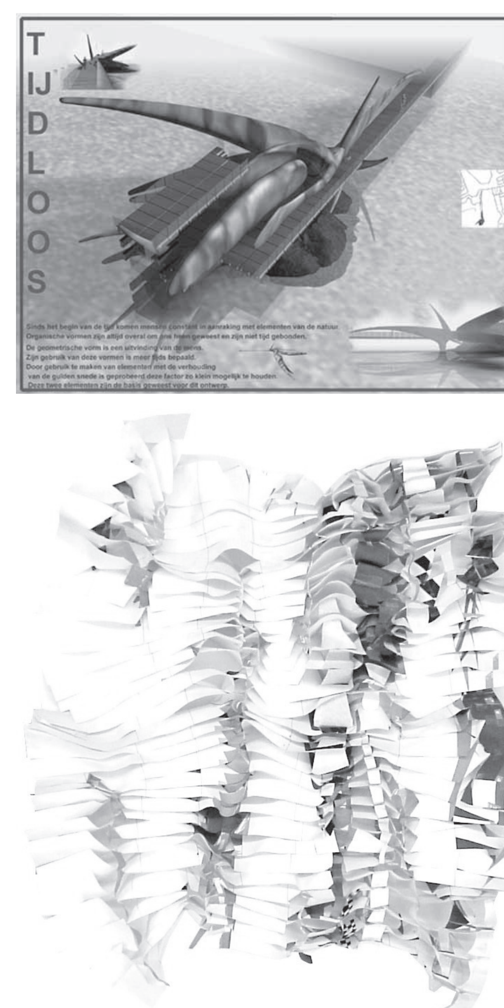
387 Deformations

41.4 THE RÔLE OF ICT IN THE CREATIVE DESIGN PROCESS

The designer has to deal with three main categories of sciences, in the Netherlands called alpha, beta, and gamma sciences. Alpha sciences deal with the subjective world of beauty and ethics, as expressed by the artistic, intuitive soul. Beta sciences bring in the objective world of facts and logic, represented by the rational mind. Gamma sciences consider society and culture. Integration of these sciences makes the task of the designer more complex. The designer must have the skills to integrate the various disciplines of knowledge, involving besides the artistic form expression of the building also the dimensioning of the structure, building physics, applied mechanics, the calculation of structures, building materials and techniques, etc. The most famous designers, like Santiago Calatrava, are those who have the ability to combine these various disciplines in their designs as architect and building engineer.

When computers were first introduced in the building sector, the applications mainly concerned administrative tasks. Gradually their functionality extended to support repetitive tasks; nowadays, software applications are becoming essential tools for creative design, materialisation (building technical aspects), and the management of the entire building process. Already, for architects, like Peter Eisenman and Frank Gehry, employment of computational programs is an indispensable means, even if it holds no explanatory power over results.[a]

In respect to creative design, spatial software development for design aids during the last years influences form finding and spatial design of the creative designer. Designing architects are more and more using the 3D modelling software like MAYA. During the International design workshop in the Netherlands Architecture Institute NAI we experienced that the design tool offered to the designer has considerable impact on how the designer is stimulated by the possibilities of the 3D modelling software. The designer dares to design more complex forms and has more flexibility. To see the rôle of the new software for design, an experimental workshop was organised by the NAI in Rotterdam. Designing architect Lars Spuybroek guided the students for the design context in collaboration with staff of Technical Design & Informatics at the Faculty of Architecture, TU-Delft. Within few days time the students could cope with various software MAYA to design a stadium.



388 'Timeless', Folded surface

389 Guggenheim, Inside and Outside

41.5 ADVANCED MODELLING SOFTWARE AND ITS IMPACT ON PRACTICE

As a result of developments in advanced modelling software and its use for architectural design, the gap between what the architect or designer can envision on one hand and what the building technician or product architect can materialise on the other is enlarging. The Guggenheim Museum (figure 389) in Bilbao, Spain, designed by Frank Gehry, is a prime example. Designed using 'Catia', modelling software developed for the aerospace industry, the form of this design would have been much more difficult to establish using traditional tools and methods of designing. The architect is provided with a richer form vocabulary and more flexibility to realise spatial ideas on the computer. Design software has reached a point where it can stimulate the designer's creativity rather than impede it as has been argued in opposition to CAD software. Also in Europe, many architects have adopted advanced modelling software for their creative design, like Dutch architects Kas Oosterhuis and Lars Spuybroek.[a]

The developments in the field of building technology and building materials have not followed these advances in modelling software, so that they can no longer answer all the requirements and demands of the new architectural forms. ICT may play an important rôle in narrowing this gap. Electronic form information is transferred directly from the design model to computer-controlled manufacturing machines, as in the case of stone cutting for a curved wall. Unlike straight or even cylindrical surfaces, free-formed surfaces cannot be composed simply of standardised components; potentially each element may be of different size. This complicates the manufacturing process and causes cost explosion. Numerical or computer-controlled equipment enables custom components to be produced at a lower cost. Connecting it to the Internet, so that there is direct control from the design model further cuts cost. As custom manufacturing increasingly replaces standardised production, these costs will further decrease. Furthermore, as electronic catalogues are extended to include information on custom manufacturing techniques, possibly allowing designers to check manufacturability and price in the design phase, custom production will become more accessible.

41.6 COMMUNICATION AND COLLABORATION OVER THE INTERNET

As the Web and Internet technologies are filtering into every aspect of society, they will have enormous impact on building practice. Already, architectural offices are using the Internet to communicate with partners across the globe, discussing designs. As distances become smaller, architects are empowered to take on a global rôle. Examples abound already, like the world's highest skyscraper in Kuala Lumpur, Malaysia, designed by Cesar Pelli Associates in the US. The use of Islamic geometric patterns in the design shows a strong influence of local culture.

Global access requires new ways of managing the design process. Building projects are increasingly becoming teamwork, where no one person is solely responsible for a design. Well-defined control hierarchies and relationships are making place for more intricate collaborative processes not as readily planned and controlled. This requires an increasingly networked thinking that brings partners to closer inter-action but, without appropriate computational support, impedes the ease of overview and understanding.[b] Web-based document management systems serve as media for exchange of information between the collaborative partners and provide facilities for organising, viewing, and red-lining drawings and images.[c] These systems can also serve development and dissemination of tools supporting specific needs and processes, leading to integrated software environments as platform for various applications to communicate via the Internet.[d]

This evolution is founded on several universal Internet technologies, like TCP/IP, HTML, Java, and XML. Using them, it is pretty straightforward to create a Web application that runs on any platform. XML simplifies communication and improves agent technology. When exchanging XML-structured data, the only thing the partners need to agree on is the XML tag set

a Schwartz, I. (1997) *A testing ground for interactivity*.
b Lottaz, C., R. Stouffs et al. (2000) *Increasing understanding during collaboration through advanced representations*.
c Burchard, B. (2001) *AEC project management online*.
d Lottaz, C., R. Stouffs et al. (2000).

used to represent the data. No other information about each other's systems is required. This makes it simple for new organisations to join an existing structure of data exchange. Similarly, XML-structured data makes it much easier for an agent to understand exactly what the data means and how it relates to other pieces of data it may already know, thereby easing one of the challenges when writing an agent, that is, to interpret the incoming information intelligently and respond to it accordingly. Another advantage to the use of XML for structuring data is that it can easily be applied to existing data and information, for archiving or indexing such information. Unlike product model representations, XML structured data is easy for a human eye to read and understand, flexible in its application, and easily applied for specific purposes.[a]

Many disciplines are developing a framework for using the XML standard for electronic communications and data inter-change in their domain;[b] also the building industry (aecXML 1999). Considering the complexity of building projects and the un-structured and inter-related nature of the project data, the building community can benefit from a unifying strategy for data inter-change. This will not only make current data exchange and re-use practices more efficient, but will also result in savings through streamlining the worldwide transactions in the Architecture, Engineering, and Construction (AEC) community.

41.7 ICT IN ARCHITECTURAL EDUCATION

In the near future designers and professionals who educate the designers on the field of Computing in general, need to adapt themselves to rapid development. Up to now, in most CAD education at faculties of architecture, attention is paid to computers as a tool, partially as a medium for communication and information processing. Technological developments allow us now to look forward and go a step further.

It is necessary to introduce existing ICT means and techniques in education and the development of the mentioned subjects of ICT. In the future architects must be able to extend existing tools and integrate them into specific needs. The level of education must be pushed: to the level that the computer is not only a tool or medium, but also a partner in Knowledge Integration, advanced modelling techniques, and a support environment during the design process.

If these developments will be left to the others than architects, the architects will face the danger that they become slaves of the tools, not the boss; partially the same kind of problem is present with the commercial tools. No commercial CAD product supports the designer as it should. The user must learn the basic principles to use the software and take the advantage of it in an efficient way. This basic knowledge should be given to the architecture students in their first year.

On the other hand, the student of the future will be a mobile student working at any time from any place. Therefore, distance learning possibilities will gain an important rôle in the future for the academics, involved in the education.

41.8 THE IMPACT OF ARTIFICIAL INTELLIGENCE ON ICT ENHANCED BUILDING TECHNOLOGY

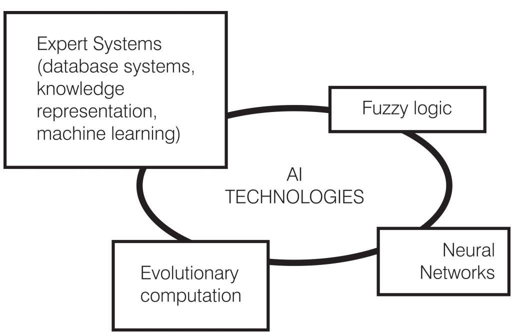
Design requires more comprehensive attention than ever. There is no doubt that the available building information must be used effectively. ICT can play a rôle in eliciting this information in a timely and exhaustive manner. Several emerging technologies have important relevance to the use of ICT in the building process and, ensuing, important implications.

As information and knowledge are being stored at a continuously growing pace, buried in gigabytes of records, they are becoming less comprehensible. Faced with difficulties of retrieving them and making them available in an easily comprehensible format at higher levels

a Tunçer, B. and R. Stouffs (2000) *Modeling building project information*.
b Cover, R. (2000) *The XML cover Pages (Extensible Markup Language)*.

of summarisation, this information becomes less and less useful. No human can use such data effectively and be able to understand the essential trends in order to make rational decisions. With reference to this phenomenon of information over-load, emerging technologies such as knowledge discovery and data mining offer a prospect of help. Knowledge discovery is inherently connected to databases: in inter-action with a database, a search for patterns or objects is performed, eliciting meaningful pieces of knowledge. Data mining provides means or methods to attain this knowledge. Among the most promising methods for data mining are artificial neural networks, fuzzy logic, and heuristic search methods like genetic algorithms. Collectively, these are referred to as 'soft' computing methods; heuristic search methods as 'evolutionary algorithms'. Artificial neural networks call for processing numeric data and building non-linear relationships. Fuzzy sets concentrate on representation of data at a nonnumeric level. The symbiotic co-operation of the two technologies results in an effect on the granularity of information.

These soft computing methods are receiving growing importance in almost every field, including building technology; slower there. Presumably, the basic reason for this is the difficulty of formulating building technological problems in a way that they become convenient for artificial neural treatment. However, these methods are especially important in the building sector, as they can handle information in various forms. A unified representation for artificial neural networks and fuzzy logic is already established.[a] It is likely that the communication between building technology and soft computing technology will be much easier than before;, due to the possibility of processing information at hand more human-like in coming years than previously.



390 Some basic AI fields of importance to ICT developments with impact on building technology.

Currently, this information processing, in combination with knowledge base systems, is mostly introduced by way of expert systems or decision support systems; in most cases unsatisfactory. In the future, we may expect computational intelligence systems to play a more important rôle.

Intelligent systems are increasingly replacing conventional systems: see intelligent manufacturing and intelligent design technologies. Some basic Artificial Intelligence (AI) fields associated with the emerging technologies connected to ICT development are indicated in figure 390. In order to cope with the demands of information acquisition and information handling of these intelligent technologies, new methodologies and techniques are being developed. Besides knowledge discovery and data mining technology, agent technology is an example.

An agent is a software program designed for a specific purpose or functionality, acting autonomously to some extent; may be intelligently too.[b] Agent technology is closely associated with ICT: agents are generally conceived for communication with other agents or software and for transmission to distant computers. The Internet allows a distant computer to be any machine on the globe. Agents are especially promising for mining databases. As an example, a fuzzy engineering agent can interact with a building design database in order to identify various trends of engineering or architectural nature. In connection with virtual reality (VR), agents can assist in design by providing sufficiently realistic feedback early in the design process. This should ease early integration of design components, particularly in collaborative design.[c] Especially for collaborative design, agents have an important rôle to play to assist participants in their task or communication, or to offer additional functionality in project-management applications.[d]

41.9 CONCLUSIONS

Ongoing development in ICT has an important impact on the design and building process. Designers can allow ideas and intuitions to take physical shape in ways not possible before.[e]

a Jang, J-S., C-T. Sun et al. (1997) *Neuro-fuzzy and soft computing: a computational approach to learning and machine intelligence*.
b Jennings, N.R. and Woolridge M.J. (1998) *Agent technology: foundations, applications, and markets*.
c Abarbanel, R., E. Brechner et al. (1997) *FlyThru the Boeing 777, formal aspects of collaborative CAD*.
d Stouffs, R., D. Kurmann et al. (1998) *An information architecture for the virtual AEC company*.
e Forster, K.W. (1996) *Rising from the land, sinking into the ground*.

At the same time, building technical developments are lagging behind. Alternative, innovative solutions have to be adopted. At the University of Cincinnati, *"all building trades (plumbing, tiling, painting) were carried out through a three-dimensional co-ordinate numerical control system implemented by an electronic laser transit on the site"*.[a] Future ICT developments for architecture and the building sector will be in the field of knowledge integration and decision support environments leading, finally, to ICT support in the entire building process, from initiative until demolition. Collaborative engineering will pervade the building design process. By these technologies, the branches of scientific disciplines will come closer than ever before to an integration. In the future, each participant in the design process will need to be able to make her own computer model in order to build up specific knowledge within it and use it as a partner in the design. Developments in the software industry show that if software firms provide the software core, architects and building engineers will be able to develop their own application tools according to specific requirements and needs. Independent of existing tools, they will be even free to create their own language of activities. Ongoing developments of Internet technology require other ways of design management and communication (data and partners communication) in the building process.

a Zaera-Polo, A. (1996) *The making of the machine: powerless control as a critical strategy.*

DESIGN STUDY

G DESIGN STUDY

As an inquiry into possibilities of a given context (site and programmatic desiderata) designing does not call for methodological requirements, but rather for liberation from down-trodden problem definitions and their solutions.

Creating space of thought

Hertzberger explores the methods assisting in opening up the possiblities, instead of determining them. Descartes' *'Discours de la Méthode'* focused on doubt. Design study distrusts, like classical sciences, all that is obvious, but does not throw everything overboard all at once. Experience evaporated into routine deserves suspicion of the scientific approach, deeming no pre-supposition sacred. However a culture, certainly a local one, surrounds us with pre-suppositions unbeknown to us; like a fish without knowledge of the water it is taken from, at the same time there is certitude of existing conditions: a table, a bed, a kitchen entails great forms of freedom.

Perceiving and conceiving

Because of this Hertzberger then appreciates greatly collecting architectural examples, references. However, awareness of these references requires a technique of reduction if they are to be used in a different context from the old one, and not at their beck and call.

Formation of the image

De Jong and Rosemann survey notions on the formation of images from scholarship, science, philosophy and the arts. Where do we cross the threshold from pure experience into making? Starting point is development psychology but the end is design.

Experience, intuition and conception

Geuze, Van Eldijk and Van Kan show the design process of a gifted student from analysis of the location until the final design with all its pitfalls and dead ends.

Designing an office

Brouwer, Van Eldijk and Van Kan then show a design process of an experienced architect directly starting with a concept, the influence of context, metaphores and fixing sizes

Designing a village

At last, Heeling, Van Eldijk and Van Kan describe the more formal design process of an experienced urban designer with a more global frame and grain.

Urban design methods

Enlarging frame and grain limits applicable methods, but, Westrik discusses so many methods in this field, that we can conclude that there are more methods than designers.

Designing in a determined context

Finally de Jong allocates them within the communicative maze of the building team.

Conclusion

There are more design methods than designers. Nevertheless, we recognise something in every design process. Though we can not name or systemise all phases, we can learn from it.

42 CREATING SPACE OF THOUGHT

HERMAN HERTZBERGER

Too often we find the creative process of the architect depicted as a succession of flashes of inspiration which the privileged evidently receive as a gift and others wait for in vain, as though ideas are some kind of thunderbolt from on high. When you see architects continually out to trump one another with new ideas, you end up wondering at times just where the hell they get them all from!

That architects have to think primarily in forms is rooted in a mis-understanding. In the first place, they must have an idea of the situations as these affect people and organisations, and how situations work. From there concepts emerge: that is, ideas regarding these situations take shape. Only then does the architect envisage forms in which all the above might be cast. Surprising architectural responses are invariably the ultimate formulation of the results of a thought process. They did not appear out of thin air, as gifts from the gods for the particularly talented!

Architects, including the seriously gifted, construct their ideas, even if these are keys to utterly new insights, out of raw material that in one way or another had already to be present in their minds. Nothing, after all, can be born of nothing.

Designing is a complex thought process of potentials and restrictions out of which ideas are born along fairly systematic lines.

New responses issue from combinations and quantities other than those we already knew. We do things with what we have in our minds, and more cannot come out of them than went in. All neuro-psychological explanations notwithstanding it works the same as it does for the cook who can only use what he has in his kitchen when putting his meals together. Ignoring the fact that a good cook can do much more with his ingredients than a less gifted colleague, in both cases the point is to fill the pantry with as many ingredients as possible so as to have richer combinations, and thus, a wider range of possibilities at their disposal.

The ingredients the architect can draw from are the experiences he has had throughout the years, and which he can directly or indirectly relate to his profession. Considering that the range of his discipline is infinitely broad and is literally about everything, that means quite a host of experiences! So, it is important for the architect that he has seen and heard a lot in his life, and anything he did not experience first-hand he has a pretty good idea of, that is, he must empathise with every situation he has come across.

42.1 INGENUITY, CREATIVITY

A culture where conditions and values shift all too easily requires an unremittingly critical attitude towards out-moded concepts (and naturally towards new potentials too). In literally every situation you have to keep asking yourself whether the familiar path is still the most effective, adequate and/or advisable choice or that we are threatening to become victims of the daily routine and the straitjacket of existing clichés. Each design decision it seems, each choice we make, needs sounding out every time against changing criteria, but all too often inevitably calling for new concepts. This is why we need ingenuity and what we usually term creativity.

Put briefly, the beginning of the design process could boil down to the following: first, there is a task, clearly couched or making a first vague appearance. You are after an idea that will give you a concept you can use to further elaborate the design. Looking around you and drawing from your memory where the ideas you once thought interesting are stored, you head off in search of analogies that might well yield an idea. Though identifiable as missing

* This text is based on: Hertzberger, H. (2000) *Space and the architect: lessons in architecture 2*. Originally published in Dutch: Hertzberger, H. (1999) *De ruimte van de architect: lessen in architectuur 2*.

Translated from the Dutch by John Kirkpatrick.

pieces of your jigsaw puzzle, these links are all too often transformed - disguised, in other words. The art then is, of course, to see through those disguises. We can assume that each new idea and new concept must be a transformation or interpretation, respectively, of something else, further developed and brought up to date.

There is no way of finding out how the idea came to you; was it there already, was it generated by old images or only strengthened, confirmed? This is a complex inter-action of suspecting, seeking and recognising, in the way where question and answer vie for primacy.

42.2 ERASING AND DEMOLISHING OLD CLICHÉS

To find new concepts as an answer to new challenges you first have to unmask the existing clichés. This means stripping the mainsprings of the programme underlying the architecture of the routinethat has seeped into them by breaking open the programme and opening it up to new arguments. Whenever a programme is judged critically it transpires each time that it has lost much of its validity. This is why we must shift emphases and shake off ingrained habits. This is easier said than done. The issue is to demolish existing clichés.

A great deal has been written about creativity and how it might be acquired, invariably pointing out the importance of forging links with other things entirely. However, it is stressed far too infrequently that the difficulty of finding the new is mainly that of shaking off the old. Room for new ideas has to be conquered by erasing old ideas engraved in our minds. If only one could keep beginning with a clean slate, approaching each task as an unknown quantity, a new question that has yet to be answered. Unfortunately, this is not the way our brains work. Associations well up immediately, whether you want them to or not, major and minor skills nurtured by experience and developed by professional expertise, tried and trusted recipes that stand there in the way of genuinely new ideas.

391 Robert Delaunay *Eiffel Tower*, 1913

Ingenuity in finding new concepts is all too often seen as something exclusive, reserved for the few who are gifted in that respect. When the prime concern is indeed the ability to shake off existing clichés and face the task each time as an unknown quantity, the problem is mainly a psychological barrier that is going to need some demolishing.

If the old, well-known, part belongs to our familiar world, the new is basically a threat. Whether it can become absorbed, and, therefore, accepted depends on the associations it evokes and whether these are regarded as positive, or at least not as negative.

A child, then, may see a flash of lightning, whose dangers we know and to which we feel a certain ingrained fear, as a kind of firework with all the feelings of gaiety that brings. *“All I have done throughout my life is to try to be just as open-minded as I was in my youth - though then I didn’t have to try.”*

When plans emerged to keep the Eiffel Tower after all - it had originally been intended to be temporary - a storm of protest blew up, most of all among intellectuals who saw the city disfigured with a monster culled from the hated world of industry. And that when in the very latest generation there was almost no-one to be found who was not inspired by it as a presage of a new world.

Whether you like a thing or not depends on the affection you feel for it. This is not only something you have or acquire later, you must have had it to begin with to have liked the thing in the first place; affection is as much a condition as a consequence.

42.3 THE EAMES HOUSE BREAKING THE CLICHÉ

The story goes that in 1946, when Charles and Ray Eames decided to build themselves a house and studio, they were forced to restrict themselves to steel beams and columns standardised for assembly plants and obtainable from a firm of structural engineers, as material was scarce so soon after the war. And if this were indeed true, you might wonder if they really felt restricted by the thus imposed reduction of their house to a pair of box-shaped factory sheds, which they placed on the highest part of their eucalyptus-strewn site in a line along the property boundary.

These industrial designers, constantly alert as they were to everything that was new and potentially reproducible in series, sounding them out and absorbing them into their world, clearly saw this as a challenge. Typically, rather than feeling limited by having only those means at their disposal that industry allowed at the time, they were inspired by the possibilities this situation brought.

And so it was that the factory shed was transformed into a house with a form unknown before then. The point is that they saw the opportunity to look beyond the factory-building forms such as the prominent open-web steel joists and suppress those associations with others closer to the domestic ambience. Charles and Ray Eames succeeded in erasing the factory element by means of simple yet marvellous elevations, likewise composed of standard elements, with areas of colour and, on the inside, sliding light-absorbent panels, the effect being as much Japanese as Mondrianesque. Again, the tiled paths and planting right up against the elevations betray the sort of care that regrettably one only expects to find in dwelling-houses.

The basic, even bare, container aspect of the building is equalled only by the opulence of its infill and contents. This consists of an endless and varied collection of objects and artefacts from all over the world, brought back by the Eameses from their travels - fascinated as they were by everything made by human hand the world over in a never-ending diversity. And what better accommodation for all these items collected by those irrepressible souls than these pre-fabricated containers. These lent themselves perfectly to being coloured in and indeed to becoming part of the collection.

When Ray Eames laid the table for her guests, it was not with the obligatory tea or dinner service of so many pieces and accessories to match, but according to quite another principle. She went through the abundant collection of plates and cups-and-saucers, finding for each guest a set deriving from differing services, but combined to meet other criteria - a beautifully conceived combination of pieces chosen to match their user.

The familiar image of a table laid homogeneously yielded to a gay miscellany of colours and shapes, like a miniature *'musée imaginaire'*, of a new homogeneity, be it more complex and full of surprises.

Two arrangements, two paradigms, both with their attendant associations.

The so-many-piece table service stands for comfortable circumstances and ancient descent, for such services get passed down from generation to generation and only in the hands of an old and established, culturally developed family do they survive through the years unchipped and generally unscathed. Combinations of table services that are brought together from here, there and everywhere rather than comprising a set, are the province of the less well-to-do who can afford less and cannot boast an illustrious past.

The infinitely varied collection of Ray and Charles Eames represents the cultural élite of the small group that expresses its passion for exploring the world, with its great diversity of cultures and customs, in a collection as precious in its heterogeneity as the family table service is in its homogeneity. Once the question of what you can or cannot afford has been dispensed with, respect for the past acquires another value and another form.

This example shows that old values, however interesting historically these are, are all too easily clung to against one's better judgement; and that suppressing and replacing such pre-conceptions creates new space, new room to move.

392 Charles en Ray Eames, *Eames House* (Los Angeles, 1946)

42.4 JEAN NOUVEL BREAKING THE CLICHÉ

These two all-metal blocks, set at right angles to a provincial feeder road to the city like some means of conveyance - more bus or train than ship - amidst a development that is more rural than urban, sit surprisingly well in their context. This is because we have become oblivious to the metal boxes of every imaginable shape and size setting the scene in increasing numbers

393 Jean Nouvel; Jean-Marc Ibos, *Nemausus Housing* (Nîmes, France, 1987)

394 Doormats

395 Marcel Duchamps, *Fontaine,* 1917

a Arman, Y. (1984) *Marcel Duchamps plays and wins / joue et gagne*.

throughout our cities and landscapes. But, it is certainly also because of the magnificent way these two lock in from either side of a strip of gravelled parkway flanked by plane trees as if they had always been there. The *allée* of slender planes continues to dominate the picture, visible from all sides as the housing blocks 'hover' on posts that are more slender still. Here Le Corbusier's *pilotis* principle is applied so convincingly *après la lettre* that one cannot help but be converted.

Other than in the Unité whose heavy columns all but blocking the view generated an inhospitable no man's land, these buildings stand on stilts in scooped-out, and, therefore, sunken, parking strips so that the parked cars do nothing to obstruct the view through.

Apart from the eye-level transparency on the ground plane this response is also a brilliant natural solution for the problem of parking which, although not new in itself, is here as open as it is objective through the minimal and simple response without balustrading or concealing walls to block the view.

This project also stands out in that everything is done to provide a maximum of space. Its access galleries are as broad as station platforms from which you enter your home with as little fuss as possible, much like entering a subway train, efficiently, but anonymously. Only the doormats identify the entrances as front doors and these ultimately are more image-defining even than the loud-and-clear graphics consistently derived from the world of transportation and including the numbering of the apartments.

The balconies have perforated forward-tilting sheet-steel spandrel panels which give the building its unmistakable, elegant, appearance, but behind which an utterly different and more varied character emerges through personal use. Each component has a certain overmeasure seldom encountered in housing, which may be why it gives off such a strong sense of space. The inhabitants respond with an almost un-French eagerness with additions of their own. Perhaps it was the restrictions imposed out of considerations of architectural purity - such as the architect's ban on adding to the crude concrete walls worked by an artist, and the metal grid landings between bedroom and bathroom - that in a presumably unintentional paradox were the very reason why tenants responded with all kinds of crazy modifications. These additions are nowhere to be found in articles about the building, yet it is these that best illustrate the space opened up by that construction.

42.5 CHANGE OF CONTEXT

Looking at the task before you in another light is the same as looking at another task, and for that you need other eyes. The problem is that everyone is constantly searching for recognisable patterns that are interpreted as rapidly as possible, in other words, that gain a place in our familiar world.

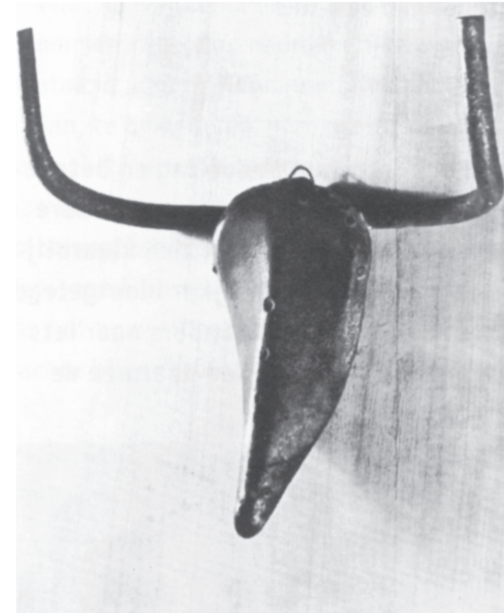
And the more familiar our world, the way we have built it piece by piece, the more trusted insights we have at our disposal and the more difficult it is to avoid them.

Inventiveness is in inverse proportion to knowledge and experience. Knowledge and experience keep forcing us back into the old grooves of the old record of meanings, the way a knife keeps returning to the original striations in a sheet of cardboard. Finding new concepts would not be difficult if only it were easier to shake off the old ones.

The first of Marcel Duchamp's ready-mades, dating from 1913, showed that presenting an 'everyday' object as a work of art could turn it into something new. He placed them in an utterly different context where something else was expected of them, so to speak, without him having changed or added anything (save for the customary signature of the artist). "*That Mr. Mutt* (Duchamp's pseudonym in that circumstance) *made the Fountain with his own hands or not, is not important. He CHOSE it. He took a common object, placed it so that its functional significance disappeared under the new title and the new point of view - he created for this object a new idea.'*[2]

A bicycle wheel or urinal it seems can lose its original purpose and meaning and take on another. This process of transformation evidently enacted in our minds is nowhere more clearly revealed than in the art of the twentieth century. By being able to perceive a thing differently, our view of things changes and the world changes with it.

A mental clear-out, making space in our minds by ridding them of so much ballast that once meant something to us. And if anyone was familiar with dis-assembling and clearing out associations, meanings and values, it was Picasso.



396 Pablo Picasso, *Tête de Taureau*, 1942

42.6 PICASSO'S EYES

Picasso's 1942 combination of bicycle handlebars and saddle as a bull's head is, after Duchamp's ready-mades, one of the most miraculous and meaningful art works of the twentieth century.

While a 'normal' collage draws a new narrative from disparate components each with its own story, here two parts of the same mechanism combine into a single new (and different) mechanism that inevitably and inescapably calls to mind the head of a bull. Indeed, so strong is this association that it is difficult to continue seeing anything of a bicycle in it.

The bike is forced into the background by the bull. Theoretically, at least there must be a transition point where the components are so caught up in each other's new sphere of influence that, in a sort of magnetic impacting of meanings, the bull all at once appears or disappears to be replaced by the bicycle, or a notion of bicycle. It may resemble the conjurer's disappearing trick, but there is a touch of magic here too! Picasso himself considered this work complete only if someone, the thing having been thrown out on the street, were to convert it back into a bike.

Yet the artist must have originally seen the animal parts in the cycle parts; he evidently saw them less strongly anchored in their original context. This then is the lesson we can learn from it: new mechanisms can ensue from another assemblage of parts freed from their original context by taking them up in a new chain of associations.

That Picasso was persistently able to see forms in their 'autonomous' - unsignified - state, loosed so to speak from the relationship they formed part of when he came across them, is clear from his studies of eyes that seemingly change into fish and then into birds without effort.

Forms for him - and materials too! - were clearly free and stayed that way until engaged, temporarily, in a particular chain of meanings, or rather, 'system of significations'.

On further consideration we can well imagine that for Picasso it was but a small step for a dish to very literally signify a *corrida*. The fact is, he was obsessed with bullfighting and it was one of the themes that haunted him the way another might see the arena as a well-filled dish.

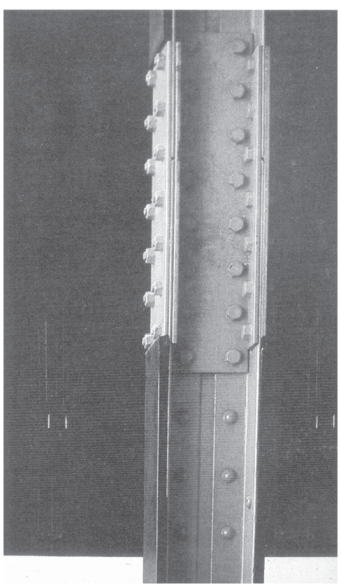
42.7 DINING TABLE FROM A DIFFERENT CONTEXT

Le Corbusier's table, consisting of a thick cantilevered marble top on two steel legs, found many times in his work and used by him in his own house in the Rue Nungesser et Colli as a dining table, can be regarded as a new 'mechanism'. While not all tables were wooden and had four legs, this had been pretty much the norm, and it was simply accepted that at times the legs would get in the way even when located at the corners (such as when tables are combined to accommodate a larger gathering).

The steel central legs of Le Corbusier's table with their weighted feet allowed a reasonably stable top to cantilever on all sides, giving free leg room all round. A drawback of this solution (one that has to be put up with) is that the enormous weight establishes a place-bound quality. So there are disadvantages as well as advantages. It all depends on circumstances, but it is certainly a novel idea, which makes it interesting to find out how it was arrived at.

397 Le Corbusier, *Dining Table (*Paris, 1933)

398 Pierre Chareau; Bernard Bijvoet; Louis Dalbet, *Maison de Verre* (Paris, 1932)



399 Tie plates and rivets, flanges with slate panels

400 Stylistic amalgam. Bear steel column, a nineteenth century grand piano and art deco furniture

On visiting a hospital one day Le Corbusier saw a dissecting table, being used for anatomical purposes, according to Maurice Besset, making the purely functional advantages mentioned above all the more logical. To see the thing as a dining table was a particularly blunt transformation, one that obviously did not bother Le Corbusier, either when he was designing it, or when it was used daily by himself and his wife. Evidently he could banish the visions of cadavers from his mind and even the channel meant for running off blood is by no means an unpractical consideration for a dining table.

Bizarre though this example may seem, it once again shows that forms are able to change their meaning. But, it also shows that Le Corbusier was able to see this particular form distinct from the chain of associations originally linked with it and slip it into a new chain. The form was freed, so to speak, of its meanings and the framework once containing them, to be given a new infill, 'signified', with other meanings in another context which it was now at liberty to accept.

42.8 CHANGE OF CONTEXT IN MAISON DE VERRE

When it proved impossible to acquire the upper apartment in the courtyard in the Rue Saint-Guillaume, it was decided to remove the entire lower three floors and slip a new house into the existing building. Then a problem arose: the steel columns that were to shore up the remaining portion suspended like a stone bridge in the sky, could not be brought into the building in their complete state. As a result, shorter lengths consisting of sundry steel sections were combined and assembled on site using tie plates and rivets. So ultimately the solution was all-technical in the spirit of the bridge constructions of those days, which for us at least, used as we are to welded joints, have a nostalgic air about them.

Was it originally the intention to clad these columns, thrusting up resolutely through the tall space, so as to mask at least something of their explicitly technical look? We shall never know. What is certain is that the columns as rendered in the well-known perspective drawing contain nothing of this turn of events, germane as such developments are to the practice of building, though generally unexpected.

There must have been a moment when the architects, reviewing the whole in the light of the overall formal world they had generated for the house, decided that it was complete at this stage. And not just that, they had it painted in two colours in such a way that the technical build-up in parts would be more prominent still.

Chareau must have been taken with these columns, unexpected images as they proved to be, fully regaled and free-standing in the space. For aside from the black and red-lead colouring he clad the flanges at places with slate panels. This is something only an artist would think of, one with his roots in Art Deco as evidenced by the innovative use of materials and joints at so many places in this house. So we see Chareau uniting the redolence of disparate worlds into an amalgam with its own individual aesthetic. Add the furniture which together with the steel structure presents a kind of biotopic unit, and it then becomes clear that our acceptance of this aesthetic is grounded not in some law or precept that guarantees beauty, but entirely in the positive associations that each of the components present here evokes in us.

Clearly then, forms and colours (and of course words) change when lifted from their original context and placed in another setting. Extricated from their earlier system of meanings they are now free to take on a new rôle.

Place things in another setting and we see them in a new light. Their meaning changes, and with it, their value, and it is this process of transformation as enacted in our minds that gives architects the key to creativity.

42.9 CHANGE OF CONTEXT AT A DOLL'S HOUSE

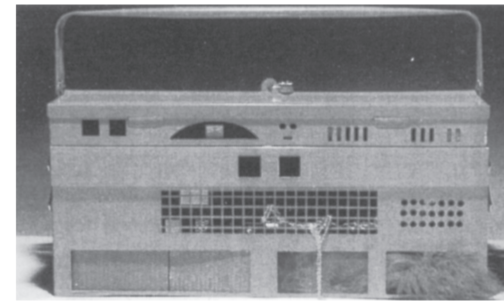
In the competition held in 1983 by the magazine AD to design a doll's house (of all things), the submitted plans gave the expected broad spectrum of reductions of contemporary dwelling forms, in the way that doll's houses through the ages were for practical reasons invariably cutaway models of usually well-to-do houses from particular style periods.

Jean Nouvel (of all people) submitted a design and won. And although by no means the greatest of his designs it is certainly one of the most remarkable. Who would have thought of a toolbox as a space for accommodating your childhood memories? Dolls instead of steel implements, one could scarcely imagine a greater contrast. But the oblong terrace-like collapsible drawers unfold their contents so that at least everything is there at hand, a lot more clearly organised that most traditional doll's houses. Although not directly a model of a house that we know, you could well imagine it as such. And although not a reflection of an existing type, it does give an illusion, an idea, of a house.

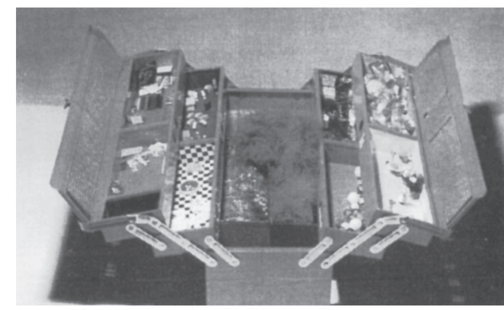
Do children really feel the need for a reduction of a literal house, where you always have too many corners that are inaccessible, and with the frustration that you cannot really get inside it and always feel shut out as a result? Here in this toolbox your things are always safely stashed away and it is made to carry around.

Come to that, you can imagine Nouvel returning to this idea sooner or later (just think of the 'pull-out' stands of his super-revolutionary competition design for the St. Denis stadium).

This concept breaks dramatically with the customary doll's house cliché. Not just in terms of the outward appearance and how it fits together, it also shows a revamping of ideas about what it is that children might want from a doll's house, taking note of the fact that they have less need of something representing a literal reality. With their capacity to think conceptionally, they are content with merely the idea of a house.



401 Jean Nouvel, *Doll's house,* AD competition (1983)

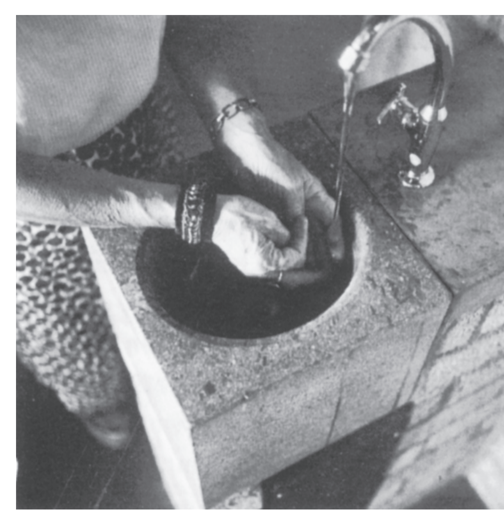


402 Toolbox of childhood

42.10 ADAPTING TO A NEW CONTEXT

Forms and things can apparently adjust to a new situation and be primed to accommodate a new and opportune purpose. Looked at this way, creativity is seen to originate in an extreme capacity to adapt, in the sense that not only are you adapting to the potentials of things but at the same time those things are adapting to suit you.

"As far as the form of the granito washbasins we wanted to build-in at various places in both the Centraal Beheer building and De Drie Hoven, I got no further than a list of conditions that this form had to satisfy, such as filling watering cans and washing hands. The dimensions were in fact already fixed seeing that they needed building-in to the brickwork, and they had to be cast in concrete. But, what on earth was the form going to be? I tried to impress my thoughts on the others and demonstrated the movement you make when washing your hands by describing circles in the air. Everyone knew that there was only enough money for something very simple and square at the most. It was clear that this rectangular form was completely at odds with the flowing movement I had outlined and would be impossible to keep clean besides. Until, all at once, a polyester hard hat appeared before us on the table. Someone's straying eye had seen it lying in the cupboard. The perfect oval form, exactly the right size, ideal as a mould, simple to install and obtainable for free from the contractor." (1986)



403 Hertzberger *Washbasin*, Centraal Beheer (Apeldoorn, 1970) and De Drie Hoven (Amsterdam, 1974)

The theory is as follows: new organisations/mechanisms/concepts are found by stepping outside your task and relating it - i.e. by association - to other known tasks and applying them to your case. The difficulty here is the usually limpet-like adherence of these known tasks to their 'original' meanings, something like a chemical compound with a strong affinity, making it difficult for us to conceive of them as freed and interpretable. The space for creativity lies in managing to forget, in demolishing foregoing prejudices and above all in an ability to un-learn. A matter of learning to unlearn, then. The age-old question, which inevitably looms up here as elsewhere is this: Is creativity something you can acquire or is it entirely a question of aptitude? And, although without aptitude you will obviously make little headway you could still say that the easier it is to pull apart forms and meanings, the greater the potentials for creativity; this means seeing forms more as self-sufficient phenomena, open to more and ever new meanings. Which brings us back to Picasso's ability to see the handlebars of a bicycle as form distinct from its meaning. The question now is whether you could cultivate this potential, and if so, how.

The pre-condition for creativity is that only the smallest amount is fixed for you, meaning that the largest amount is open-ended. The more doubt you have about the fixed meanings and established truths imprisoning you, the easier it is to put these in perspective and the more curious you need to become about other possibilities, other aspects.

Creativity depends on the ability to open your eyes so as to see things in other contexts and in particular beyond the restrictions of the arguments in the closed circle of the 'architectural world'.

It is more a question of mentality than of insight and teachers should perhaps do something about this by stopping scaring students with all that discipline-bound information and instead use the time to challenge students to enlarge the circle of their interest, to see more, to bring in other aspects; to arouse their enthusiasm, receptivity and curiosity, that they ask more questions than they expect answers to, that they experience more of the world, that they widen their frame of reference. Education, and this includes education of architecture students, should, before anything else, unfold mental space so as to explore the unknown, the new, the other and put it within their reach instead of filling the space in their heads with what we know already.

Make them hungry instead of nourishing them with information.

42.11 EDUCATION

The climate at the university is overly determined by fear. Fear on the part of the professors that students will not get a thorough training, and the students' fear of failing to satisfy the expectations of the professors. Yet the two parties agree on one count: it has to do with being able to think about your subject of study, the rest is a question of looking things up. Because you are only able to think when you get pleasure from thinking, it is 'the pleasure of thinking' that should colour every task you are set. The best tasks I know of in this respect are the following:

1. Comparative analysis (introduced by Kenneth Frampton at the Berlage Institute) of buildings. This involves carefully choosing a number of objects that have to be of one type per analysis (i.e. railway stations, residential areas, schools) and expressly suitable for comparison. Groups of students (this can only be done in groups) try to assess, on the basis of what are initially self-imposed criteria, the extent to which the different objects satisfy those criteria and which score the most points. They, therefore, have to think about how a building fits together, why this is so, and whether this really is the case. The basic conditions that projects have to satisfy are exposed together with whatever unexpected and exceptional spatial discoveries they may prove to elicit.
2. Once again, by dint of comparison, a number of preferably large buildings or structures, whose construction was of decisive influence on the underlying concept, are examined to ascertain the degree of influence the form had on the construction or indeed the construction's influence on the form. The exercise gains added depth by the inclusion of examples from the past as well as the present, such as the Hagia Sofia, the Gothic cathedral and the Sagrada Familia, thus presenting quite differently grounded relationships of form, material and ways of spanning. Without referring to history as such, various eras and their specific possibilities can then be compared, thereby laying low the unspoken but generally prevailing prejudice that there is no place for the past in the maelstrom of the present.

42.12 INDESEM

Indesem is a two-yearly International Design Seminar. A short-lived school of architecture held at the Faculty of Architecture in Delft, it is an explosion of learning without education. This time it is the students that decide which teachers they want to hear and what the subjects are to be. Students themselves are one hundred per cent responsible for everything and it is they who see to it that the technical and academic staff warm to the idea of breaking plenty of rules for a week. And you should see what happens when you do! Work continues into the early hours and the building is turned inside out to get at its hidden qualities. The daily routine is disrupted and the cleaners are made aware of their importance.

Spectacular though the week of the seminar undoubtedly is, it is merely the tip of the iceberg of preparations attendant on each new INDESEM when twenty or so individuals are kept busy for at least nine months. Each time a group of students comes together to perform the Herculean task of getting this event off the ground, their own regular studies largely left to one side for the duration. It is only much later that they realise just what they have received in return when, their studies over, it transpires that designing and realising a building demands an identical attitude where it is again all down to anticipating, deliberating, seeking out conditions, making (and keeping) appointments.

The task is enacted in the city. It is not primarily about building itself but about what building in the city does to space.

Those taking part come from all over the world, perhaps initially attracted by names and by the Netherlands, but also for the thrill of actually being able to meet and talk with so many others in the same boat. The task is no more than a pretext and catalyst for coming into contact with others and having something to discuss with them.

No-one really believes that a week is long enough to do more than make a start on a barely under-pinned plan, nor is that the prime reason for INDESEM. The idea of results is chiefly to drive the process. The performance that needs generating is to get a group of complete strangers, almost all of whom are obliged to try to express themselves in a language other than their own, to formulate and present an idea and go on to defend it against all others.

42.13 TAKE HOME ASSIGNMENTS

Part of the curriculum of the Faculty of Architecture at Delft consists of so-called 'take-home tasks': written assignments that students come and collect. These are to be completed and handed in fourteen days later, after which there is a discussion involving the teacher who set the task and those who took it on.

The essence of the task is that you can only resolve it properly through a combination of perspicacity, empathy and enthusiasm. It entails a written rather than a drawn situation; much like the physics problems you get at secondary school. It is a situation familiar to everyone, as intriguing as a puzzle you feel obliged to solve if only to keep up with the others.

These assignments never involve problems, they are challenging more than anything else. They call not for diligent draughtsmanship, but for an idea, a brainwave-in-miniature, and are expressly aimed at bringing out the assignee's own ideas, interpretation and choice of site. Thinking up a problem is possibly just as mentally taxing as thinking up a solution. As a teacher you have to extricate yourself from all the stuff that constitutes ninety per cent of the architect's practice and that you are all too readily inclined to immerse your students in, to show them just what a difficult business it all is. Instead you should be looking for the exciting, challenging and, most importantly, the fun sides to architecture that will arouse interest and hopefully curiosity too.

Looking through the results of the take-home exams, a coherent image has taken shape through the years. There are always a few who get totally stumped and a large group of boring, decent, reasonable students clearly divided into those who went out of their way to resolve the task and those who ploughed through it with an often remarkable dexterity. But there is also a select band whose responses are frequently surprising and at times even astonishing.

"The artist doesn't make what others regard as beautiful,
but only what he considers necessary."
Arnold Schönberg

"It is easier to pulverise atoms than prejudices."
Albert Einstein

43 PERCEIVING AND CONCEIVING

HERMAN HERTZBERGER

Perceiving is the ability to extricate certain aspects from within their context so as to be able to place them in a new context. You see things differently, or you see different things, depending on your intentions in perceiving. Each new idea begins with seeing things differently. New signals bombard you, persuading you that things are not the way you thought, making inevitable the need or demand for a new response. To observe and so understand your situation, your surroundings, the world, differently, you have to be capable of seeing things in another light, seeing those same things differently. For that you need another sensibility, resulting from a different perspective on things, your surroundings, the world.

The architect's most important attributes are not the traditional emblems of professional skill, the ruler and pair of compasses, but his eyes and ears.

At a certain moment in the nineteenth century, painters began painting the patches of light in the shadow of trees, where sunlight falling between the leaves perforated so to speak the areas of shadow. You could say that those patches of light must have always been there, and they undoubtedly were as long as there were people to look at them, yet those painters saw them for the first time. At least they only then became consciously aware of them as an essential aspect of the configuration we call tree. Their attention focused on the exceptional quality of trees as providers of shade and shelter, and on the fact that people tend to linger there rather than elsewhere. Searching for other things, with the shift in attention that brings, they became conscious of aspects they had in fact always seen without being aware of it.

Often it takes painters and their interpretations to make you aware of how things hang together. For instance we see the landscape of Provence influenced by the way Cézanne experienced it; we are in fact looking through the painter's eyes. You become aware of what you are actually seeing only when that perception occurs in the right context at the right time. Pre-historic caves with paintings on the walls, now regarded as pinnacles of artistic endeavour, were discovered at a second viewing, long after they had been closed up because no-one had then seen anything in them.

People began perceiving things that, until then, had simply had no part in the general frame of reference. There was no interest in them because the focus was on other aspects that were more relevant to them then. So other glasses were needed, so to speak, 'to see what had not been seen to be seen'.

404 Max Liebermann *Restaurant 'De Oude Vink'* (Leiden, 1905)

43.1 SELECTIVE PERCEPTION

The same tree observed by an ecologist, a biologist, a forest ranger, a painter and a transportation planner is seen by each through different eyes and therefore regarded and valued quite differently.

Whereas the biologist probably assesses its health above all, the forest ranger calculates roughly how many cubic metres of timber it would give him, and the painter appreciates its colour, form and maybe the form its shadow throws. For the transportation planner it is bound to be in the wrong place. All look at things through their own glasses and consequently assess things quite differently, each within their specific context.

We can regard such specific contexts of assessment as a system of significations, and this system is accessible to the focused eye of the practised observer. Eyes that are experienced in a particular area see the smallest difference that would be missed by those skilled in other areas and remain hidden to them. So, for instance, it seems that Eskimos can see from the type of snowflake whether it comes from the mountains, the sea or from any other direction, something that is of vital importance to them to be able to find their bearings in an endless expanse of snow that otherwise has nothing recognisable to offer.[a] Indians are able to distinguish the presence of hundreds of plant species, and from several hundred metres away

* This text is based on: Hertzberger, H. (2000) *Space and the architect: lessons in architecture 2*. Originally published in Dutch: Hertzberger, H. (1999) *De ruimte van de architect: lessen in architectuur 2*.

Translated from the Dutch by John Kirkpatrick.

a Hall, E.T. (1966) *The hidden dimension*.

too. If this is inexplicable to us, it is equally inexplicable to them how, for example, we can distinguish and identify so many kinds of red lights and other signals on the roads at night, lights that cause us to slow down hundreds of metres away because they tell us that something may be wrong farther along the road.[a]

Everyone has an eye for a particular system of meanings because it is of special and relevant importance to them. They hardly see the other things if at all, such as the jungle-dweller who leaves his native forest for the first time and pays a visit to Manhattan. When asked what struck him the most he replies that the bananas were bigger than those back home.

Thus throughout the history of painting, and in that of architecture, we see different aspects coming to light that, each as a coherent system of meanings, made claims on the attention, evidently because at a certain time they were important or simply regarded as particularly attractive. Focusing on certain related aspects infinitely increases your powers of discernment *vis-à-vis* that relationship, yet it seems as though you can only focus on one area of it at a time.

Fixated on that one area, you are blind to everything else which, though potentially perceivable, fails to get through to you. It is as though you need all your attention for that one aspect on which you are concentrating and to which you are clearly receptive.

When holidaying as a family in France, our children were dragged from one cathedral to the other without their interest being aroused in the slightest. They only had eyes for coffee-makers, scooters and most of all a new phenomenon in those days: parking meters. Until one day they suddenly made their way to the cathedral in Auxerre. Had we finally managed to kindle their enthusiasm for the richness of this form-world that occupied and inspired us so? It took us only a short time before, having scrupulously scanned the surroundings, we succeeded in isolating from its exuberant backdrop a type of parking meter they evidently had not seen before!

43.2 PERCEPTION FROM EXPECTATION

Travelling through a remote desert area in India en route for Rajasthan, in all the stations you are served tea in fragile earthenware bowls that most resemble off-yellow flower pots without the hole at the bottom. Once empty they are thrown out of the train window where, with a dull plop, they smash to smithereens on the pebbles between the rails. The reverse of this phenomenon is that of our throw-away plastic cups; considered worthless in the West, there they are so exceptional that anyone succeeding in acquiring an intact example places it as a source of admiration among the other treasures set in a special place in the house. Isolated as a unique examplar in a culture of mainly handcrafted artefacts it can only be regarded as a creation of unattainable refinement. It is only with the greatest care that we managed to bring back undamaged one or two of those supremely fragile bowls as an elementary example of primitive production to our industrialised world, where they occupy a special place in our home as relics of a world lost to us long ago.

We only perceive what we more or less expect to find, confirming our suspicions as it were, in other words there is an element of recognition. Thus discoveries are in fact always re-discoveries and, invariably, the missing pieces from an already conceived totality.

The researcher can do little with phenomena he encounters that are impossible to fit into his research, based as it is on a known theory. Should he not wish to ignore those new phenomena, all he can do is accommodate them in a new theory using inductive reasoning. It is not merely that we can only see things as part of a context (system of significations, field, paradigm). For a thing only has meaning and value when placed in the context of the relationship in which it performs, the situation, the environment it occupies. To be able to perceive something it has to hold your interest, you have to have been searching for it to some extent, even if unconsciously. It seems as though certain fascinations, perhaps borne with us since

5 Lévi-Strauss, C. (1962) *La pensée sauvage*.

our childhood, persist in guiding or at all events influencing our preferences and decisions as well as our powers of discernment. You could call this secret force intuition.

Schliemann, the man who discovered Troy, was apparently able without prior knowledge to point out the right hill to start digging which indeed was to reveal the city, covered by nature as it had been and quite invisible. It cannot have been anything other than co-incidence, but why did he decide to start digging there as opposed to anywhere else? Psycho-analysts explain the accuracy of his actions through the resemblance of the Trojan landscape to that of Schliemann's childhood in the Rhineland.[a] His intuition - what else can you call it? - arguably was guided by an unconscious experience that had stayed with him from his childhood.

There has to be an impulse to excite the interest; curiosity comes before perception.

When Le Corbusier came across that marble table on two solid legs in the dissecting room of that hospital he must have recognised the form as an answer to one of the questions that had been haunting him: the dining table he had still to design that would not be the usual four-legged affair. Or had he long borne it in mind as an 'interesting solution' for possible use at a later date?

43.3 PROCESSING PERCEPTION

Even today Le Corbusier is still the greatest purveyor of ideas, concepts and images which, stored in his schemes, are still being adopted by the latest generations of architects, whether consciously or unconsciously. So what he himself accumulated from the past gets imperceptibly passed on as inspiration and converted into fuel for modernity.

A great many, mainly young architects see little in the past with its forms, materials and working methods which they regard as no longer applicable because these belong to another brief, with other labour relations and for other social contexts. Might knowledge of past forms guided by nostalgia not encourage an eclecticism of old stylistic traits?

Yet the occasions when Le Corbusier adopted historical forms almost literally, as in the Ronchamp chapel - call them direct influences - are few and far between. Come to that, everything he borrowed, or stole if you prefer, became profoundly modern through his intervention, such as the use of coloured glass, admired by all and sundry in Chartres Cathedral without it occurring to them that it could be applied in a modern setting.

Influencing is in the main an indirect and usually unconscious process of transformation, but you can also perceive in such a way that, looking through the expression of the form, you can, as it were, single out what of it may be of use to you. You are then interpreting what you see in a new rôle that is apposite and applicable to you. This is how characteristics come to be selected with a more universal value than their original stylistic manifestations.

Unlike historians, who tend to foreground traits that adhere typewise to a particular period, architects are more keen on those elements that do not. Because these have not lost their validity they could well be of use to us. We visually extract what we can use, indifferent to what the original intentions may have been, and label it timeless. It is the timeless that we seek, and, these days timeless means of all time. Elements unhitched from a particular time frame are those with a more general significance and ever present in different guises, evidently because they can be traced back to basic human values which persist, if with varying emphasis, in the way that different languages share an underlying generative grammar. You need history not just to see what happened when and where and how different or unique it was and if there are breaks in the thinking, but also to establish what it is that is unchanging, to recognise the underlying structure of similarities that we can merely piece together, like a pot unearthed shard by shard.

History keeps unearthing different aspects of an unchanging structure under changing conditions.

a Niederland, W.G. and H.F. Stein (1989) *Maps from the mind: readings in psychogeography*.

43.4 COLLECTIVE ARCH-FORMS

"The only available escape from the fundamental limitations of our imaginative faculty lies in directing our attention more to the experiences we all have in common, the collective memory, some of it innate (!) some of it transmitted and acquired, which in one way or another must be at the base of our common experiential world. (...) We assume an underlying 'objective' structure of forms - which we will call arch-forms - a derivative of which is what we get to see in a given situation.

The whole 'Musée Imaginaire' of forms in situations whatever their time and place can be conceived of as an infinite variety out of which people help themselves, in constantly changing variety, to forms which in the end refer back to the fundamentally unchangeable and underlying reservoir of arch-forms. ... By referring each one back to its fundamentally unchangeable ingredients, we then try to discover what the images have in common, and find thus the 'cross section of the collection' the unchangeable, underlying element of all the examples, which in its plurality can be an evocative form-starting-point.

The richer our collection of images, the more precise we can be in indicating the most plural and most evocative solution, and the more objective our solution becomes, in the sense that it will hold a meaning for, and be given a meaning by, a greater variety of people.

We cannot make anything new, but only reevaluate already existing images, in order to make them more suitable for our circumstances. What we need to draw on is the great 'Musée Imaginaire' of images wherein the process of change of signification is displayed as an effort of human imagination, always finding a way to break through the established order, so as to find a more appropriate solution for (the) situation.

It is only when we view things from the perspective of the enormous collage, that, with the aid of analogies, we can resolve the unknown and, by a process of extrapolation arrive at solutions which can improve the circumstances.

Design cannot do other than convert the underlying and the idea of ever being able to start off with a clean slate is absurd, and moreover, disastrous when, under the pretext of its being necessary to start completely from the beginning, what already exists is destroyed so that the naked space can be filled up with impracticable and sterile constructions. The various significations of everything that has taken place, and is still taking place now, are like old layers of paint lying one on top of another, and they form for us, in their entirety, the undercoat on which a new layer can be placed; a new signification which will slightly alter the whole thing.

This transformation process, whereby the outmoded significations fade into the background, and new ones are added, must be ever-present in our working methods. Only by such a dialectical process, will there be a continual thread between past and future, and the maintenance of historical continuity." [a]

43.5 COLLECTION OF REFERENCES

In the above quote dating from 1973 the emphasis is mainly on forms, conceived as time-dependent interpretations of more universal 'arch-forms'. What we are concerned with is the kind of space those forms generate and for this we must expand the idea of a '*Musée Imaginaire'* of images to include the space forms that they result in. Whereas forms always more or less bear the stamp of their time or place, space - even if their counterform - steps outside that time and place, conceptually at least, and is therefore less time-bound.

When considering architecture of other times or places, we need to turn our eyes from the things to the space these give shape to, and look beyond what is too specifically formed to distil the essence of that space, thus shifting the emphasis from the architecture to what it is that it manages to generate in the way of views and protection and what can happen as a result.

a Hertzberger, H. (1973) *Homework for more hospitable form.*

The more you have seen or the more impressions you have experienced in whatever other way, the bigger your frame of reference. We cannot be greedy enough in our cravings as ‘receiver’ of images wherever, whenever, whatever. Everything can produce useful associations: butterfly wings, feathers and fighter planes, pebbles and rock formations, images that enlarge the space at the architect’s disposal.

And then there are all the imaginable situations people can find themselves in; you have to recognise and identify these to bring those people to the centre of attention.

Your ability to generate ideas that lead to new concepts is contingent on the wealth of your frame of reference. And the wider the horizon of your interests, the sooner you can break free of the snare of architectural inbreeding of forms that are doomed to keep reproducing while their substance diminishes; and the greater your chances of avoiding the backwash of tricks and trends everywhere about. It is precisely by not thinking of architecture that you come to see analogies with other situations that incite new ideas (by seeing it more as X you discover its potential fitness for Y).

Your frame of reference, as it happens, also works in reverse: in the design process, it is by establishing which potential possibilities are unsuitable as a response to a particular task, the negative selection if you like, that you become aware of the direction you must then follow. Not only do you become more aware while working of what you are, in fact, looking for, criteria of quality also suggest themselves. These set themselves up as touchstones that inform you whether you have ‘arrived’ or need to keep on searching: designing is rejecting.

More important than being sure of what you want is knowing at least what you do not want, and so to design is most of all to keep looking and not be too easily satisfied with what you find.

The richer and more universal the influences you concede, the more mental elbow room you create for yourself. It is a question of exploring of everything there is, everywhere and of all time to discover how old mechanisms can be transformed into new ones by eradicating the old meanings and rebuilding them for new ends. It is, then, a question of making your frame of reference as large as possible.

43.6 EXPERIMENT-EXPERIENCE

The more experience you acquire, the clearer the bigger picture becomes, but regrettably it is also the case that the closer your experiments bring you to knowing what works, what is fit and what is not, the more your open-mindedness disappears and experience slowly, but surely strikes home. This process shows a certain analogy with the way space seems pre-destined to make the transformation to place.

Accumulated practical acquaintance leads eventually to experience, habituation and finally routine, as a result of repeating formulas that have proved to be successful. In spite of yourself, you measure every new experience against the quality of all foregoing experiences of a like nature, so that your chances of finding something new that is better than what you already know keep diminishing, and so for most people the need to continue searching will diminish too.

So we see everyone doomed by a natural process of selection, so to speak, due to the tendency to follow self-made paths, thus with a minimum of risk.

When this preference for previously trod paths goes hand in hand with a decrease in curiosity, it means that we are adapting more and more as time goes by to the possibilities, instead of seizing and exploiting these possibilities by adapting them to us.

The more you experience, the more experience you gain. All garnered experience remains in place and works with you in establishing values, and so influences your thinking and irrevocably restricts your freedom. Experience is what you know of the world and because of it you adapt to the world, whether you want to or not.

"Our brains persistently urge us to change our surroundings in such a way that we fit there, but when the limit is reached the reverse happens: our expectations and needs are modified until they fit the surroundings. The first happens in childhood, the second after that. Only artists manage to persist in the first stage." [a]

First, we make the world, later the world makes us. The architect's thinking, which guides his creative process and production, is controlled by the tendency to deepen and perfect his earlier discoveries on the one hand and to keep doing it differently with the hope of making new discoveries on the other. That is how we move constantly between experiment and experience. That is to say, risks and danger (*periculum*) obtain when we embark upon experiment, whereas experience safeguards us against them.[b]

The more experience takes over, the more earlier weaknesses will be eliminated and in time what we experience as quality will gain strength. Experience finds its own way and every teacher helps it in this by being naturally inclined to want to administer knowledge. Experience rests upon knowledge and insight, whereas experiment by contrast is out for discovery, finding the unknown. Experience assumes that the aims are clear. This is not the case with experiment. Yet, all too often we see ideas launched like unguided missiles with an excess of energy and enthusiasm, yet the targets are vague or simply not there. It would be fine if experience and experiment were to act as complementary categories, but unfortunately they oppose one another instead and that is the dilemma of the creative process.

If only we could escape our experience.

43.7 THE GUIDING CONTEXT

You have to step outside the context of your profession and be in a position to draw your ideas from a wider context than that of architecture which although itself revolving keeps taking its arguments from other arguments within its own system. Ideas relating to form or space can never derive from architecture alone. This raises the crucial discussion of whether there is any real point to such ideas. What are the things you can and cannot say with architectural means, and do they lead anywhere?

As an architect you must be attuned to what goes on around you; open yourself to the shifts of attention in thinking that bring certain values into view and exclude others. The extent to which you allow yourself to be influenced by these shifts is a question of vitality. That architecture changes is not just a hedonist, narcissistic, unconditional hankering, as in fashion, for the spectacularly original in the design of the exterior, but over and above that its ability to capitalise on what it is that shifts in society and in the thinking on society, and the new concepts that are discovered as a result.

Architects must react to the world, not to each other.

Architecture must be about something other than just architecture. Just as the painter needs a subject, so too the architect needs to have something to say that rises above the obscure jargon that architects share with one another. But it must also rise above obediently following and implementing some brief. Many of our colleagues are happy to have managed to cram everything in, within the budget and within the site boundaries. Though this may be an achievement in itself, you cannot call it architecture yet. Moreover, it is debatable whether anyone stands to benefit from it at this stage.

Often it seems to be something new, but is in fact an age-old formula that appears new when looked at differently; the proverbial old wine in new bottles.

Actually, every new design should by rights bring new spatial discoveries: exhilarating spatial ideas not encountered in that form before, in response to newly diagnosed conditions. You should be asking yourself each time what it is you really want, what idea - limited or expansive - you are trying to express. If this is a formal fabrication only, however interesting theoretically, is it of any good to anyone, and if so, in what way? Again, though, what is to be

a Hillenius, D. and N. Tinbergen (1986) *De hersens een eierzeef, open lectures at the University of Groningen*.
b Tuan, Yi-Fu (1977) *Space and place*.

given up, sacrificed, what is to be gained and what lost and for whom? Inevitably, these questions imply what it is you in fact expect of architecture, except perhaps instant fame.

On completing each design, you should once again ask yourself whether the result, despite all its efforts to look interesting, is indeed more than merely built output expressible in so many square (or cubic) metres of building; while there is nothing wrong with that, neither is it a reason to call it architecture, let alone art. This makes the self-satisfaction of architects about the import of their offerings more than a little disconcerting.

43.8 IDEA AND CONCEPT

Every new step in architecture is premised on disarming and outspoken ideas that engender spatial discoveries: call them spatial concepts. A spatial concept is the way of articulating an idea in three-dimensional terms. It is only as clear as the idea that produced it. The more explicitly it is expressed, the more convincingly the architect's overall vision comes across. A concept can be defined as the more enduring structure for a more changeable 'infill'. It encapsulates all the essential features for conveying the idea, arranged in layers as it were and distinguished from all future elaborations as, say, an urbanistic idea, set down in a masterplan and interpreted at some later date by sundry architects each in their own way. To concentrate the essence into a concept means summarising in elementary form all the conditions of a particular task on a particular site as assessed and formulated by the architect. Trusting on the insight, sensibility and attention he accords the subject, the concept will be more layered, richer and abiding and not only admit to more interpretations but incite them too.

It is the conditions as they obtain for that particular task that foster the idea for a design and the concept distilled from it. Those conditions dictate that the end-product satisfies that idea and that its special qualities get expressed as 'hallmarks'; this way the idea encapsulates the DNA, so to speak, containing the essence of the project and guiding the design process from start to finish. The concept, then, is the idea translated into space - the space of the idea, and bearer of the character traits of the product as these will emerge upon its development.

Designing, basically, is a question of finding the right (read appropriate) concept for the task at hand. But, all too often concepts, however dazzling they may be in their own right, are dragged into the proceedings and pitched at the world with no thought given to whether the task in question has anything to gain from it.

Our work needs placing in the context of society, whether we like it or not, venturing beyond the safe haven of architecture where we designers together attach meaning and weight to formal inventions. Admittedly, things always look good in the country of the blind, but beyond its borders the takers are usually few and far between. Genuine spatial discoveries never ensue from the mental cross-breeding in the small world of architecture. They have always been inspired by the wider horizon of society as a whole with its attendant cultural changes, whether or not incited by social and/or economic forces.

With each new task - and this implies components of a building, each and every one of which can be regarded as a distinct task - you should always ask yourself what purpose it serves in society, what idea it represents and what, finally, is the issue it seeks to resolve.

43.9 CONCEPT REACTING TO TASK CONTEXTS

You have to fathom out what is, and is not, required of a particular task; which conditionsare germane to it and which are not. You need the right species of animal, so to speak, that fits, or meets, those conditions that apply specifically to the task in question. Whether we are designing for savannahs with tall trees or for more swampy terrain will determine whether a giraffe or a crocodile is the most appropriate choice of beast. But, architects are usually all for designing a giraffe for a wetland region and a crocodile to keep the tall trees company.

What conditions, we should be asking, form the immediate cause and the departure-point for the direction a design will take?

The assumption that an idea underlying a design needs to fit the task does not mean that the concept can be deduced from it. It all depends how you interpret the conditions. For spatial discoveries you have to move beyond the bounds of the task, in other words beyond the surveyable area, to be able to see this in a wider context and then interpret it through inductive reasoning in its enlarged context.

The idea that points the design in a particular direction needs to be strong enough to free the task from the confines of its conditions and overcome the clichés entrenched in it.

It is important that the concept guides the elaboration of each distinct component if there is to be cohesion between the idea of the whole and that of the components. Every design of consequence presents a coherent narrative, built up as it is from components that have something to say individually and in concert rather than contradicting and counteracting each other.

Only by thinking through the project consistently and sensitively can the architect safeguard overall quality and prevent the design from being no more than a gimmick. Just think of the number of prize-winning competition designs, chosen for their sterling underlying concept, that come a cropper when fleshed out. What marks out a good architect is that his schemes only improve by being worked out in detail.

The eventual design is always an interpretation of the concept. Another designer would probably have made something else, as everyone has their own individual world of associations to throw at it.

A concept has to be challenging, must incite responses. It must leave room for multiple interpretations and say as little as possible about solutions in a formal sense, or about form, and concentrate all the more on the space.

Thinking in such proto-forms pre-supposes an abstraction towards the syntactic, such as pictograms which encapsulate the essence of a message. Concepts, then, are ideas expressed as three-dimensional ideograms.

In the practice of design, a guiding idea is seldom forthcoming right away. First it is noses to the grindstone on the strength of a few vague suspicions and only after persistent kneading of your material, and with a better overview of the field of conflict, do your objectives begin to assume shape. The biggest danger is that of the rash solution which you find yourself stuck with before you know it, a groove that is all too difficult to escape from. By contrast anything seems possible when drifting without a fixed course but it will not lead you anywhere.

The concept may be a compass, but it is hardly the final destination of the design process. The end-product can be nothing other than a development and interpretation of that concept, the way one might apply or render an overall vision. Thinking in terms of concepts, models, strategies etc - deriving as this does from seeking out the essence of what you are occupied with - does mean that there is a danger of that abstraction all to quickly leading to simplification. The issue is how to couch complexity in simple formulas. Who has never been lured by the bait of simplicity and who would not be inclined to reduce or rather distil until only the essence, the basic idea, remains?

43.10 THE COMPLEXITY OF SIMPLICITY (OR THE PITFALLS OF REDUCTION)

Simplicity is more easily associated with true, pure and serene that with barren, dull and poor. Every architect strives after simplicity, even if only because ‘truth’ would seem to equal simplicity. Saying ‘I want to make something very simple’ is construed as an expression of extreme modesty. Unfortunately not everything that is simple is also true, pure and serene.

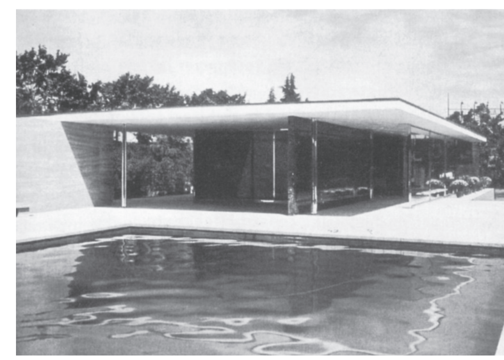
Many architects think that leaving things out is a surefire way of getting to heaven. The seduction of ‘less is more’ often leads all too easily to ‘all skin and bone’ - at excessive cost. Once you have acquired a taste for omitting things you are in real danger of succumbing to *anorexia architectura*. The 'art of omission' consists of leaving out only those things that are irrelevant, in the way that a sculptor (Michelangelo, by all accounts) was once asked by an admirer how he could possibly know that a beautiful woman was to be found inside the unhewn stone. Of course, the answer is that he must have had the form of the finished figure in his mind to begin with. You can only reduce a thing when you know what and what not to leave out; you have to know exactly where you are headed: you have to have a concept.

Omission is a dangerous business and whether less is indeed more depends entirely on the concept you had to begin with; this is what decides what can go and what must stay, not some assumed will to simplicity. Simplicity is not an end in itself, you arrive at it during the design process while searching for what is essential to your concept. Leaving things out is less a question of reduction and far more a process of concentration.

It all depends on what you want to express - not with the absolute minimum of means, but as clearly as possible without being thrown off course. It is obvious that you can say more with more words, but what the poet does is to arrange just those words in just that order so as to express what he wants to say as clearly and as precisely as possible.

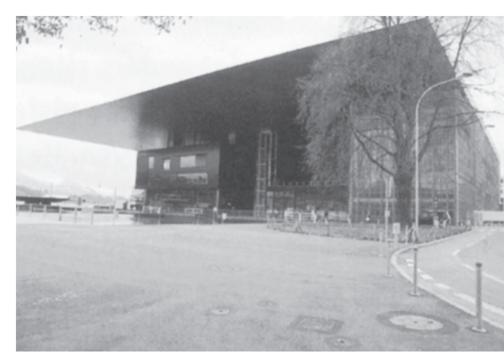
"Where economy of means is concerned, architects could learn much not only from engineers but also from the poet: the way in which he selects his words and structures them into sentences to achieve maximum power of expression and beauty of sound: 'la poésie est une chose aussi précise que la géométrie' *(Poetry is as precise as geometry, Flaubert). What we term poetry is particularly that utmost precision of thought, which while reducing its means can actually increase the layers of meaning."* [a]

Each time for the form-giving architect there is the tightrope to be trod between too much and too little, between 'under-designed' and 'over-designed'.



405 Mies van der Rohe *Barcelona-pavillion*

In that respect the engineer can serve as an example to the architect; after all, his aims are simpler and fixed firmly in advance. His task is easier, say organising a certain span with a minimum of material, or with the least structural height. For that matter, you usually need complex constructions and measures to achieve outward simplicity. Here, too, simplicity can fool you. For instance when rebuilding Mies van der Rohe's Barcelona Pavilion it proved a supremely complicated business to reconstruct the slender slab of cantilevering roof and uphold the appearance of simplicity. Again, the expressive roof of Jean Nouvel's concert hall in Lucerne must have required moving heaven and more especially earth. The structural tour de force rids the building of its objectness. With its seemingly wafer-thin roof and the way it spreads out across the surroundings, the building conjures up visions of a gigantic bird that has just landed, having chosen this monumental waterfront site between the mountains as its territory.



406 Jean Nouvel *Concert hall*, Luzern

43.11 CONSTRUCTIVISM

Showing how a building is constructed is a spectacular invitation to all-embracing form. Although this does express the essence of constructivism it does not necessarily result in space. Form expressed along constructivist lines is a demonstrative show of the pride its makers had in making and achieving structures that were unattainable (and less necessary) before then. They were, therefore, the symbol of a new era of new and unprecedented possibilities. And of its space, though the sense of space was ultimately due to the elegance of ease rather than the heaviness of effort. Which is why we prefer the poised quiescence of the ballet dancer to the tensed muscles of the weightlifter.

Attractive as it is to show how things fit together, and legitimate too, if only to keep then from getting too abstract and therefore unnecessarily obscure, there comes a moment when the aspect you wish to express begins to dominate all the others.

a Hertzberger, H. (1992) *Introductory statement* in 'The Berlage Cahiers 1'.

In addition, structures and constructions have the tendency to visually become increasingly complex and more and more difficult to understand, so that their expression imposes rather than informs. This holds not only for expressing how a structure is made, but also as to its purpose, which is more likely to be concealed in such instances than revealed.

Just as modern technology is no longer self-explanatory in a visual sense, so functions and allocations, volatile as they are, are suffering a marked decrease in identity as time goes by. We will have to accept that buildings, like household and other appliances, are showing less and less of their contents and their workings, and starting to behave increasingly like urban containers.

Architects are continually competing to make the most beautiful box. With control over the contents looking likely to disappear, the form of the packaging has become more important that the form of the contents. *'l Esthétique du miracle'*, as Jean Nouvel puts it.[a]

With the expression of how a thing fits together and what its specific purpose is pushed into the background, the concern for objectness cedes to an expression of the spatial idea - activating, enfolding and unfolding both construction and function - and the spatial characteristic this brings to bear. The more we are able to make, the more pressing the question of what our intentions are. First you have to have an idea of where you want to go before setting up a strategy to achieve that aim.

43.12 HEAD AND HAND

Do we think while we draw or draw while we think? Does the hand guide the head or the head the hand? Was there an idea before we began designing or did the idea arise during the design process?

At first sight this would appear to be a non-issue. Of course, you draw as you search and search as you draw and this way you immerse yourself in the task. The longer you work on a task, the more clearly focused its essence becomes. While proceeding you subject all manner of references to scrutiny and so ultimately arrive at an idea and an approach. 'Begin, and the results will follow'.

The artist, unlike the architect, can count perhaps on one of the themes he has been nursing for some time to yield results in the end. In the films of Picasso painting, he gives the impression that his ideas emerged spontaneously to be just as easily erased and replaced by new ones. Later, when his endless series of sketchbooks was published, it transpired that each motif in his paintings was carefully prepared beforehand and often even practised, as a performing artiste would do.

The architect's tasks, other than those of the artist, are more specific in the sense that each task makes its own conditions that require an appropriate answer. Unlike the artist, he is not in a position to throw random ideas about. The architect's ideas concern less autonomous concepts which can only be applied, in general, to the most specific circumstances, that is, if those circumstances did not produce them in the first place.

The danger of 'just beginning' to draw and design in the hope and expectation that something will come of it, is that before you know it you are resorting to well-trod paths or clichés. This is virtually unavoidable, as it happens, for it is impossible to envisage something that was not there to begin with. You are borne on by what you already knew, because you yourself, but more particularly others you admire, have already left a trail. The composer Hector Berlioz relates that, as possibly the only composer unable to play the piano, he was at an advantage compared with his colleagues who were in the habit of composing at the keyboard, so that like it or not they were drawn by their hands to already familiar sequences of already familiar chords.[b]

"The tyranny of keyboard habits, so dangerous to thought, and from the lure of conventional sonorities, to which all composers are to a greater or lesser extent prone." [c]

a Jean Nouvel, lecture at the Berlage Institute, Amsterdam, 1996.

b Cairns, D. (1987) *A life of love and music. The memoirs of Hector Berlioz 1803-1865*, p. 13. *'My father would not let me take up the piano; otherwise I should no doubt have turned into a formidable pianist in company with forty thousand others. He had no intention of making me an artist, and he probably feared that the piano would take too strong a hold of me and that I would become more deeply involved in music that he wished. I have often felt the lack of this ability. On many occasions I would have found it useful. But when I think of the appalling quantity of platitudes for which the piano is daily responsible – flagrant platitudes which in most cases would never be written if their authors had only pen and paper to rely on and could not resort to their magic box – I can only offer up my gratitude to chance which taught me perforce to compose freely and in silence and thus saved me from the tyranny of keyboard habits, so dangerous to thought, and from the lure of conventional sonorities, to which all composers are to a greater or lesser extent prone. It is true that the numerous people who fancy such things are always lamenting their absence in me; but I cannot say it worries me.'*

c Idem.

We know that Mozart heard entire works in his head before committing them to paper. This enabled him to turn those endless journeys in bumpy carriages to his advantage. Why should not architects design buildings 'in their head'? Are plans and sections really more complex than the voices of, say, twelve musical instruments, each with its own timbre, such as need weaving together in a symphony?

First you must have something in mind (heard or seen), call it an idea; only then can you note it down - although of course it is never quite as simple as that. Drawing can bring out an idea, give it a clearer outline if you like, but it must have been in your subconscious to start with. It should proceed more like research. The researcher does not start anywhere, at random, he does not begin without an idea, a hypothesis, about what he expects to find, and where. That he may well ultimately end up with something other than he sought is another matter.

43.13 DESIGN PROCESS

"The architect's design process, as such, should be viewed more as a method of research. It should then be possible to make explicit the steps of the process, so that the designer is better able to realise what he is actually doing and what reasons are guiding him. Of course, sometimes you may discover something seemingly out of the blue, but those moments, for the architect at least, unlike the artist, are rare. Mostly, when you muster up enough courage and take the trouble to be conscious of it, the underlying thought process will prove to be less mysterious than that of the pure artist. We work according to strategies to achieve specific aims, preferably with as limited means as possible. We make use of practically all the resources and techniques which the researcher uses in, for example, operational research." [a]

But, for those who flinch at the usually strict rules that scholars wield with such gravity, we can look closer to home.

The working method in the design phase in many ways resembles cooking. Even when the cook works without a recipe, he has a fairly clear idea about what his aims are, and before he can start he must gather together the necessary ingredients. If certain spices turn out to be missing from his kitchen cupboard, then the outcome will be a different dish from what he had in mind. In the same way the architect, bearing in mind the requirements his design will have to meet, can draw up a shopping list of ingredients, as it were, with which he intends to set to work.

"Cooking consists of a fairly complex set of actions, undertaken in an order that is apparently without logic, at least without any logic that might correspond with the logic of the end-product. For instance, some ingredients have to be soaked beforehand, or dried, cooled, heated, thickened, or liquified, be kept for a long time on a low heat, or stirred vigorously for a short time on a hot burner, and all these actions are undertaken in an order that bears no resemblance whatsoever to the order in which the final product is eventually served on the table. Similarly, the design phase proceeds in an ostensibly chaotic fashion, and we must not try to impose an artificial order onto the different stages, because it does not work like that." [b]

43.14 PART AND WHOLE SIMULTANEOUSLY

"What we can do, is to keep in mind, throughout the design process, the final product as we envisage it in its totality, and thus ensure that the initially fragmentary image slowly but surely comes into sharp and complete focus.

That is why you should, ideally, concern yourself with all aspects of a design at the same time, and of course not only with how everything is going to look, but especially with how it is to be made and how it is to be used.

While absolute simultaneity in the work on all aspects of a design is impossible, it is at least possible to spread our attention evenly and alternate our focus of interest with due deliberation, so that all the screws, as it were, can be tightened in turn - a little, not too much at a

a Hertzberger, H. (1995) *Designing as research*.
b From Hertzberger, H. (1992) *Do architects have any idea of what they draw.*

time - until the correct allover balance is achieved in the work as a whole. The greatest danger constantly threatening us is that, fixated as we often are on a small problem whose solution eludes us, we spend too much time on that one problem, more because of a psychologically felt necessity than because of a demand inherent in the design. And paradoxically, when an excellent solution eventually presents itself, it often has a disastrous effect on the design as a whole. After all, the more convincing that (partial) solution is, the more strongly the temptation becomes to adapt the rest of the design accordingly, which inevitably results in lopsided development.

There was once a painter, who spent an inordinate amount of time on a portrait that he was finding impossible to get right. Everyone agreed with him about that, and incidentally also about the fact that one feature, the nose, was outstandingly good, unlike the rest of the face. This nose met all the demands that could possible be made on it, it was indeed the sole component that was truly finished. So it was not surprising that the painter, falling into his self-made trap, kept on altering the mouth, ears and eyes, erasing them time and again from the canvas and starting all over again, in the hope of portraying the right mouth, ears and eyes to go with the already perfect nose. Until another artist came along and saw his predicament. He offered to help, and asked for the palette knife. In one fell swoop he dealt with the problem - to the horror of our painter. He had slashed the only successful feature of the face. Once the handsome nose had gone, the only obstruction to the painter's ability to see things in their proper proportions had gone, too. In the wake of this destructive deed came the possibility of a fresh beginning.

The complexity of the architect's design process and the underlying thought pattern is in a sense also comparable to that of the chess player, who also has to deal with a great variety of possibilities and choices and mutually influential factors. The chess player who becomes too preoccupied with the possibilities offered by one particular piece is punished with disasters that will inevitably occur elsewhere on the board. And just as the chess player (like the cook with his efficacious but apparently random sequence of actions) keeps track of all the possibilities of the game, the architect too must develop a manner of thinking that enables him to monitor the range of his attention so as to take in as fully and as simultaneously as possible all the inter-related fields of interest. Only then can he arrive at a design in which the different aspects are properly and fully integrated in the whole. Both chess player and cook succeed in developing new strategies to deal with ever-changing situations, and also the architect must be capable of undertaking his design process according to such strategies, so that the form does not evolve without consideration for construction and material, the organisation of a floor plan not without consideration for accompanying sections and the building as a whole not without consideration for its environment."[a]

43.15 THE FLOORPLAN IS NOT A DESIGN

"A particular difficulty is faced by the architect ... he cannot represent his ideas in reality, but has to resort to representing them by means of symbols, just as the composer only has his score with which to render what he hears. While the composer can still more or less envisage what he has created by checking to hear what his composition sounds like on the piano, the architect depends entirely on the elusive world of drawings, which can never represent the space he envisages in its entirety but can only represent separate aspects thereof (and even so the drawings are difficult to read).

That is why the average architect usually starts by getting his floor plan technically right, whereupon he may think up an interesting section to go with it, after which he must finally complete the structure with façades that remain within the framework of the possibilities of floor plans and elevations. This unsatisfactory state of affairs is maintained and even aggravated by the fact that the drawing, irrespective of the meanings it seeks to communicate, evokes an independent aesthetic image, which threatens to overshadow the architect's original intentions

a From Hertzberger, H. (1992) *Do architects have any idea of what they draw.*

and which may even be interpreted by the maker himself in a different sense than initially foreseen. A complicating factor is that, due to the sheer superabundance of this type of image and our constant comparisons with antecedents, which has given rise to a sort of meta-language full of such things as lucid concepts, well-positioned staircases, interesting spatial effects - in short an insider's jargon of extensive qualifications which do not refer so much to the actual building as to its abstract graphic representation on paper, i.e. to an expectation.

However absurd this may sound, we must in all seriousness ask ourselves how many architects are actually capable of reading their own drawings, that is of interpreting them with an eye to the spatiality of the structure that they are supposed to represent, as well as to the social and utilitarian objectives. Most architects read their drawings as an autonomous graphic image, thereby involuntarily placing them on a par with the graphic work of an artist.

'Thus the architect can be said to be the prisoner of his own drawings, which seduce and mislead him by their own imagery and which do not transcend the confines of the drawing board."[a]

The space we visualise relates to our drawings as a landscape does to an ordnance survey map. Exactly perhaps, but two-dimensional and most particularly incomplete.

43.16 DESIGNING IS THINKING

Designing is in the first place thinking, and then drawing as you think. It is not just visualising something that goes with what you are drawing, but much rather rendering by drawing what you visualise. Other than that, it is a question of organising your imaginative powers as best you can. Designing is a quest that you want to have proceed with maximum efficiency, purposefully if possible.

Therefore you should not fritter away too much time chasing fly-by-night 'solutions' that shortly after have to be dropped - there was something you overlooked after all - for the next rising impulse. All this leads to is depressing piles of sketching paper. It is better to leave the paper and certain the computer screen alone and begin by thoroughly exploring the field. Just as detectives in popular TV series needs to first grasp the plot before they take off after the villain, so the design process consists in principle of a like period of looking, listening and fixing the conditions.

Prior to resolving the task, the designer must develop ideas proceeding from his insight into the full complexity of the task, that lead to a concept, just as the doctor diagnoses the problem before embarking on a therapy. The concept contains the conditions you wish to fulfil, it is a summary of your intentions; of what needs saying; it is hypothesis, and premonition. There can be no quest without premonition; it is question of finding and only then seeking.

"D'abort trouver, chercher après."

Jean Cocteau

a From Hertzberger, H. (1992) *Do architects have any idea of what they draw.*

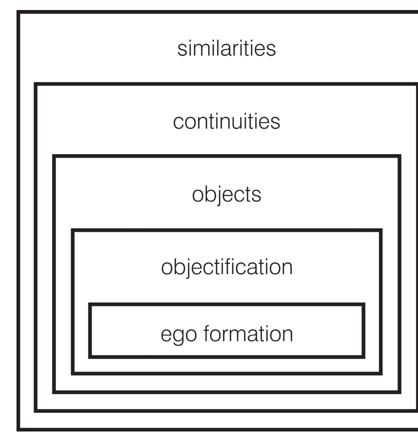
44 FORMATION OF THE IMAGE

TAEKE DE JONG
JÜRGEN ROSEMANN

This Chapter in an epistemological intermezzo in which psychologists, philosophers and artists enter the discussion (and the picture) regarding formation of the image. This short overview cannot do this topic justice. Positions will be briefly elucidated. Whoever wishes to read more is referred to other literature via the references. From the entire argument, only one pointer towards creativity is given: creativity pre-supposes leaving behind at least one notion otherwise considered self-evident. Furthermore, the idea that formation of the image pre-supposes a goal will be criticised, as this just shifts the issue of creativity to the concept of a 'goal'. A goal, after all, is an image.

44.1 CONSTANTS IN CHAOS

The great developmental psychologist Piaget describes a newborn's visual worldview as a *tableau mouvant* of disconnected shapes and colours (chaos).[a] Similarities and continuities must first be recognised to begin to be able to think *about* the world. It is not self-evident, for example, that a baby's experience of his mother from a distance is the same as his experience of her from up-close. The visual impression of both is completely different. It is only through repeated experience of amalgamated and formative images in this *tableau mouvant* that the baby realises this process involves an object that changes place in perspective outside of one's own body, but that otherwise remains the same itself ('object constancy'). What is equally uncertain is the subsequent distinction between one's own self and something that, on the basis of externally observed object constancy, leads its own life ('objectification'). The difference between 'I' and that, which has been made into an object, has been postulated by Fichte[b] as the first pre-condition for thinking. The object then temporarily remains a *object distinct* of the observer: "I see an object". If the child later gives a verbal description, it becomes an active *subject* of a sentence: "the object is yellow".

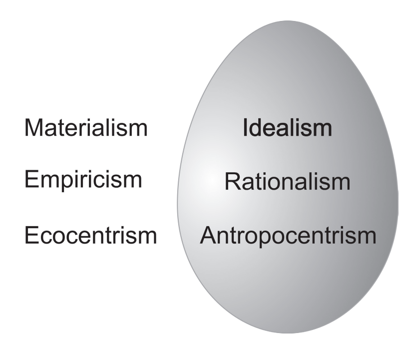


407 Continuities in similarities

44.2 'INSIDE' AND 'OUTSIDE'

A familiar philosophical position proposes that the difference between what takes place inside and outside of our thinking is theoretically improvable, that the 'I' is the only thing about which one can make a statement (solipsism). This is understood in psychiatric disturbances as autism. This extreme assumption that there is no outside world, certainly raises the question, as an experimental idea, of what one's own thinking would consist of if there were no conceivable astonishment *about* some unexpected thing that exists outside of us.

Psychological experiments depriving people of external stimulation (sensory deprivation[c]) are never endured by volunteers longer than three days, and lead to hallucinations. According to some, forced sensory deprivation will, based on several known cases with babies and animals[d], lead to death. The neuro-physiological system requires external stimuli. If one pre-supposes a stimuli producing outside world (easy to do), then the question arises where, precisely, the border lies between the observer and the externally observed. The problem with the relationship between "inside" and "outside" of our thinking has been studied in philosophy for 3000 years.



408 External and internal priority

a Piaget, J. and B. Inhelder (1947) *La representation de l'espace chez l'enfant*.
b Fichte, J.G. (1979) *Grundlage der gesamten Wissenschaftslehre (1794)*.
c Sensory deprivation has been investigated by many psychologists, see Vernon, J.A. (1963) *Inside the black room, studies of sensory deprivation*.
d See Montagu, A. (1971) *Touching*.

Is the observed only a projection of our way of seeing, or our underlying ideas (idealism[a], rationalism[b], and anthropocentrism[c], largely developed in continental Europe) or is there something more in our thinking than simply everything that has passed through our senses or even through our mouths[d] (materialism[e], empiricism[f], ecocentrism[g], all of which are largely Anglo-Saxon)? Projecting an idea into a new context is obvious in design, in the making of artefacts, and in taking action.

409 Magritte, R., *La condition humaine* (1934) Private collection, Paris.

44.3 'TRUE' AND 'POSSIBLE TO EXPRESS'

One finds several of the many attempts to unify both streams in human thinking in Kant (critical idealism)[h], Husserl (phenomenology)[i], and logical empiricism (logical positivism, neo-positivism). Logical empiricism is now considered the most widespread foundation of scientific thinking. Here, the expressability of thoughts in the form of language (logos, logic) forms the border of pure empiricist thinking. Science is only that which can be communicated. Wittgenstein (*"Wovon man nicht sprechen kann, darüber muss man schweigen"*) taught as a Viennese philosopher in Cambridge (amongst, for example, Russell, Keynes, and Skinner) and was thus also a literal bridge between continental and Anglo-Saxon thinking. The discovery in (particle) physics[j], biology (animal behaviour theory[k]) and sociology[l] that every reality is upset by human perception then set in motion yet another fundamental relativisation of perception.

410 Ghirlandaio, Domenico, *An old man and his grandson* (1480) Musée du Louvre, Paris

44.4 INTERSECTION OF SENSES

According to Piaget, another crucial moment in the formation of consciousness in child psychology is the pre-supposition that what you see and feel can be 'the same' object. This requires that at least two very different, even theoretically incomparable impressions from two senses (for example vision and taste) repeatedly appear at the same time. Experiments where children are able to feel something without seeing it and are then shown the same thing without feeling it lead Piaget to conclude that at the age of approximately one and a half (for some a bit earlier, for others a bit later), one's conceptual capacity comes into existence. At the intersection of the two synchronous but various (syn-aesthetic) sensory impressions, the idea (the concept) liberates itself from an object that one can immediately feel and see. From that moment onward, one can also imagine that object without seeing, feeling, hearing, or smelling it.

Considered from this perspective, one has to see the popular children's game of 'peek-a-boo' as a serious string of repeated empirical experiments based on testing the hypothesis (by means of various sensory impressions) that objects continue to exist even though one does not always see them. The stereotypical shaking of the head or dancing to and fro goes hand-in-hand with the way small children will, as soon as they can stand, devote large and amounts of visual attention to the parallax between the foreground and background of what they observe. The child will often laugh as a result, which leads parents and grandparents to intervene, although this laugh is often not meant for these observers; the child starts to cry when the outsider affectionately interrupts the child's experiments. The adult's face in the background is, at that point, nothing more than an interesting demonstration of the parallax[m] that confirms notions of object constancy.

a Plato can be seen as the founder of idealism. He thought of observed objects as reflections if ideas (comparison of size). Hegel gave the most extreme 19th century elaboration of this.

b Descartes is the most important founder of rationalism. In his very readable Discours de la méthode, doubt as the result of contradictory notions in his environment is the main motivation to only trust in his own reason. Descartes, R. (1637) *Discours de la méthode*. Recent edition: Descartes, René and Clarke D. M. (1999) *Discourse on method, and related writings*. Recent Dutch edition: Descartes, R. and Th. Verbeek (1997) *Over de methode*.

c Anthropocentrism proposes that 'the world' and therefore 'nature' form part of human culture. "Humans are the measure of all things".

d Feuerbach: "You are what your eat" (*"Der Mensch ist was er isst"*).

e De Lamettrie (man is a machine) en Feuerbach (see previous note) are the most outspoken representatives of materialism.

f Locke, Hume and Stuart Mill are the major Anglo-Saxon predecessors of empiricism who opposed rationalism.

g Ecocentrism contrasts with anthropocentrism. It considers people and their culture a product of evolution.

h Kant proposed that sensory impressions could be stored into 16 categories such as space, time, quantity, quality (Kant's categories). They represent the reception of impressions as systematic-critical bookcases of the consciousness.

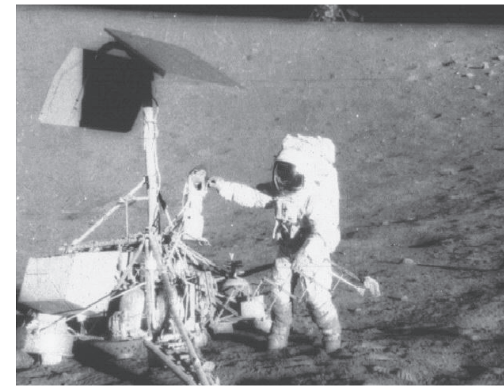
i Husserl (phenomenology) proposed forgetting about interior and exterior worlds ("put them between quotation marks") and instead focusing on the construction of their interface, the window on the world: phenomena.

Continued on next page

44.5 IMAGINATION BY INTERVENTION

An often under-estimated sense has to do with the use of our locomotor system. Even without feeling, seeing, and smelling, we can ascertain the relative position of our arms and legs, their weight, and what they are bearing. This enables coherence in our movements in space (co-ordination) and in time (synchronisation) and therefore also enables effective taking of action. Sequential reporting of our other senses on the basis of our actions (sensory motor system, the empirical cycle *avant la lettre*[a]) is, according to Piaget, crucial for the development of the ability to imagine (conceptual capacity).

After the Second World War, this insight had an enormous influence on education. Since Piaget, more attention was consciously paid to manual dexterity and gymnastics during primary education. Children can now, thanks to his research, get up out of their chairs more frequently during lessons. Many new teaching methods try to use the locomotor system in the formation of concepts. This is perhaps also a call for the use of models in design education. The science of making (technique) may benefit from a scientific notion that avoids the philosophical discussion between empiricists and rationalists by proposing: "'True' is what works" (pragmatism)[b].



411 'True' is what works

44.6 A SERIES OF ACTIONS

Conceptual capacity is defined by the biologists Harrison, Weiner, Tanner and Barnicot as *"the ability to maintain an overview of a series of actions of which only the first can immediately be executed"*.[c] One could add: *"and of which only the last brings satisfaction"* (yet this is difficult for an observer to establish). In this respect, people are different animals. This capability pre-supposes Piaget's definition, but goes further.

In archaeology, without written sources, discovery of tools provides proof of the early presence of people, even if various species also display the beginnings of this kind of capacity.[d] The individual involvement of intrinsically senseless actions into an overall functional whole is not yet proof that the sequence of actions is seen in its totality (planning). With instinctive actions, one can still imagine a built-in stereotypical programme (routine, compare this with computer programmes) set in motion as result of triggering stimuli from the environment (with computers, the external tasks of 'click', 'enter' or 'run') without being consciously planned.

412 A series of actions

44.7 SETTING ROUTINES IN MOTION

The research of animal behaviour experts (ethologists) is specifically focused on genetically pre-determined series of actions and triggering stimuli that set them in motion (Tinbergen[e]). Building nests, for example, will only begin at a certain temperature and solar position, and then only in specific environments. Humans also have any number of such routines, that can be learned partially, and that do not require further conceptual capacities. There is a counterpart in psychiatry: the blocking stimulus is very important. In these cases, setting in motion the theoretically self-evident routine is blocked. Removing these blockades is an important field in this discipline, and in design education as well. Sometimes attention from others can have a blocking effect. The idea is to unlearn the blocking habits by becoming conscious of unspoken pre-suppositions, and going back to their origins.[f]

a Groot, A.D. de (1969) *Methodology: foundations of interference and research in the behavioural sciences*. considers the cycle of experience, action, experience as the basis of science. One must therefore interpret action as the construction of models. Originally published in Dutch: Groot, A.D. de (1961) *Methodologie: grondslagen van onderzoek en denken in de gedragswetenschappen*.

b In 1878 C.S Peirce introduced the term 'pragmatism'. William James popularised it (pluralism) and F.C.S. Schiller (humanism) and John Dewey (instrumentalism), G. Papini, and H. Vaihinger ("Concepts are tools which have us behave as if they were true") elaborated on these ideas in various directions.

c Harrison, G.A. (1964) *Human biology*.

d On one hand one can consider the capacity needed to use tools, and apes do have this capacity, yet on the other hand is the question of the capacity to produce tools, and apes do not have this capacity (or have it only to a very limited degree). If they are taught a language, it seems that they can use it and pas it down to their offspring. See the various animal behavioural studies on the behaviour of apes.

e Tinbergen, N. (1953) *Social behaviour in animals*.

f Gaudí: "Originalidad es: volver al origen", originality means returning to the origins.

See Husserl, E. (1913) *Logische Untersuchungen*. Recent English translation: Husserl, E. and D. Moran (2001) *Logical investigations*.
This phenomenology had a major influence in the 20th century on his student Heidegger, on Sartre (existentialism: "Existence expresses itself in liminal experiences") and their followers Foucault, Lévi-Strauss (structuralism: "The social structure drives our expression, our language") and Derrida (postmodernism: "Grand narratives are deconstructed by external remarks in the margins").

j Heisenberg demonstrated that the energy one draws from the motion of atomic particles in the process of perception leaves us fundamentally in uncertainty regarding the location, or regarding the time of what is being perceived.

k Tinbergen, N. (1953) *Social behaviour in animals*. describes cases in which, for example, the behaviour of birds cannot neutrally observed.

l The Hawthorne experiment demonstrated that even a survey into working conditions was itself a work condition that improved performance. Roethlisberger, F.J., W.J. Dickson et al. (1939) *Management and the worker*.

m The shifting of object and background as a result of the observer's motion.

In order to distinguish between conceptual capacity and routine, one has to be able to ascertain that the involved series of actions (or the results they lead to) have not yet taken place in the given form or context. In exceptional cases, this might even have to do with a genetic mutation, where co-incidence is the creative factor. Yet when artefacts are repeatedly created by an organism, this can be ruled out. One is then dealing with creative conceptual capacity (creativity).

44.8 CREATIVITY AND ROUTINE

Some routines can be learned. This can be done by aping all actions in the sequence (master-and-apprentice), but people can then only go through the motions, and then repeatedly follow the recipe. Over time, this becomes routine. Therefore, a goal-orientated and creative conceptual capacity is initially necessary to finally develop the automatism that then liberates this conceptual capacity for other tasks. The dark side of such routines is that one forgets one's pre-suppositions, and can no longer account for them. They become self-evident actions, also pre-supposed by those watching. This often leads to the case where those who practice these exercises (and who are often well-known) are bad teachers. The concept of 'culture' can be explained as the collection of unspoken pre-suppositions during communication: what does not have to be explained in a certain context, because it is already considered obvious. Some pre-suppositions in a culture are theoretically no longer capable of being traced: they are already pre-supposed in communication itself.

Academic Impressionistic

413 Body or light

Left: Bouguereau, *Jeune fille se defendant contre l'Amour* (1880) Museum University of North Carolina in Wilmington.[b]
Right: John Singer Sargent, *The canvas* (1889) Brooklyn Museum.[c]

Language is just such a routine that, when being learned, pre-supposes creative conceptual capacity to connect words to experience. After that, it gives wings to creativity, but can ultimately also obstruct it as a collection of clichés which force themselves in. A new idea often consists of new combinations of routine ideas. The negation of one or several existing routines and assumptions is an important source of creativity. The ambiguity of the French word *'néant'* is telling: denial and birth. Thus we see in the origins of Impressionism the rejection of the academic notion that objects need to be painted in one colour scale if they are to be to recognisable.[a] This led to a completely new way of painting.

44.9 CREATIVE CONCEPTUAL CAPACITY

Creativity assumes a conceptual capacity according to Harrison *et al.*, and is also implied by Piaget, though it encompasses more and occurs less frequently than routine. This added value is attributed to an assumedly goal-orientated quality of human activity. Aimless experimentation (playing) can, however, also lead to something new (for example the invention of electrical power, or of Impressionism) when the formation of a goal is only addressed *afterwards* (electric motors, light bulbs, computers, Expressionism). A goal-orientated quality is thus not a *pre-condition* for creativity. A desire, goal or schedule of requirements is, after all, always an assumption of the result, be it an incomplete idea requiring means-orientated elaboration.

This again suggests the question *how one can take an idea to the point that it is no longer an already existing idea*. Let us call such an idea a 'conception' in order to distinguish it from Piaget's notion of a 'concept'. This question essentially refuses generalisation, and, therefore, predictive empiricism. Empiricism can only study existing pre-suppositions or causes verbally and visually, and not locomotorically their origins themselves (*generating* experience, which usually is temporarily transferable between master and apprentice). If this were the case, one would be able to predict new formations, along with their elaborations. Design would then no longer exist. The requirement of empirical research, i.e. that there be a problem from which an objective can be derived, which then has to be made operational in terms of concepts in order to begin the actual research itself, pre-supposes the creativity that is needed to devise objectives and to put concepts into operation. This research cannot therefore entirely solve the issue of creativity on its own.[d]

a See Struycken, P (1996) *De impressionistische doorbraak*.
b Source: http://sunsite.dk/cgfa/bouguereau/bouguereau2.htm
c Source: http://www.jssgallery.org/Thumbnails/Sargent_Paintings1889.htm
d Further reading on creativity: Vanosmael, P. and R. de Bruyn (1992) *Handboek voor creatief denken;* Csikszentmihalyi, M. (1996) *Creativity: flow and the psychology of discovery and invention*.

44.10 APPLIED COMBINATORICS

In order to achieve recognition as an empirical researcher, some design researchers let themselves be seduced by the idea that a design is *exclusively* a new combination of existing assumptions (existing routine assumptions regarding situations, urban ensembles, buildings, constructional elements, building components, abstracted into types). In this sense, design is a form of applied combinatorics. The defenders of this position bypass the question how these assumptions themselves ever came about, or they implicitly assume that they need only indicate a historical co-incidence, like mutations in genetic evolution.

Yet, the number of new formations per year, or even per day, makes this pre-supposition improbable. In addition, one cannot learn to cook exclusively by using a summary of all recipes and ingredients ever devised (like Durand proposes for education of architects).[a] Choosing from this abundance also assumes this negation, from the perspective of one's own preferences (discretion), while creativity even pre-supposes, except for new combinations, a rather focused rejection of generally accepted pre-suppositions (operative or typological *criticism* according to Argan[b] or Tafuri[c], see page 103).[d]

44.11 CONCEPTUALISING WORK OR ITS RESULT

In order to clarify creativity, one must distinguish between the spatial assumption of the result, and the assumption of the action or series of actions that lead to it. This demands a diverse (pattern and process-orientated) conceptual capacity, probably because they use the various senses (sensory and locomotor) as basic assumption or reference. There was a good reason for construction management to separate from the architectural profession as a distinct discipline. With this discipline, one that is more orientated to temporal sequences, there is indeed still design, though it is a kind of design based on a series of generally recognised actions with interim results. There are various series of actions that can lead to the same result, and the same actions can, in another sequence or in different circumstances, lead to a different result. This lack of a direct causal relationship between series of actions and result is a problem in business management with regard to the empirical model.[e]

44.12 MAKING IMAGINATIONS

Despite this division on the process side of things, the architect (designer of the result) has to operate on another level of abstraction with a process (work): the management of consecutive design actions in order to arrive at a design. Let us call this 'design management'. Some designers, like Carel Weeber and Frank Lloyd Wright, claimed to see suddenly the final result before their eyes as a flash: architects with the 'magic touch'. Drawing is for them just routine elaboration of the conception. The design itself would then not be 'work', but rather inspiration without perspiration.

There are three reasons for doubt. One has to do with an internal process of theoretical transformative assumptions, or an experience that smacks of routine. Furthermore, many renowned designers, especially when working in a team-context or design competition, insightfully unfold their design process with interim results, which then form the basis for the subsequent design session. This is also advisable for beginning design students so that they obtain insight into their own strengths and weaknesses. Fundamentally, the 'future' of this process is largely unpredictable; there is always a case of beginning anew on the basis of what has been already achieved, or parting ways with what has already been achieved, and falling back on previous phases.

The crucial questions are always, "How do I begin to design? What do I accept from what already exists (including the previous design results) and what do I reject?" For designs that are more likely to be completed in phases, the dialogue with paper or screen, or construction of a model, is an accepted and sometimes crucial phase between taking inventory and analysing effects in the design process. In order to get a better grip on phases like the scientifically traceable process (without a preordained sequence), one should not presume *a*

a Durand, J.N.L. (1975) *Precis des lecons d'architecture (1819)*.
b Argan, G.C. (1965) *Sul concetto di tipologia architettonica*.
c Tafuri, M (1968) *Teorie e storia dell' architettura*. English translation: Tafuri, M. and G. Verrecchia (1980) *Theories and history of architecture*.
d See for a discussion of Tafuri and Argan, and for additional references Engel, H. (1999) *Hybride interventies*.
e Riemsdijk, M.J. van (1999) *Dilemma's in de bedrijfskundige wetenschap*.

priori that there is one "best" method per context (series of phases and their sequences) that one should adopt as routine for designing in other contexts.

44.13 MORE DESIGN METHODS THAN DESIGNERS

Perhaps the candid starting point would be that there are just as many design processes as there are designs. Methodology is then not the establishing of all of these design methods, but rather "understanding each other's methods". If there is anything that can be *generalised* about design, this is included, but here this involves *generating* designs and only afterwards analysing their effects empirically. This evaluation of the design consists of projecting familiar relationships onto the new context of the design, and there is always doubt regarding the validity and reliability of this (see page 92). An important part of design education consists of trying to find the most productive sequences of (nameable) design actions and routines for each individual student.

The disciplines of construction management and design have gone their separate ways so as to give the designer the opportunity to develop his own more fruitful dynamics, apart from the construction process and therefore presumably in the competition of the marketplace. The designer who meshes this process with that of the standard construction process is lucky, as no differences in phase appear between his creative process and the interim products that the construction process successively demands. This is the case, for example, with designers who begin with a grid that establishes the basic structural frame (and thus the position of the foundation piles as well), and who only later complete the process of adding the final details that do not need to be known until later in the construction process. Again, many good designers are inspired precisely by these details in order to use the principles of form and measure that result from them in a total design.

44.12 IDEA AND ENVIRONMENT

The pre-eminent example of order in nature, the crystal, grows on the basis of an exogenous contamination. The accidental form of this contamination extends in the growth of the crystal as dislocation in the roster, without which the free molecules would not be able to find any point of application to allow the crystal to grow. This is a warning for perfectionists. Without small heterogeneities in the air, no raindrops could condense from saturated vapour, and no snowflakes could find a starting point to grow uniformly in six directions. Some designers need to find at least one exogenous starting point, even if this seems of secondary importance, in order to base their integral work upon it.

The remaining context then leads to new dislocations. The starting point is often the specification (of which a schedule of requirements may form a part), or the topography or bordering of a site, but it could also be an artificial fascination, an impression from the past. The capriciousness of these starting points sometimes awakens the desire to find once again an autonomously continuing idea (for example a grid) from which the constructional elements derive their dimensions (as in an automatism), and upon which they can be based. The designers of sweeping, often sudden interventions find precisely therein their formal (morphological) starting point, which can then be projected onto the specification and the site. Yet a crystal is not a design; it is the result of a physical automatism.

Every homogenous design theme winds up on the borders of the given site; it runs off into fascinating interim variants, or forms remarkable contrasts with the adjoining plot. This dialectic between homogeneity (or autogeneity) and heterogeneity in the creative conceptual capacity brings us back to Piaget or Fichte. One can also see a relationship with the dualism between idealism (Plato) and realism/relativism (Aristotle), rationalism (Descartes) and empiricism (Hume), the Expressionism and Impressionism of the 19th century, psychological distinction between projection and identification, and methodological distinction between goal-orientated and means-orientated design.

45 EXPERIENCE, INTUITION AND CONCEPTION

ADRIAAN GEUZE
JOB VAN ELDIJK
LENNEKE VAN KAN

45.1 INTRODUCTION

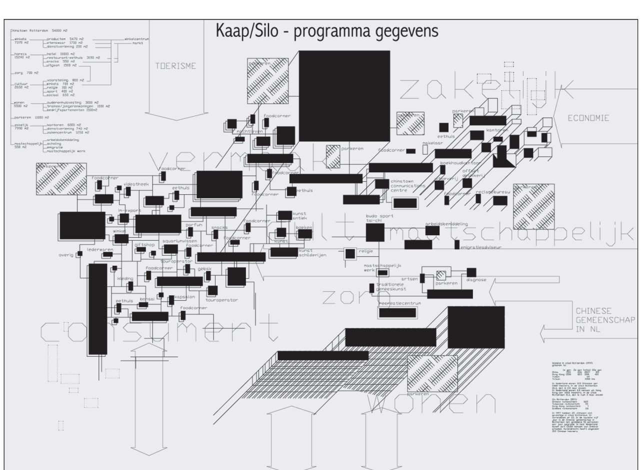
This is the report of a design process of a student of Adriaan Geuze. The report describes the design for the transformation of a grain silo in Katendrecht, Rotterdam, into a residential structure. Each illustration indicates an important step in the design process.

I am convinced that personal events, anecdotes, passion, urge for survival and fear of dying are contributing greatly to 'quality' and creative products. Callas, Cruyff, Otis Redding, but also Aldo, all have employed at a time methods (probably intuitively and unconsciously) to link together their youth, passion and talents. I have often experienced that it is possible to connect one's students to their own background, dreams and affinities and that through this a more intensive and authentic result is generated. Designing by your gut is also proven to be attainable by some people. Allergies and frustrations may well feed a design process. It is possible to put nightmares on a pedestal and next dance in triumph around it.

It is my experience that in Design Schools (like the one in Eindhoven) the intuitive and the subjective are considered the most important values; in Delft we term this unscientific, not fit for engineers. Yet we must learn to draw from these mysterious reservoirs, these pits of degeneration and suffering. It is important that this will yield nothing, if at the same time the systematics, the context, the programme of requirements and the feasibility are not taken into account. That should also be taught to our students. How to connect one's own difficult young age to the question put by a principal or school? Unfortunately, self-respect and insight into one's personal character and roots are obligatory; and I do not know how that would be done within a method.

I will explain my ideas concerning the design process on the basis of the graduation project of a student of mine, Marten de Jong, who made a design for the Elevator Building in southern Rotterdam. The design trajectory may be rendered in various characteristic stages. In my personal design process I am making these steps as well, although at a higher speed because of routine. It comes even to a point, that I go through the first and the last stages concurrently, since they are the most interesting ones.

45.2 DESIGN PROCESS

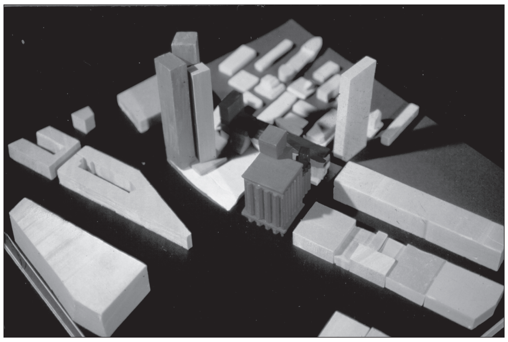


414 Stage I Analysis of the location

Analysis of the location and quantitative study of the programme of requirements are very important; that way ideas may emerge you would never have discovered just by yourself. In the present case it concerned the questions: What is going on in Rotterdam? What is happening with an area transforming from a nautical one into a residential one? The analysis intended to study how the Chinese community might be able to take residence here. The final product of this stage was a programme of requirements for that site.

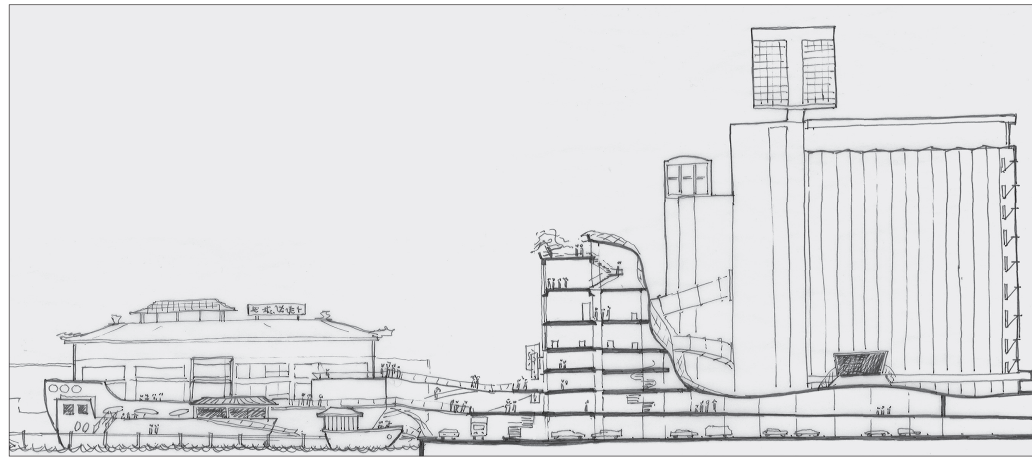
Of the location Marten de Jong said: *"I selected the building, not the* location. *However, such a factory is obviously located somewhere; that proved to be Katendrecht. At that moment, and, maybe, still now, a rather 'hot spot' in Rotterdam. In order to come to grips with the context of the task put to myself, an analysis of Katendrecht was indispensable. To get it really at my fingertips thorough analysis was needed; history, plans for the future, development plans, earlier initiatives, spatial effectiveness, fascinations in the environment, connections of Katendrecht with the rest of the city, traffic analysis, etc.. With such a variety of perspectives you do sense more quickly whether certain solutions are good or bad. A good solution is linking all these aspects, addresses them all; half a solution just does not work. 'What I wanted to do in the first place' is then also not working anymore, I just wanted to do something with the building, not with the area as a whole. And as soon as the location started to play a rôle, the first pre-occupations were already long off the table."*

The area of the grain silo: Katendrecht, used to be a China town, a red-light district, and was cleared in a city renovation project. With the data from the study Marten then interviewed members of the Chinese community.



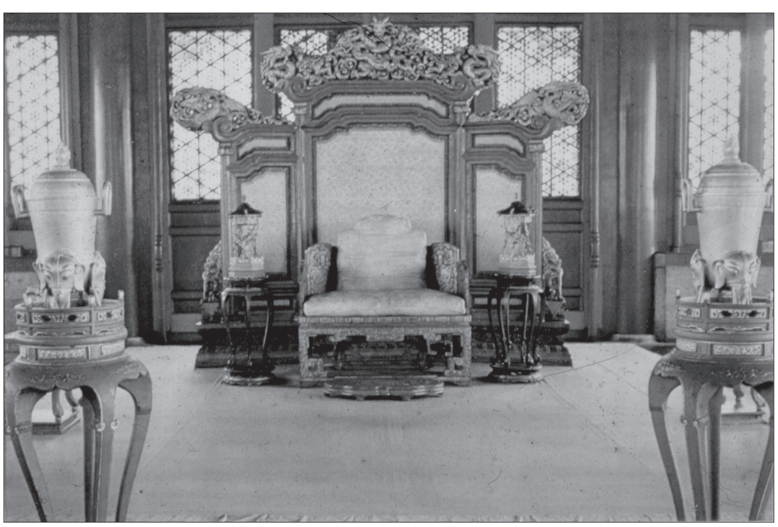
415 Stage II Making the findings spatial

During this stage the main thing is to make the programme of requirements spatial, piling up little building boxes, whilst keeping in mind the luggage of the programme of requirements just developed. Marten discovered that the programme could be realised in an existing elevator building. That complex could be stripped inside and voids could be filled in with the programme. This was the beginning of his study.



416 Stage III Specific questions

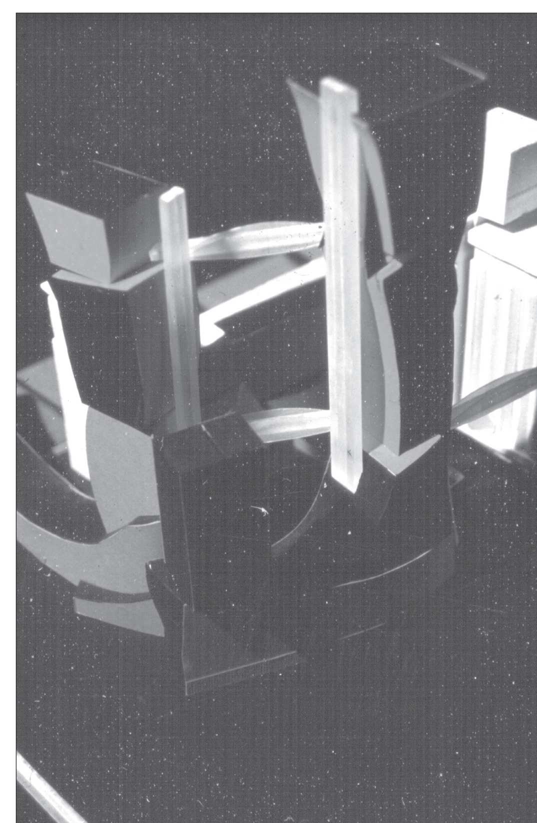
When this preliminary work was done, Marten could formulate the questions of the study. They were two: Can a post-war industrial monument serve a programme with a high social profile? And: What is the meaning of architecture for a cultural minority?
It is a highly interesting question, since it is involving a taboo in The Netherlands. What to do with minorities: do you build especially for them, or do you see to it that they adapt themselves?



417 Stage IV Study of material and construction

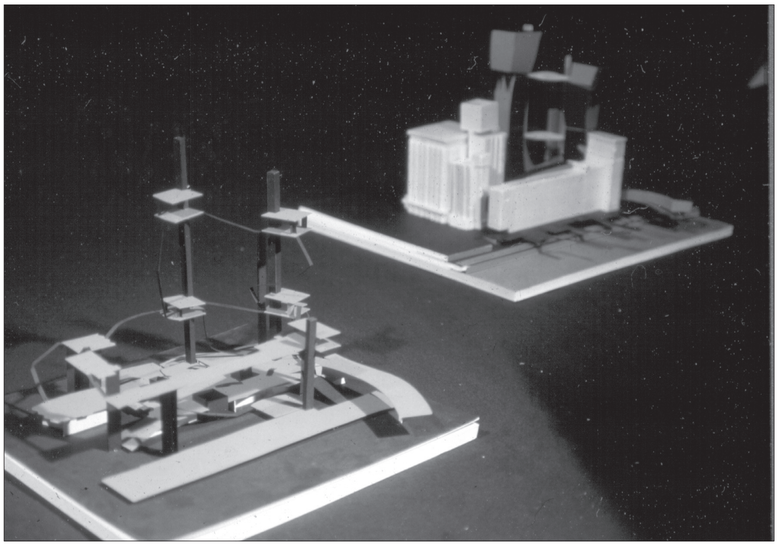
Next, a study was conducted – among other points – of the possibilities offered by the existing concrete construction. It was important to assess how many holes could be drilled in it.

I considered it to be of great importance that Marten would be steeping himself in Chinese architecture, that he would go to Peking so to speak and that he would read a great many books. The results of his study contributed greatly to his design. One of the most significant conclusions from the study of Chinese architecture proved to be that empty surfaces as we know in modern architecture are completely absent in the Chinese tradition of building. Other discoveries included, for instance, the significance of the circle, Feng Shui and detailing. In addition the massive use of colour was striking. These findings became guiding motives in the design.



418 Stage V Stuck

Just as in each graduation process, Marten got stuck at a certain moment in time. He knew everything, but could not go anywhere. He discovered that the adding of all conclusions does not lead to a sound design. It was not beautiful; is was too much; it did not fit. He had soaked up everything like a sponge and could neither advance nor retreat.



419 Stage VI Gaining depth

The first step towards a solution was halving the programme to be developed; opting for the most inspiring part; and, within it, what was the most promising. That meant coming out, completely subjectively, from his personal background and historical past. The part he selected was the Elevator Building.
For the design he needed more self-confidence, more trust in his own fantasy, getting rid of that Delftish stuff called reasoning. Then a grand formal language was unleashed, a quest for his own sources, for inspiration.
How to apply in such a business-like, 'Rotterdamned', stark and inhabitable building a warm and juicy layer? The answer resulted from the study of the location, from the interviews he had with members of the Chinese community and the study of Chinese architecture he had now to conduct one more time with the new insights in the back of his head.
In addition I asked him to study the work of Leonidov in order to find a link between the theatrical and the functional.

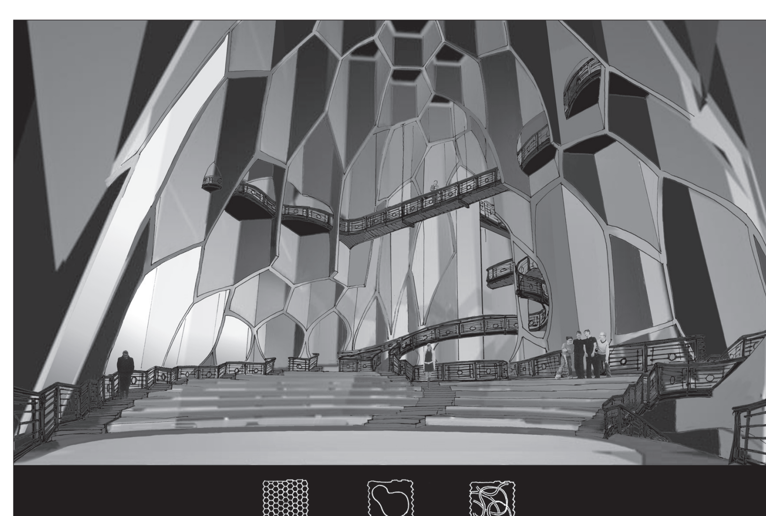
420 Stage VII Beyond being pleased by one's self

The final stage is all about testing in order to allow architecture to emerge. All vague hypotheses and conclusions are being built and tried out. Marten worked with models on two scale levels, 3D computer models and day-light studies of the weird façade that should make for a Chinese sky-line with three slender towers like fighting Chinese dragons on the building; in order to understand them he made experiments, scale 1: 1, of design, like railings and details.

During this stage the model is important, for sculpturing, in order to get the programme into one's hands. This stage is about synthesis, the integration of all aspects. You should look at the model on your knees; the architecture must become sensual and physical, getting dirty hands, enjoyment. You must really look, get the design out of the world of thought, making it more erotic, more beautiful with your imagination. In this, Marten was a champion.
This stage is important as a prevention of the snugness for which designers are often known. Students usually postpone this stage until the week before the presentation. However, in this stage the plan is ripening, the design is born, then it is becoming great fun. This stage is the true architectural act really. It is partying on many scale levels with very many media.

The final result had many layers, a construction in concrete, Chinese culture, an erotic layer.
Following that, you must go back again to the point of departure for a presentation of the first water and a very precise documentation of what you have found out and what the results are.
I recognise all this in my own work. The final stage is the nicest. You say good-bye to your pre-occupations. During this stage the project is born. It is a holistic utopia.

Each process is different, but stage VII is characterising my work. My lectures are also used often. A speaker, a performer should make a story an interesting one; that 'interesting' is the design incident, is what makes a design convincing. At Delft University this emotional side of designing has been obliterated completely. The analysis is coming later, but is also ingrained in my pragmatic nature as an engineer.



46 DESIGNING AN OFFICE

JAN BROUWER
JOB VAN ELDIJK
LENNEKE VAN KAN

46.1 INTRODUCTION

This is the report of a design process of Jan Brouwer. The report describes the design for the Water Board Rijnland in the city of Leiden. Each illustration indicates an important step in the design process.

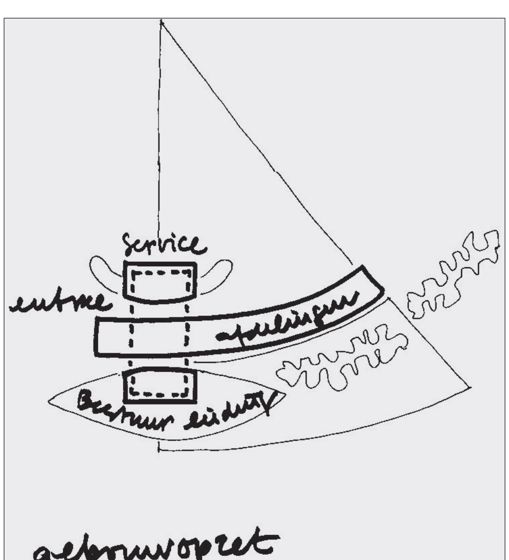
My design process starts with reading the programme of requirements. I am just making notes, no little sketches. Next, there's a half-day visit to the location. Then I determine at quite an early stage the smallest modular unit of the building, in this case the size of an office unit. This happens schematically; without knowing the context well. With this knowledge I make the first little sketch.

In the present case the programme proved to be simple. A clear tri-partition of the Water Board came to the fore: Directorate, Departments and Services. It entailed an office space accommodating 350 employees and further functions such as a large formal and representative conference space, an archive with maps, an office restaurant, a small laboratory for the restoration of historically important maps, a library, a printing shop and an office for mail.

Important points of departure for the design included:

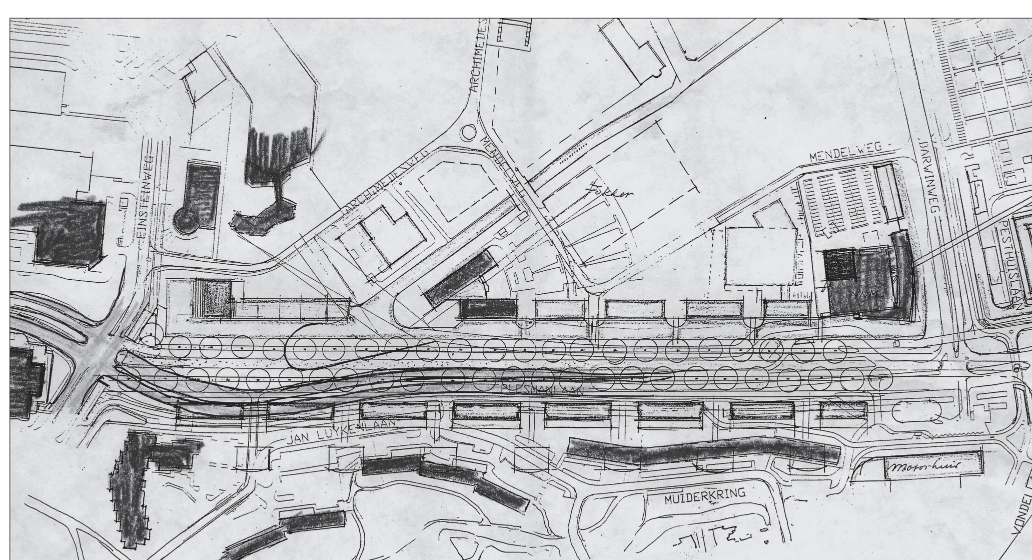
- Adjusting the design to the location
- The metaphor of the Gate to Leiden. The Water Board is an important governmental institute that should occupy an important place. The building lot is positioned on a characteristic spot on the main road into the city. Through this, the idea of a Gate emerged.
- Sustainability seen from material and method, looking for different sources of energy than the usual ones.
- A climate façade.

46.2 DESIGN PROCESS



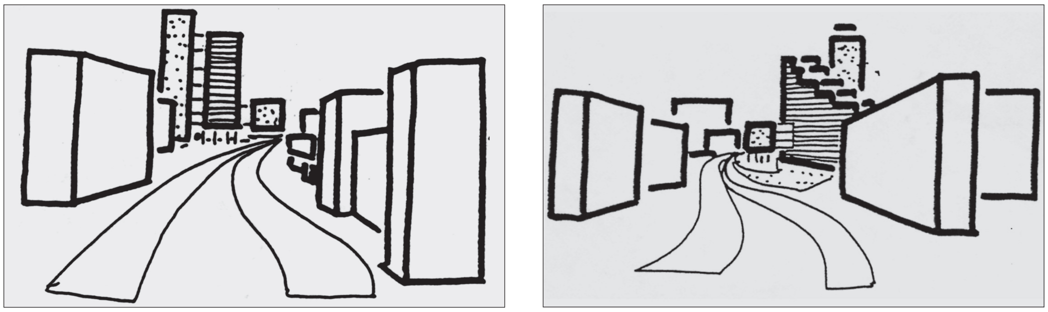
421 Concept

This drawing shows the first idea occurring to me after reading the programme of requirements. The building is partitioned into three parts: the Directorate along the road, the office rooms in the middle and services in the third part.



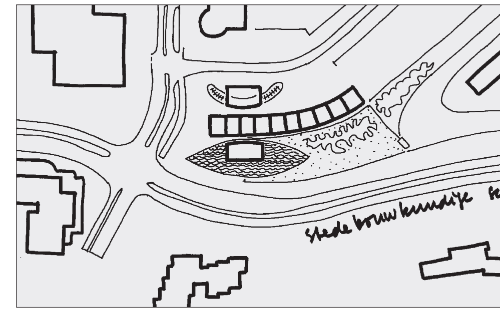
422 Avenue

The Urban Office of the city of Leiden wanted to straighten a curved road into a straight avenue. I proposed a different urban plan preserving the curve.



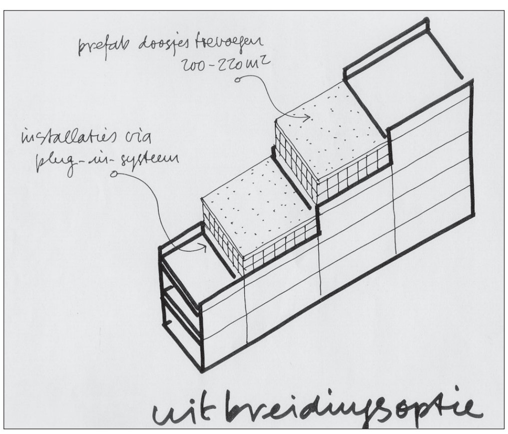
423 Curved Avenue

The illustrations show the motor-road to the new building from two sides. The curve is creating a certain tension. Loss of the curve would entail in my opinion an impoverishment. And what is more: by making a straight avenue there would not be sufficient space left for the building itself on the lot. (Zoning constrictions as to height also applied.)



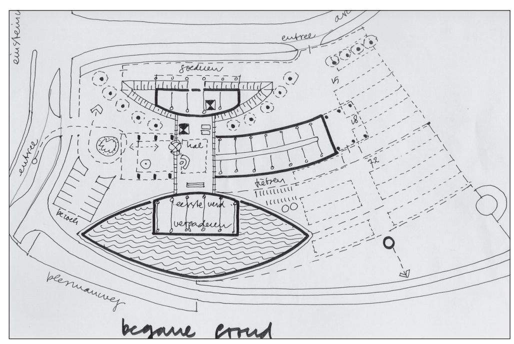
424 Form

The form of the building is studied with the help of an analysis of the context in terms of urban architecture. Ideas emerging due to the analysis of the location: first, the building can be experienced as a gate to Leiden; second, the building should follow the curve of the road.



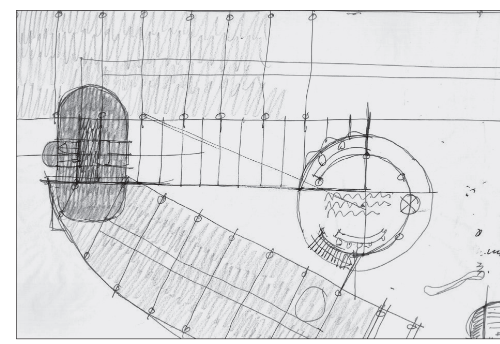
425 Option for extension

One of the requirements put to the building prescribed that extending it would be a possibility. By applying a form in steps parts may be added to the building without causing a significant visual change.

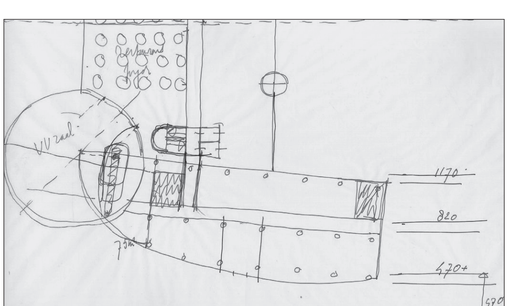


426 Structural lay-out

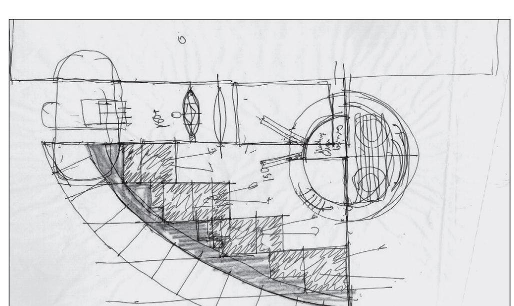
At an early stage the alignment and size of the structural layout were already determined. For the direction the east – west parallel to the road was chosen and the size was derived from the sizing of a 'standard' office module.



427 Study: office wings curved, circular conference room, central staircase.

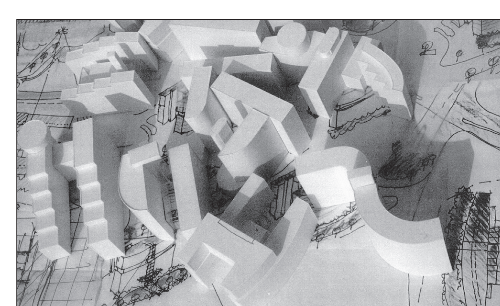


428 Same study; but staircase and CC room (Combined Conference, the 'parliament' of the Water Board) shifted.



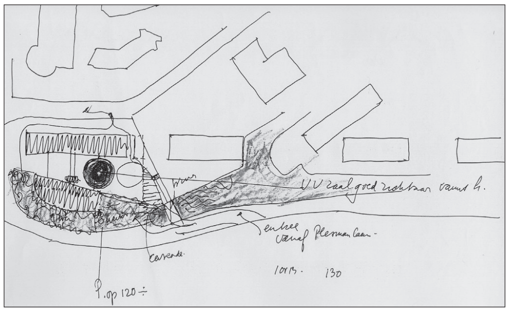
429 Study office wing south.

It became clear in each study sketch that the walks within the building would end up being too long. That necessitated a change of concept: from the tri-partition of the building to a separation in two for the offices. This would also fit well in the structure of the institute, since there are two large departments, one for financial and administrative affairs and a technical department. These three sketches (figure 374-376) are representing the study of the form of both parts of the building and of their positioning *vis-à-vis* one another.



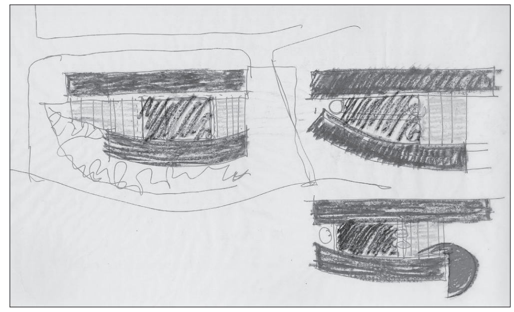
430 Several test models

The forms of the two parts were tested with the help of models. It was studied in which way this idea could be placed on the location. The two parts were called pencil and banana.
Bi-secting the organisation proved not to co-incide with the wishes of the departments, there was a wish to be able to extend if need be. Between banana and pencil, bridges proved to be needed.



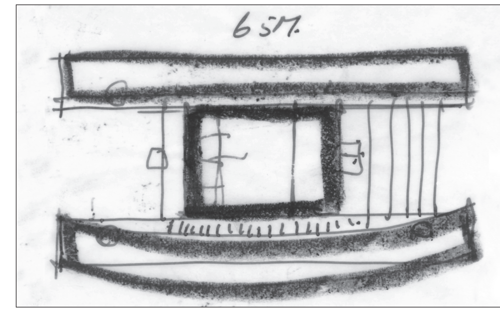
431 Edges sharpened

Important lines-of-view are sharpened. The idea of the gate function is further developed and the positioning in the water became an important point of departure.

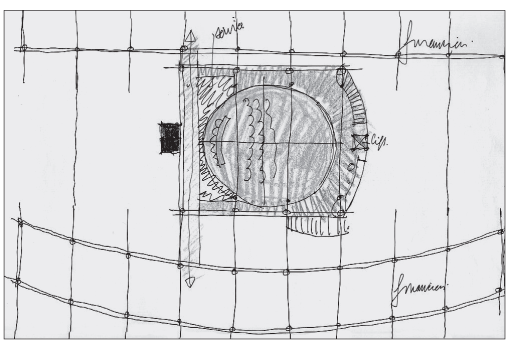


432 Cutting the banana

The form of the banana and the pencil still were changed. Since I considered the gate function to be very important, I did not change that anymore.

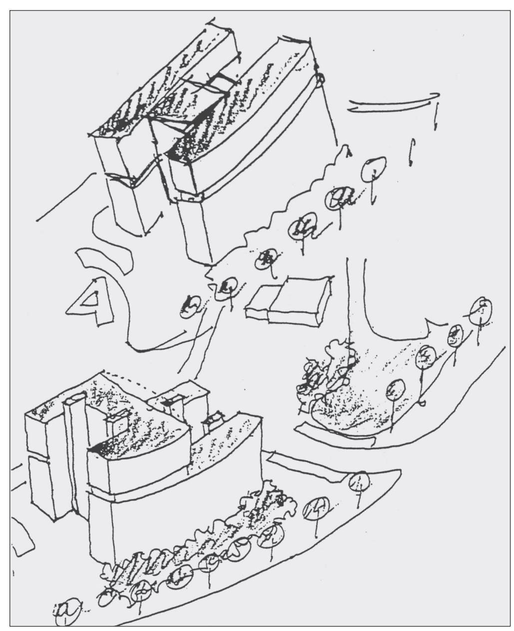


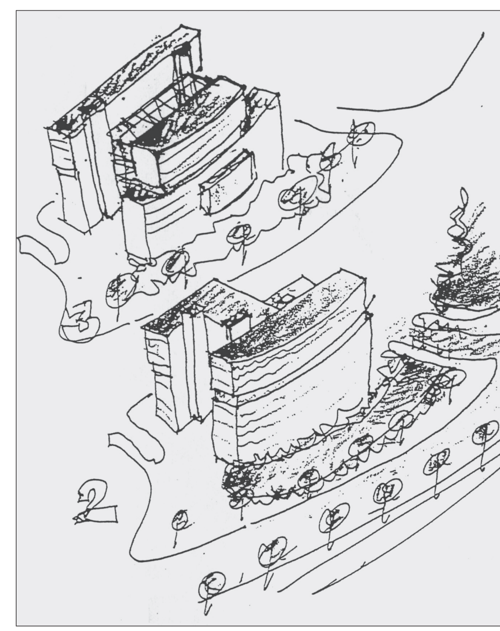
433 Orientation banana – pencil in parallel

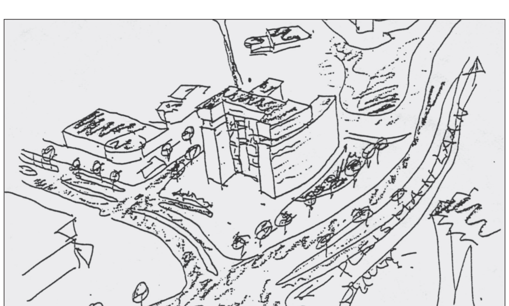


434 Determining module size carrying construction offices

The sizing of the module was already fixed in the beginning. I fixed the size of the room module on 1.80 m. The façade articulation would get the same size and the structural module size would become 7.20 m. (4 x 1.80)

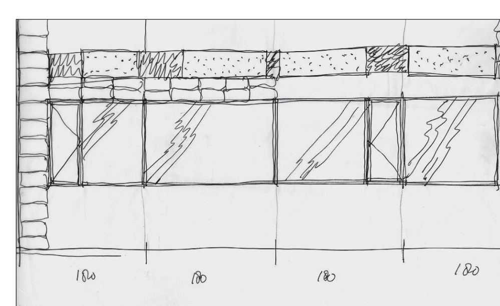






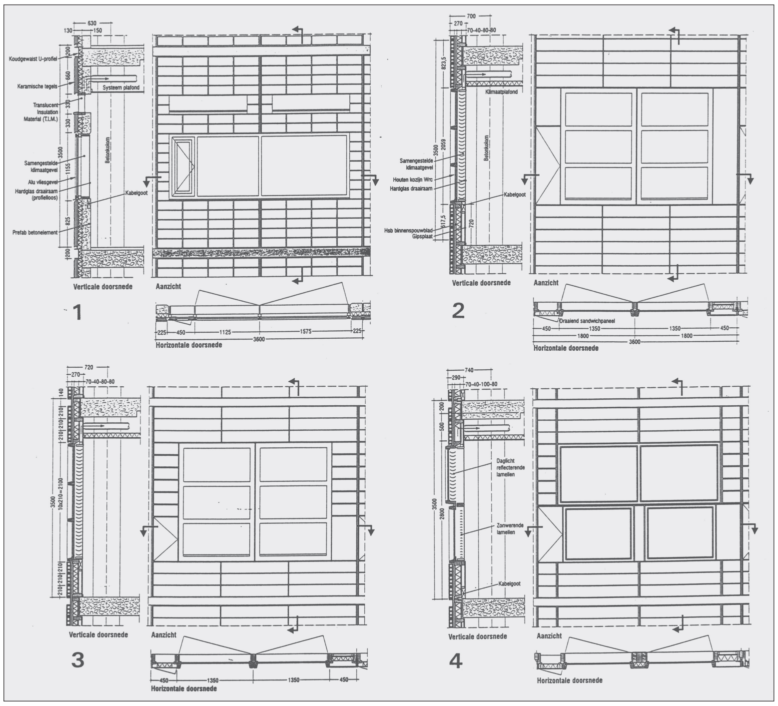
435 Connecting banana & pencil

These are sketches of several solutions for connecting the banana and the pencil, while retaining the idea of a gate function to Leiden.



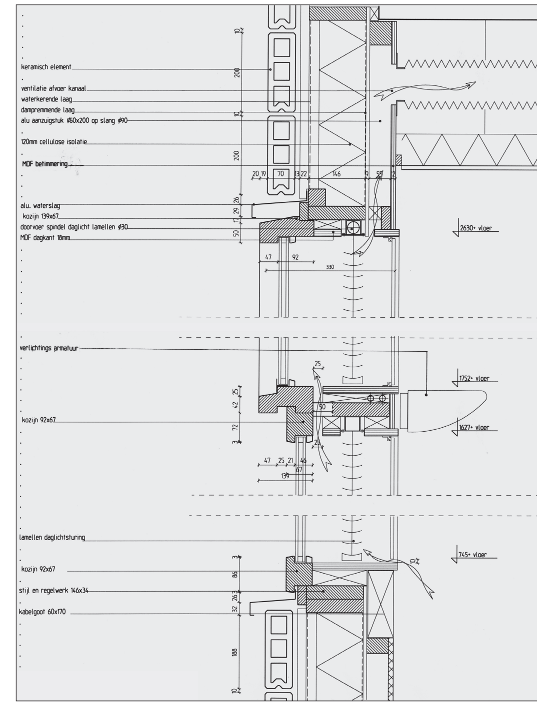
436 Design of the façade

The design of the façade is a story in its own right. Optimising the quantity of daylight into the office spaces was an important point of departure. That is the source of the idea of a lighting-window and a viewing-window. The lighting-window is a separate, high window seeing to it that extra light is penetrating deeply into the office room. This economises on the energy bill for artificial lighting.

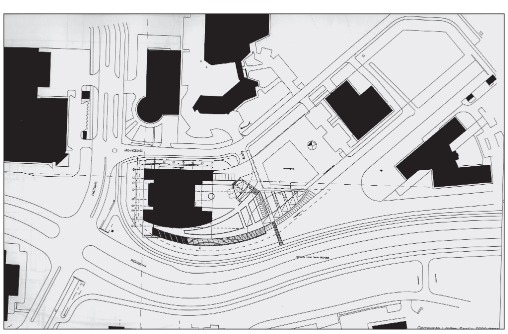


437 Façade development

Usage of reflecting strips for optimising daylight



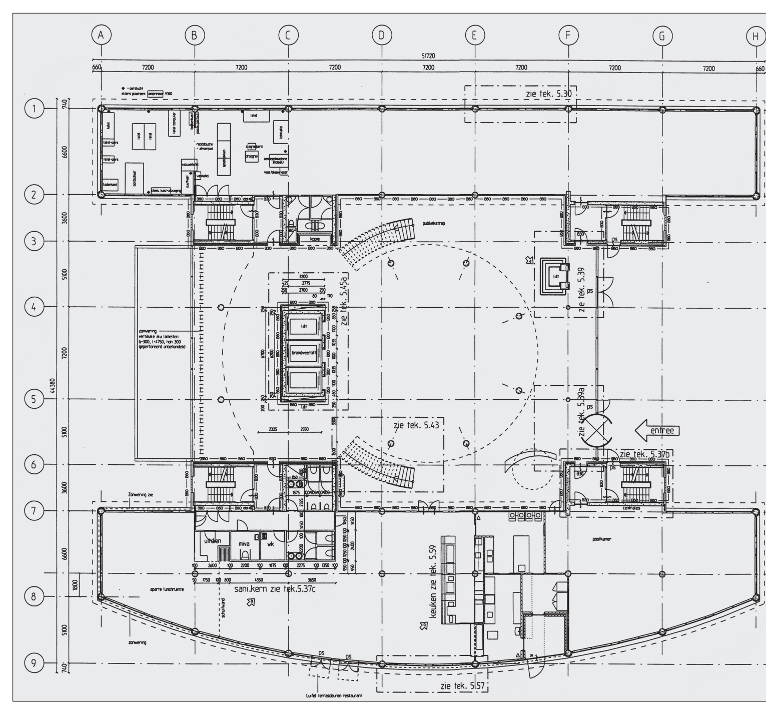
438 Detailing of the climate façade

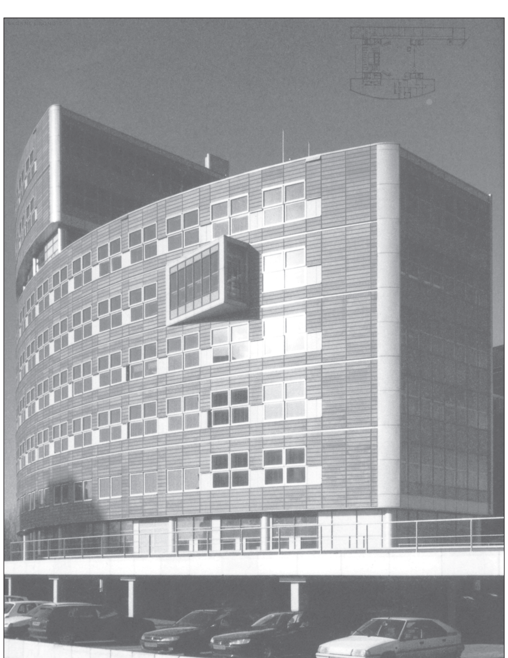


439 *Adjustment*

Urban adjustment of the building.

440 *Floor plan, final design*

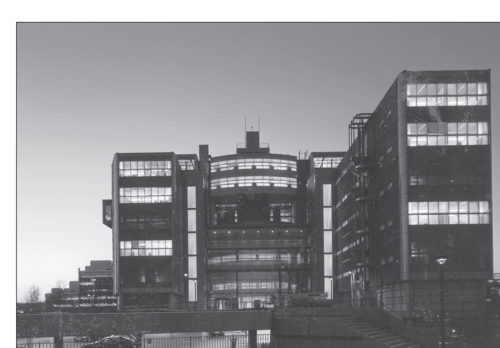




441 *Boring*

To the taste of the 'Dijkgraaf', chief executive of the Water Board, the façade was too boring. With some regret I added a small, protruding box to the façade. In utilising the building this exception has been negated.

442 Final result: the eastern wing after sunset



46.3 LOOKING BACK

Acquisition of the commission

The project was a European contract. Some 30 – 35 architects competed. The demands were quite high. Ten architects qualified themselves. Five of them were excluded by balloting, while the remaining five had to describe of one sheet A3 how they would proceed and what their wages would be. Our sheet A3 doubted the need for a new building rather than presenting a new design. That must have drawn attention.

Vital constraint

Crucial was my personal sustainability doctrine, thus making this commission interesting.

Golden moment

Never. Designing is a perennial battle. However there were some decisive ideas; such as the strengthening of the tri-partition of the organisation and the banana-pencil concept.

Dead ends

There were many dead ends, on all parts, like in the façades and the positioning of the stairs. It is important to find the right trail. Sometimes you have to take a few steps back in order to get along later.

Additional requirements for the building

An additional requirement stemmed from myself. It was the choice of as many pre-fabricated components as possible, given their sustainability.

How long is the design indeterminate?

Already during the preliminary design I draw 1 : 5 principal details. There is very little that I leave indeterminate. From the very beginning I have the feeling that things must be produced in a proper way.

Working method

I do not work methodologically, I am sorry to say; for there are many good things to be said for Architectural Design Management.

Impact of budget

In this project the budget was not very influential. It became clear during contracting that a million guilders had to be saved. Following that, some elements had to be left out; like a pergola and sun-shades and less sophisticated types of material were used.

Meeting with the constructor

The builder was not used to the unconventional techniques we proposed, like inter-leaving concrete floors rather than laying an additional covering floor, using granulated concrete and isolation with cellulose. He was persuaded by studies and examples.

Great transformation

A great transformation during the design process was the separation of the offices into two wings. For this there were arguments in terms of the urban context as well as the fact the physical relations in the building would become too long.

47 DESIGNING A VILLAGE

JAN HEELING
JOB VAN ELDIJK
LENNEKE VAN KAN

47.1 INTRODUCTION

This is a report of a design process of Jan Heeling for the extension of the Frisian village Wolvega. Each illustration indicates a step in the design process.

The first two illustrations are maps of the area. From the third up to and including the fifteenth drawing we are reporting a brain-storm session with some five colleagues in one day. They were made with greasy chalk on sketching paper on a roll. Each time they were super-imposed on the maps of figure 443 and 444. Each part of the area was studied separately; eventually the parts were joined together. Next, the whole could be further processed.

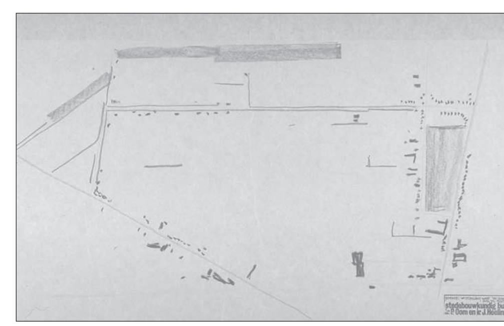
47.2DESIGN PROCESS

443 Map analysis

I commenced with an analysis of the map, not with a visit to the location. The map can yield a wealth of information.
Wolvega is built on a ridge of sand; it is bordered by a railway and a road to the city of Leeuwarden. The village may be partioned roughly into squares. A square consisted in pasture on which something could be built. This is the part at the other side of the railway. Some 900 homes were being planned.

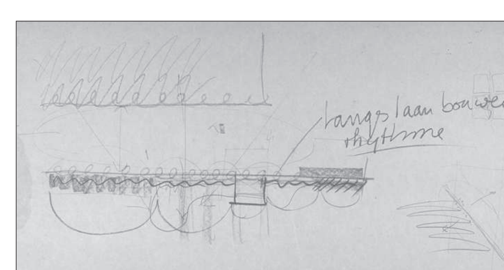
444 Built and unbuilt

Study of the built typologies. In black and white it is indicated what is built and what is not. On this map it may be seen from which period in history a building is resulting.



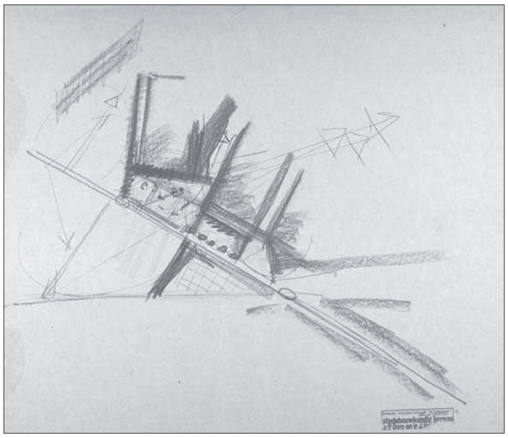
445 Essence

Exploration sketch of the edges and the main lines. In this sketch I attempted to clarify the essence of the area. The inner area is empty. Starting from the area there is no reason to start with a particular form. I have to invent ordering concepts myself to give form to the design. Designing has always ordering and forming at its core.



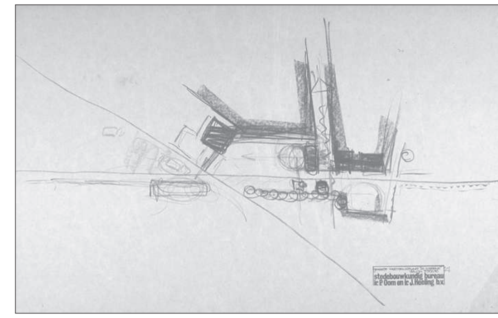
446 Eastern border

The eastern border has been drawn here. I did not want to consider this a closed afterside of the neighbourhood, but a transparent layer that may be crossed, a rhythm of open and closed.



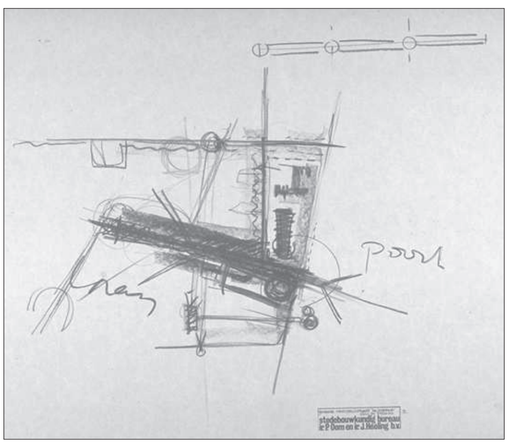
447 Northern border

The northern border is the road to Leeuwarden. In it, I wanted to introduce an articulation with vistas through the built environment, departing from existing opportunities (farmhouses, etc.). In my opinion it is important that it is possible to estimate depth, while making one's entrance into a neighbourhood. In order to connect pasture and meadows to the old centre I want to work with increasing density coming closer to it. It is, really, a new entrance to Wolvega.
The western border is the railway. The noise requirements saw to it that a large area should remain empty; tennis fields provided a solution.



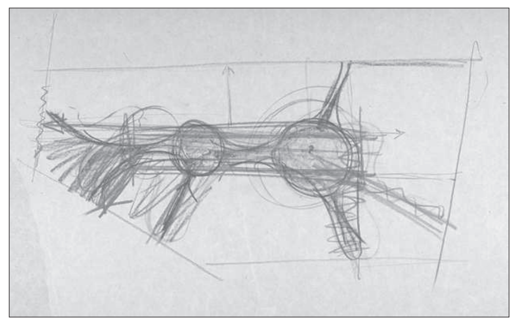
448 Western border

On the southern border there was an area with a factory. In addition, on this side is the main entrance to the surroundings as seen from the village and vice-versa. I wanted to emphasise this by a gate and a lane, leading deep into the new segment of the village.



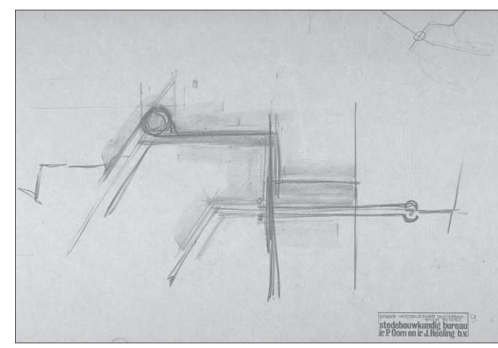
449 Southern border

At this side I planned the entrance to the area. There could come a gate and a long road leading deep into it.



450 Inner area

The edges have now been determined. Next in turn is the inner area. Given the shortage of factors leading to forms, I started to work from the outside to the inside. There is space for two public squares in the area that might give structure to the connections in the inner area. Up to now, these are all imaginings. I do not deal with political or social considerations in my design; my designs are lacking an ideological bias.

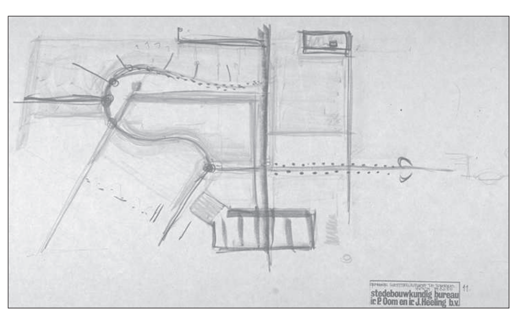


451 Combining

In this drawing, separate ideas are connected to one another for the first time.

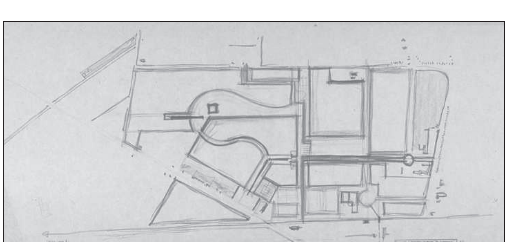
452 Curved form

In the inner area a curved form has been employed.



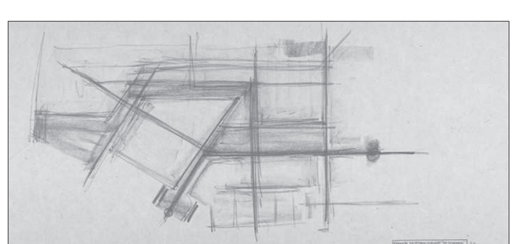
453 Bits and pieces

This drawing represents a study of the inter-dependence between the various design ideas. We came to the conclusion that it was largely an affair of bits and pieces. There was no unity, no sense of conviction. The feeling of the compositions was just no good; so we had to start one more time.



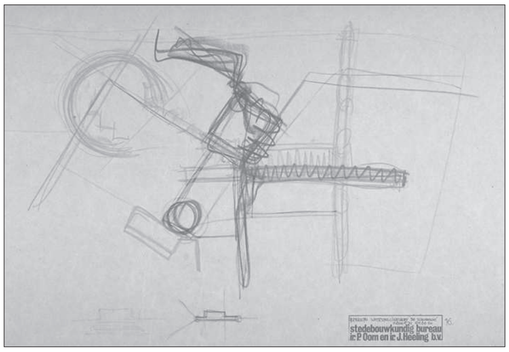
454 Development

The development of the bad idea. This drawing demonstrates the cleavage in the area.



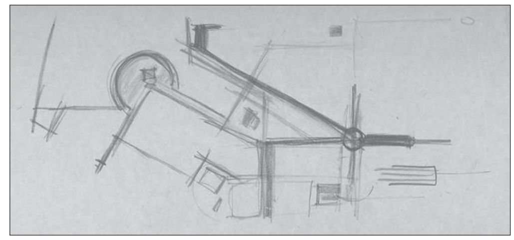
455 Wedge

We tried various strategies out in order to solve the problem of the angular twist present in the orthogonal system of the area causing the lack of coherence: a search for formal coherence. In this drawing the form of a wedge was used for solving the problem of the angular twist. Now the composition felt alright, but a triangle in the centre is just falling unluckily.



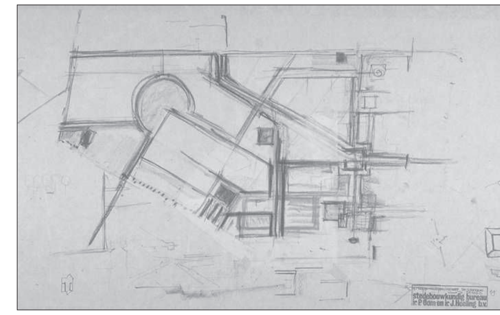
456 Circle

The situation became desperate. A circle drawn at random proved to be the final solution. Clearly, this is not a concept on an ideological basis, only employed because of formal aspects. A different form could have emerged just as well.



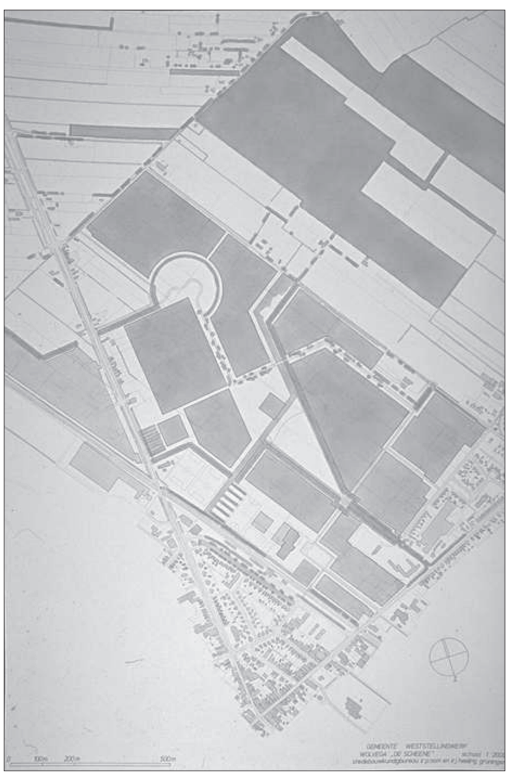
457 Beak

Now a form has emerged resembling a beak opening itself.



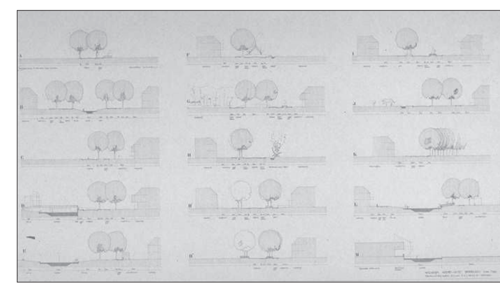
458 Development

The solution developed.



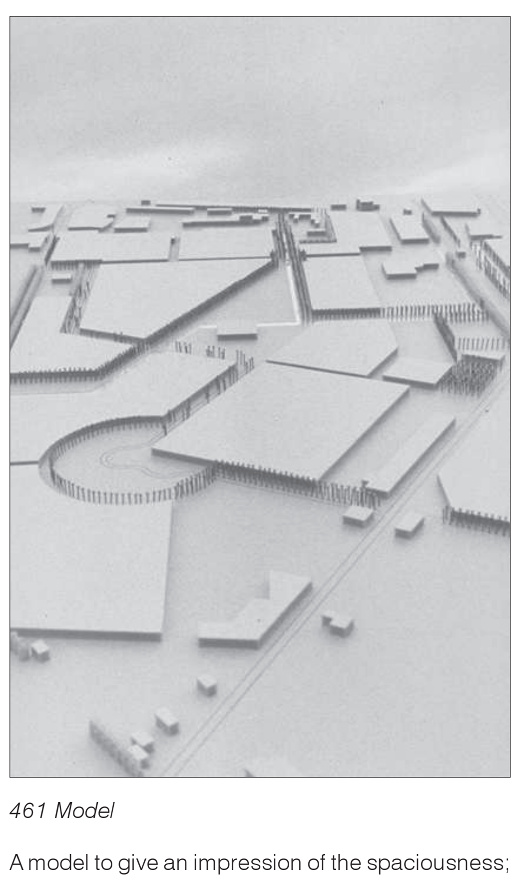
459 Check your watches

The next day we 'checked our watches' for the idea. This was also suggested by the guidelines of the municipality. This is the blueprint.



460 Context

Within the context. For each space we studied the cross-section.



461 Model

A model to give an impression of the spaciousness; this model was presented as well.

462 Adjustment

Adjustment to the existing situation, in order to study the effect.

47.3 LOOKING BACK

How did you get the commission?

A partner in my Office, Mr. Oom, advised the municipality of Wolvega.

What did you do first?

I started with an analysis of the map. I made the conscious decision not to visit the location. I have noticed that those who do are just using some 10% of the material assembled. Except for thinking this to be rather inefficient, I do believe that you look during such a first visit with tourist eyes and that you do not see what is relevant.

What was a decisive constraint?

Requirements were few; the location and the number of homes, 900, were the only ones. The rest you had to find out by yourself.

Did a requirement exist that had nothing to do with the concept?

The concept was not so rigid that new elements encountered generated disturbance.

What was the golden moment?

Finding the circle.

What was a dead end?

The stage before the circle, when unity was lacking in the plan.

What was the rôle the budget played?

A small rôle. On the basis of the bye-laws we made an estimate; it influenced the design but a little. When I was making this design the relation between the designer and the commissioner was different than it is now. One gets acquainted.

For how long continued the stage of indeterminacy?

For a very long time; that has been the nature of the profession. In my designs my determining extends to the lines of private and public properties, central lines of the infrastructure and remaining structuring of public space. The remainder is staying open.

Are you working methodologically?

Yes.

What materials are you using while designing?

In the beginning with chalk and sketching paper, later the computer.

48 URBAN DESIGN METHODS

JOHN WESTRIK

The subject of this Chapter is the development of urban design following design methods: design methods specifically addressing the design problems manifesting themselves in a design in urban architecture. Before focusing on the methods themselves some consideration is devoted to what a design in urban architecture is and what the elements are of a design in urban architecture.

A design in urbanism is understood to be a spatial proposal comprising a number of usually multi-functional projects and a system of public spaces for an urban area, like the inner city or its important parts, areas of re-structuring – harbours, railway emplacements, industrial areas – entire residential neighbourhoods and industrial locations. Making large buildings fit their environment or articulating the site for residential complexes is part of a design in urban architecture.[a]

48.1 URBAN DESIGN

Urbanism is more than just designing (the making of plans for building in cities). Planning and technology play a significant rôle as well. In the book *'Stedebouwkundige Ontwerpmethoden'*[b] urbanism is divided into three segments with different methods for each of them. The first addresses the functional-technical segment. Rittel and Webber[c] call it 'tame-problems': that is to say problems with clear explanations and viable solutions. 'Functional' relates then to the spatial consequences of the programme (destination, density, mutual relations of the destinations, etc.), while 'technical' relates to the potential for execution (site preparation, roads, sewage, bridges, etc.).

The second segment has to do with the making of plans (the process) and addresses decision making, participation and feasibility (practicability). In that case evaluation of the plan on financial, social, legal and environmental technical feasibility is addressed. Rittel and Webber call it 'wicked-problems': that is to say socio-political problems, lacking generally consensus in a pluralistic society. This consensus should still be attained for each plan.

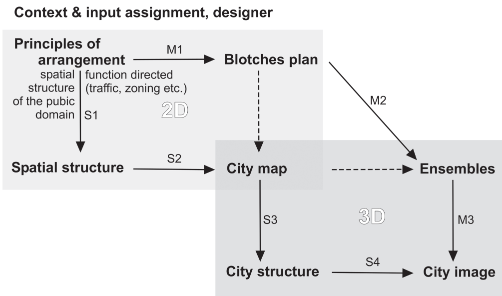
The third segment relates to the content of an urban architectural plan and the way in which its content comes into being (designing / ordering). The methods available for this third segment are the subject of this Chapter; those for the remaining two will not be discussed here.[d]

48.2 DESIGN IN URBAN ARCHITECTURE

According to Heeling[e] designing = planning + establishing form. However, ordering is also viable without establishing form. In that case functional ordering, plans for spatial ordering, is the topic. With a functional planning the way in which the programme is allocated to the location stands central. Planning insolubly linked to establishing form, that is designing, leads to a formal ordering: a design (in urbanism). As mentioned, the content stands central here; that is to say, what are the components discerned, and how are these components assembled into a spatial composition? 'Components' are understood here to be the means of design in urban architecture, like site articulations, the closed building block, building in lengths. Not only the means of design chosen are important in a design, but also the way in which these means have been put together. Generally a (form) concept is used to get to such a formal ordering.

A form concept is understood to be a consistent package of design ideas containing the main structure of a design. The form concept used is influenced to an important degree by the specific properties of the situation; as well as the way in which the programme requested is spatially translated in the various means of design and the inter-connections resulting from this (functional ordering). Next to the means of design employed, the form concept

a Boer, N.A. de (1984) *Architectuur -Stedenbouw, over tweespalt in een vakgebied*.
b Westrik, J.A. and H. Büchi (1989) *Stedebouwkundige ontwerpmethoden*.
c Rittel, H. and M. Webber (1971) *Dillema's in a general theory of planning*.
d Westrik, J.A. and H. Büchi (1989) p. 41-50.
e Heeling, J. (2001) *Een zoektocht naar de grondslagen van de Stedebouwkunde*.



463 According to the M-line (M1-M2-M3) the map of the city needs no designing, but comes into being as resulting.

S1 = dimensioning and establishing the form of the network in the two-dimensional plane

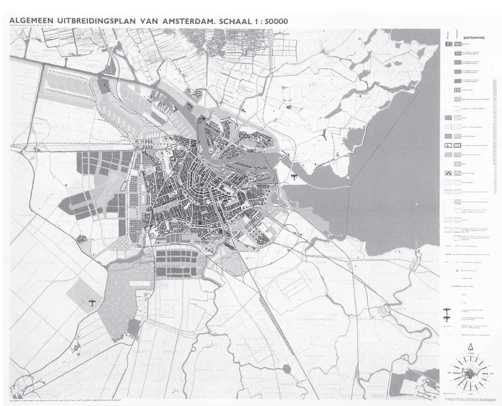
S2 = organising the location (programme of the network and programme of the building commission)

S3 = design of the public space + formulation of rules for building

S4 = the use within the urban structure determines the urban image

M1 = urban functions allocation on basis of the programme (for network and building commission)

M3 = the use within ensembles determines the urban image



464 AUP: General Expansion Plan Amsterdam; Map A, survey of all types of usage

and the spatial translation of the programme the way in which the individual properties of the situation have been assimilated in the design in urban architecture is important.

Finally, it should be noted that the content of a design in urban architecture is often built in several design levels, where each level meets its specific design problems. They must be solved with different kinds of means of design. Fitting together the various levels of design to one design is an essence of design in urbanism. Ultimately, if a design in urbanism is involved, a designed urban image emerges. This Chapter addresses the specific rôle of urbanism and the design methods employed. The design products requested may shape this rôle. Three possibilities, where the urban architectural plan is employed in three different ways, leading to an urban image are discussed here.

48.3 FUNCTIONAL PLANNING

The urban image can be designed by a functional planning (‘blotches’ plan) made by the urbanist, followed by specific designs for blotches in various architectonic ensembles. The map of the city is not designed, but results as it were (in figure 463 the M-line). This procedure is characteristic for the urbanism of the functionalists. A memorable example of this urban architecture is the AUP. of Amsterdam by van Eesteren.

In The Netherlands legislation for spatial ordering – WRO – pre-supposes this way of thinking with for planning instruments the global plan of destination (‘blotches’ plan), structure plan and regional plan Expressing the programme in terms of destinations plays a main rôle and generally results in separate spatial units based on the programme to be realised.

48.3 STRUCTURAL DESIGN

The second possibility, structural design, recently put into words by Heeling, distinguishes for the urban design four themes, to wit:

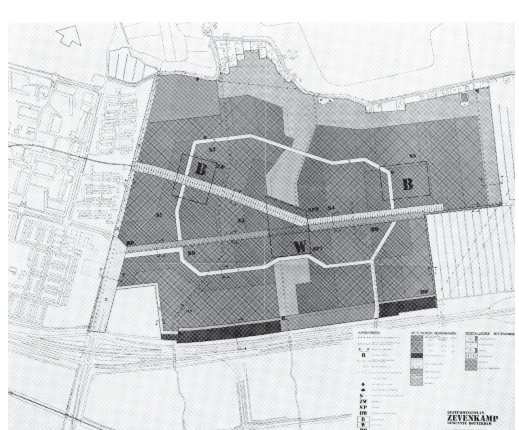
- the spatial functional organisation of the city;
- the design of the urban ground plan;
- the design and filling-in of public space;
- the rules for building.

This possibility acknowledges the autonomous position of the designer in urban architecture and provides to him/ her an conditioning position in the origination of the urban image, particularly by introducing the design of the map of the city as an independent design product. The spatial functional organisation (programme utilisation) is implicitly assimilated in the design of the groundplan of the city.

The design and filling-in of public space is the next step of the design of the ground plan of the city. It is the subsequent working-out of the system of public spaces establishing the network of the groundplan of the city.

465 ‘Blotches’ plan

466 Grachtengordel Amsterdam, de Amstel[a]

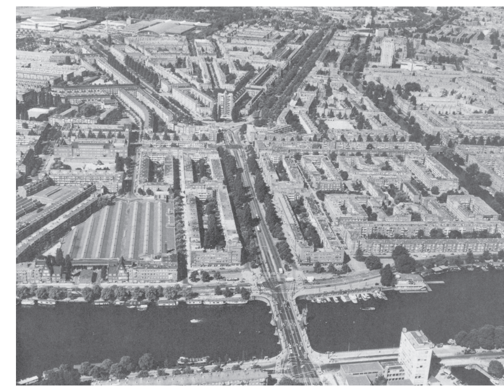


a Duncan, F., L. Glass et al. (1993) *Amsterdam: the comprehensive street-by-street guide with bird’s-eye-view mapping.*

The rules for constructing and building are the conditions put to the buildings to be designed by the groundplan of the city; the architectonic tasks. The girdle of the Amsterdam canals provides a historical example of this way of thinking. A recent example is the urban design for the Java island in the Eastern harbour area in Amsterdam. This way of thinking pre-supposes an open system in which the boundaries of the task are generated by the situation, or lacking in the whole.

48.5 THE DESIGN OF THE URBAN IMAGE.

At the third possibility the urban image is designed directly in its entirety. The design is a mix of city building and architecture (architecture of the city). Generally the architect takes the part of urban design into account. The building designed (the architectonic unity) is also the urban unity. Berlage's 'Plan-Zuid' for Amsterdam is a historical example of this case.
Recent examples include the designs by Coenen for the 'Céramique' site, Maastricht, and by Bhalotra for the 'Kattenbroek' neighbourhood in Amersfoort. Also in these cases the design has been designed as a separate unity, its image included.


467 Aerial photograph of 'Plan-Zuid', eastern part, Amsterdam

As befits this age, combinations of these three possibilities manifest themselves, termed 'hybrid' in contemporary parlance.[a] The urban architectural plan for Borneo-Sporenburg, in which the urban building blocks have been designed directly as an image and the 'strips' for urban units of the urban groundplan is an example; another is the urban design Ypenburg, in which on one side a design for the ground plan of the city (the frame-work) is made for the entire area and on the other side for each field a separate further detailing.

The question emerges on what grounds this kind of motifs among the three possibilities is used. In this Chapter it suffices to state that the task as commissioned, as well as the design concept of the designer, might provide a motif for selecting one out of three possibilities.

48.6 THE URBAN TASK

The commissioner not only formulates the commission, but also determines who is going to make the plan. The commission generally comprises: a programme, boundaries to the plan, and limits to the plan, as well as the design product to be expected. This means that the commissioner for whatever reason (flexibility, size of the planning area, real estate property, staging in time) influences implicitly which possibility – out of three – will be applied. The size of the planning area plays an important rôle in this, as well as the dominance of the next higher level of scale: what elements are almost pre-supposed, such as matching main thoroughfares, ecological main structure, etc. The various levels of scale as they have been integrated into an integral design commission – for instance the 'Zuid-as' in Amsterdam – also imports. All these factors influence the design product to be delivered. Finally it may be the designer himself/ herself who applies one of the possibilities.

48.7 FUNCTION OF THE URBAN DESIGN

In the previous paragraph it was explained that the commissioner has great influence on the design process. In this it is of eminent importance for which purpose the design is made. A design in urbanism is mainly used in favour of a plan of spatial planning, in the case of the Netherlands based spatial planning regulation (destination plan and structure plan).


468 IJburg

Under such conditions urbanism finds itself caught between two poles: the one determined by planning, procedures, decision making and processes to be governed; the other by a discipline of designing still akin to architecture.[b] Van der Voort thinks that the practice of contemporary building of cities in his country is increasingly making use of types of planning, regardless of Legislation and the Decision as to spatial planning: urban plans, master plans, like, for instance, the plan for the 'Kop van Zuid', Rotterdam, or the one for IJburg, Amsterdam.[c]

a Meyer, H. (2000) *'Hybridisatie' van stedelijke gebieden*.
b Vink, H. (1980) *Geen stedenbouw zonder architectuur*.
c Voort, R.Th. van der (1988) *Stedenbouw in de jaren '80, ruimtelijke kwaliteit onderzocht*.

This kind of 'planning figures' is required in order to distinguish neatly from one another, as they are, spatial qualities like elements determining structure; such as articulations of surfaces, types of buildings, rise of them, as well as the system of public spaces linked to situative, programmatic, (civil)technical and financial boundary conditions. Urban design has become, in cases like these, an autonomous product, used in order to influence public opinion and mobilise financial resources. Next to a planning function, the design of urbanism has come to embody a communicative function. Meyer and Reyndorp[a] remark, that this type of design does not result, in the strict sense of the word, in urban plans; and certainly not in those with the legislative nature associated with them until recently: more likely than not ideas, speaking to the imagination, creating the possibilities for an era dedicated to a 'New Urbanity'. Also, the frequently occurring pluriform urban architectural commissions[b] envisage to draw attention to certain urban areas and to indicate which future developments are possible through spatial proposals and which contribution to the urban image as a whole is provided. It results in a situation in which the urban design is severed from spatial planning.

This severing serves to give the design next to its communicative function a studying function as well.[c] This study focuses on the consequences of the design decisions taken. They determine the content of a design in urbanism. They include in any case the means of design previously mentioned, like the elements determining structure, site articulations and the system of public spaces, but also study by design, interested in the consistency of the design, the (form) concept employed and the characteristics of the situation itself, as well as the position of the situation in the urban area surrounding it. This study by design is a type of study that differs greatly from the study performed in the 'plan' function of a design (design study); under those circumstances the study of programmatic and technical possibilities and financial and political feasibility gets more emphasis. In addition this study by design may be focused on the designing process and the design methods possibly employed.

48.8 DESIGN METHODS

This paragraph deals with methods determining the content of a design in urbanism, or influencing it. Büchi and Westrik describe nine design methods and a number of aspects determining content, to wit: the spatial translation and ordering of the programme (functional planning); the interpretation of the present situation serving the design; the design components chosen; as well as the form concept used (the formal ordering). The way in which the functional planning is allocated in the formal design plays an important rôle.

48.9 THE NEED FOR DESIGN METHODS IN URBANISM

The need to study design methods in urbanism is derived from an effort to make private thinking and acting of people associated with architectural design, especially designers of urban architecture, public. The use of design methods sees to it that the urban designs developed this way can be readily studied and discussed. The use of design methods also favours transfer, clarity and verification of designs. In addition, Jones thinks that the beneficial effects of the use of the design methods described earlier include that the designers are obliged to look beyond their immediate need for apparently relevant information and to suppress the inclination to adopt and cuddle the first idea surfacing.[d] In addition to these arguments pleading the case for the use of design methods the following ones could be mentioned:

- the use of design methods contributes to systematic design and process;
- since it is known beforehand which steps and design elements will be used;
- applying design methods enables and favours co-operation between those who face together the task of finding spatial solutions;
- applying design methods necessitates study by design: this may focus on the design itself, as well as on the further development of the design method;

a Meyer, H. and A. Reyndorp (1988) *Stedenbouwkunde, een nieuwe stedelijkheid.*
b Heeling, J. (1988) *Meervoudige opdrachten kritisch beschouwd.*
c Pasveer, E. (1988) *Planvorming Kop van Zuid te Rotterdam.*
d Jones, J.C. (1970) *Design methods: seeds of human futures.*

- applying design methods leads to a consistent (balanced) design of urbanism;
- the use of design methods enables the development of a design in which the link between well-formulated points of departure and the spatial solutions is rendered as clearly as possible.

48.10 WHAT IS A (DESIGN) METHOD?

A method is a fixed way of acting, well thought out, in order to attain a certain aim.[a] Methods are systemic procedures to attain formulated aims, means to deal with a certain type of problem with a certain degree of success. Methods reflect experience assimilated in the past. A method is not the specific knowledge of an individual, but may be shared and applied by others.[b]

Design methods in urbanism are methods regarding the content of a design in urbanism; that is to say: design elements and the way in which, with these elements, a design in urbanism is developed. In the development of urban architectural plans, other groups than this design group are used. These methods may indirectly influence a design in urbanism; however they have not been developed especially for determining the content.

Design methods do not just reflect past experience, but might as well be based on the results of a study by design. The design of urbanism and the design method, in their mutually relating, are then the object of study; as there are typological/ morphological studies; studies of (form) concepts; spatial structures, urban images and the process underlying a design.

48.11 APPLYING A DESIGN METHOD

A no-nonsense application of design methods is treacherous. De Boer says on employing methods:

> *"It is just as dangerous to over-value methods as to underestimate, or reject them. A satisfactory urban plan, or more generally, a plan in spatial planning, never results exclusively from the application of method alone. Creativity, and the power to imagine and invent are required; as well as a sense and insight regarding what is social. There is no reason why methods should be a unique blessing; nor why they should be dismissed as an aid."*[c]

In order to prevent mindless application of (design) methods some points apply:

- design methods should never be used unless knowledge of underlying thought is taken into account;
- generally a design method can only be used for one aspect of the design problem;
- design methods do not feature a well-defined outline, applicable in any situation; according to the specific design problem one should strive towards an approach befitting the situation;
- employing design methods should not benefit exclusively the position of the user of the method;
- the selection for the application of a specific design method establishes the contours of the design solution. The design method itself does not provide for the creative filling in of these contours;
- applying design methods does not result necessarily in the 'quality' of the design;
- the 'quality' of a design in urbanism is depending on the insight, knowledge and capability of the designer employing the design method.

48.12 DESIGN METHOD – DESIGN ASSESSMENT

Each and every designer entertains personal ideas and theories concerning design; they influence them greatly. Brandes distinguishes in a study on the filling-in of newly built residential areas the design concepts mentioned into four main streams: functional, experimental, ecological and decisional.[d] According to her, the main difference between these streams stems from what is stated in a design primarily, with what ideas the first lines or words have been

a Dale, J.H. van, G. Geerts et al. (1989) *Groot Woordenboek der Nederlandse Taal, 11e druk*.
b Bergman, H. (1978) *Ontwerpmethoden op bestemmingsplanniveau*, p. 78.
c Boer, N.A. de (1982) *Planvorming in de ruimtelijke ordening.*
d Brandes, E. (1980) *De stedenbouwkundige inrichting van nieuwbouwwijken*.

put to paper; what (form) concept has been developed, which means of design have been introduced, and the way in which the existing situation is interpreted. A first idea like that determines the initiation of the design. The way of working, the design process, is strongly influenced by these first thoughts as well. Applying a design method, consciously or not, is part and parcel of specific considerations of a designer. By opting for a deliberately chosen design method affinity with design theory, respectively design concept, underlying the design method is expressed. It may suffice here to mention the underlying thought per method described. No stance is taken *vis-à-vis* the several design concepts/ theories on which the design methods are based.

Westrik and Büchi give a survey, based on some concepts of importance for design in urbanism, how the several design methods are received.[a]

Foqué gives insight into the method-theory:

"A method as such is a description by means of language. Inherent in each description is reduction of experience; what is beyond spoken language evades it. A method is not value-free. It produces its very restrictions, influencing this way the result. The underlying value pattern of the method, the so-called theory, is reproduced. In fact, designing is a process of transformation of the facts of life to what is native to design. Continuously, the designer orders facts specifically, particularly according to the possibilities to be able to execute within this ordering his designing activity; starting from his personal design language and addressing it. In practice, order is constructed by itself, and not by theory! The designer will have to state by himself what the operational limits are of the design method used, while any method is a certain, but also limited, way to take a stance vis-à-vis a design problem." [b]

48.13 CONSISTENT DESIGN

'Consistent' means here that also those aspects are considered in the design that are not mutually exclusive and do not overlap, but who support and complement one another. The following aspects are concerned:

- a tuning of formal and functional ordering;
- a functional ordering based on a spatial translation of the programme, in which the relations between the various functions have been tuned to one another (opportunity to live and to work, connections and facilities;
- a formal ordering, comprising:
- a (form) concept, a consistent package of design ideas,
- an ordering with the means of design employed, and
- the ways in which the existing characteristics of the area have been acknowledged in the design
- tuning and connections between the various levels of the design with their specific design problems;
- the potential for execution within the urban design.[c]

In the next three paragraphs design methods are ranked according to their contributions to the three possibilities how a plan in urban architecture can be made: the 'blotches' plan, the map of the city and the city image.

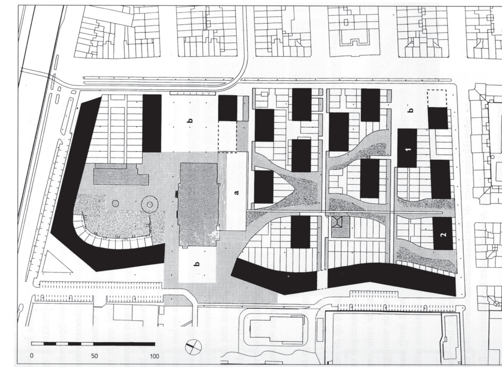
48.14 'BLOTCHES' PLAN

In the case of a functional planning the spatial translation of the programme is the central issue. Generally this happens by way of a model-like approach. Lynch[d] discerns several kinds of (urban) models; like city shape models, (hierarchical) models of facilities, density models and traffic models. The 'early' work of Alexander also departs from a model-like approach in order to achieve a functional ordering.[e] From the functional angle it is often tried to head towards a spatial differentiation. Programmatic differentiation is a new development and is

a Westrik, J.A. and H. Büchi (1989) *Stedebouwkundige ontwerpmethoden*.
b Foqué (1976) *Zin en onzin, verslag van 9 gastlezingen aan de afdeling Bouwkunde, TH-Delft*.
c This urban architectural design was never executed as such. The execution is taking place through building plans and installation plans for public space.
d Lynch, K. (1985) *A theory of good city form*, appendix D, p. 453-455
e Alexander, C. (1964) *Notes on the synthesis of form*.

employed, amongst others, in the plan ‘Leidsche Rijn’ in Utrecht. As mentioned in paragraph 1, rather planning methods than design methods are involved.

De Boer developed a basic site articulation in order to realise an urban image for the blotches in an early stage.[a] The same applies for the well-known *‘stempel-verkavelingen’* applied amongst others in Pendrecht and Frankendael. Presently this kind of blotches like fields are being worked out in an architectonic emsemble (GWL area in Amsterdam)

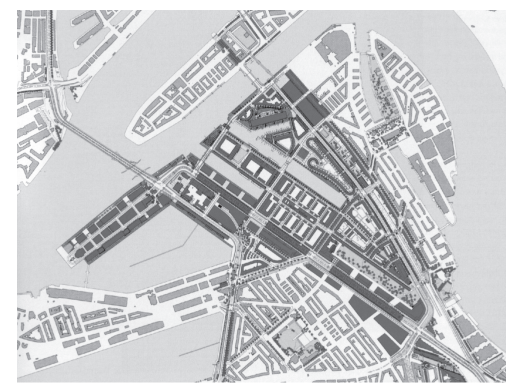


469 Surface design West 8 for the GWL area in Amsterdam. Urban plan of the Christiaanse office.

48.15 THE MAP OF THE CITY

The spatial composition and the design components required for it are the central problem. Allocating the programme within this composition is a related problem. The components are often determined by a typological approach. Types *vis-à-vis* public space are then concerned (standard profiles and islands/ fields of the areas to be built) in which the mutual relation and scaling play an important rôle. Heeling is one of the people asking for attention for this composition problem.[b] Marks and Hinse developed a design method for integration of properties of the area, the programme and the composition.[c]

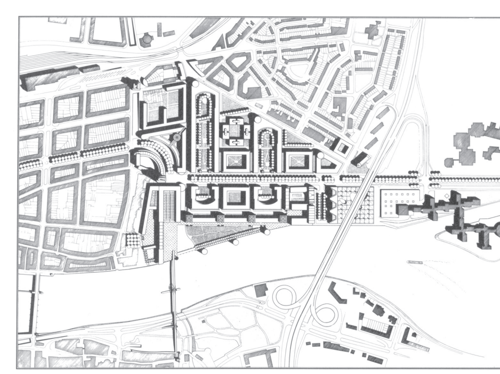
In current practice the design of the map of the city often carries the name ‘Master Plan’ (‘Kop van Zuid’, Rotterdam, ‘Zuid-as’ Amsterdam), where the position in the city and accessibility are the most important considerations for the design.



470 Urban Master Plan Kop van Zuid, 1996. City map.

48.16 THE CITY IMAGE

Well-known design methods intending to arrive at an image of the city have been made by designers like Cullen (Townscape)[d] and Alexander (Pattern language).[e] The city analysis by Lynch (Image of the City)[f] has become a classic and is often used as a basis for a design method. In the Dutch situation the ‘Pattern method’ of the SAR tried to achieve a global (preliminary) image of the city starting from a built space typology. Current practice is aiming at unique images of the city without applying a specific method; for instance the ‘Céramique’ location in Maastricht (fig 471). The images might be based on metaphors (Bhalotra, Kattenbroek in Amersfoort); on motifs of sustainability and environmental concerns (Duyvesteijn, ‘DE Wijk’ in Tilburg, see page 313) or by considering the city as a complex of buildings (Koolhaas, centre Almere).



471 Urban Master Plan Sphinx – Céramique site of Jo Coenen, Maastricht, 1987 Map.

48.17 PRIMACY OF FORM OR FUNCTION

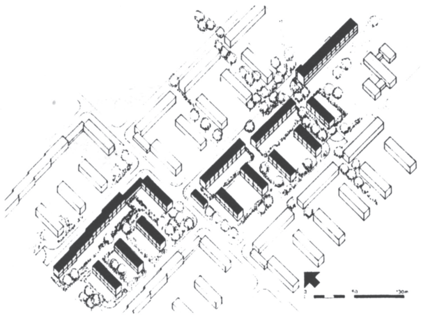
Summarising, a threefold division can be made with regard to the question how methods deal with connectedness:

- methods with an emphasis on formal design: Form concept, Basic Articulations, SAR-pattern method, Method Lynch, Townscape;
- methods solely addressing functional planning: decomposition method
- methods combining the functional and formal design: Environmental differentiation, Three Traces method, Pattern Language

48.18 SYSTEMATIC OF THE PROCESS

The systematic intended here particularly concerns the way in which a consistent design comes into being. In order to systemise the design process one often is basing oneself on the notions model, type and concept. A design method may result from a method of analysis for urban architecture (for instance the method Lynch, Townscape). It can be further developed by design analysis of design made with a method. Per method it can be indicated how and in what sequence the aspects of the preceding paragraph have been tackled.[g] Such a design study shows the applicability of design methods in a certain context. Often the method causes a certain systematic or structure in the design process. In what follows it is indicated per design method how the method influences the design process.

a Vliet, K. van (1989) *Systematisch ontwerpen: planvormings experiment in Emmen*.
b Heeling, J. (1989) *Vormconcept*.
c Hinse, T. and F. Marks (1989) *De drie-sporenmethoden*.
d Cullen, G. (1961) *The concise townscape*. See also: Westrik, J.A. and H. Büchi (1989) *Stedebouwkundige ontwerpmethoden*, p. 259-281.
e Alexander, C. (1977) *A pattern language*. See also: Westrik, J.A. and H. Büchi (1989) p. 283- 307.
f Lynch, K. (1960) *The image of the city*. See also: Westrik, J.A. and H. Büchi (1989) p. 207-236.
g Westrik, J.A. and H. Büchi (1989).

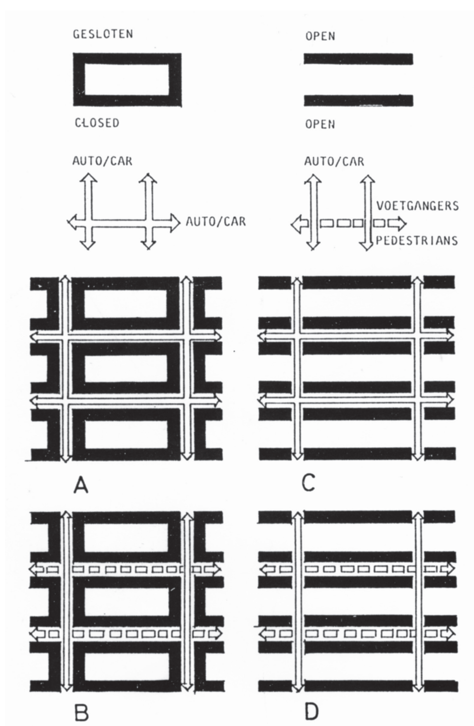


472 Basic allocation method

48.19 THE BASIC ALLOCATION METHOD

The basic allocation method puts the quality of living in the first place. For the benefit of a design in urbanism this quality aimed at is expressed in a basic articulation/ prototype. Opting for a basic articulation is always linked to historical time; that is to say to social and situational considerations. It is of importance whether a basic articulation has been developed for an area in the inner city or for an area of extension.

With the help of basic articulations one can be confronted in an early stage by a basic articulation for the entire area (tentative articulation). By this one can react to the situative and programmatic requirements with mutual adjustments in the main structure and the basic articulation. The basic articulation method should be regarded as a typological approach.



473 The SAR-pattern method

48.20 THE SAR-PATTERN METHOD

The SAR-pattern method has also been developed in order to agree in an early stage on the residential environment desired. This method departs from the pattern of the city, the recognisable combination of spaces with and without buildings and the possible margins between both. In contrast to the method 'Basic Articulations', in this method the outside space to be designed stands central in relation to the future building. It has then become possible to observe according to what rules this co-existence has come into being. On the basis of this co-existence further agreements can be made concerning the position and the size of the building and of the space. This is also an instance of a typological approach.

48.21 THE DECOMPOSITION METHOD

Functional inter-dependence is emphasised in the case of the decomposition method. An extra step is needed in the design process to get from a design problem to a design solution because of the increased complexity of the reality. This extra step involves searching for inter-dependent subsets on the basis of criteria previously formulated. Subsequently, these inter-dependent subsets may be translated into constructive diagrams that may serve as constituent elements for the mental picture (the design) of the shape to be developed later; a modelling kind of approach.

48.22 THE THREE-TRACES METHOD

The three-traces method features three design paths. One of them aims at function, one at composition and one at topography. Under topography is understood the whole of the manifold visible and invisible data determining together the structure of the landscape and its future development. Crucial in this design method is that the three paths are developed as autonomously as possible, although synchronously. In all three paths the concept 'pattern' plays a rôle. This dichotomy autonomous – synchronous is chosen in order to link a design process that is as clarifying and controllable as possible to a balanced plan development.

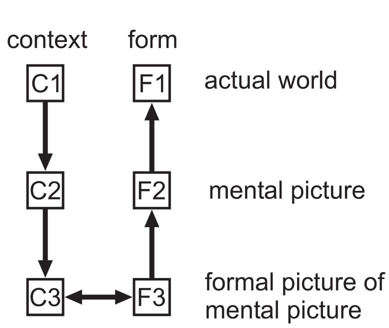
474 The Decomposition Method

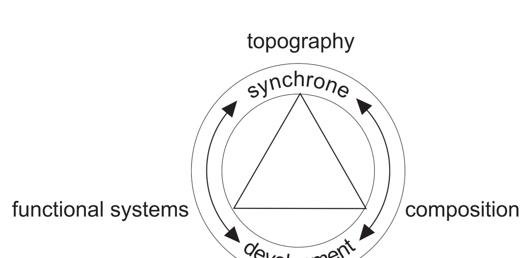
475 The three-traces method

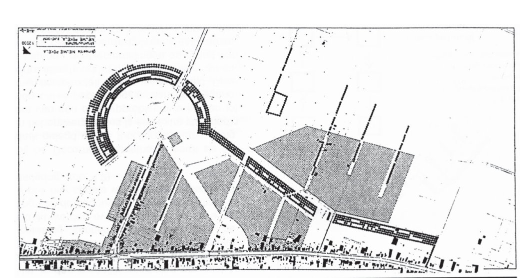
476 Form concept

48.23 FORM CONCEPT

The notion 'form concept' should not be regarded as a method as such, but as a methodological tool to indicate in an early stage of the design process which ideas are decisive for the spatial inter-dependence of a design. A design cannot possibly be thought out in its entirety in one fell sweep. The design problems are too complex for that; a form concept can assist in



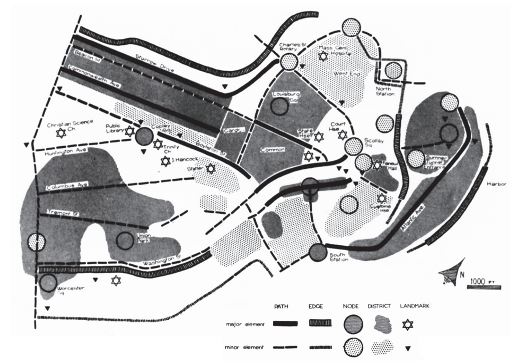




dealing with this. The concepts developed differ in each commission and in each situation. Depending on the prevailing points of connection with the existing situation the concept can be based on this to a higher or lower degree. One can also look for points of connection not based on the existing situation, but for other connecting elements, as there are analogies or metaphors.

48.24 THE METHOD LYNCH

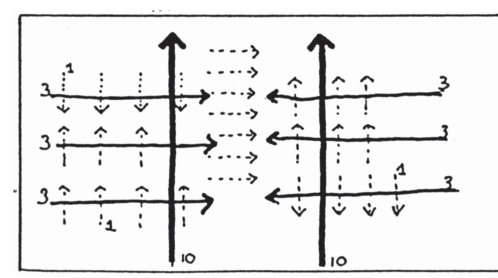
The method Lynch departs from the urban image and the way it is experienced collectively. The spatial quality of that urban image is expressed in the 'legibility' of the city: the ease with which the city may be recognised in its parts and put together by its user to an inter-dependent whole. If the method Lynch is used as a design method, a spatial structure is developed with regard to the design elements determining the urban image: routes, edges, areas, connections and landmarks.



477 The method Lynch

48.25 THE ENVIRONMENT DIFFERENTIATION METHOD

In this case 'structure' is understood to be the hole of distinguishable parts and elements sharing perceptibly an inter-dependence. The notion of structure also plays an important rôle in environment differentiation, but structure is here also seen as an intermediary between form and function (the abstract notion of the spatial reality). Next to the aspects form, function and structure the aspects 'content' (what varies; the variables) and 'intent' (the objectives) are distinguished. A concrete structure exists (the way in which constituent parts make for one area) and an abstract structure (the way in which constituent variables make for a model). Added to these five aspects is a classification in scale levels.



478 Environment differentiation

Each scale level has its own design variables enabling environment differentiation recognition on the level of the residence, but also on the level of the neighbourhood, city, region, or country as a whole. Spatial structuring is especially important in a design: separation of (environmental) variables irreconcilable between one another, and connection of (environmental) variables supporting one another. The structure is then a tool with which a designer influences function and form without determining them. It is the first step in a design process and it has a modelling character.

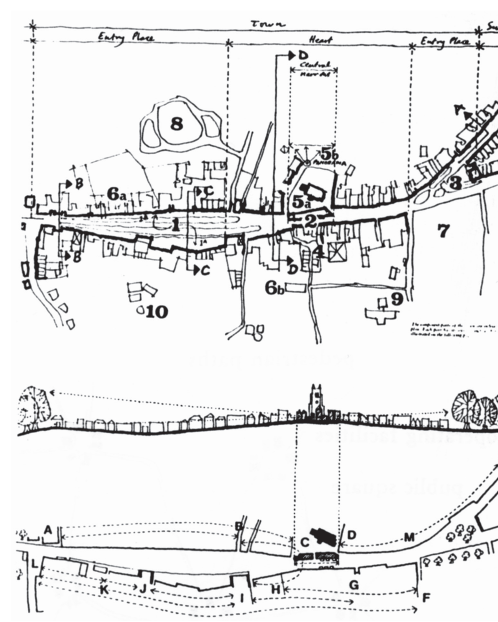
48.26 TOWNSCAPE

Townscape departs from the urban image as a factor generating a plan, but also from the image of the village and the landscape. This results in translation of neutral design schemes in comprehensible three-dimensional environments.

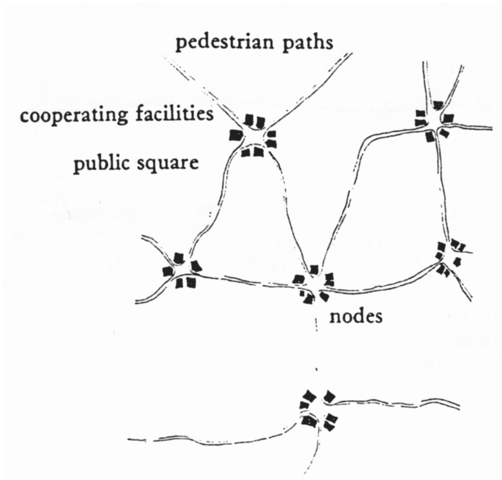
Individual design elements are worked into a composition. According to Cullen, the urban image is experienced by the spectator emotionally in three ways, viz.:

- the sequence of images resulting from movement: 'serial vision'
- the place, experience of the here and now
- the content, the intrinsic quality of the objects of the environment in their context

While analysing and designing urban environments Cullen uses in addition to the points mentioned in the above a frame of communication that can be regarded as a checklist. By translating the notions occurring in this frame (structure, route, space, place, element and orientation) into well-considered design elements, this pre-supposes preceding studying and making explicit the spatial significance of these notions. In this, properties of the situation may serve as guides. The existing situation is made expressive in the putting together of these design elements into a composition. The design elements achieve by their mutually weighed positions in this composition a visualising significance. Emphasising experiential qualities favours communication between the environment and the spectator: a communication can be visualised already during the design process, as a design tool. Drawings in perspective are eminently fit for making the mutual communication comprehensible.



479 Townscape



480 Pattern language

48.27 PATTERN LANGUAGE

Pattern language can be regarded as an instrument, a utensil, a language allowing everybody to design by himself and together with other people. It comprises design directives for cities, neighbourhoods, residences, rooms and also the basic construction of minor building commissions. The elements of the (design) language are the patterns.

A pattern describes a design problem. It indicates essentials of the requirements put to the solution of a problem. A pattern may be applied any number of times without leading necessarily to the same result twice. The relation between the patterns is not linear; between the various levels and within the levels a wealth of connections is possible. A pattern does not lead to a design. However, it indicates in a general and abstract way which essential conditions should be taken into account. The designer must make the design himself, while he / she may / should be guided by personal ideas, experience and by specific local circumstances. Actually, patterns are 'hypothetical' and give an exact number of possible essential properties and processes of and within our environment. Pattern language is a typological approach.

49 DESIGNING IN A DETERMINED CONTEXT

TAEKE DE JONG

Design study, unlike design research, typology, and study by design, is part of the normal practice of architectural firms as well as urban development or technical consultancy firms. In this regard, location, social and material restrictions, the nature of the assignment, and possibly a programme of requirements essentially form the determining factors (context). The object, however, is variable; it has to be designed after all.

This object to be designed does not *causally* stem from the context; if this were the case, one would no longer have to "design" the object, as it would simply be "predicted". The context only sets the conditions for solutions. There are always very many solutions, even though one does not *see* them before they have been designed. Empirical, generalising research is not sufficient to generate these designs on its own.

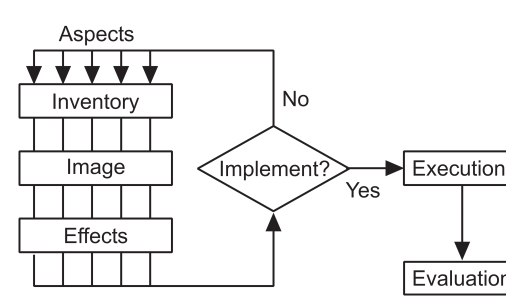
In the process of design, one indeed looks for existing examples (precedents, references) for the object (design research, see page 89), and for familiar forms that come up for consideration in this context (typological research, see page 103). Yet copying from an example is rarely sufficient, and a form is by definition not yet a design (model). A form and an existing model of this form may fit into the location and its context, allowing one to decide whether to apply the model (model-based design). In the process of detailing, however, one always runs into a need to make design decisions that were not included in the model.

		OBJECT *Determined*	*Variable*
CONTEXT	*Determined*	Design research	Design study
	Variable	Typological research	Study by design

A compass is always needed that also represents the context, so that one can see the direction that the form can consistently be elaborated in, and the direction in which changes have to be made. This kind of compass or idea, which may be a drawn or schematic picture (pattern or process), which addresses the participating parties, and which may also contain the context and *various types* (concept or better conception)[a] , leads to consistency in such decisions and to recognisability amongst participants. A conception has to be designed, but it is not yet a design (model). A conception *generates* design activity and design resources, while a type *structures*. The issue of creativity is, upon this realisation, only transferred from design, model, and form to concept, but it can indeed be nameable in phases. The question remains: "how does one arrive at a concept?"

49.1 TAKING AN INVENTORY OF 'CONTEXT'

In design study, the context of the object is indeed essentially familiar, but only becomes completely clear during the process of making plans. For this to happen, documents and meetings are necessary. The perception of the context changes with each meeting in the process of making plans, in which parties from the context are involved; they are also involved with every document that comes to the table. Some meetings lead towards clarification and wide-reaching definitions of the context, while others are more likely to unsettle once again the perception of the context, so that new inventories become necessary.



481 Cycle of forming plans

49.2 THE CYCLE OF FORMING PLANS

Every consideration regarding the design process can be distinguished by at least three phases: the formation of the image, that which precedes it, and that which comes afterwards. What proceeds it can be called 'taking inventory' and what follows can be called 'decision-making' (analysis of effects, and a decision to execute).

Eekhout calls this entire cyclical process 'development'[b]. He makes diagrams of cycles that repeatedly contain this three-phase process. Brouwer does this in an even more complicated way[c], but also returns to the same three aspects. Here we are using a more abstract

a The conception is also referred to as a 'concept', but this leads to scientific confusion with the psychological term "concept".
b Eekhout, A.C.J.M. (1997) *POPO of ontwerpen voor bouwproducten en bouwcomponenten*.
c Brouwer, J. (1998) *Contribution RSDC-congress*.

outline of a single cycle, noting that this cycle can be "nested" (a computer term that indicates that a procedure can be recorded "in itself").

As soon as one has made the decision to execute, once again various designs must be made: one also needs to have an image of the design's technical, economic, and social execution. They vary based on the context. In organisation theory, we also have 'the design of the organisation'.[a] These three executive design processes all include the same three phases of taking inventory, forming the image and making decisions. The decision-making process consists of conveying the effects of the designed image (analysis of effects), followed by the actual decision.

If the decision to execute is negative, one can throw the entire project overboard, or begin anew by again taking inventory (possibly in a minimal fashion) and using these results to arrive at a new formation of the image, and a new decision process. This process and its variants have been extensively described as 'design methods' in the literature. In this Chapter, we will limit ourselves to short critical comments and a certain perspective on methods and techniques of image formation.

49.3 TAKING INVENTORY BEFORE THE DESIGN

The formation of the image and decision-making process is orientated towards, respectively, the possible and the (collectively) desirable. Taking inventory, however, is a reduction from the *existing* context and the probable developments within it. It is therefore orientated towards *probable* futures (see the diagram on page 21) in the perspective of what is possible. It can involve an inventory of wants (those of society, of the customer, of the party executing the commission), but here the taking of inventory itself does not form part of the mode of what is desired. The inventory involves objectivity with regard to the "probable" desires of others.

Even an inventory of current possibilities, like the dimensions of the site, or current drainage and outcropping situation, do not need to form part of the mode of what is possible. Thus a morphological analysis of the topography, or typological research into previously presented solutions, is per definition empirical, stemming from experience with what exists, and what is therefore probable.

This first 'objective' taking of inventory, however, would be pointless to carry out for the design if all data were simply copied, a mistake that every beginning designer makes: he traces ever more data from the site onto their transparencies. This kind of excess can obstruct the view of possibilities. There needs to be a reduction in perspective of what is possible and desirable. Thus one deliberately excludes some elements in the inventory (though this must be mentioned during the presentation), but one can also include elements no one has noticed yet.

A postulated concept or type helps in this taking of inventory, but can also get in the way during later consideration of other concepts. This form of 'reading' the site with its buildings can, in its drawn representation, already bear the traces of selective attention, which then shapes the delimitation of components in the site and its buildings in a way other than expected (focus). This form of selective attention is based on personal experience with other objects, sites, forms, and concepts, without pre-supposed categories and legend units (erudition), or on experience with one's own designs and the design resources represented therein (repertoire).

49.4 THE INTERFACE BETWEEN TAKING INVENTORY AND IMAGE FORMATION

As soon as one starts drawing lines where they do not exist (interpretation), one crosses the border between taking inventory and image formation. Yet these lines do not necessarily need to be part of an image already present in the mind's eye of the designer. In the process of interpretation, it is wise to delay any such image as long as possible in order to give a chance to all possibilities. The formation of the image is such an individual matter that every gener-

a Ramondt, J.J. (1996) *Organisatiediagnostiek, een methode voor vraaggericht onderzoek*.

alisation one tries to draw in that area can impede formation of the image. A special Chapter has been dedicated to the general philosophical and psychological aspects of image formation (see page 413).

We are restricting ourselves here to two analytical methods, both a possible start of a design: transformation of the existing situation by re-design and composition analysis.

49.5 TRANSFORMATIONS

If one changes the legend category of ‘concrete’ into ‘steel’ in an architectural drawing, a completely different design is created (legend transformation). Often, the shape of the indicated elements in the drawing has to be changed because a different construction is necessary. There will be other important technical effects, like construction-physical effects, effects on the building process, effects on the intersections, mechanics and function of constructional elements. Yet there are also visual, therefore cultural effects, economic, therefore administrative effects.

Aside from transformations in the legend, one can also propose transformations of form and transformations of structure, which lead to new forms, and structures in a certain initial position. Thus the Amsterdam district ‘De Baarsjes’ was re-constructed as a result of an image improvement campaign as if it had to be re-designed from scratch, with a minimum of design interventions (morphological reconstruction). Towards this end, a pattern of standard housing blocks was drawn over the area (division). Thus the current composition was approached with a measurement tolerance of 30%.

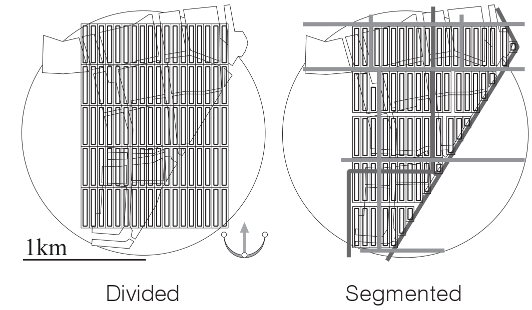
As a result of this initial adaptation of the area, a second was applied: ‘segmented’. This meant that some streets were expanded, at the cost of the housing blocks, for the benefit of connecting roads that open up the neighbourhood to the outside. With this adaptation, the current area was approached with a tolerance of 20%. A third adaptation, ‘tailoring’[a], brought with it both narrowing as well as expanding within the composition, whereby it was fit into the existing borders so that a tolerance of 10% was achieved. The last adaptation, the ‘detailing’ was only schematically represented. This required arrangement of components in the composition so that elements like details could be named as a result.[b]

These kinds of transformations can be described as objects of study by design. In landscape architecture they are applied for the theoretical transition from a natural landscape to a cultural landscape, and from a cultural landscape to an urban landscape.[c]

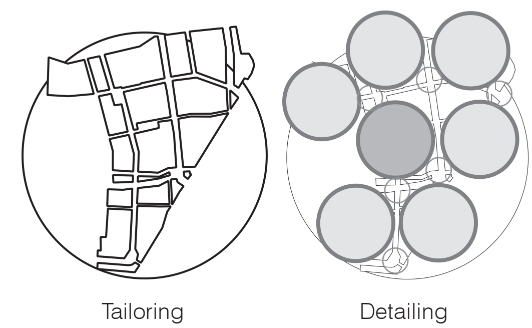
49.6 COMPOSITION ANALYSIS

The constellation in a diagram or prototype does not yet have proportion. Yet in a composition, the proportion of the components and details does play an important rôle.[d] A composition is thus scale-dependent, a constellation much less so. A detail in a composition can be a component in another composition on another scale, with another grain. That is why it is important to keep sight of scale of components and details in the composition. As a rule of thumb, one can maintain that the “radius” of a component is about 1/3 of the composition as a whole. The surface of a component is then abut 1/10, the content 1/30. Yet the details can also play an important rôle in the composition. As a rule of thumb, one can maintain that elements with a radius smaller than 1/10 of the composition as a whole are called ‘details’.

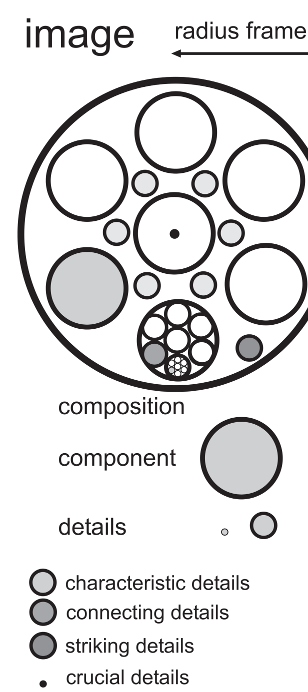
There are many kinds of details. Characteristic details identify a component. If one draws such a detail, the reader knows that more of these details appear in the components. They can play a rôle in explaning the legend that accompanies the component. Connection details lie in-between components. The term is mainly used in the field of construction, but connection details play an important rôle in urban development as well. A district, for example, can consist of seven components (neighbourhoods). If two neighbourhoods are separated by a



482 Division and segmentation



483 Tailoring and detailing



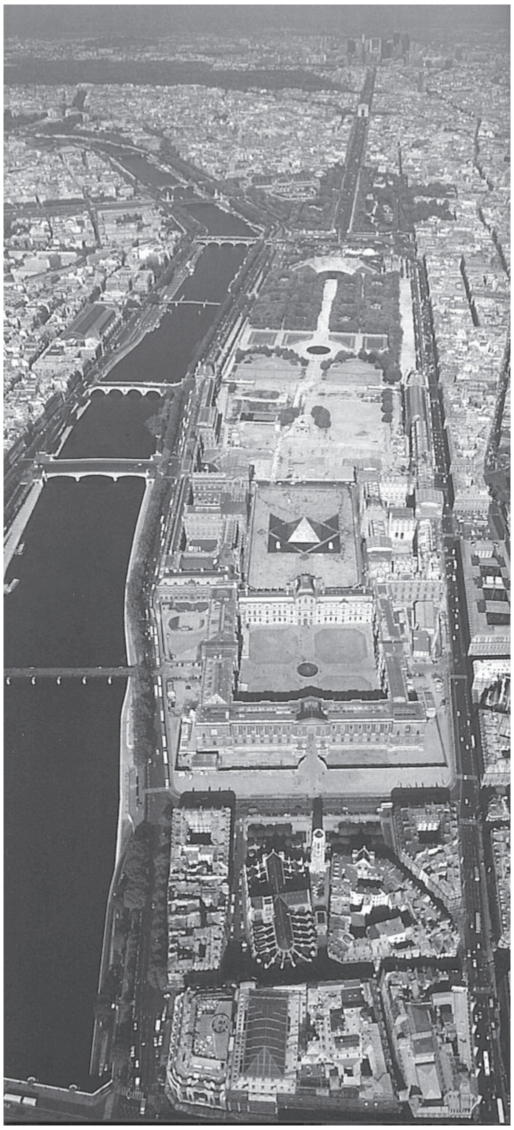
484 Composition, components and details

a This ‘tailoring’ adaptation and what follows are completely analogous to what tailors (couturiers) mean by this: making something fir the body and on the basis of this, applying the details such as seams and buttons.

b This method was inspired by the publication by Hoeven, C. van der and J. Louwe (1985) *Amsterdam als stedelijk bouwwerk: een morfologische analyse*.

c Reh, W., C. Steenbergen et al. (1995) *Landschapstransformaties*.

d This composition does not address the separations and connections (structure) that technically keep it together. In that case, we have a system.



485 Vista from the Louvre to La Défense[84]

road that opens to the larger district, then, at district level, this road forms a connection detail between the neighbourhoods.

This observation can be reason to give this road an asymmetrical profile, or a reason to provide the neighbourhood with varied façades that would give a characteristic impression of the areas that one is 'in-between'. In this case, a road that leads out into the larger district might then have to display a more symmetric profile. If the road comes to a square between three neighbourhoods, this square is then an important connection detail.

Striking details do not need to be characteristic, or have a connecting function, to be still a hallmark in the entire composition. Thus one can speak of the 'area by the windmill' if an old windmill provides a prominent point of recognition. Striking details can hallmark important positions in the composition.

Crucial details are details whose influence on the composition is as significant as a component's. The importance of such details extends well beyond their size. Thus the Arc de Triomphe on the Place Charles de Gaulle in Paris is a crucial detail in the line of sight from the Louvre to La Défense.

49.7 ANALYSIS OF EFFECTS EX ANTE

Analysis of effects is pre-supposed in every decision process, but is never completely executed. The methodological problems of effects analysis preceding the execution (evaluation ex ante, see page 159) are enormous. Each new perspective on the probable future leads to different effects on the same design. This is why people like to leave effects analysis to individual participants in the decision-making meeting. After all, before they arrive at the meeting, these participants have already studied the design from their own perspective of the future, as well as the effects they consider important, and have possibly already discussed in reports.

Yet, it is their significance in the meeting that determines how heavily the various effects will be weighed in relation to each other. Furthermore, in absence of their suffering objects (for example the future user) or scientific operationability, many effects simply remain outside consideration during the decision-making meeting. This is a major responsibility for the designer, who of course has already considered these effects with every pen stroke of his or her design. Does this design intervention have the intended effects on the programme of requirements and the individual ambitions of the designer of the job? To which unintended effects (desired, probable or possible) does this transformation lead?[b]

These considerations during the design process must be at hand during presentation in a decision-making meeting. All the more reason to document the design process verbally as well. Computer programs for assisting designers can help in this regard, but to a degree.[c] The choice of words, metaphors, and arguments that make an impression in a specific context boils down to a question of verbal talent and experience.

Unfortunately, evaluation after the execution (evaluation ex post, see page 151) usually remains unpublished, due to budgetary considerations. Not every party that commissions objects with structures as long-term as those in construction necessarily benefits from such an evaluation. A potentially bad evaluation can have major consequences upon the object's value, and bad publicity can be ruinous.

49.8 VARIOUS LANGUAGE GAMES DURING THE MEETING

Decision-making demands a reduction into discussable topics that can be tested against what is collectively considered desirable. The chairman of a meeting, and its administrative participants in the decision-making process, reduce reality to points on the agenda. And not everything gets a place on the agenda. The first concern of every participant in the decision-making process is ensuring that the points important to him or her be included on it.

a Source: Guides Gallimard (1994) *Le Louvre*.
b Jong, T.M. de (1995) *Systematische transformaties in het getekende ontwerp en hun effect*.
c Boelen, A. (in preparation) *Clarifying presuppositions in design*.

During the meeting, an extensive reduction takes place, in which at least location and time are recorded in the form of appointments and agreements. The minutes testify to this process of reduction. They do not need to be a completely accurate historical representation of the meeting, with all agenda points and the discussions and considerations that these points invoke, as long as everyone can approve of this account. It may have even been reduced to the form of agreements, during the next meeting. And here the term 'agreements' refers to where and when things are to take place. Thus in the mode of what is desirable, there is a case of two reductions of the polymorph and confusing reality: a reduction to sort, and a reduction to place and time.

One can also discern these two kinds of reduction in other language-games[a] regarding what one knows what one is capable of, and in the modes[b] of the probable and possible. These, however, wind up looking different, and this leads to confusion of terms between the sectors, and to significant methodological differences.

	Choosing	Knowledge	Ability
Modes:	Desirable	Probable	Possible
Sectors:	Management	Scientific	Technical
Education:	LLM.	Doctor	Engineer
Activities:	Policy	Empirical Research	Design
Reductions Towards:			
Type:	Agenda	Variables	Legend
Place And / Or Time:	Arrangements	Relationships	Tolerances

486 Language games

The empirical researcher plays an important rôle in the inventory process. He or she reduces his or her reality not into points on the agenda, but rather into variables. These are nameable characteristics, be they verbal, denumerable, numerable, or measurable[c], which can take on different or changing values without negating the designation of the given characteristic. This is a reduction to sort: a dissection (analysis) of perceptions about actual objects reduced to 'characteristics' that can be represented and put into operation for studying. This reduction of perceptions allows for differences or changes (specifically between 'values') in only one direction ('dimension') per variable.

The rest of the perception is excluded[d] as a result of the processes of naming and delineation (definition), and is often presumed to be the same (*ceteris paribus*). This unspoken, undifferentiated quality of 'the rest' is only penetrated when a characteristic can be designated a variable in the excluded area. As long as this remains impossible, Wittgenstein's rule applies: "*Wovon mann nicht sprechen kann, darüber muss mann schweigen*".[e] Any sense of doubt regarding the acceptability of this kind of reduction can be witnessed, according to the later Wittgenstein[f], in the post-modern discussion on the contextuality of 'general' statements (which, if only for that reason, are no longer 'general') and the differential thinking it has resulted in.[g]

49.9 THE EMPIRICAL REDUCTION TO PLACE AND/OR TIME

The reduction to place and/or time is then the (mathematically documented) simulation of the relationship between variables in order to find a similarity with reality. The researcher will not rest with the fact that every variable can take on any arbitrary value: instead he looks for relationships among these variables in order to further limit their ability to move, with the goal of being able to make predictions.

If, after all, possible future characteristics of objects (variables) are supposed to be able to take on values independent from eachother (as is sometimes required or caused by design), then there are no longer any expectations one can rely on.

Relationships between variables pre-suppose a far-reaching reduction to place and/or time, not always acceptible for designers. Indeed, relating two variables demands a sequential (denumerable) and corresponding arrangement of values in both variables.

If in the set of perceived values Y from the variable y, for example, any value is twice as big as that of the same position in x (the first position is 1, the second position is 2, the third position is 3, etc.) in every counted position in this variable (the first position is 2, the second position is 4, the third position is 6, etc.), then this is documented in a mathematical 'equation' (y=2x). This relation would become inconceivable if one were to compare the 1 in X with the 6 in Y, and then the 2 and X with the 2 in Y. Sequentiality tacitly pre-supposes a fixed sequence in one space or another (differences) or in time (changes). Without such an *inter-*

a This is a term of Wittgenstein, L. (1953) *Philosophische Untersuchungen*. Recent edition: Wittgenstein, L. and G.E.M. Anscombe (1997) *Philosophical investigations*.
b This is a Kantian term that has taken on a new interpretation in modal logic.
c Stevens, S.S. (1946) *On the theory of scales of measurement*.
d Spinoza: 'Every determination contains a negation.'
e Wittgenstein, L. (1922) *Tractatus logico-philosophicus*. Recent edition: Wittgenstein, L., Pears D.F. et al. (2001) *Tractatus logico-philosophicus*.
f Wittgenstein, L. (1953) *Philosophische Untersuchungen*.
g IJsseling, S (1986) *Jaques Derrida, een inleiding in zijn denken*.

nally denumerable spatial or temporal order, every relationship *between* variables would become impossible.

There is, however, in this seemingly self-evident form of reasoning, something else pre-supposed between the lines, something designers are not always able to deal with: a likeness in distance or duration *between* the values within one variable (intervals). The values are not only made denumerable (numerically varying only in their position) but also countable (computationally the same in the spacing of their sub-divisions).

Counting pre-supposes *equality* in the elements being counted. Thus this is fundamentally insufficient, if only on the basis of the elements' different positions in reality.

If, for example, a programme of requirements is compiled this way, the designer can find opportunities in the formation of the image to combine or analyse numbered and computed functions into new functions (categories) that were not provided for in the variables (and their implicit and largely traditional delimitation) initially chosen. These must first be designated again in new variables in order to relate them then to the customer's list of desires, which list has since been changed by the design. This demands the necessary conceptual abilities from all participants.

One can *logically* conclude that "if x=1, then y=2". Yet this does not establish any *causal* relationship: "doubling x *causes* a doubling of y" (think of the temporal proportion between the number of storks and births that was once demonstrated in Sweden).[a] In empiricism, the step from logical to causal conclusion is often made too easily, and on closer inspection it has something mystical to it.

49.10 REDUCTIONS THAT GO TOO FAR FOR THE DESIGN

These methods of reducing and representing reality have turned out to be unusually fruitful in almost every scientific field, except that of formulating the image in design. The epistemological limits of these 'scientific methods' are greater than many realise, and are often too big for 'integral' (and differentiating) designers. Designers are not called in to recreate what already exists, but rather to create new possibilities that do not yet exist in a given context. Furthermore, this method is subject to the law of diminishing marginal returns, now that most of the globally generalisable relationships between nameable and named variables have been elucidated. What now remains are more and more context-dependent local problems.

And with this, more (and more varied) causes, or should we more cautiously call 'conditions', are leading to new possibilities within this context. The desired possibilities here form part of a much bigger collection of possibilities which may be useful at some point in the lifespan of an architectural object, yet which cannot be provided for in the programme of present desires. These same causes then lead, even as a result of minute variations in material and social conditions, to various results (chaos theory), or the same consequence is elicited by various causes (many roads lead to Rome). These problems with the empirical method have been studied not only in architectural design, but in organisation theory and ecology as well.[b]

49.11 IMAGES OF A REALITY THAT NEVER EXISTED

From an empirical, truth-seeking point of view, the designer is a liar, making, after all, images of a reality that does not exist. What matters, though, is that it *can* exist in the mode of the possible, without being an extrapolation of perceived relationships (prediction). The empiricist is also involved with possible futures (probable futures, which are per definition possible futures) in the form of predictions, but the designer is only called in when these are undesired, when a customer wants *something different* than the most probable, or something different than the average one gets from the calculus of probability (for example, something different than the standard-setting VINEX districts).[a]

a Draak, J. den (1993) *Van blauwdruk naar draaiboek, scenario's in de ruimtelijke planning en volkshuisvesting.*
b Riemsdijk, M.J. van (1999) *Dilemma's in de bedrijfskundige wetenschap.*

From an empirical perspective, the designer can also be considered a charlatan, since in this outline phase of the design, he cannot fall back on any verbally or numerically arranged list of characteristics regarding the object proposed, because it is multi-functional and pre-eminently context-sensitive. A lit match in a petrol station has a completely different effect than in a living room. This can be mono-causally established by putting one of the context's variables into operation, but a multi-causal bit of havoc that simply feels better here than there cannot usually be verbally expressed in the form of points. That's why *various* living environments should be made available, so as to leave the choice up to the user.

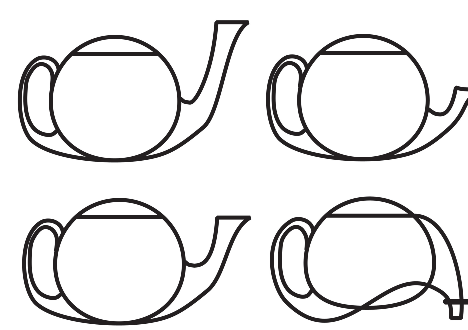
These various environments have to be designed. In architecture, there are few one-to-one, cause-and-result relationships not generally known, but that have rather been declared as solved, and subsequently recorded in the body of design experience without much challenge from the science of design. This does not alter the fact, by the way, that many design mistakes are still made in that field, and should be empirically refuted via ex ante and ex post evaluation. Yet image formation itself does not fulfill the standard requirements of empirical-scientific reduction of the present reality. There is another very valid reason: many design decisions for multi-functional facilities like a flat or a district cannot verbally or numerically be put into operation in this manner, are not clearly verifiable against a specific goal, even though they are accounted for in retrospect. These are choices from an infinite number of alternatives with one result that is, considered from many viewpoints at once, presumably equal.

49.12 OBSTRUCTIVE PRE-SUPPOSITIONS

There are solutions that can empirically be rejected, though they lead to an unexpectedly favourable result under particular additional circumstances (context). In these cases, empiricism notoriously interferes with creativity. From a debate with Klaasen (see page 183), I have borrowed the example of the design for a teapot.[b] In that design, knowledge of the empirical law of the two communicating vessels is indispensable. After all, if you make the spout higher than the mouth, the tea pours out of the mouth, and not out of the spout. If you make it lower, then the tea spills out of the spout if you fill the pot with too much water.

The property 'height' from the mouth H_v must therefore be the same as the property 'height' from the spout H_t, in the formula $H_v = H_t$. This empirical schedule of demands, however, impedes a creative solution: having a spout near the bottom that points downwards, with a small valve in it. The pre-condition for this is once again that the teapot be placed a bit higher than the base. And, incidentally, if we place a small plate under the spout, we have also reduced the problem of the spout dripping on the tablecloth.

The question is now whether the name 'spout' still suffices, and whether, in retrospect, the scientific reduction to a variable 'spout height' in the inventory phase might have set us off on the wrong foot. The general concept of 'spout' was tacitly presumed in the inventory process.



487 Teapot

These unspoken pre-suppositions form a major problem in the use of seemingly reliable computer programs, for example. They inadvertently steer your thoughts. Powerpoint is a good example.

Boelen[c] defines creativity as the wilful excluding of at least one generally accepted and thus collectively concealed pre-supposition. He designed a computer programme that initially lets the designer draw freely without a legend, and that makes predictions on the basis of shape and size, which the designer can then accept or reject in the process of drawing up the legend. Hereby, designers also become conscious of their own or others' tacit pre-suppositions. The general and indiscriminately accepted pre-suppositions in environmental policy, and the environmental research dependent upon it, also warrant a thorough study into unspoken pre-suppositions.

a VROM (1992) *Vierde nota over de ruimtelijke ordening Extra*.
b Klaasen, I.T. (1998) *Stedelijk regionaal ontwerpen*.
c Boelen, A. (in preparation) *Clarifying presuppositions in design*.

STUDY BY DESIGN

H STUDY BY DESIGN

Design research as discussed in Chapter 10 concerns determined designed objects within determined historical contexts. Design study in the preceding section considers the actual context, the location and the commission for the time being determined as well, but the object is variable because it has to be designed.

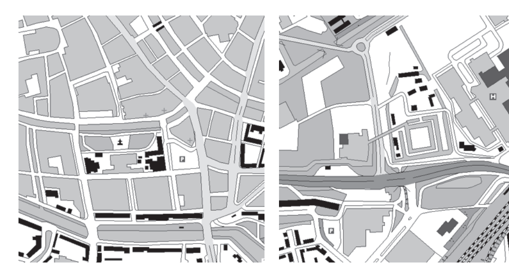
But, as we all know, context is always differing, changing and could even be object of design as well on a higher level of scale. Research on different locations and historical periods produces types (Typological research as discussed in Chapter 12) as long as we find object constancies. Sometimes we do not. Considerable experience has been gained in forms of study where the object or context is fixed by typological research or design study. If both context and object are variable (study by design), an alteration of typological research and design study can be resorted to. In this the object and the context are alternately varied. However, it is not inconceivable that this research can hold its own unaided by these two research methods.

Types of study by design

Van der Voordt and De Jong try to find some classifications of study by design. They do not choose but give some examples to find a scientific direction at last.

Designing Naturalis in a changing context

When the location changes during the design process, as happened designing Naturalis by Verheijen (see page 459), the type of building and even the programme of requirements may change as well. How do we study a variable object in a variable managerial, cultural, economical, technical, ecological and mass-space-time context? That means also, that goals out of that context are shifting. The study becomes more means-orientated and less determined by assumed goals.



488 Changing the location of Naturalis from downtown Leiden into the edge of the old city

Designing a building for art and culture

Röling, Van Eldijk and Van Kan describe the design process of an experienced and socially involved architect with great sensitivity for changing contexts

Contemplations for Copenhagen

Van den Bergh describes the development of a design without a programme of requirements. That brings him back to the very roots of the discipline of design, the ancient sources of our culture.

Learning from The Bridge project

The Faculty of Architecture TU Delft three times bore witness to an experiment, organised by Breen arousing scientific discussion by exhibiting the results of the last two in the main hall of the Institute. With a very strict, but limited programme of requirements in 1993 he asked approximately three hundred students to make a high quality model of a table at scale 1:5. In 1996 he did it again requiring a bench and in 1999 a footbridge at scale 1:20. Three beautiful publications describe the experiments and publish a selection of the results. The scientific community became increasingly fascinated by the combinatory explosion of solutions within a strict, but limited programme of requirements, culminating in the bridge exposition. The programme of requirements and the exhibition did not contain contextual data. The visitors to the exhibition had to imagine different contexts themselves when observing each bridge. So, object and context both varied, meeting the definition of ‘study by design’ in this book. In the Chapter '*Learning from the bridge project*' Breen describes his own perception of the experiment.

Creating non-orthogonal architecture and design in strategy

Vollers' and Frieling's study are the first indications of systematic study by design. Vollers proceeds from the desing resources opened up by the use of CAD to give form to potential objects and applicable contexts. Frieling's basic premise is a dynamic public deliberation between projects on a small scale (objects), and perspectives on a large scale (contexts) in connection with the decision-making on the Delta Metropolis.

Conclusion

Graduation projects, in which the students are allowed to determine context and object themselves, present an archive of more and less successful experiments in the field of study by design. However, this archive is not yet sufficiently documented and updated, or accessible for scientific study (http://iaai.bk.tudelft.nl). Such an effort is necessary to find enough comparable examples for design research. Design research supports our most challenging effort, to bring study by design on a scientific level.

50 TYPES OF STUDY BY DESIGN

THEO VAN DER VOORDT
TAEKE DE JONG

50.1 TYPOLOGY OF STUDY BY DESIGN

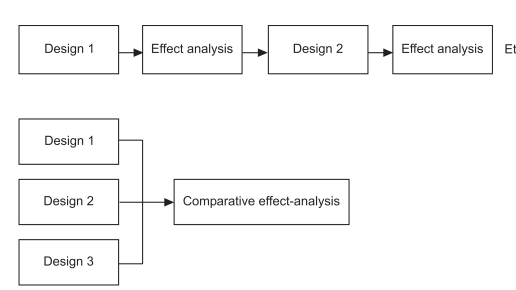
In this book study by design – also called research by or through design – is defined as the development of knowledge by designing, studying the effects of this design, changing the design itself or its context, and studying the effects of the transformations. The 'TOTE-model' from systems analysis may be recognised in this : Test → Operate → Test → Exit. Methodologically this should be preceded by a pre-design study, particularly in order to ascertain which requirements should be met by the design; although a design does not need to be goal-directed by definition.

'Means-orientated designing' is rather a journey of exploration, in search for unknown design solutions for goals yet unknown when the goal-generating context changes. In it the figure *'homo ludens'* fits, trying out things by playing. Means-orientated study by design in its pure form will occur rather infrequently. Who searches, always searches for something catering for a need. So there is minimally a latent idea of the results aimed at, for instance a higher experiential value, lower cost or better insight into the potentials of an existing area. An example is the doctoral study of Vollers (see Chapter 55) where, whilst designing, new and exciting forms of building façades have been developed. Means-orientated as well as goal-orientated study by design tries to generate insight into the relation between goals and means of design.

Next to the distinction in goal-orientated and means-orientated study by design, study by design may be cassified according to the degree in which object and context (in space, time, programme and boundary conditions) are constant or variable.

a. The object varies and the context follows. This is the case when a design intervention is made (under constant circumstances otherwise) in order to study its consequences on, for example, perceptual qualities, aesthetics and context, like in the design studies for the *'Kop van Zuid'* in Rotterdam, in order to introduce the programmatic and formal potential of that area.
b. The context varies and the object follows. An example is the positioning of the same design on a different location, in order to study the effects of the urban architectural or cultural context on the design and vice-versa (see for instance Röling's contribution, Chapter 52). Another example is provided by the changing of the requirements a design should meet, or of the weight given to the individual requirements. The subject of study is then which interventions in the design are desirable in order to acknowledge these new requirements.
c. The object as well as the context are manipulated, by changing an existing design and study the effects in different contexts.
d. A variant is that also the actors in the context vary. This applies, for instance, when a designer takes a design from another designer for point of departure and explores new possibilities by transformations in this design, generating different effects.

Another variable to classify study by design is the factor time (figure 489). Designing followed by research may take place chronologically (transformations in the design and analyses of effects on the context take over from one another) as well as synchronously (during the same period different design variants are subjected tot comparative analysis). Put differently: design variants may be developed sequentially or in parallel fashion. An example of the latter is an analysis of the contributions to a design contest. It also happens that the analysis of design variants occurs only after a sequence of design variants in the course of time. This way Frieden[a] studied a sequence of designs for Horton Plaza in San Diego, California. Due to



489 Chronological versus synchronous study by design

a Frieden, B.J. (2000) *Changing plans in midstream, a strategy for design innovation*, p. 109.

a lot of causes the plan preparation resulted in significant delay. Between the initiative and inauguration some 11 years passed into history. Since the requirements and the boundary conditions changed several times markedly (different norms for parking, different opinions about retail centres) nine different designs were made in the course of time. The comparative plan-analysis of Frieden is strictly speaking to be classified as design study. But, analysing the step-by-step changes in design and negotiations about design revisions comes close to 'study by design'.

A final variable to be mentioned, in which studies by design distinguish themselves mutually, is the kind of effect analysis. Design variants may be studied 'on paper', as well as in reality, by studying the effects in a full-scale mock-up or following realisation of the design.

Summarising study by design can be classified as to orientation on goal, or means; and the degree in which the following factors are constant or variable:

- the object (design);
- the context apart from actors (location, performance criteria, pre-requisites, legislation);
- actors involved (designer, client, researcher);
- time (moment of designing and effect analysis);
- way of testing (theoretical, experimental, Post-Occupancy Evaluation).

When study by design is orientated primarily on generating knowledge and insight we can rightfully speak about a study. If optimising a spatial solution is the first aim, it is a case, actually, of product development.

50.2 PROTOTYPE DESIGN

The development of prototypes involves both elements of study by design and product development. It includes a sequence of designing – testing – re-designing - and so on, until an optimal solution has been achieved. However, contrary to mass-production of consumer goods, a prototype design of a school, a health centre or whatever can not be reproduced regardless of its context. Most often the urban context, client's preferences and the number and characteristics of the users will differ from place to place. Still a prototype design may be used as a model needing only slight adaptations to local circumstances. As such, lessons learned from ex post evaluation may be used in continuous design improvement. For examples of prototype design including ex ante and ex post design research we refer to Chapter 20.

50.3 EXPERIMENTAL DESIGN

In order to conduct a technical experiment that aims at context-independent results, a test object (model) must be designed that meets certain specifications. A test model, however, does not have to meet the context-linked schedule of demands that it would actually be exposed to in reality, though the context of the experiment has its own requirements (experimental design). A good example of this kind of study by design is a wind-tunnel study that has to cover various constellations of a neighbourhood in order to expose the parameters that determine how energy is lost as a result of wind in various contexts.[a] The required local designs were re-created in circular models of three metres in diameter and tested in the wind tunnel.

50.4 DESIGN RE-CONSTRUCTION

Sometimes design research calls for a design re-construction in order to be able to compare a certain design with others. Thus 25 various plans for the Randstad were compared.[b] The basic materials could not be compared due to different planning horizons, different residential capacities, and different ways of creating the legend. The designs were then redrawn using the same legend.

This phase encompassed "interpretation" of the plans. The design of the legend formed a separate problem, since a legend in which the lions' share of the plans can be expressed by

a Jong, T.M. de (1978) *Wind Weren*.
b Jong, T.M. de and J. Achterberg (1996) *25 plannen voor de Randstad*.

some of the plans was insufficient. A continuous adjustment of this legend (in order for it to also include the plans) again demanded a re-interpretation of plans already interpreted in the old legend, only now in the new one. When all plans had finally been included in a single legend, the interpretation was presented to the designers.

The adaptation of the legend led to a reduction that did not satisfy all designers. In many plans, key details were omitted so that the 'soul' of the plan was considered lost. This had not only to do with omitted topographical, context-linked details, but also with solutions essentially useable in the other plans as well, in another context. These details were thus not important for the comparison of the plans on the scale that the comparison involved.

After the interpretation came interpolation and extrapolation of the plans. One plan was made with 5 million people in mind, while the other had taken into account only 0.2 million people. Each plan with a capacity too small for the comparison therefore had to be expanded into a plan that would theoretically include 1 million people. For the plans with large capacity, a theoretical phasing-down was made in order to compare the plans' phases at which the plan capacity for 1 million was reached. Both treatments of the plans are forms of study by design in regard to plan comparison (design research).

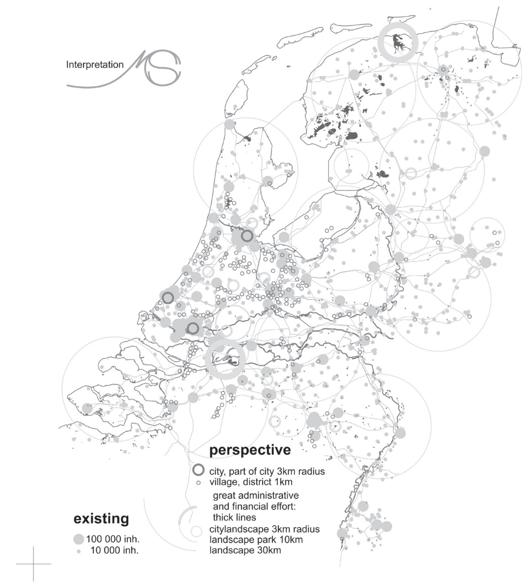
50.5 SCENARIO DESIGN

A scenario does not only contain the extension of empirically established probable developments perspective, but also the unexpected policy interventions and possible spatial interventions. When developing scenarios so as to have different conceivable contexts at hand for the decision-making process, these possible spatial compositions need to be designed. In preparation for the Netherlands' Fifth National Policy Document on Spatial Planning, four such 'perspectives' were made:[a] Palette, Stream Land, Park Land and Urban Land. These scenarios each contain, aside from different forms of policy and empirical pre-suppositions, a spatial image as well (possible design).

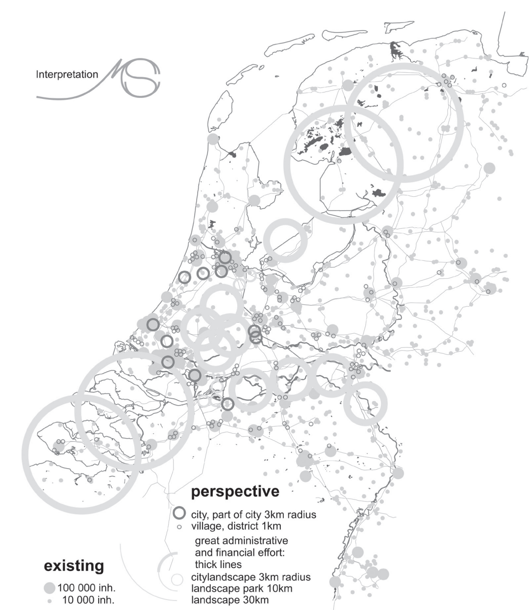
50.6 LEAVING OUT PRE-SUPPOSITIONS

At the Faculty of Architecture in Delft, Zwarts presented a constructive design assignment for a steel building *in* a hall. Thus there was no need to take into account the climate, which meant that radically deviant details and additions could be made to the exterior surface. In this process, the influence of the climate on traditional detailing became clear.

Weeber did something similar by formulating an assignment for a building for a border crossing on a site where it was always a rainy 28ºC.[c] The people on one side of the border were also twice as big as those on the other side. Hertzberger calls for 'impossible assignments' in education as well, such as a house without any view atop a flat building.[d] With these kinds of assignments, the student is forced to abandon 'self-evident pre-suppositions'; a condition for creativity. Culture is the accumulation of unspoken pre-suppositions in the process of communication. Thus in early-classical Greece, mythical pre-suppositions regarding the creation and the working of the world were of course part of the explanation. Trade confronted the Greeks with other cultures. Thales of Milete was the first person to relativize the mythical pre-suppositions (doubt) on the basis of what he perceived. The revival of arts and sciences in classical antiquity testifies to the value of raising unspoken pre-suppositions.



Palette



Stream Land

490 Two out of four perspectives, see also page 496.[b]

a In this book, the word "perspective" is meant more in the sense of "probable future" than the scenario meant here as "possible future".

b This interpretation is derived from Jong, T.M. de and M. Paasman (1998) *Een vocabulaire voor besluitvorming over de kaart van Nederland*.

c Smienk, G. and J. Niemeijer (2000) *De hand van de Meester*.

d Hertzberger, H. (1999) *De ruimte van de architect: lessen in architectuur 2*, p. 28. English translation: (2000) *Space and the architect: lessons in architecture 2*.

51 DESIGNING NATURALIS IN A CHANGING CONTEXT

FONS VERHEIJEN
JOB VAN ELDIJK
LENNEKE VAN KAN

51.1 INTRODUCTION

This is the report of a design process of Fons Verheijen. The report describes the design for the Naturalis Museum for natural history in the city of Leiden. Each illustration is indicating an important step in the design process.

Two things are important to me during the beginning of the design process: the programme of requirements and the context in terms of urban architecture. I do a lot of thinking about the programme of requirements; making calculations while manipulating the numbers. I want to get the programme of requirements completely in my head: numbers, relations and square metres. The context in terms of urban architecture is studied on its material and immaterial boundary conditions. In the case of Naturalis this was particularly important, since the entire area was still lacking order. The Leiden municipality had a global plan for the area, but no further detailing.

When this first ordering is ready, the second stage starts: the sketched design. The programme of requirements does not bring me far: so much is clear when I talk to the commissioner. Often, the commissioner is someone without a lot of knowledge of building; so he can not make his wishes clear in an unambiguous way. Usually, he does not know himself as yet what he really wants. He will always present concrete pictures. I consider it to be the task of the architect to watch out during an interview for immaterial things the commissioner is saying unintentionally. The architect is making the concrete pictures of the commissioner abstract and gives them then his own form. I enjoy finding oppositions, since they are leading usually to innovative solutions. In the case of Naturalis I had to do with professional commissioners.

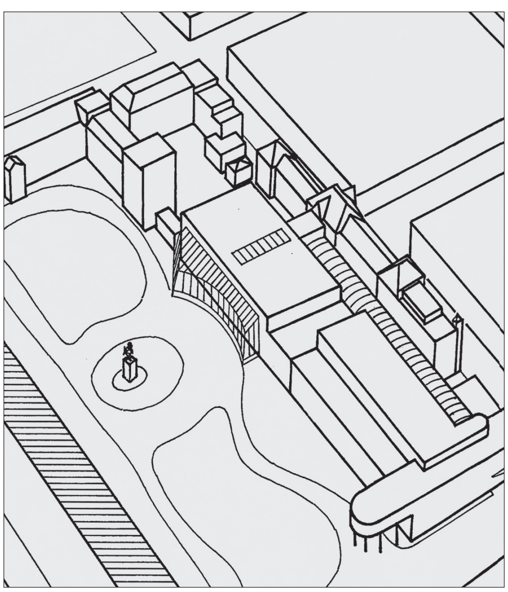
One of the first things I do, is to make an urban model and exercise on it with the programme of requirements. Usually there are a lot of wishes, proceeded from the context in terms of urban architecture and from the interviews with the commissioner. This can all be put in a drawing, but this drawing is then much too full and too rich; but this will get alright during the next stage, the stage of reduction. Reducing is a wonderful process. It is the slow removal of all that is superfluous, while maintaining the essentials of the requirements, wishes and thoughts that have been drawn. At some moment, all of a sudden a very beautiful structure is then coming to the fore. This requires that one should be drawing shamelessly. It means drawing endlessly, without any regard for beauty. Only when you are drawing something do you see whether something is wrong somewhere.

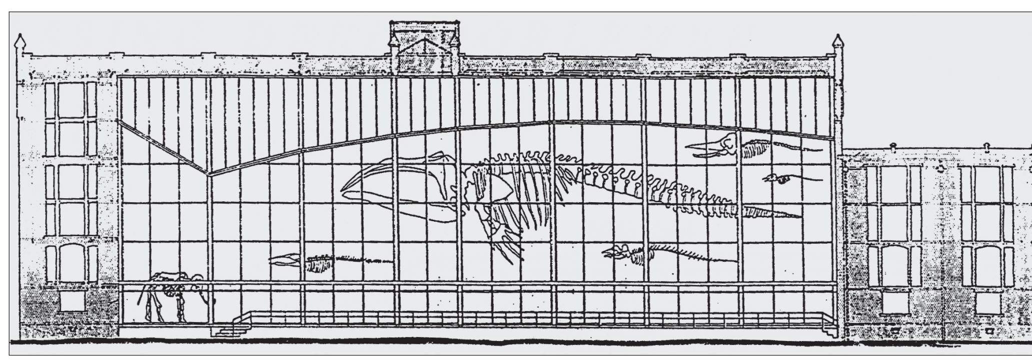
In this project the commissioner had as yet no concept of the exhibits in the building. The design of the building and the design of the exhibition went hand in hand. Therefore, communication with the commissioner was very important. By making very many models and many simple drawings it was attempted to create as many pictures as possible on which the discussion (and so the design) could go on. I never reject a first idea totally. It is always further embroidered upon. The date on which the sketched design should be ready is fixed. On the moment you are filing it, you think your design to be the work of genius. Later you think it a mess. However, it is a necessary step in getting on; for the commissioner as well as for the architect. Usually the sketched design is, as yet, less than perfect. After a while, all of a sudden discoveries are emerging. In this project there has been a number of these clairvoyant moments giving the feeling that everything was inter-locking together. Now it is a matter of erasing and making things more simple; with occasionally a sound solution for something only your subconscious self knew to be less than perfect. At a given moment in time the final design must be ready. In the design process as a whole this is a moment selected at random. You are working towards it; but you could have been designing much longer; or perhaps even better (what should not be the case ideally).

The final design is the ‘concept’; now further work must be done on the details. These detail sketches are crucial. Bad detailing may ruin a good concept completely. Detailing is a feast. Everything ends up alright. A building will become a good building if the concept is carried into the details. So in this process there have been several ‘final’ designs. Also during this stage it is of great importance to try out all solutions in models and to preserve good communications with the commissioner.

Next to the commissioner there are many more people to reckon with during the process. For sticking to your building you have to talk endlessly. For bolstering your story you will be needing a lot of visuals: models of all kinds, but also things like cartoons and very simple pictures.

51.2 DESIGN PROCESS



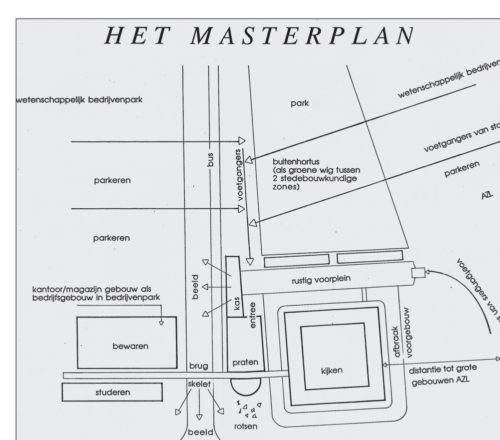


491 First idea

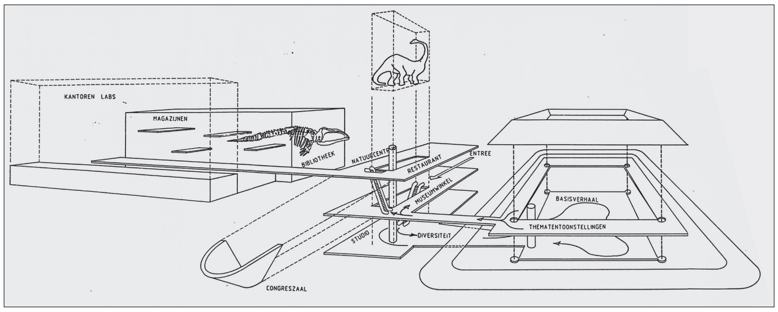
When I had restored and modernised the monumental *‘Droge Magazijn’* (1911) of the NNM, the National Museum of Natural History in Leiden, I was given the commission of the national buildings service to make a master plan with variants for the combinations and the extension of the museum buildings. Part of it was a glasshouse for storing (and exhibiting) large skeletons.
The illustrations above are a spatial drawing of the existing building with a new glasshouse and the idea of a whale floating in the air in the glasshouse that can be seen from the Van de Werff Park in Leiden.

492 Twin-city vision for Leiden

There was no exhibition space included in this museum; it was a museum of just two functions: housing a collection of conserved animals and scientific study. The ‘Plague House’ in Leiden was ear-marked as the location for the new exhibition space. In olden days this Plague House was standing completely apart from the city. Now, it is starting to become totally surrounded by new buildings. For that part of Leiden no urban plan existed; there was just the idea of the twin-city. With the railway station for a centre, a new city should come into existence, next to the historical inner city. Now it was the idea to add new building to the Plague House, so that both other functions could also move to this location, transforming Naturalis into one whole.



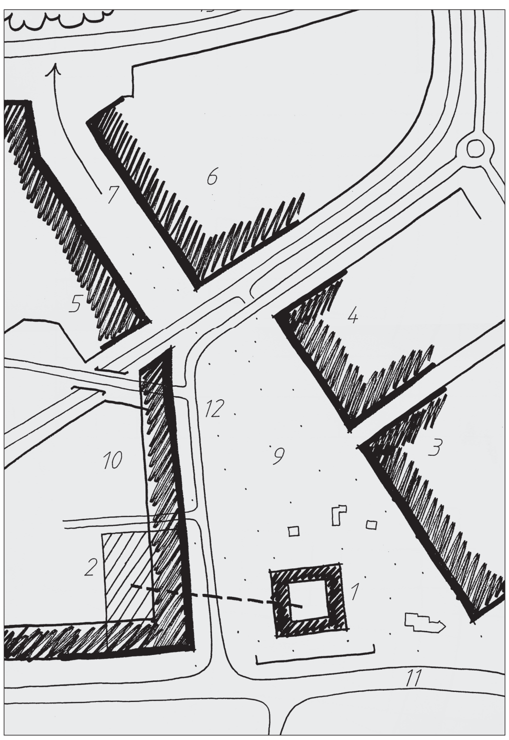
493 Blueprint of the new building



494 Spatial drawing of the new building; in it an idea for the exhibition

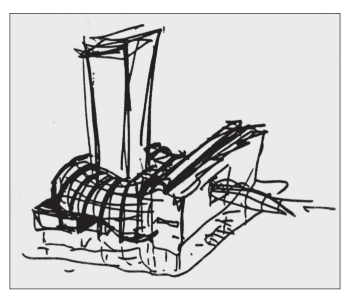
It was important for the new building that the new museum would get three functions: science, collection and exhibition. All three should be accommodated well in the new building. Because of conservation problems, it was decided that the old Plague House would not house collection or exhibition. Finally it was decided to go for a new building.

495 Workshop: all together around the model

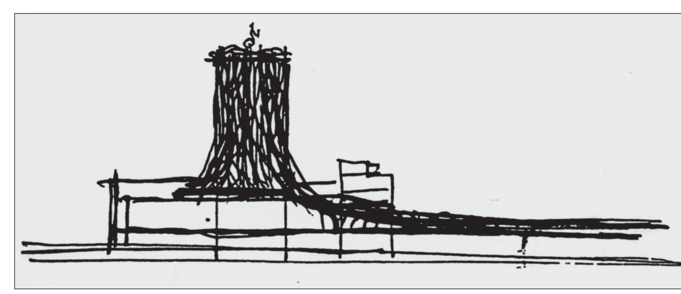


496 Urban plan

These illustrations show the plan in terms of urban architecture for leaving the Plague House area open. The museum park is also the park for the 'new city'. Form was given to this by way of a workshop with a model.
The analysis of the urban architecture resulted in the idea that the Plague House should be standing on its own with a park surrounding it. The new building would line up with the blueprint for the city.

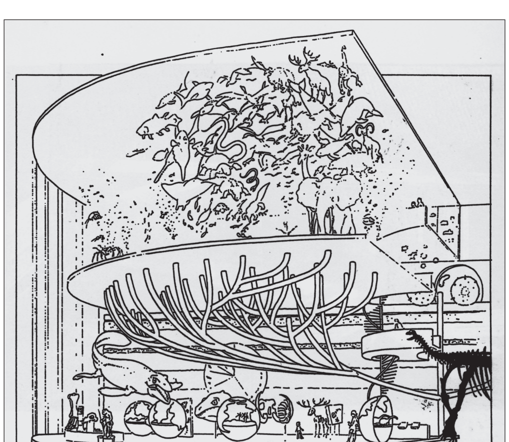


497 Tower in the middle of the building



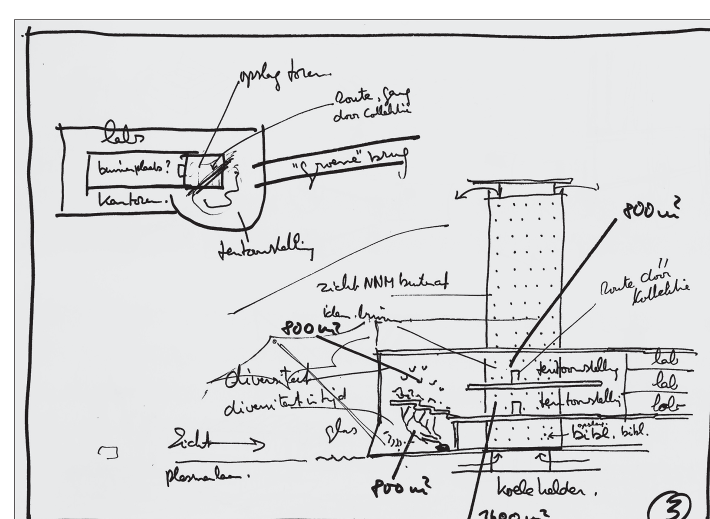
498 Through the scientific department to the collection in the tower.

The idea emerged to house the collection in a proud tower. The workshop did also show that the Plague House would also stand out better by a tower on that spot. Spatially it looked as follows: via the scientific department one arrives at the collection in the tower. The exhibition is embracing this. I made these sketches during a holiday.

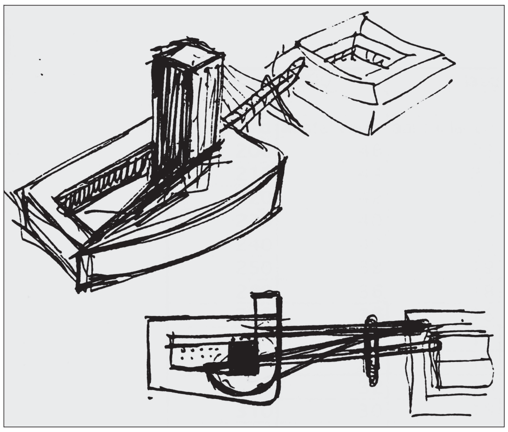


499 Exhibition concept

With the help of this picture biologists tried to explain their ideas on the exhibition.



500 Aerial view and vertical cross-section

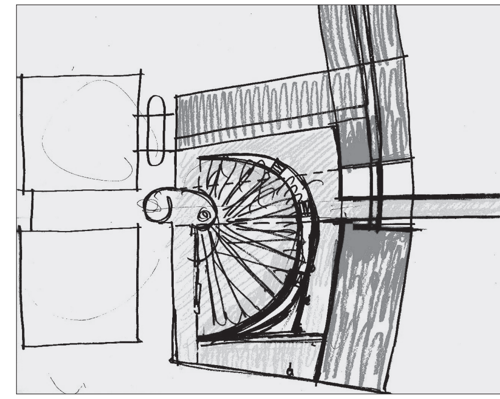


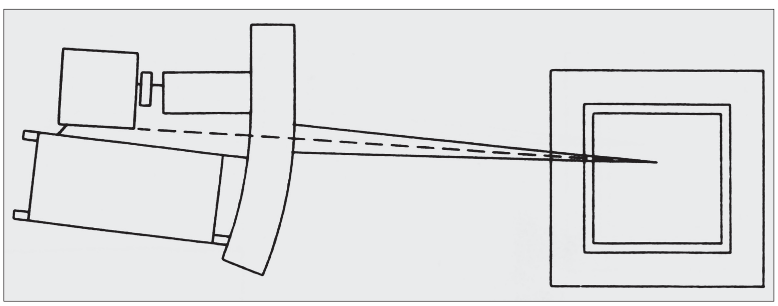
501 3D image and aerial view

Adaptation of the picture given by the biologists to the building thought out so far.

502 Test of form

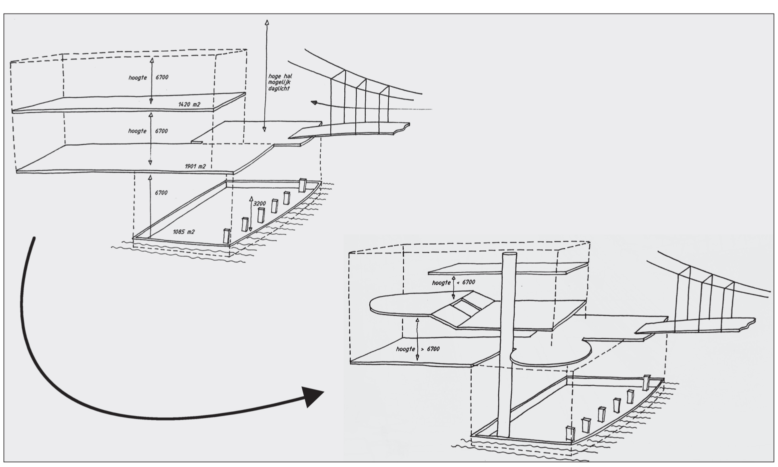
This illustration represents the further working out of an idea. The major part of the idea survives: the passing through the scientific department and the exhibition space behind it, although the last two rooms have become square ones now.

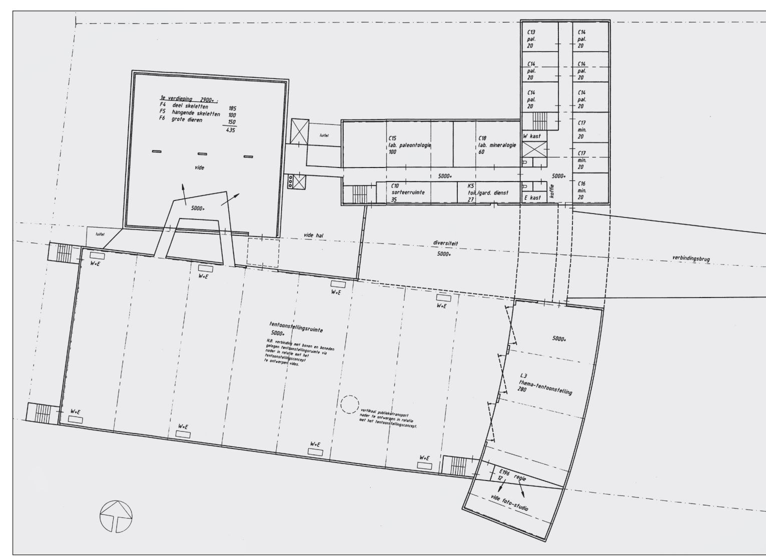




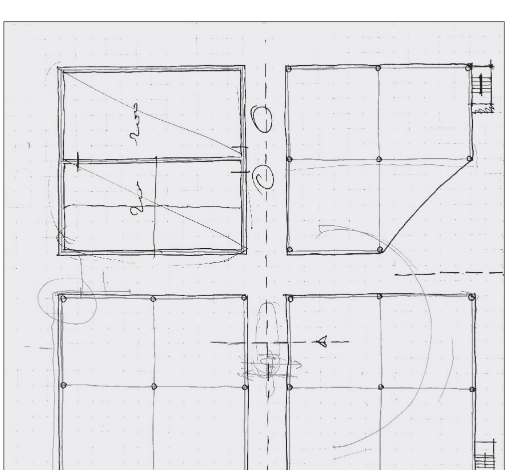
503 Blueprint

The spatial drawings indicate the spaces for the exhibition. They should be kneaded further. For the museum it now became serious to come with an exhibition concept.





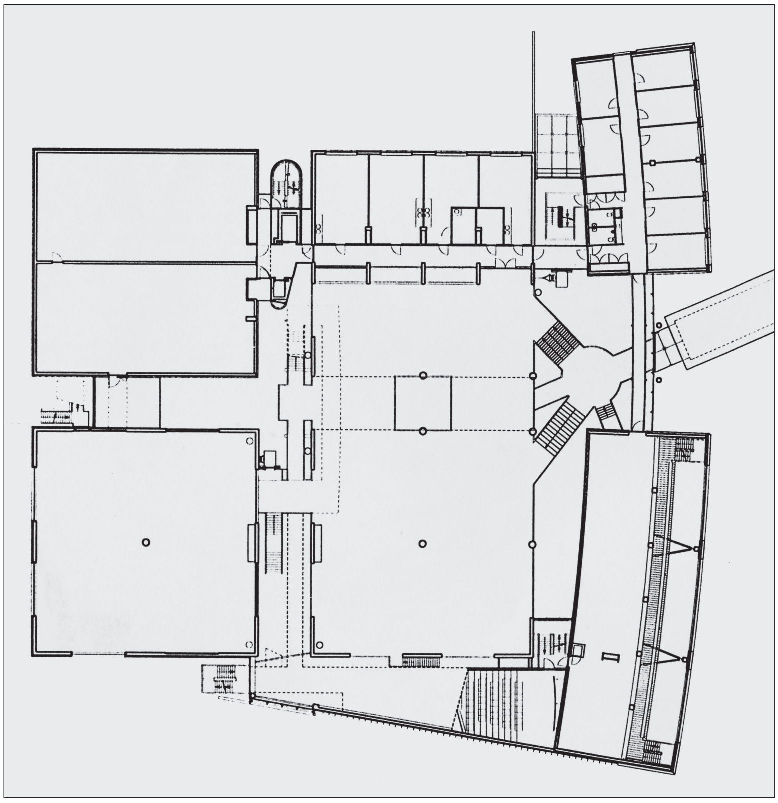
504 Blueprint from the sketched design



505 Timelessness

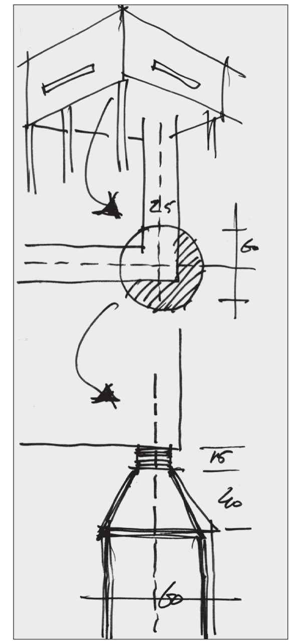
The director of the museum opposed casting the exhibition concept in stone for the building. Exhibition concepts do change in time and the building should be capable to adapt to changes like that. Finally, all wishes and ideas melted into a clear schema. The drawing represents the final stage, the last reduction: the square top-right is done simply rectangular; the diagonal is crossed out.

506 Urban plan



507 Blueprint final design

After quite an odyssey, the grid of four squares that emerged proved to match with the structure of the Plague House.



508 Design sketch of the column

509 Final result

One out of many detailing aspects: the column. The engineer calculated a column with a thickness of 60 cm. Connecting it to a wall 25 cm thick presented a problem. The solution (point of a pencil) was yielding a strengthening of the concept (floating box).

510 Photographs of the final result

The building is still standing out, but will become part of the urban landscape.

511 The image of the skeleton of the whale proves to be a constant during the design process.

51.2 LOOKING BACK

Golden moment

The simplifying of the blueprint, the way in which the zebra crossing's bridge touches the Plague House, the astronaut's suit idea for the climatic requirements within the tower and the snake's skin of the tower were the golden moments.

Impact colleagues

Particularly with connection to the models and the detailing my colleagues had significant impact on the work.

Requirement not linked to concept

A requirement not linked to the concept is that the museum is comprising three parts, not just the exhibition building. Architecturally many museums have exclusively the look of an exhibition building. In the case of Naturalis I did not want to make the elements already existing for 175 years: a scientific institute of repute and a phenomenal collection, marginal in order to glorify the exhibition department. I wanted to combine all three elements making a museum into a museum on an equal footing.

Impact of budget

The commission was characterised by high ambitions and low budgets; it was alluded to as a 'social housing museum'. However, half of the programme of requirements was earmarked for storing the collection, with a great sum budget-wise for temperature control, since the scientific collection is containing predominantly organic materials. By not conditioning the storage in the tower (20.000 m^3), but in the inner skin of the outside wall (200 m^3) a significant part of the budget could be transferred to the rest of the building.

Interface with the builders

For the tower clever constructions were devised: 2 x 4 social housing modules per floor.

Interface with the constructor

I think the architect should make the construction; the constructor is coaching and calculating. Understanding the principles of applied mechanics is giving the designer wings. Working a concept through into details may strengthen the concept unexpectedly. If one is a full sparring partner to the constructor, the construction can be managed; as in the case of the concrete beams under the scientific wing: I could halve them, with many fewer steel diagonals, by convincing the constructor of the merits of a different stability principle.

Significant transformation

The design process took its largest and highest flight during the intensive co-operation with the Director and the Faculty of Biology staff when the designing for the building went hand in hand with the exhibition concept. This design adventure resulted in the quadratic structure with the tower for one of the quadrants and in the split-level accumulation of the exhibition space: an unambiguous clear structure, in which the visitor may freely roam through the building in several ways, while keeping a birds eye view of the space as a whole without constraint.

Post scriptum

In a search process the moments of euphoria are delightful. Discussing the design with other people will sharpen one's concept. Responsibility for the design decisions; not just one's personal infatuation.

52 DESIGNING A BUILDING FOR ART AND CULTURE

WIEK RÖLING
JOB VAN ELDIJK
LENNEKE VAN KAN

This is the report of a design process of Wiek Röling. The report describes the design for a centre for arts and culture in the city of Velsen. Each illustration indicates an important step in the design process.

52.1 INTRODUCTION

The first spark for this project was struck eight years ago. Evert Jan Meijer, member of the governing board of the theatre group Amsterdam, Chairman of the '*Witte Theater'* in Velsen, and building contractor as well, asked me to build something for him. That commission came to nought, but a comparable one in Velsen resulted.

The existing theatre in Velsen is at odds with the availability of space. The building was constructed in the thirties as a home for clubs and as a cinema (REX). It was changed in 1954 by Bijvoet, who added an auditorium, and between 1988 and 1990 it was extended by the city architect of Velzen – with a lounge and a theatre house. The whole did not function as yet, but money for further improvements was lacking.

There are three more institutes in Velsen with housing problems: the *Witte Theater (the "White Theatre")*, housed in an old storage space for life-boats (the theatre wants a cinema room; furthermore the municipality has another destination for the location. Meijer saw a connection between the two); then there is a creativity centre in Velsen, an amateur academy of arts (this centre is housed in a school-building beyond its prime; in an area that will also be used for something else.); and finally there is a set-dressing workshop of set-dressing hobbyists fighting lack of space (a room free of dust is needed for painting), maintenance problems and a changed destination plan. Meijer saw that these four institutes might fit within one building: a Centre for Arts & Culture Velsen.

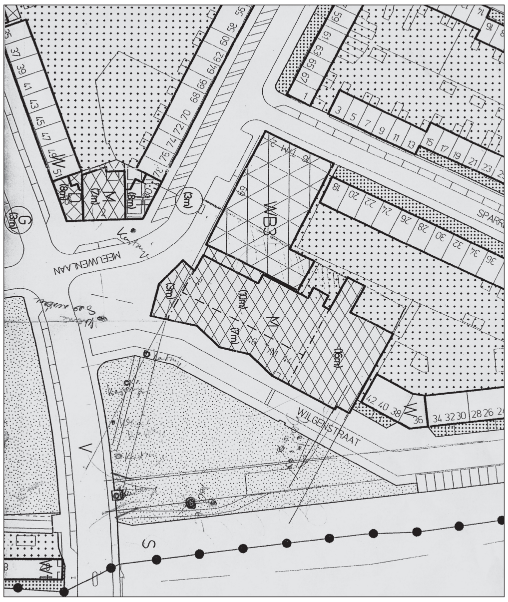
The four parties and their wishes itemised:

- *Theater Velsen*; wants a better lounge and a 'grand café', a restaurant and a rehearsing room.
- *Witte Theater*; is pleased with its present small auditorium, but would like to have a cinema. In addition the delivery of stage props is very good; the new situation should at least match it. The distinct identity of the theatre is sacred. It should be possible to organise pop-concerts with a lot of noise; that audience not mixing with the more sedate theatre audience.
- Creativity Centre Velsen; must move to a different site because of the destination plan. In addition the maintenance costs of the present building are too high. They are contented with the spaces they've got now, excepting some smaller adjustments.
- Set-dressing Workshop Velsen; is lacking a dust-free painting workshop. Like the Creativity Centre, the painting workshop is now occupying a spot in the city's centre for which the municipality has different plans; and there are maintenance problems as well. There is an additional requirement: storage for the collecting boxes of a national charity.

I received the commission to study the question, whether the programmes of the four institutes could be combined in one building. It is logical to select for the location the area surrounding the existing theatre. It features the largest auditorium, there are 900 parking lots available at the soccer stadium of Telstar, next to it, and it is fairly accessible by cars and public transportation.

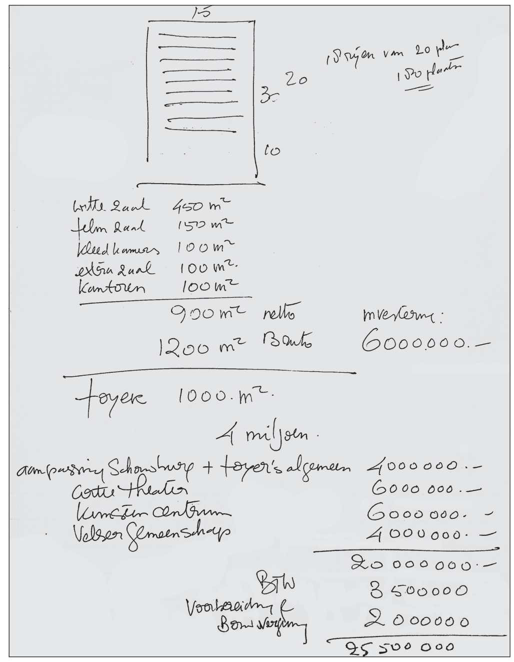
Meijer initiated a Foundation that would act as the commissioner. The Municipality and the Province (North-Holland) should also help to finance the project. The *Witte Theater* rather wanted that this commission should go to architect Crouwel. However, the parties could not come to terms in financial conditions. I was proposed by Meijer in March of the year 2000. I got a commission for making a sketched design; a model, cross-sections and floor plans, plus an estimate of costing.

52.2 DESIGN PROCESS



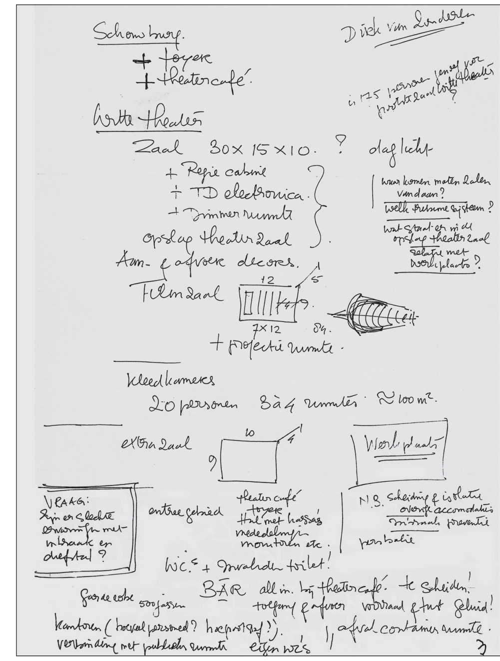
512 Visit location

As I am wont to do for each design, I visited the location first. I have been there some dozen of times. The first time I indicated on the map the positions of trees and important visual lines.



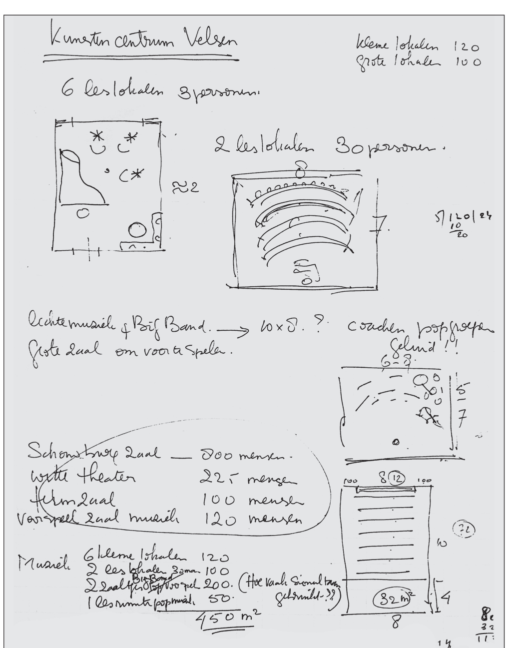
513 Costing calculation

A first global costing calculation; just to see whether it is possible to put there a new building at all.



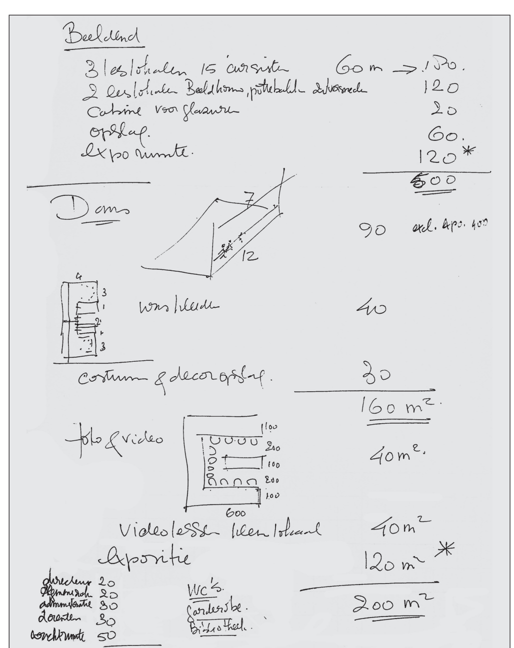
514 Programme of Requirements

I study the programme of requirements and verify it by attending the theatre performances and visiting the workshops. In this way I am learning the programme of requirements by heart. I am making notes, small drawings (without scale, 3D, floor plan, cross-section), calculations, while conducting small studies in ordering.



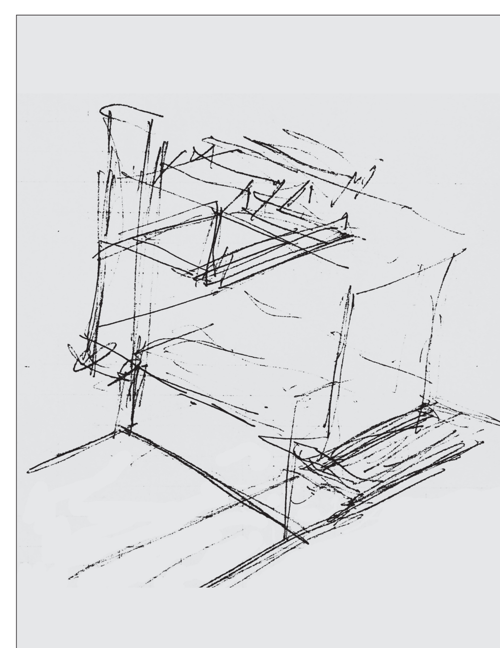
515 Interviews

I interview users and observe their behaviour in order to see whether they have been asking too little or too much in the programme of requirements. Often one is too forgetful about what is existing, while emphasising too much what is lacking. It is important that the programme of requirements should be written in accordance with function and intention, not solely in terms of surfaces.



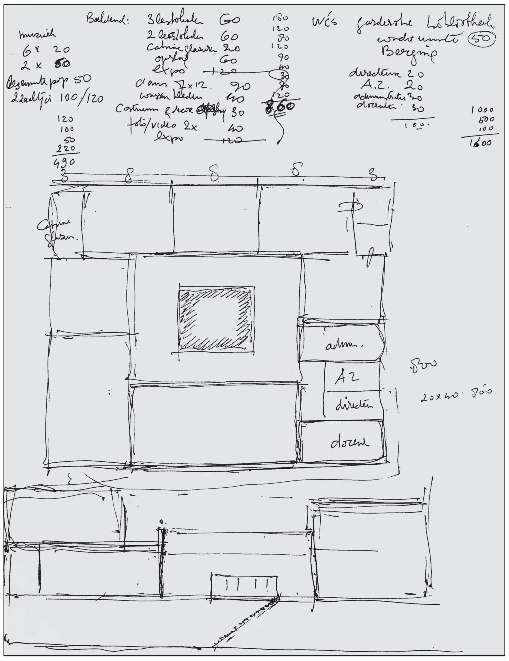
516 Experiencing

Experiencing wishes and the existing is important; if I design a house, I usually ask the principal whether I can stay over for a weekend. The design sketches are made in a fresh A4 notebook, squarely ruled, with pencil and pen, by hand.



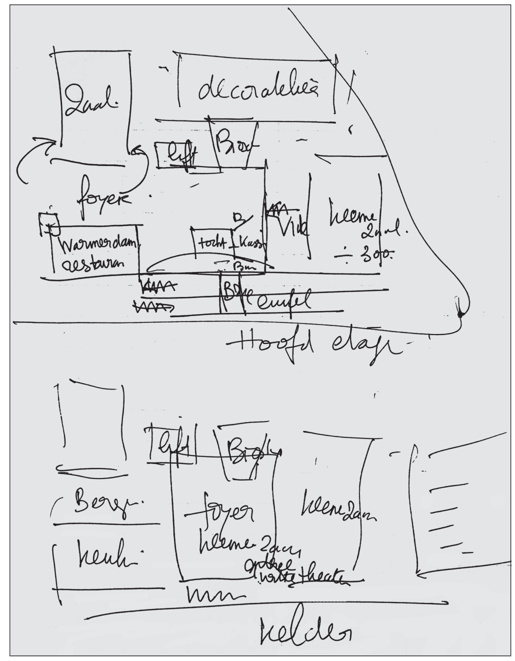
517 Northern light

It is great luck to be able to put the set-dressing workshop and the new painting loft to the northern side of the building. Usually this side of the building is less useful, but these spaces can make good use of the favourable light from the north.



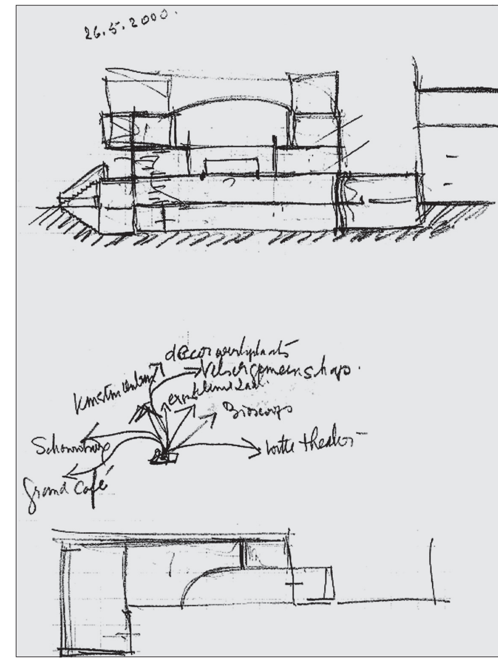
518 Surfaces

As a start I calculate the surfaces that should minimally be available.



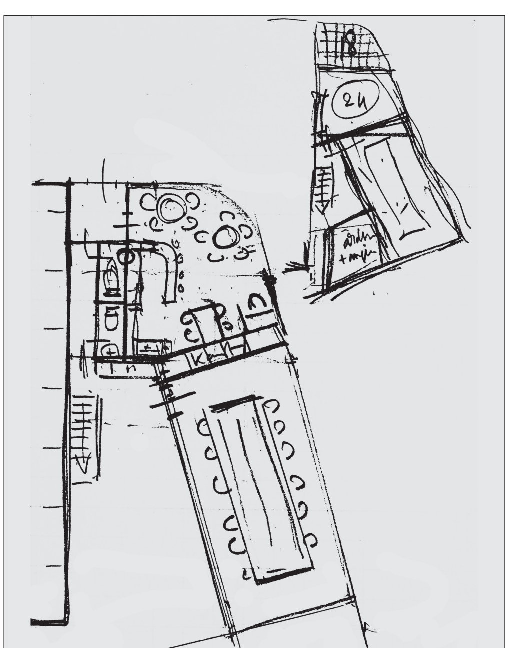
519 Rectangles

All these spaces with minimal surfaces I draw as rectangles and fit them together in order to see, whether all wishes would fit into the situation. At the same time I make a cross-section occasionally to see which spaces might fit on top of one another.



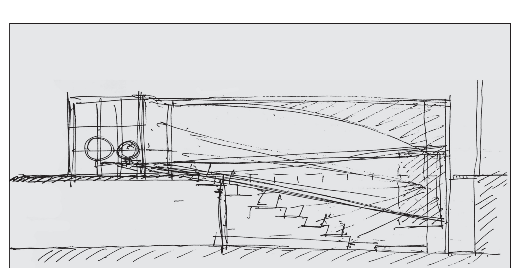
520 Light

The beauty of walking from the shared entrance for the four institutes into the light was a point of departure. This may be realised by positioning the building within a square. However, that is not possible on the site. A light from above in the heart of the building may serve the same purpose. As soon as I had imagined this, the idea occurred of an exhibition space connecting the institutes. This is something I added myself to the programme of requirements as a connecting element between the institutes. It happened in a split second and it became the guiding motive for the design.



521 Café Warmerdam

During a guided tour in the Theatre in The Hague I saw Café Wasserman, a part of that theatre. I had great difficulty with the former residence of the caretaker of the theatre in Velsen, Mister Warmerdam; and with the lounge of the theatre. In an analogy with Café Wasserman in The Hague I invented Café Warmerdam in Velsen. The example of the theatre in The Hague was the inspiration of my design intervention.
(Wasserman was a famous actress; Warmerdam is a famous now living 'actor's family' known for their movies and house 'Orkater'. The brothers Warmerdam are the sons of the former property man (and occupant of the official residence) of 'REX'.)



522 Idea for cinema: below street level

It was an idea of Meijer (remaining from the commission of the Amsterdam Theatre Group) to build the *Witte Theater* in a sub-terranean way. However, the programme of requirements specified a wish for daylight in the auditorium. In addition this vast space was some ten metres high and it was an important requirement that loading and unloading of stage props and requisites should be done very simply.
So the idea of sub-terranean building was discarded quickly, but it seemed to be a good idea to make the entrance of the balcony on the main level and the entrance of the cinema on minus three metres. The operator room can be seen as the Cineac of Duiker in Amsterdam. In this way the wish for its own identity would also be honoured.

523 Adjustment

I adjusted the spatial and organisational structure to the context of the urban landscape and the existing theatre. The trees present were no problem; I preserved as many of them as I could and gave them space. However, the adaptation built in 1988 did pose a problem. I found out that this extension was clashing with the logic of the building. Each building has its own logic, its own consistency, its own laws. Everything I questioned in terms of functioning and fitting in the new approach proved to be a part of that adaptation.

524 Line of the façade

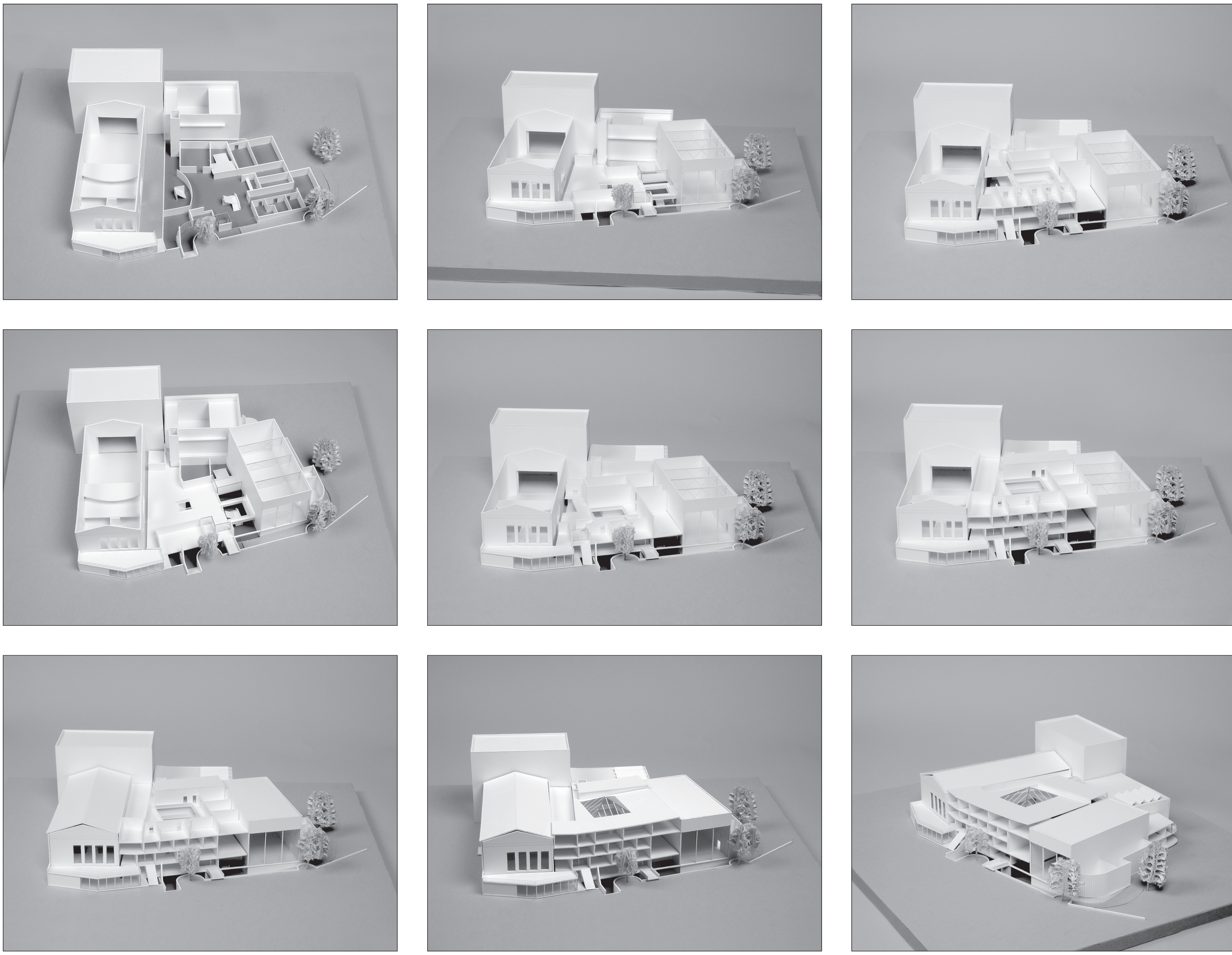
What I did take over, though, was the line of the façade of the new lounge. That became the basis for the orientation of the new building.
Now, that the organisation of the spaces, the traffic and the urban adjustment have been settled designing starts: the tuning of the lighting, the atrium, the expression of the mass of the building.

525 Exposition space

Up to now I am pleased with the accessibility, the organisation of the building, the connecting idea of the exposition space, lounge of the *Witte Theater*, entrance and in- and output.
I still want to give thought to the fact that the street is not accessible anymore for cars; and the volumes are still needing change.

526 Mayor & Aldermen

August 29, 2000 I visit Mayor and Aldermen with blueprint, cross-sections and façades.
I always make models in order to see whether there is a bottle-neck and how the form of the building happens to be and to improve the logic and "building"aspect of the design.



527 Photographs of the working model

51.3 LOOKING BACK

Start

Meijer has been commissioning me for years. Given previous experiences with him, it seemed appropriate not to begin before I had a commission. Nevertheless, I went immediately to the site to have a look; I always do.

Golden moment

A golden moment in this design is the intuition that for all forms of art collected in the building the visual arts can be a connecting factor. Other golden moments were the visit to the theatre in The Hague; the insight that I could use the exposition space as unifying element for the four parts; the example of Café Wasserman, seen during my tour in the theatre in The Hague, legitimising my making a suitable building in what is, after all, a true small-town environment.

Dead end

Up to now there has not been a dead end. In a flash I saw the solution. Actually, I always have that in all my projects. And I always come back to them.

Decisive constraints

I like to keep the existing building as classical as possible, I even try to give it more the looks of a classical theatre, so that it may be recognised as such. I want to give the *Witte Theater* the atmosphere of a real hall theatre (like theatres in factory halls). I want to give the four institutes their own identities with great emphasis. I do this by giving each institute its own entrance. In order to get a unity in spite of that, I want to make a central hall as well with a central box-office. In addition a space with visual art on a central spot can be a connecting principle. Another point of departure to me is that the building should be a hospitable one for 30 as well as for 2000 visitors at the same time. Finally, the façade should disclose something of what is behind it. However I want to give to the building a façade with the same handwriting.

Requirement not linked to the concept

I want to preserve as many trees as possible. I am also very happy with these trees in the design. I also want to bring the existing building closer to its original state. That means retracting from the change of 1988.

Indeterminacy in the design

I want to maintain the indeterminacy in the design as long as is possible; for instance in the height of the rooms.

Method

I do not work methodologically.

Budget

This is a study commission, based on a building costing 30 million.

Possible problems

Perhaps it is not acceptable that the road is vanishing; one of the partners may bow out; and the budget may get smaller.

Contact with commissioner

I have design meetings very regularly with the study group composed of representatives of all interested parties. I speak with people that have to do the work (stage manager, actors, cleaners etc.). Up to now I have already given six presentations. Everybody is very enthusiastic. That has also to do with the fact that everybody is seeing his wishes honoured. Nobody had thought that four such different programmes could lead to such a consistent building.

The use of former research or research from third parties.

Of course I read a great deal. I try to follow the development in architecture by a subscription to four periodicals and I read very many books. The periodicals I read a lot are: *'Bouw'*, *'De Architect'*, *'Gezond bouwen en wonen'*, *'Duurzaam bouwen'*, *'Oase'* and foreign journals. For a specific commission one is going to read in a more directed way. For this commission I have read as an extra book: Ian Mackintosh, "*A Book on Theatre Building*". It is about history and contains advice. Of course books and magazines about acoustics make further reading. The periodical about theatre techniques especially was very interesting.

The influence of other people on my design.

In principle I strive for making every design decision myself to take care that the building receives a great consistency of thought. The influence of future users is great; beyond measurement. I keep on speaking with them until I understand what they want and make and change proposals until they are content or do not change them if I can persuade them that my proposals are better than their ideas. The installation advisor and particularly the construction advisor do have a great influence on my decisions, provided that their result pleases me. I want their advice as early as possible in the design process, so the building, not only concerning its use, but also the 'making', looks self-evident. (Logical building methods are often to be realised more easily and through that more economically.)

Iterative and more cyclic design process?

Alongside all attempts I do to rationalise my choices (analysis of the place, analysis of the methods of the making) to me the designing is an absolute intuitive, inimitable process. Very often I have a flash of the requested building at the first meeting with the commissioner. I see it, so to speak, before me and can 'walk' in it. The reality value of that image is often as unreal as buildings you dream of, in which rooms seem to lie logically near to each other. As soon as you think what the building looked like when you awake you discover that such a building can not exist at all.

During the work (finding out what the building should look like) the invented building appears continuously in my head. And, if the building is noted down and recorded, often very soon in the beginning of the design process, I continuously doubt whether this is, indeed, the best solution.

It happened to me once that I finished my design in a week, then for at least four months I tried out all kinds of alternatives, tested them to the analyses, discussed them with eventual commissioners and discovered at last that the best plan in my opinion very much resembled the plan of the first week. However, these months of wrestling with the right plan turned out to make the setting of functions and their relation to the construction more logical.

53 CONTEMPLATIONS FOR COPENHAGEN

WIM VAN DEN BERGH

The architectonic commission described here and its execution did not commence (in the usual way) with a programme, a piece of land and a budget within which an architect is asked to deliver a solution for a spatial-material problem. The problem was, that there was no 'problem'. Circumstances of a much different type applied. A commission like this makes one conscious of one's own professional conditioning.

53.1 INVITATION

In 1996 Copenhagen was declared cultural capital of Europe. Helle Juul and Flemming Frost had conceived of an opening exhibition that would be called *'Overlooking the City, Copenhagen as it is perceived'*. With this in mind, next to artists, film-directors etc. five foreign architects were invited: David Chipperfield, Enric Miralles, Thom Mayne of Morphosis, Hani Rashid of Asymptot and the author. The task we were presented with as architects was called *'The Cartography of the Pause – Architectural Visions for Copenhagen'*. There is a certain esoteric ring to this title and also the material accompanying the invitation did little to clarify the (architectonic) commission, to indicate the 'problem' or the question.

The commission as a whole however made a thoroughly professional, excellently produced and well-considered impression; sufficient to accept the invitation. The wooden cassette, built with sophistication, that contained the material, aroused already curiosity before its content could be inspected. The opening of this cassette displayed on the inside of the lid the invitation and the concept for the exhibition. The box itself contained, covered by a wooden plate engraved with numbers and lines, and perforated with sixteen quadratic holes, the following:

- a foil with UTM[a] gridlines;
- an aerial photograph of Copenhagen;
- a number of black and white maps showing the historical development of Copenhagen as a spatial-material fabric;
- and sixteen quadratic cuttings from an aerial photograph[b] with grouped around them for each cutting four photographic renderings of the respective directions of viewing from the intersection of the grid lines.

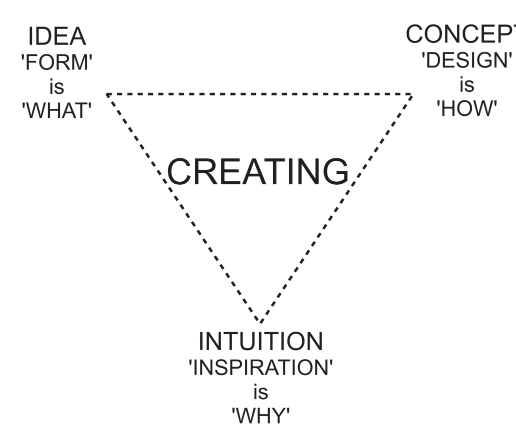
That had to suffice.

On a moment like that, one realises that – in contrast to the usual professional commission –a disciplinary commission is involved, in which architecture is interrogated as a (scholarly) discipline, as a way of thinking and acting: and by the same token of (spatial) designing.

53.2 BEGINNING

Additional scrutiny of the material also provided precious few hints to find the direction for a design. The task had to be interpreted and defined on the basis of the individual self; if something had to be designed at all. The 'problem' was the problem of creation itself, the question of the 'beginning'. The moment the 'what', 'why', and 'how' questions, fundamental to creating (or 'designing') come to the fore simultaneously.

The first choice made, the first step put into the direction of the unknown, can not be thought logically or rationally. The first step is – by definition – pre-conceptual. 'Creating' simply takes doing (and the courage needed for it): that is literally and figuratively the 'art', preceding all science and knowledge.



528 Creating

a The Universal Transverse Mercator Grid is a co-ordinate system for position determining on the globe with respect to the projection of this globe on the flat surface of a map.

b Scale-wise these were cuttings of 100 x 100 metres in reality with the intersection point of the UTM gridlines for a centre.

53.3 CONCRETISING FREEDOM

Creating is a form of spontaneity hovering on the edge of what is possible and what is real; on one side shunning a mode of randomness – in which everything is possible – on the other, a mode of absolute determinism; in which just one possibility finally remains. This freedom as creative imagination is therefore a form of spontaneity within structures and rules.

Merleau-Ponty terms this capability to generate a situation within which things become possible (and only because of it) 'concrete freedom'.[a] Usually it is a form of freedom emerging if one takes a certain distance to 'reality' and recognises that something like a 'playing-field' or 'space of the possible' does exist. In this case exactly the opposite applied. The 'playing-field of the possible' had to be restricted in an earlier stage in order to be able to come to the 'reality' of a design.

As in any design, the art is to design a 'game of creation'. In it, the 'act of designing' (as a process) is itself the playing of the game that creates something. Like poets are wont to, but architects as well – just think about the *oeuvre* of John Hejduk – I thus had to formulate for myself some rules (a structure) that could and should enable the 'game' of designing.

53.4 INTERPRETATION

My interpretation of the material and the title: *'The Cartography of the Pause'* boiled down to that it centred around the question to what extent the notion of place, as defined by the intersections of the U(niversal) T(ransversal) M(ercator) grid may be put into relation with the place in the urban fabric of Copenhagen.

My definition of the 'problem' (the commission) became endowing form to the relation between – on one side – a very precise abstract point – a (geometrical) 'place' as dictated by 'higher powers' 'top-down' ;and on the other side the concrete, spatio-material 'non-place': as witnessed on the projectionof this point in reality. This calls for instituting a (spatial) ordering linking the abstract (the 'higher') to the concrete (the 'earthly').

53.5 INAUGURATION

This is an old, and to architecture, fundamental 'problem', considering the two main reasons why the cultural phenomenon 'architecture' was invented at all. Architecture is on one side the predominantly physical protection against earthly 'nature'; on the other it is the pre-dominantly spiritual ordering of that same (but now a higher, so-called 'cultivated') 'nature'.

In whatever way we look at all cultural phenomena – be they architecture, language, legislation, manners and morals – they are always forms of ordering. They all order a certain kind of 'space'; or, in the perspective of Huizinga's phrasing[b], they define a 'playing-field'. In this regard this 'making into a place' of a 'non-place', this creation of an ordering of 'space' (and time) is a fundamental (architectonic) act. In antiquity it had its own (playing) field and (playing) time, its own ritual. Stonehenge, pyramids and temples, all of them (re)present a space-time ordering of this (higher) 'nature'.

It just happened I knew from Rykwert[c] the description of the ritual Etruscan and Roman priests – the 'Augurs' – performed in Antiquity in order to found a new city or temple. Founding means the making into a place of something that in space and time has no place as yet: literally 'inaugurating', instituting an order. In Rykwert's description of this ritual some points come to the fore displaying much affinity with the material I received from Copenhagen. It did not take too long for me to understand and to get the idea to introduce this ritual by way of a 'rule of the game' and to observe what it would yield towards a design.

53.6 CONTEMPLATION

Transforming a 'non-place' into a 'place', commencing it to become part of the ordering of the 'space' (or the territory), as it comprises the grand total of all 'places', involved for the Romans an old and complex ritual, called *'contemplatio'*. This *contemplatio* consisted out of: the naming of 'signs', a 'circumscription' of the panorama as viewed by the Augur within

a Merleau-Ponty, M. (1962) *Phenomenology of perception*, p. 434-456. Originally published in French: (1945) *Phénoménologie de la perception*. Dutch translation: (1997) *Fenomenologie van de waarneming*.

b Huizinga, J. (1952) *Homo ludens, proeve eener bepaling van het spel-element der cultuur*. English translation: (1980) *Homo ludens, a study of the play-element in culture*.

c Rykwert, J. (1988) *The idea of a town: the anthropology of urban form in Rome, Italy and the ancient world*.

the *'templum'*, as well as contemplating, 'reading' and weighing (interpreting) the significance of the 'signs'. Our word 'temple' still refers to this concept 'templum'. Literally it stands for 'the defined open space within which the signs are read and interpreted'. The Latin *templum* goes back etymologically to the Indo-German stem *'tem'*, indicating cutting. As such it establishes a strong architectonic link to the 'cutting out' (in the sense of defining or de-termining) of a 'space' from the infinite, 'natural' space.

Much the same can be observed in the etymology of the enclosed sacred space of the Greeks of Antiquity, the so-called *'temenos'*, referring in a similar vein to the Greek verb *'temnein'*, also meaning cutting.

The temple is a cut-out space within which the signs become significant. According to Rykwert the specific elements of the ritual of this *contemplatio* were: *'conregio'*, *'conspicio'* and *'cortumio'*. In this the Augur proceeded as follows.

For the *conregio*[a] the Augur drew with his staff (the *'lituus'*) a diagram on the ground. In doing so he divided the space of the *templum* and determined as well the four main directions: east, south, west and north. At the same time he named the 'significant' elements in the landscape defining the *templum*, by way of pointing at them with his 'lituus'.

For the *conspicio*[b], conducted in parallel with the *conregio*, the Augur followed with his eyes the direction of the gestures of the other one. By looking around and gesturing he united the four separate *templa* of east, south, west and north into the whole space of the templum, defined and ordered now; subsequently he internalised them for the contemplation.

Next, he pronounced the *"legem dixit"* (the what the law says, or what the rule prescribes). This way he made a kind of covenant on the future, by indicating on what topic he made a prophetic statement and which omens or preceding 'tokens' were meaningful in this respect.

Finally the *cortumio*[c] ended the ritual of *contemplatio*, when the omens, signs or tokens were judged by the Augur according to the rules of his 'art and science'.

This ritual of the *contemplatio* got its name on the basis of the diagram, the pattern (or the 'template')[d] the Augur kept projecting on to space to order it. The (geo-metric) pattern of a square or a circle, with which he represented the defined (cut-out) space, with on top of that – starting from the middle - a cross, dividing the infinit space and as such ordering it in four directions: 'in front / east', right / south', 'behind / west' and 'left / north.

The combination and sequence of 'in front-right-behind-left' and 'east-south-west-north' I use deliberately here, since 'in front-right-behind-left' originate naturally from the upright human body; they are relative compared to 'above' and 'below'. However, the Augur – in seated position – created a 'fixed' ordering; in the largely horizontal space of the territory, by making use of the ('fixed') course of the sun, that made the space, with its 'fixed' ordering of above-below truly three-dimensional; if not four-dimensional.

53.7 CONTEMPLATIVE INTERPRETATION

Looking now to the material I received from Copenhagen, and particularly, to the cutouts taken from the aerial photograph, with the four views in the directions of the UTM grid lines, the ensemble actually embodies sixteen different *templa*.

One could say that one's task as an architect in this case may be regarded as the one of an Augur with the responsibility to 'contemplate'. To myself I regarded it in such a way that I was supposed to interpret the 'signs' that I could recognise in the several *templa* and to make a 'pronunciation' about them by way of a 'design'.

In any case, one has the feeling now to have come a bit closer to designing through this analogy with the ancient Etruscan-Roman ritual for founding a city; after all, this ritual did put on a wealth of architectonic forms,- just think of all the cities and temples built by old Etruscans and Romans.

a The *'regio'* in *conregio* represents a direction and/ or border and refers in its turn to the Latin verb '*regere*', meaning 'ruling, guiding, directing', as a form of movement in a straight line.

b The *'spicio'* in *conspicio* is referring to *'spicere'*, meaning 'watching carefully' or 'observing'.

c The '*tumio*' in *cortumio* is etymologically akin to '*tueri*', meaning 'watching carefully', 'observing' and 'contemplating', as also heard in words such as intuition and tutor.

d Hence the English word 'template' for a linear mould.

529 Labyrinth, after ancient Cretan coin[a]

At the same time it is clear that this does not say anything as yet, because ‘what’ should now be designed? You just know, you could also conduct a ‘conspicio’ and try to read the ‘signs’ per place from the photographs. And also one might apply a ‘conregio’ by projecting on each place a directed diagram, a ‘template’.

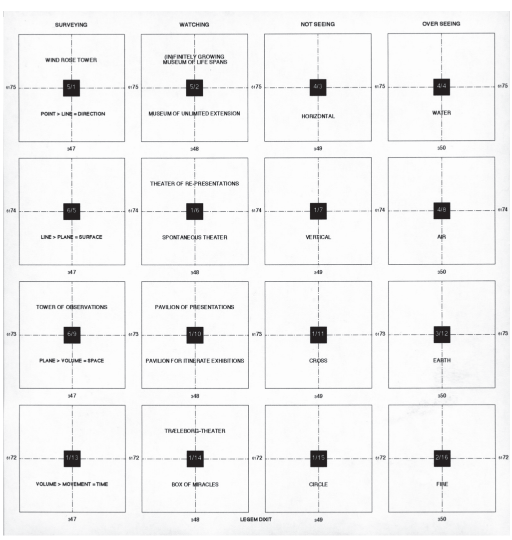
For the Augurs such a diagram usually was a square or circle, with within it a cross. I choose the diagram of the labyrinth according to the myth designed by the architect Daedalus.

53.8 LABYRINTH TEMPLATE

This labyrinth figure might be square or circular as long as it has seven tiers:[b] a labyrinth of the Cretan type. The labyrinth is not only a kind of architectonic (spatio-temporal) ‘diagram’, with an old fascination on me because of its many ‘dimensional’ aspects, but it also has a lot in common with the diagram employed by the Augurs.[c]

In addition to the *conspicio* and *conregio* it is possible to apply a *cortumio’* as well: that is to say: one may judge the ‘signs’ in relationship to the labyrinth diagram from one’s perspective as an architect and let it accumulate in a concrete design.

The process of designing or creating may be seen as a continuing cycle between three questions: ‘what?’, ‘why?’, and ‘how?’. In this case I could cover the ‘why’ in first instance by the ritual of the *contemplatio*. There was no need to worry as yet about the ‘how’ question: that is in first instance concerned with one’s own confidence in oneself as a designer. Before that is put to test however, one should first know a little more about the ‘what’ to be designed.



530 Matrix

So the game needs an internal logic, similar in a sense to the *legem dixit* (‘the rule says’) in the ritual of ‘contemplatio’. The most obvious internal logic was the one of the matrix, of the 4 x 4 points themselves as prescribed by the material itself. I could make groups of four points which had to be charged next by a theme. Given the fact that not only the 4 x 4 places were numbered through horizontally, but that in the description of the concept for the exhibition four themes were also indicated - all of them associated with ‘looking/seeing’ - I simply used these themes, respectively ‘surveying’, ‘watching’, ‘not seeing’ and ‘overseeing’, as the vertical grouping principle of the ‘matrix’, in the present case perhaps better called the ‘playing field’.

This also does not provide, as yet, a concrete ‘what’ for the various points, but resulted in more ‘order and structure’.

53.9 CONSPICIO

The next step was to play the ‘game’: that is to say to conduct the *conspicio.* And you start to understand that this has many similarities with a psychological association test. In order to get from the start many associations and so to see which ‘signs’ in the photographs were ‘significant’ (meaningful) I asked all my colaborators to write down per place and photograph some key-words; without giving it much thought, ‘from the gut’ as it were. I collected their reactions and looked at them together with the photographs from the perspective of the (vertical) themes in the matrix. I stood surprised by the consistency one can apply as an architect in such an ordering by some fantasy.

It is an old principle, particularly applied by writers. A fine example is Italo Calvino’s *‘The Castle of Crossed Destinies’*, in which he generates, with cards from the Tarot he puts out in a matrix, vertically and horizontally a number of stories.[d] These stories originate from the elements he finds on the pictures on the cards. Consider also Georges Perec’s book *‘Life; a users manual’*[e], in which he does something similar from a picture of a doll-house like cross-section of a 19th century apartment building.

This *conspicio,* linked to the *legem dixit* (what the ‘law or rule’ says about the theme), provided me with a further structuring of my ‘playing field’. Now I could venture into the *conregio* and *cortumio* of actual design.

a Source: Kern, H. (1982) *Labyrinthe, Erscheinungsformen und Deutungen 5000 Jahre Gegenwart eines Urbilds*.
b That is to say that the labyrinth should be of the Cretan type.
c Not to be explored further: a story in its own right.
d Calvino, I. (1977) *The castle of crossed destinies*.
e Perec, G. (1987) *Life: a user’s manual*. Originally published in French: (1978) *La vie, mode d’emploi: romans*. Dutch translation: (2001) *Het leven, een gebruiksaanwijzing*.

53.10 SURVEYING

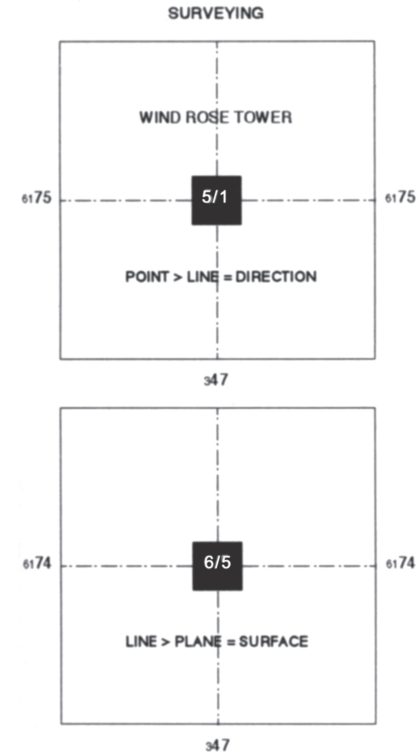
The vertical row of 'surveying' could, for instance, rather easily be read from a geometrical point of view of surveying as land measuring.

On the first location the wealth of lines was apparent, for instance, on the second the squared planes of the pavement, on the third the enclosure at four sides of the inner court in a building block and on the fourth the railway cars on a platform of exchange:

point → line = direction
line → plane = surface
plane → volume = space
volume → movement = time

This resulted then – while continuing to imagine and associate – in an ordering of the kind we know from a drawing by Paul Klee, in which he tried to clarify by arrows the various geometrical dimensions.

From the point (dimension zero) the line (first dimension) grows via an arrow of movement. On its turn this line transforms through arrows of movement to a plane (second dimension), then to a volume (third dimension, space).This volume may then be imagined as a representation of the fourth dimension, time; again, through an arrow of movement.



531 Surveying

53.11 WATCHING

The second vertical row, with 'watching' for its theme, proved programmatically to be the easiest one, since I could associate in this row 'watching' via the 'signs' per location with the unity of the four elements occurring continuously in the oeuvre of Le Corbusier as a kind of *'Gesamtkunstwerk for watching'*. The architectonic work of Le Corbusier as a whole is pervaded by a kind of obsession for the eye and for watching.

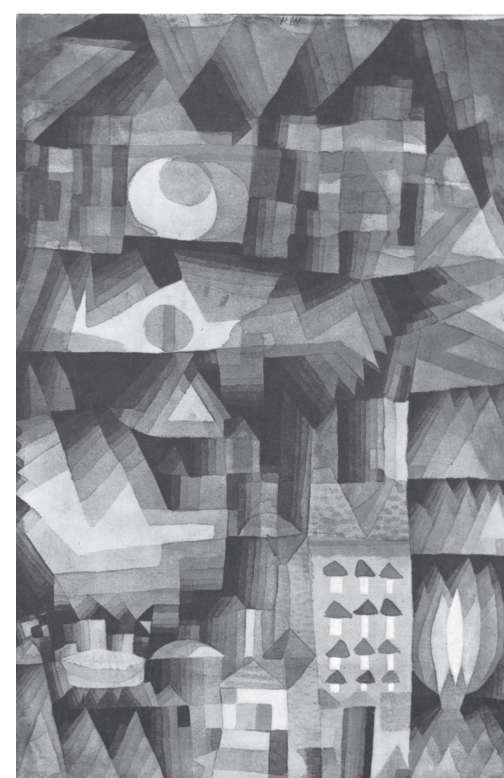
Every time when he projects in his many urban plans a *'Musée à Croissance Elimitée'* again, this is accompanied by a *'Boîte à Miracles'*, a *'Théâtre Spontanée'* and a *'Pavillon des Expositions Temporaires'*. Obviously these designs do already have a programme.

In my case the 'Museum of Unlimited Extension', situated qua *templum* on a churchyard, became an '(In)finitely growing Museum of Life-spans'.

The 'Spontaneous Theatre', situated in the park of the Palace, became a 'Pavilion of Representation'.

The 'pavilion for Itinerate Exhibition', situated opposite the building of Parliament, became a 'Pavilion of Presentations'.

The 'Box of Miracles', situated qua *templum*, opposite of the old ramparts, became a 'Traeleborg Theatre'; more on that later.



532 Paul Klee, *Traumstadt*, 'Dream City' (1921) Watercolor and oil, 18 7/8 x 12 1/4" ; Private collection.

53.12 RESULT

The remaining two rows will not be dealt with, since there was not space enough within the concept of the exhibition for more designs. I made designs for six locations: two from the first and four from the second row. Per row I formulated some playing rules, such as the material used and the technique for the making of the models (perspex for the first, wood for the second row).

With the rather strict exhibition regimen in view, dictated by an exhibition piece of furniture with three large, upright double glass-plates, I presented each design as a model, scale 1/ 100 in a perspex cube of 30 cm and a quadratic perspective drawing of 60 cm in pencil. This was drawn in such a way that the 'outside' of the design at one side of the transparent paper was visible in the 'inside' of the design, rendered at the other side. In addition there were per design one or two quadratic computer drawings of 30 cm, with plans, sections, elevations and an explanatory text.

So what was presented on the exhibition in Copenhagen were six 'contemplations', six designs for six different locations, all based on the same two-dimensional labyrinth diagram (one circular and five rectangular, in terms of basic pattern and measure all identical). Seen from above, the intersections of the UTM grid lines would thus be marked by the same two-dimensional emblem of the labyrinth (circular or square), while in reality they would represent as three- and four-dimensional architectures each of them a different spatial experience and ‘function’.

53.13 INTUITION

As a piece of study by design this project clarifies what happens often subconsciously as intuition in the process of creating. Intuition is the knowledge and capability embodied in the person of the designer that operates on a level between the un-conscious and the conscious. Intuition, or in-sight[a], plays an important rôle in the design process, because one has to be able to follow as an architect, designer and generator of form (and within the design process of course also as an evaluator) a rapid route on the edge between what is possible and what is real.

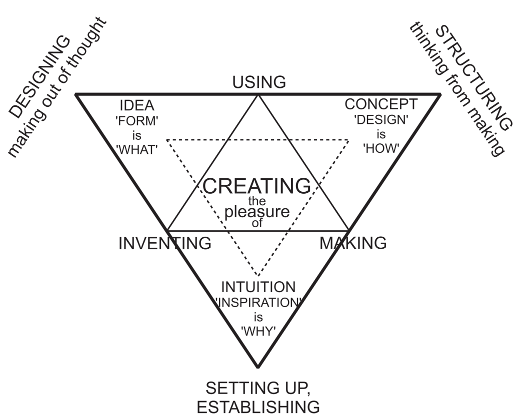
It is a narrow road. On one side the ‘scientific and objectivistic’ monster of absolute determinism is lurking; on the other the ‘artistic and subjectivistic’ monster of gratuitous randomness. One operates in an in-between area that one has become to embody insight through embodied experience.

Deliberately, the word ‘embody’ is used. Still, all too often, it is attempted to ascribe insight in Cartesian sense to a so-called ‘pure’ spirit, severed from the body. A morality claiming descent from Plato further sees to it that we extol in our western culture thinking above acting. The work of the hand is still regarded as subservient to the work of the mind. However, Plato was a ‘thinker’ by profession, and lived in a culture where slavery was normal.

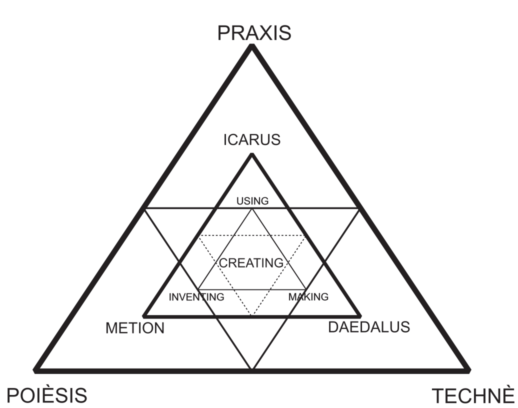
It takes one’s entire somatic reality to experience and to learn; and I mean by ‘embody’ exactly the unity of ‘body and mind’ as one meets with in Waldenfels[b] or Johnson[c]. In the same way one arrives at one’s own experiences physically – and to a high degree unconsciously – this ‘area in between’, the area of the ‘imagination’ (one’s powers to imagine and to (re)present) as an architect is not explored exclusively by thinking, but (particularly) also by doing.

Just ‘thinking a design’ resembles trying to learn to ride a bike theoretically. In the first instance certain things are learned by doing; and it often helps not to think at the same time, but to postpone it to later. In the case of ‘designing’ we could talk about an ‘art’ in the fundamental meaning of that word, knowledge and capability linked to insight and vision.

During designing these embodied kinds of knowledge (science) and capability (art), manifest this ‘experience’ (physical) by insight, or intuition. The concept ‘intuition’ comprises next to insight also the aspect ‘vision’, that is so important to designing.



533 The Pleasure of Inventing and Making



534 Setting in Classical Philosophy

53.14 CREATING

As we use it in our discipline, the concept ‘designing’ puts too much emphasis on just one aspect of creating: thinking. That is the reason why I use the word ‘creating’ here. By creating I intend to indicate at one side the ‘making’, the rather ‘profane’ form of creating that should always be serious, and on the other ‘creation’, the rather ‘divine’ form of creating that can and should be occasionally frivolous and idiosyncratic. When we try to understand how creating goes about its business, we should first inspect the mindsets in which creating as a philosophical category is viewed in western culture in past and present.

Within Greek philosophy (and its predecessor, mythology) we discern largely three modes of creating: *‘poièsis’*, the rather abstract, spiritual way to create (think of the semantically inclined figure op the ‘poet’); *‘technè’*, the rather concrete, physical way to create (think of the rather syntactically inclined figure of the engineer, the ‘technician’); and *‘praxis’*, the creating that originates from using, from executing and performing (think of the rather pragmatically inclined figure of the virtuoso).

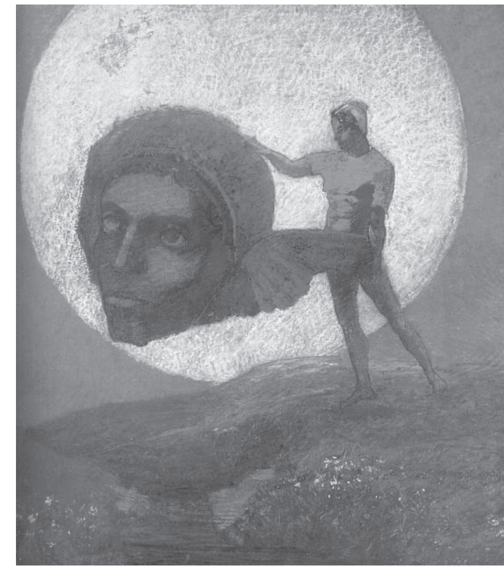
a Intuition is derived from Latin ‘*intuèri*’, meaning ‘looking at’, ‘contemplating’.

b Waldenfels, B. (2000) *Das leibliche Selbst, Vorlesungen zur Phänomenologie des Leibes*.

c Johnson, M. (1992) *The body in the mind: the bodily basis of meaning, imagination, and reason*.

Creating as the human mode of the 'divine game' of creating may be seen as the pleasure and satisfaction in the 'game of thinking out (inventing), making and using'.

The three faces of creating: very schematically and coarsely expressed in *poièsis*, inventing, *technè*, making, and *praxis*, using (and evaluating) can admittedly be distinguished from one another, but do remain a tripartite unity, enabling the game only as a closed form. This tripartite unity is reflected in the predecessor of philosophy, mythology. The unity is presented as a family relationship between mythological figures representative for ('human') creating. The best-known figure is Daedalus, the mythical architect-engineer-artist-inventor, the 'Maker', representing *technè*. His name is derived from the Greek '*daidal*', meaning something like 'cunningly crafted'. His son, Icarus, the 'User' of the wings made by his father represents as the first test-pilot *praxis*. Daedalus' father Metion, less well-known, is the 'Thinker'. His name is derived from the Greek '*metis*', meaning not only spirit, but thinking as well. He represents *poièsis*.



535 Odilon Redon, *The fall of Icarus* (1900) pastel, The Rothschild Art Foundation.

The idea of triple unity and trinity also exists in the Christian version of the 'Creating' (divine) Trinity in the figures of God the Father, Creator of the world, Christ the Son, descending into the world to try it, and the Holy Spirit, surveying the ensemble from up above.

However, the most important aspect for 'creative disciplines' in general and for architecture in particular is the joy one should experience as 'designer / creator' or 'architect / artificer'. One experiences it in the trinity of inventing, making and using, or of what one designs (invents), endows with form (makes) and applies (uses, tests and evaluates).

'Designing as planning' stands for 'making by thinking', 'designing as giving form' for 'thinking by making' and 'applying/ evaluating' for 'the evolution of what has been thought and made, by re-thinking and re-making again and again'.

53.15 THE TRAELEBORG-THEATRE

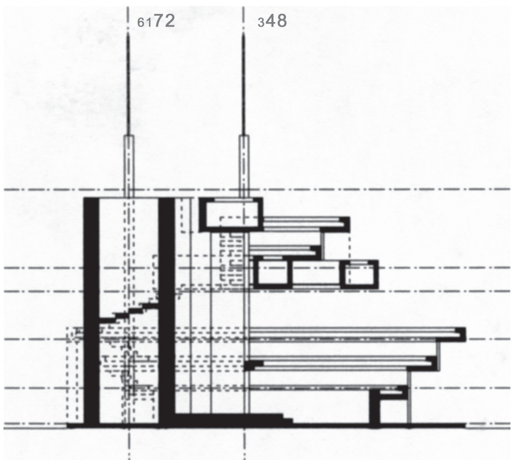
How this continuous cycle of 'what', 'why', and 'how' questions are expressed in the design within the design process can only be shared and expressed, given the continuous considerations the cyclical process of 'inventing/ thinking', 'making/ doing' and 'applying/ evaluating' entails, in the designs themselves.

For an example I take the only circular design, since it shows how one can transform the two-dimensional pattern of the labyrinth (read as a figure of movement) into a spatial-programmatic architecture.

CONSPICIO: the reading of the signs within the 'Templum' represented by the four views and the aereal photograph.

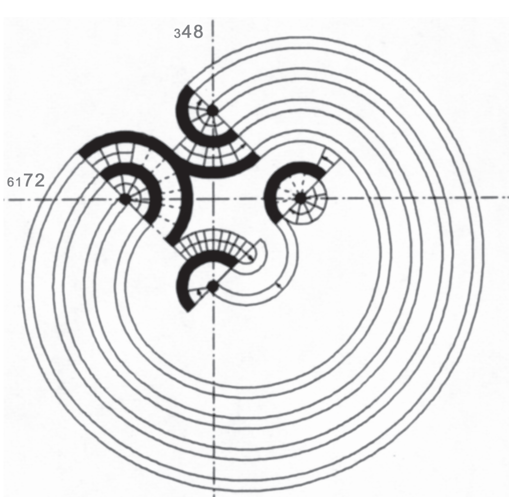
536 The areal photograph

Boulevard: a wide city street, often tree-lined and landscaped. French, from Old French *'boloard'*, *'belouard'*, rampart, promenade converted from an old rampart, from Middle Dutch *'bolwerc'*, bulwark. Bulwark: a wall-like structure raised as a defensive fortification, a rampart. A boulevard missing its bulwark? A field, a landscape not landscaped? A platform with traces of former buildings and columns, a tower not a tower.



537 A tower that is not a tower

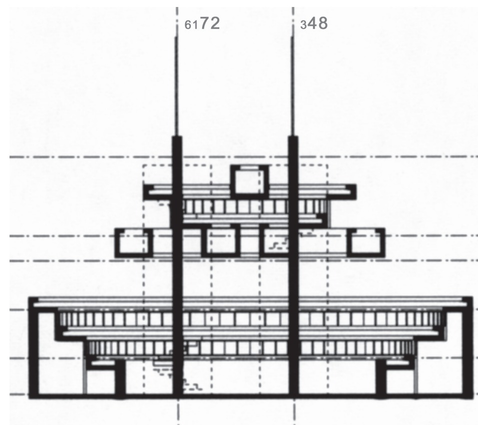
Within this square these corner-points are then used as the centres of fourquarter-circles with a radius 1/2 x 4.80 = 2.40 m. and fourquarter-circles with a radius of 1/2x 2.40 = 1.20 m.



540 Fourquarter-circles

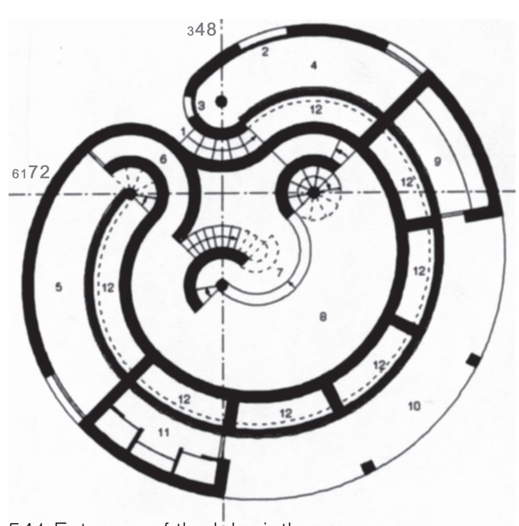
LEGEM DIXIT: the 'theme' for this specific *Templum*.

Box of Miracles.



538 Box of miracles

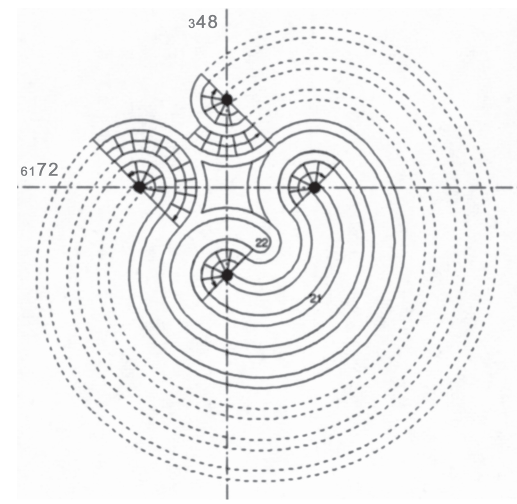
After that the entrance of the labyrinth is determined by choosing a point on the square between two of the quarter-circles. This also defines the end-point since it will be situated on the line that leads from the entrance point via the UTM Grid point to the square. The entrance will be the centre from which the old city in the direction of boulevard and bridge. The end-point will be the centre from which construction of the labyrinth-diagram starts.



541 Entrance of the labyrinth

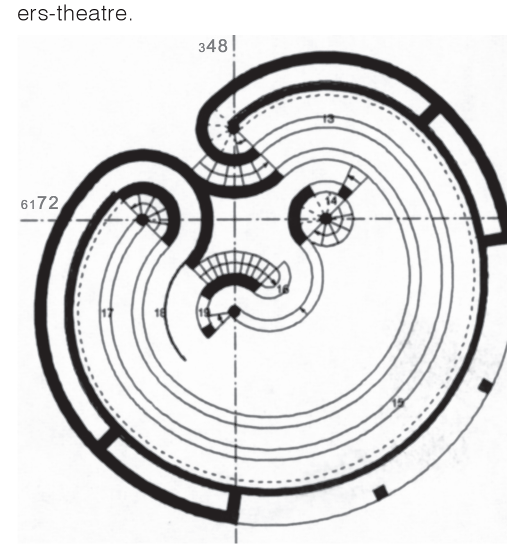
1 spectators entrance
2 ticket-booth
3 ticket control
4 office
5 performers dressing room
6 performers stage-entry
7 stage
8 arena
9 cafe
10 terras
11 toilets
12 storage

CONREGIO: the laying out of the 'Template' of the labyrinth and its directions.
The construction of a labyrinth-diagram on to the location and the determination of its exact placement and directions according to the UTM Grid point takes place as follows.
The UTM Grid point is projected to be the centre of a cross laid out in the directions of the UTM Grid, this cross is marked by four points in such a way that these points form a square of 4.80 x 4.80 m.



539 Corner-points

CORTUMIO: assessing the signs by the rules of the inaugurators's science: the proposal of a design.
The Trealeborg-theater or Box of Miracles is a collection of different theatres within one volume, an Arena, an Amphi-theatre, a Puppet-theatre, a Projection-theatre, a Panorama-theatre and a Speakers-theatre.



542 Collection of theatres

13 puppet-theatre
14 puppet-stage
15 amphitheatre
16 stage balcony
17 projection-theatre
18 projection-screen
19 projection-stage

VERBA CONCEPTE What could an offensive bulwark be, what an offensive fortification? A theatre? Traelleborg, Trøjborg: was the Danish labyrinth a fortification?

53.16 MAKING A MODEL

Making a model needs improvising creativity as well as experimental study. The curves, for instance, have been made by winding 1 mm thick plywood on pvc tubes with different diametres, while simultaneously gluing the sheets of plywood together. Obviously, curves produced that way at first do not have the exact size , because standard tubes never have exactly the right diametre; and when you cut open the winded triplex circle, after the glue has dried, you will see that the wooden arch produced veers a little back because of the tension in the wood.

This implies that you have to make each arch several times, while thickening the tube with tape, meanwhile observing how far the arch opens up after cutting, until you have produced the arch that is right for that part of the model.

53.17 LABYRINTH CONSTRUCTION

Constructing such a labyrinth diagram (the *conregio*) is relatively easy as long as you know how to do it.[a] In principle one always departs from a square with its four corners marked. These are the four endpoints of the four lines that are going to establish the labyrinth pattern. This square defined by its corner points is divided by means of a cross into four smaller equally sized squares. The centre of this cross / square is the starting point of the four lines that are going to establish the labyrinth pattern. In the case of a labyrinth of the Cretan type – one with seven tiers – one should sub-divide these four squares one more time still by means of hooks in equal distances.

Next the ‘weaving’ of the labyrinth pattern starts, by connecting one of the endpoint of the cross with the nearest point of one of the hooks (left or right), next by going to the nearest following point and connecting that in the opposite direction again with the first free point at the other side of the cross and so forth, until one has connected, by means of equally distant lines, all points. In this project the basic gauge between the lines of the labyrinth pattern was invariably 1,2 metre.

For the figure I used for the circular labyrinth, I went one step further still and replaced the cross with four quarter circles. This results in a smoother route (without straight lines) as well as in the possibility to project the entire (round) pattern this way perfectly and on real size on the ‘site’ quite simply with a couple of sticks and a piece of rope.

Opting for the circular, by the way, had to do with a complex of factors resulting from the *cortumio*, the interpretation of the ‘text’, generated by the *conspicio*, the reading of the ‘signs’. In its turn this should be seen in the light of the *legem dixit*, the playing rule that prescribed that as a programme this should become a *Boîte à Miracles*.

Le Corbusier’s *Boîte à Miracles* was a kind of multipurpose theatre, normally a large box with at one side a gigantic sliding gate, so that the actor’s space could be orientated and used in different ways (inwardly or outwardly) and directed towards different spectator areas (inside and outside).

53.18 THEMES

The *conspicio* provided two aspects (‘signs’) that could be connected – via etymology – one to another: the ‘boulevard’, along of which this *templum* was positioned and the view (from our so-called ‘non-place’) on one of the old bulwarks of the city at the opposite side of the boulevard.

Etymologically the concept ‘boulevard’ is derived from the medieval *bulwark*, the earthen works of defending constructed in such a way – often with their star-shaped structure of protruding elements – that all parts of the defensive works could be surveyed and that, if necessary, the attacker could be shot in his back.

a See ‘Constructie van een Labyrint’, derived from: Kern, H. (1982) *Labyrinthe, Erscheinungsformen und Deutungen 5000 Jahre Gegenwart eines Urbilds*.

The (vertical) theme was 'watching' and the programme a kind of multi-theatre where watching is revisited etymologically. We had a bulwark in which, just as in the theatre, watching plays such an important spatially shaping rôle.

In my personal surrealistic mind, added to that was a fascination for the now suddenly strange Dutch word '*schouwburg*': literally translated into English a 'fortress to watch from'; a neologism coined by our national poet Joost van den Vondel. The parallel is obvious: the theatre itself seen as on offensive.

From '*burg*' , '*burcht*' and '*borrow*' it is then not far anymore to the concept 'Troy-burg', closely associated with the figure of the labyrinth[a], particularly in its relation to Denmark – and Scandinavia as a whole – where there are still many traces of earthen labyrinths, and city names related to them, which are called then 'Traelleborg' or Trojborg'. With a little fantasy it does not take much to put the 'poetics' of such a *cortumio* together.

53.19 DESIGNING

What remains is the actual architectonic design. But, that is also not so difficult if one considers that the essence is to develop from a two-dimensional diagram a three-dimensional space with the potential to comprise a specific programme.

It is readily admitted that it takes some trying out, but in this specific case I could conclude before too long; since the figure of the labyrinth is also a very specific figure of movement inviting use in a vertical direction in order to make out of a two-dimensional diagram a three-dimensional space. By the same token, I had to introduce, via (literally and figuratively spiralling) stairs, verticality. I situated them as a form generating 'rule of the game' in the armpits of the movement around the four endpoints of the 'walls'. The 'walls' are the black lines of the pattern defining the movement, 'Ariadne's thread': they are the spatial elements restricting one's movement in one sense, but guide them in the 'right' course in the other; as such these 'walls' could also be slits.

If I ordained for the 'walls' a thickness from 30 to 40 cm, they would make for excellent seats, while leaving another 90 to 80 cm to go around and about.

This meant I got a *Boîte à Miracles*, featuring: an amphitheatre, an arena for normal theatre performances with a roofed space for the actors, amongst other applications; two small theatres in the shape of a quarter circle; one puppet theatre and a projection theatre; a panoramic theatre where one may survey the environment; and a speaker's theatre, where the speaker in a kind of pulpit (the endpoint of the route through the labyrinth) is elevated above his audience in order to address it. Under the seating area the ticket office and ticket control could be located, plus the dressing rooms for actors, sanitary facilities, a bar and a small covered terrace. Constructing the Traeleborg theatre did not cause truly big problems. Looking back at it, a design like this just seems a child's play.

a See a.o. Kern, H. (1982) *Labyrinthe, Erscheinungsformen und Deutungen 5000 Jahre Gegenwart eines Urbilds*.

54 LEARNING FROM THE BRIDGE PROJECT

JACK BREEN

In February 1999 the exhibition The Bridge (*De Brug*) was held at the faculty of Architecture in Delft.[a] A presentation consisting of some three hundred models of student designs for a pedestrian bridge. A vast and varied collection of objects, many of them arranged along a monumental 'canal' axis spanning a large part of the faculty's main hall. This extensive collection of work was the result of an exercise offered by the staff of the Form Studies department, as part of a second year educational block entitled 'Imaging and Materialisation'. The exhibition was the third of its kind, two previous activities being 'The Table', 1993 and 'The Bench', 1996.[b]

The theme of the original Form Studies exercise was 'The Footbridge'. Students were asked to develop a pedestrian bridge for a given – imaginary - site: a relatively modest canal with a width of just five metres and identical walled embankments on either side. The students had to 'realise' their ideas in the form of a presentation model scale 1 : 20, plus a design portfolio. Ten selected designs were eventually worked out scale 1 : 5, forming the visual 'centrepiece' of the exhibit.

The ambition of the exercise was to confront students with design themes like functionality, form and proportion, but also with specific qualities and possible combinations of materials, logical and expressive detailing and the consequences of 'making'. The idea was that students should continue refining their designs in the 'realisation' phase (in this case model making). For many students, this was an experience approaching 'realising' a first project (although reduced in scope and scale).

Despite constraints (or perhaps precisely because of them) a considerable number of students managed to come up with interesting propositions, often realistic, carefully detailed pieces of work, whilst a small group of students proved to be able to tackle the design task with such ambition and inventiveness that their designs can be said arguably to throw new light on the familiar phenomenon of the (foot)bridge

The exhibition generated a wealth of responses and interpretations. Some faculty members even regarded the initiative as a kind of prototype for new forms of *study by design*. Why

a The exhibition – designed and organised by Jeroen van de Laar - was documented in the Faculty of Architecture's yearbook: Breen, J.L.H. (2000) *The Bridge*.

b For an article on the exhibition 'The Bench': see Form Studies Staff (1998) *The Bench*.

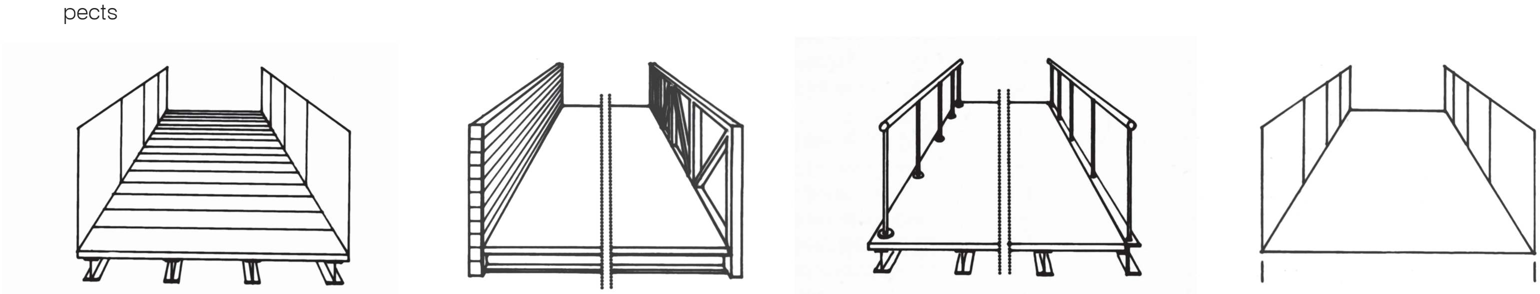
543 The Bridge exhibition (some photo-graphs of the exhibit at the Architecture faculty)

was this? What might be learned from the project? In which ways may design activities like this one lead to – or even be considered forms *of* study?

Firstly, it became apparent that a presentation like this tends to activate to ‘private study’ amongst visitors; may be because there was a clearly recognisable ‘format’ that allowed – and indeed stimulated – comparison. At the same time, the *diversity* of the solutions proved to be a source of fascination. There was a tendency amongst *all* kinds of visitors (from professor to window cleaner) to identify *favourites* and to communicate one’s opinions concerning the *qualities* (in a positive *and* negative sense) of specific designs. Such qualities might vary from the *originality* of the solution, the expression of *form* and the *technical* translation of the concept (even on a model level), to name but a few aspects.

Possibly researchers who recognised a ‘study by design’ potential in the exhibition discovered something for themselves. It might be they were to some extent able to ‘re-construct’ the process of designerly enquiry underlying different design solutions, fuelled by a spontaneous, personal process of comparison and selection. Naturally, this response generated by the exhibition ought not to be considered a merit on *research* level, but it might be possible to learn something from the project’s approach…

544 A comparison of characteristic design aspects



Apparently, the simultaneous confrontation with of a diverse, but thematically consistent collection of objects stimulates focused scrutiny and consequently selection and identification of qualities. Clearly, the *binding* theme - with an underlying set of design constraints - meant that the results could in principle be compared and analysed, initially in an intuitive way but potentially also in a relatively systematic way. The individual selection processes mentioned may also have been stimulated by the organisation - the *design* - of the exhibition: a clear overall spatial concept with a (seemingly) random placement of the artefacts. The emphasis on variety rather than on thematic or typological clustering may have offered a 'puzzle' to the viewers, who were thereby stimulated to seek out some measure of *order*, to recognise *themes* and to identify objects for which one felt a particular kind of *appreciation*, possibly even affection.

Secondly, the exhibition was not the only product of the Footbridge exercise. As with the previous projects, The Table and The Bench, a publication was prepared to co-incide with the manifestation.[a] Besides offering a generous overview of results, the articles in the book attempted to probe the bridge as a *phenomenon* and to reflect on the project as a whole. In this case the theme of the educational exercise was taken as a *starting point* for research activity.

Drawing from a wide range of sources and precedents, issues like the bridge as symbol, development of structural systems and impact of bridges in (sub)urban landscapes were addressed. In addition, an attempt was made to identify recurring design themes (see illustration). Such themes can be considered as - fundamental - design options, contributing to determining the manifest form of the bridge *as a whole*, as well as creating occasion for individual designerly *variation* of material and structural detailing.

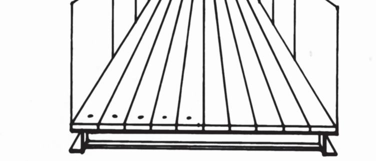
In the book a selection of the students' work was presented in seven thematic clusters.[b] Rather than suggesting thematic order by choosing a potentially rigid organisation in *types*, a group of compositional categories was developed, intended to stimulate visual interpretation by the reader. In addition, a selection of ten 'laureates' was discussed in-depth, focusing on individual design themes and specific aspects of 'concretisation' of the designs. In this way the 'catalogue' to the exhibition was used as an intellectual exercise, exploring both formal characteristics and cultural connotations.

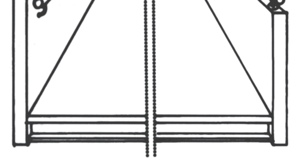
In retrospect, The Bridge experience might to be appreciated on different, inter-related, levels:

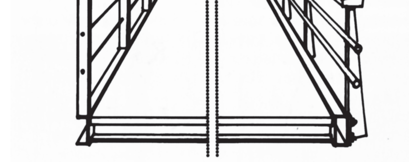
- As a design *laboratory* with the primary aim that students should acquire new insights, by designing and 'doing'.
- As a quest of *discovery* for students as well as teachers, allowing interpretation and comparison on a design studio level, as well as overall.
- As a collective, *thematic* form of enquiry, whereby the energy and open-mindedness of students were made instrumental for developing and identifying relevant design options that could be evaluated more or less systematically afterwards by a wider audience.
- As *design driven* research, firmly embedded in an *educational* context.

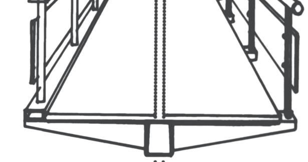
a Breen, J.L.H. and B. Olsthoorn (1999) *De Brug / The Bridge*.

b The themes were: The bridge as a piece of sculpture; The bridge as a play of lines; The bridge as a spatial object; Proportion and rhythm; Curved and folded; The dynamic form; The bridge as a device.









55 CREATING NON-ORTHOGONAL ARCHITECTURE

KAREL VOLLERS

The application of curved lines and surfaces in architecture, with their characteristic associative qualities, is receiving more and more attention. To realise these shapes at a reasonable price, one must make use of the newest techniques and stimulate innovation. This requires knowledge of the relation between function, form, means of materialising and structure of the market.

55.1 TWISTED SURFACES

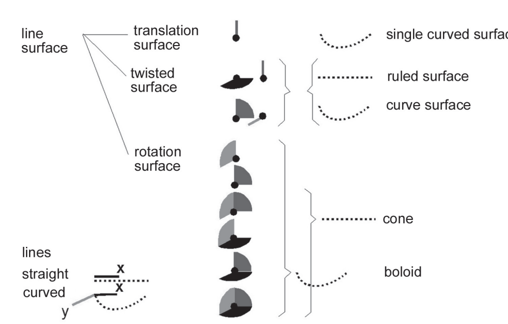
In order to realise double-curved surfaces in their pure geometrical shape, various problems related to complex shaping were dealt with in phases, in a series of surfaces with an increasing degree of plasticity and complexity. This Chapter focuses on twisted surfaces. As they consist of straight lines, they are to be placed between the freely double-curved surfaces and the unfoldable surfaces, like single-curved surfaces and cones.

This kind of surface can be described by moving a straight line along a curved path. ‘Ruled surface’s’ are twisted surfaces, constructed by moving a straight line and additionally rotating it. ‘Curve surfaces’ (a new kind of surface) are twisted surfaces too, but are constructed by moving and rotating a curve. Characteristic for twisted surfaces is that they always have a component of the rotation perpendicular to the movement vector. Twisted and double-curved surfaces have many similarities in their geometry and way of producing. The latter are, because of the different curvatures of neighbouring lines, more complex.

Twisted surfaces are archetypal forms, important to designers because they imply a great increase of the available semiotic vocabulary inherent to the use of shapes in architecture. Linked with the degree of transforming, the connotations of twisting range from associations with strangling, getting caught in a tight situation when the degree of twisting is big, to that of a romantic desire to break out of it, when the surface is twisted only slightly.

The different kinds of surfaces have specific names. Similarly it is useful to differentiate the various kinds of building volumes. In the sequence of volumes of increasing geometrical complexity, the following names may be included:

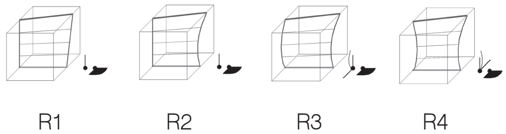
- Ortho’s, shaped orthogonal
- Rotaters, rotated shapes: Cylinders, Domes, Globes, Cones, etc.
- Twisters, twisted volumes with a straight rotation axis
- Tordo’s, with at least one twisted surface connecting with its rules to an orthogonal superstructure
- Blobs, freely double-curved surfaces



545 New scheme to differentiate between shapes

Many more specific names may be included, like Pyramids, Cubes, Morphers, etc. This Chapter is restricted to twisted shapes. Parallel to developing a scheme to organise the various twisted surfaces and volumes, their use in architecture was studied, and a building system developed to materialise them.

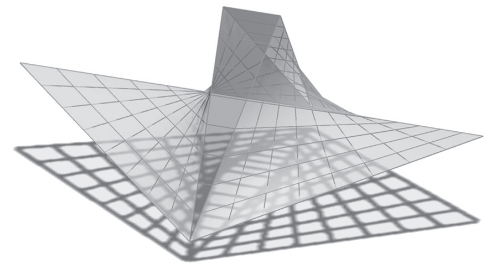
If twisted surfaces are to connect to an orthogonal built structure, the structure may be represented by a cube showing the starting position of the rule (red) that is manipulated to construct the surface, with icons depicting the vector of movement and direction of rotation. Additional directions of rotation may be added. They imply that the surface will no longer connect with straight lines to horizontal surfaces (floors) or parallel vertical surfaces in which columns or walls usually lie.



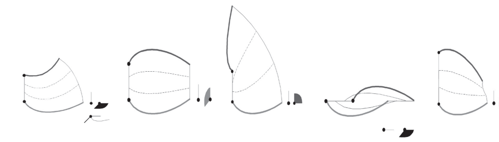
546 Four basic types of twisting

Four basic types of twisting can be defined when moving along a straight line:

R1 Two straight sidelines (a hyperparaboloid)
R2 One straight and 1 single-curved sideline
R3 2 sidelines curving in opposite directions
R4 2 sidelines curving in the same direction

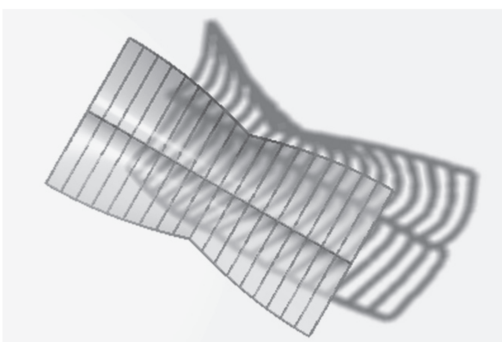


547 Example of a combination of two ruled surfaces type R1

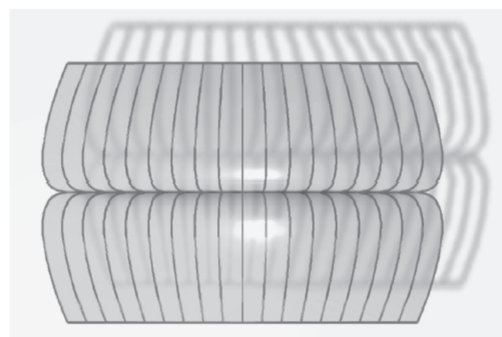


548 Five basic curve surfaces

Similar way to ruled surfaces, curve surfaces can be described with icons, instead of mathematical formulas.

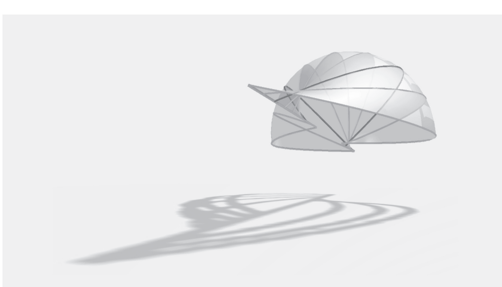


549 Curve surface K1

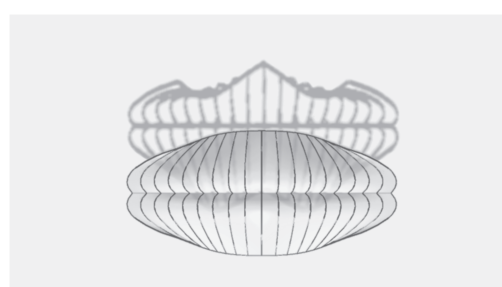


550 Curve surface K2

551 Curve surface K3



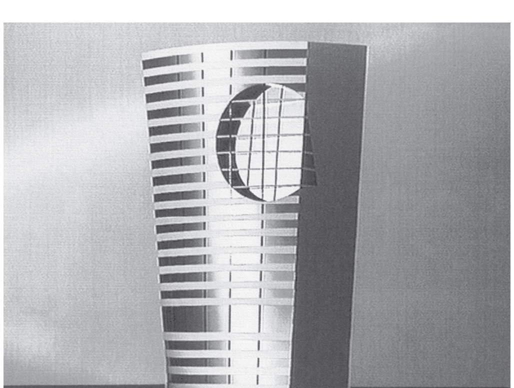
552 Curve surface K4

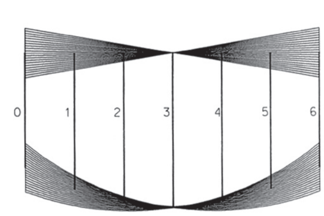


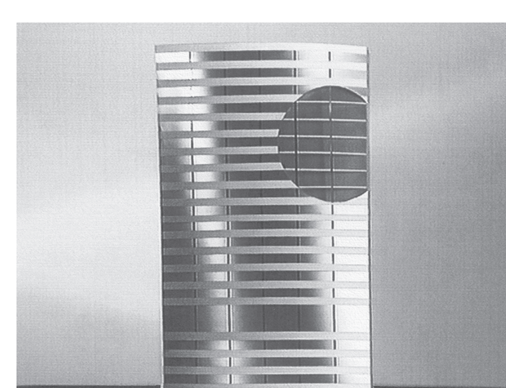
553 Curve surface K5

55.2 EXAMPLES OF TWISTED SURFACES IN ARCHITECTURE

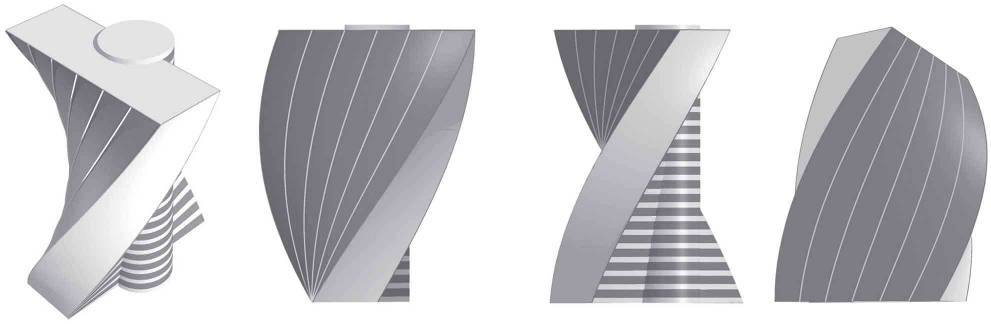
This high-rise ‘tordo’ with twisted (and flat) façades, with floors and walls meeting under straight angles, is relatively easy to materialise, due to the straight lines in the twisting surface connecting to the superstructure. The façades at the front and backside of the model are a ruled and a curve surface.





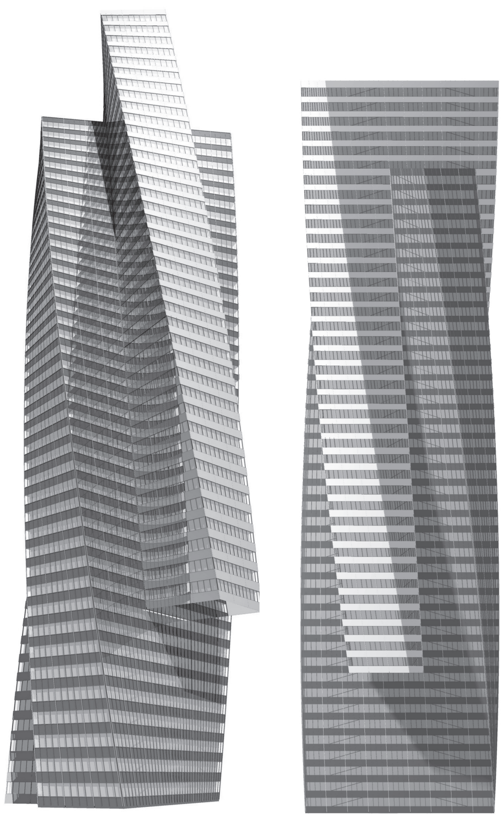


554 Tordo 1

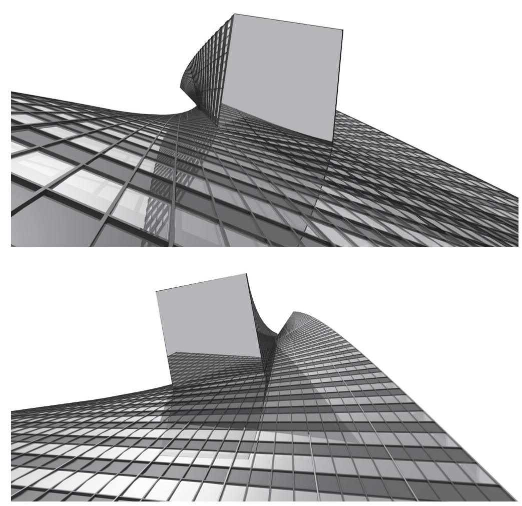


A ‘twister’ has floors positioned around a vertical axis; in this 20 floor high model the twisted volume has been combined with a cylinder. In the core some building components (like elevators) rise vertically, while other components (like sanitary units and stairs) rotate in conjunction with the officewings. The varying positioning of the components results in a different plan in the core on each floor.

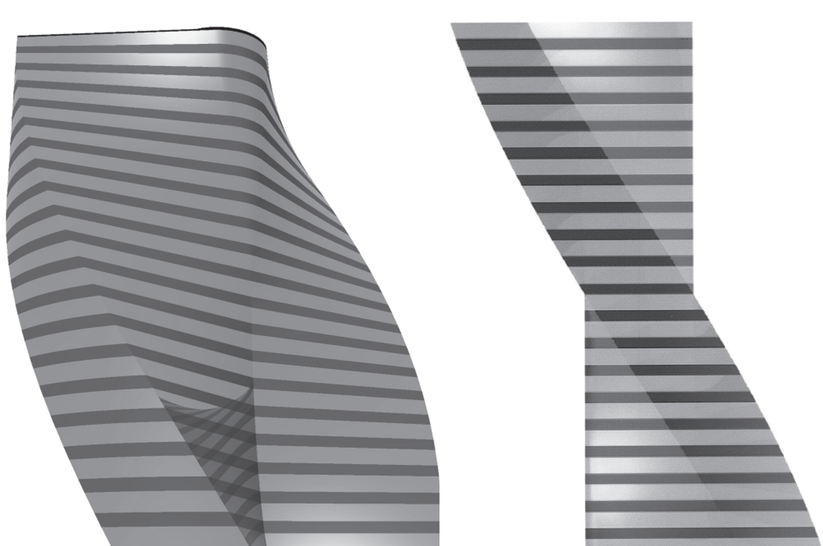
555 Twister 2

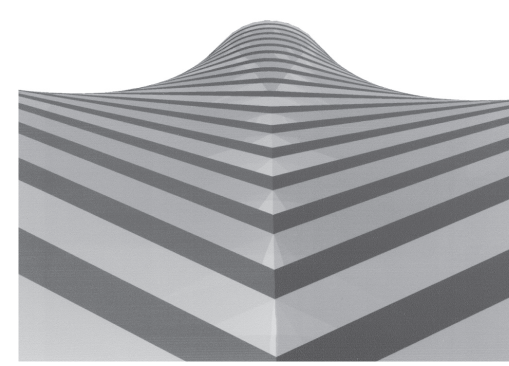


The two perpendicularly inter-secting volumes of this 150m high twister, offer a playful contrast of façade finishing. The building is conventional in use; as a result of the only slight twisting of 0,5’ per m1, the façades hardly incline. The volume as a whole looks spectacular, with the many slightly twisted elements, adding up to the considerable twist of 70’. There is an enormous repetition of parts. The structural design was made by ABT Engineers.



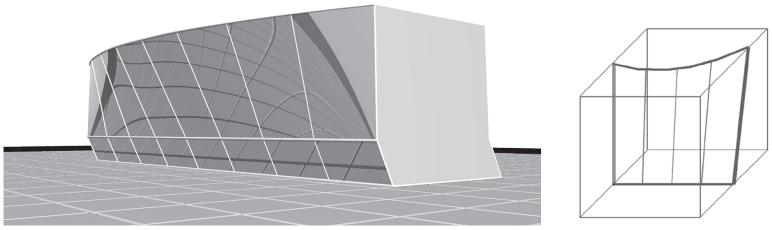
556 Twister 3





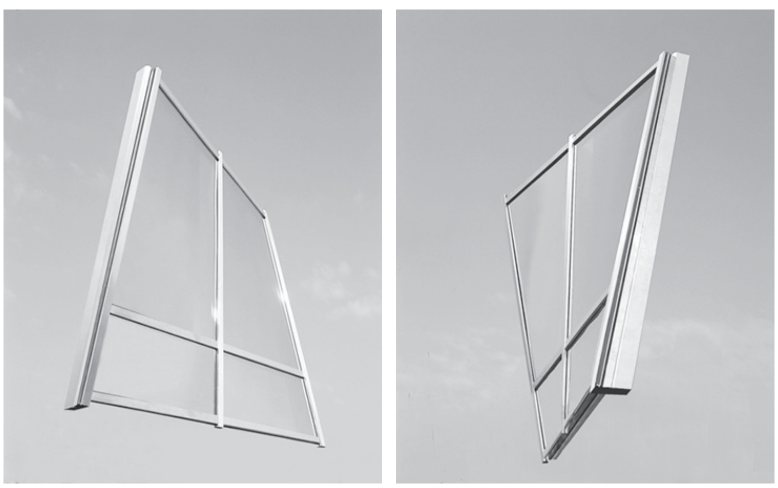
To study an alternative for the superstructure, this symmetrical composed 60m high twister was designed. Two wings rotate in opposite directions around a cylindrical core. Because of the contrary rotation of the wings, the floor plans in the core vary on each floor. The concrete core is essential for the stability. The reflection of a twisted façade in a twisted façade, results in unexpected images.

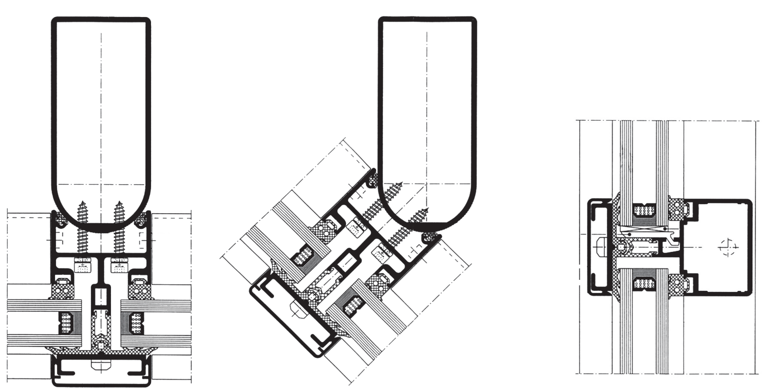
557 Twister 4



558 Low-rise tordo 2a

This is a low-rise tordo, with a ruled surface façade type R2. The moving reflections of cars, or pedestrians, will distort and slow down or accelerate.





559 The reyno twist window frame-system

An industrially produced framing system for twisted façades was designed, with warm bent twisted glass (both a world-wide first). The frame combines a stiff backing profile (for example positioned everywhere parallel to floor and wall), with a glazing profile parallel to the glass surface (twisting or if preferred freely-doublecurved). The system was developed in collaboration with:

Reynolds Architectuursystemen, Reynolds Special Products and Van Dool Constructies.
Van Tetterode Glasatelier, Eijkelkamp and Glaverned.
Hellevoort Visuals

56 DESIGN IN STRATEGY

DIRK FRIELING

All planning is rooted in the belief-system that people are free agents that by conscious actions may influence the course of events in the way they deem fit. Designs are means to enlarge awareness of potential consequences of specific actions. For that reason, plans are instrumental in improving human ability to organise society and to shape the world according to attitudes to life and images of society present in the human mind.

Conceived this way, planning is a human activity implying considerable responsibility: one reason to oppose planning. The most effective way to escape this responsibility is to deny the possibility of planning: *'it is not up to human beings to shape the future'*. Devout as this may seem, it opposes the essences of Christianity and humanism alike, both focusing on freedom of the individual and responsibility of that person to act accordingly. For practical reasons too, this kind of opposition to planning is not to be taken seriously. Human society, and especially the city, by far the most impressive human achievement, just would fall apart if people stopped planning.

A second reason to oppose planning is that is encroaches on personal liberty. Evident as this may seem, it is true only, if one leaves planning to others and does not take personal responsibility by participating in the planning process oneself. On a deeper level, the tension between individual and collective liberty can be seen as tension between a concept of freedom as something in the nature of things, that everybody is entitled to as a consumer, and a concept of freedom as a potential of human beings, that every single person has to develop as a producer.

For both reasons, this kind of opposition to planning should be taken quite seriously. To overcome the encroachment argument, planners must participate or fail. To overcome the consumers approach to liberty, planners are wise to show how small, frail and unstable human freedom is and how only joint effort may sustain, strengthen and enlarge it.

Planning is concerned with future action under future conditions in a future situation: a heap of uncertainties to be considered. As most people do not like to live with uncertainties, planning can be seen as a way to reduce uncertainties. The main characteristic of the future is that it is not yet there, it exists only in the human mind, it is by definition a virtual reality.

56.1 FOUR WAYS TO FACE THE FUTURE

To find out what may come, one can follow several methods. This article distinguishes four of them. One is rooted in the idea that everything embodies a spiritual existence or energy; aeternal, beyond time and space. To find out what may come, contemplate that existence or energy and articulate what comes up in your mind: the way of art, the alpha way.

Another one is rooted in the idea that everything is organised according to rules inherent in energy, time and space. To find out what may come, try to discover them by analysing the evolution of systems. Knowing the rules, we may predict their future course: the way of natural sciences, the betha way.

A third one focuses on people as the main source of human events. If we can discover the driving forces of their actions we may influence their behaviour in the future. The rules of the game here are as important as in the natural sciences, the difference being that they are manmade and open to human influence: the way of social sciences, the gamma way.

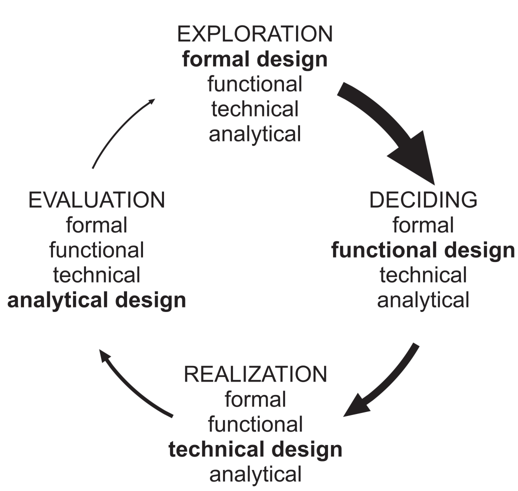
The last method distinguished here considers everything as ongoing recreation. The focus is on emergence of the present not from the past but from the potential of the future. In it the present is not caused by the past, but conditioned by it. The past does not push the present; the future attracts the present. This is the way of designers and engineers, people inventing things: the delta way.

In day to day reality, of course, all these methods continually intertwine. But, in University, these methods have to be dis-entangled to clarify them by ongoing research and to test and improve them for educational purposes. As this book is written for designers and engineers the focus is on design, the delta way.

First of all, the rôle of design in strategic planning will be explained in theory. After that, the case history of the emergence of the concept Deltametropolis[a] will be used to demonstrate the rôle of design in practice. It will be elaborated by three examples: design as a method to clarify political options[b], the contribution of design to investment strategies and design as a method to forge social alliances. The concept 'Deltametropolis' was not there from the beginning. There was no hidden agenda. Nevertheless, it emerged from several more or less independent design exercises.[c] The hidden order of Deltametropolis was exposed by inter-action of discoveries and inventions, generated by an intermittent process of design[d] that started in the middle of the eighties and is still going on.[e]

MEANS / AIMS	undefined	defined
undefined	potential futures	desirable futures
defined	probable futures	necessary futures

560 Typology of futures



561 The rôle of design in different phases of a development process

56.2 THE RÔLE OF DESIGN IN STRATEGIC PLANNING

Strategic planning starts with acknowledging that there are all sorts of futures to reckon with.[f] As far as people want to influence the future they do this by setting aims and allocating means.

When aims and means are both undefined, we find ourselves in the realm of potential futures; the domain of inventors, designers and engineers. Design is mainly conceptual.

When aims are defined, but means are undefined, we are in the realm of desirable futures, the domain of all kinds of private associations, interest groups and political parties. Design is programmatic, functional and system orientated.

When, the other way round, means are defined unlike aims, we enter the realm of probable futures; the domain of traditional research. Design is aimed at process, not product: design is to conceive rules regulating the course of events.

When aims and means both are defined, we can call them necessary futures. Strictly speaking, the word 'necessary' is logically not allowed, because aims and means are defined by arbitrary human decisions. However, for this typology of futures within a framework of strategic planning, the word 'necessary' is clear enough.

Designing has several dimensions that will be referred to with four different adjectives: formal, functional, technical and analytical. In the same way the four dimensions of time-space generate undivided experience, these four dimensions of design are included in undivided action. They are continuously present in the hand and mind of the designer. But, the force of their presence changes with evolution of the design and with the different rôles of it and of the designer in that evolution.

In the phase of exploration, when aims and means both are indefinite and undefined there is nothing more to design than form, formal composition and formal relations. Via these forms I explore my environment in search of viable combinations of placebound situations and timebound activity patterns. Because of this, designs in this phase of exploration often have a rather formal and schematic character.

In the phase of deciding there will be requirements to meet. They may become dominant as soon as a client has to decide on a design, having to take all kinds of political and financial risks. The functional dimension of design will grow in importance as form and function have to harmonize.

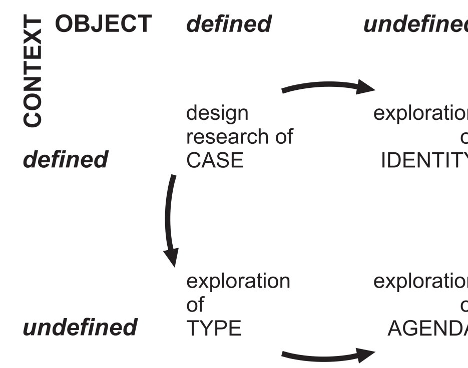
In the phase of realisation the aim is always to find the optimum solution for a wide array of conflicting requirements. There technical design is needed, the invention of the most effective and efficient combination of mutually contradictory demands.

a Frieling, D.H. (1995) *Het metropolitane concept*.
b Frieling, D.H. (1997) *Verstedelijking als politieke opgave*.
c Frieling, D.H. (1996) *Het metropolitane debat;* Frieling, D.H., W. Mitchell et al. (1996) *The future of design and research*.
d Frieling, D.H., W. Reh et al. (1998) *Onderzoekateliers Bouwkunde Onderzoek Deltametropool Atelier Stad*.
e Frieling, D.H. (1998) *Het metropolitane debat*.
f WRR (1977) *Nederland over 25 jaar;* WRR (1981) *Beleidsgerichte toekomstverkenningen;* WRR (1983) *Poging tot uitlokking*.

In the phase of evaluation – whether ex ante or ex post – designing will become deconstruction, an analysis aimed at exposure of the inter-action between an object and its environment, as well as its use and users.

56.3 EXPLORATION

To clarify the specific rôle of design in the phase of exploration we must further analyse the specific contribution of formal design. Since one explores the future by design, and both aims and means are undefined, one may fear to wander aimlessly in the dark.



562 Exploration by design

Any object in any context, designed for a specific programme of requirements in a specific situation for a specific client, at a specific moment by a specific designer is, because of all that, considered to be unique. However, in strategic planning, objects and contexts have to be used for typical reasons, as well as for reasons of unique fit to situation or vice versa.

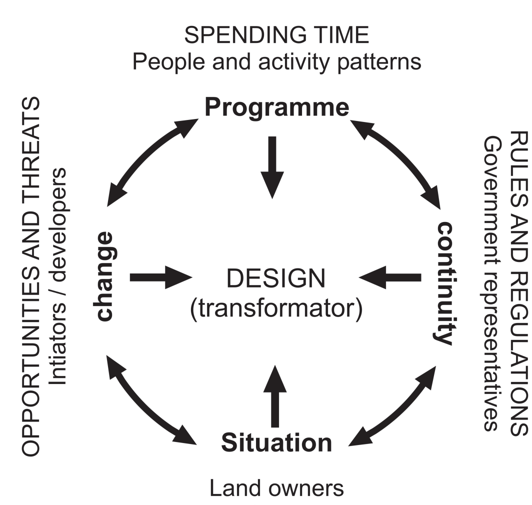
This double identity of design, being both singular and a type, can be clarified by the scheme shown distinguishing between defined and undefined objects and contexts. When both object and context are defined, we can evaluate like in a case, analysing properties, internal inter-action and other characteristics. This is what we may call design research.

Exploration by design starts when one or both of these components are kept undefined. By liberating an object of its context, and projecting it in all kinds of contexts, we can analyse its transformations and discover its continuous properties, that is: its type. By liberating a context of its object and projecting all kinds of objects in this context, we can analyse its continuous influence on these objects, that is: its identity or *'genius loci'*.

Both forms of exploration by design are useful by themselves. They also serve to explore areas where both object and context are undefined. There and then design is used to discover an agenda.

One may think this scheme does not work for inventions or discoveries: there is no case to start from. Experience shows that the creative mind in this situation does not work in empty space, groping in the dark. It is trying an endless series of examples that might serve as an analogy. This may explain why designers often speak in metaphors. They have to use these analogies to explain what they are looking for. The 'Deltametropolis' is a perfect example of this. By choosing this name, two directions of exploration are introduced: connectedness and inter-action between people to explore the type of metropolis the people living there may become; and connectedness and inter-action between watersystems to explore the identity of the delta that is the breeding ground of this metropolis.

To conclude this short introduction to the theory of the rôle of design in strategic planning a simple scheme may help (figure 563) to improve awareness of design as a social process. This awareness is important in organising participators in planning and in keeping in mind that good planning enlarges liberty and does not diminish it.



563 Design as a social process

The design as a material object is the product of the inter-action between a territorial situation and a programme of requirements, generated by an activity pattern. This inter-action is personified by respectively landowners and people using the land. The design as an intervention is the product of the inter-action between change and continuity, personified respectively by initiators of change (developers) and people in charge of certainty, safety and continuity (government). In a more abstract way the design can be conceived as the transformator of four interacting forces: use of space and spending time transform under pressure of opportunities and threats that work to generate change but interact with rules and regulations to maintain the status quo.

56.4 DESIGN TO CLARIFY POLITICAL OPTIONS

In the seventies the Netherlands were influenced rather greatly by co-incidence of the Club of Rome report on 'limits to growth' and the first energy crisis, triggered by OPEC-countries. A few years later, even planning for the future became politically incorrect. This standstill in planning triggered an initiative by the Foundation Architectural Museum (presently the Netherlands Institute of Architecture, NAi) called *'The Netherlands Now As Design, the rules of growth'*. The idea: to organise an exposition on the Netherlands in 2050.

The initiators[a] took two policy- orientated explorations of the future by the Scientific Council on Government Policy as a starting point for their exercises in design. They decided to make four designs for 2050. The social-democratic design is called 'Critical', the conservative design 'Dynamic'. The christian-democratic design 'Careful'. And a future based on technological and political breakthroughs 'Relaxed'. With the exposition on the Netherlands in 2050 they aim to kill three birds with one stone: regain attention for planning, explore future transformations of the Netherlands under different sets of rules for growth and, in the wake of the Scientific Council, to revitalise politics. The Foundation NNAO (1984 – 1989) organised the support of government departments, universities and private research organisations, collected four million guilders and engaged the 'fine fleur' of the design profession. A three – year design programme followed with more than 200 professionals participating, meeting every three months to discuss designs and progress.

Radius	*DISPERSION*							
100 km	Deconcentration				Concentration			
30 km	Deconc		Conc		Deconc		Conc	
10 km	D	C	D	C	D	C	D	C
LANDUSE			Careful	Critical	Dynamic			Relaxed
Urban system			+	**+**	+			+
Transport system			+	+	**+**			+
Rural system			**+**	+	+			+
Water system			+	+	+			**+**

564 The Netherlands as a choice of policy options

The exposition of these four political perspectives was opened by the Prime Minister in Amsterdam in 1987; a second viewing organised in Rotterdam in 1988. The State Printing Office published a two-volume catalogue: one with all the designs, the other with background research. Exposition and books were widely discussed in the press and covered by television.

In the course of this design exercise the organizers developed a method to make political options comparable, by conceiving the spatial system of the Netherlands as consisting of four sub-systems: water system, rural system, transportation system, urban system. They conceived landuse policy as a multi-level system of planning offering a choice between concentration and deconcentration on each planning level. And they conceived the governance of this landuse policy to be influenced by the value systems of different political parties as generated by their respective images of society. Figure 564 shows the frame of reference as developed by NNAO, each party programme containing positive statements on the different spatial sub-systems and each proposing a different option of settlement patterns.

	1986	Careful	Critical	Dynamic	Relaxed
Water	9	9	16	10	10
Nature	14	22	29	35	30
Agriculture	65	51	39	34	46
Infrastr.Industry	5	7	8	6	9
Urban areas	7	11	8	15	5

565 Landuse in % of total area of the Netherlands

The Scientific Council was helpful in commissioning Rob van Engelsdorp Gastelaars and Leo de Klerk from the University of Amsterdam to write the political scenarios for the Critical, The Dynamic and the Careful future. The Foundation commissioned Taeke de Jong, from Delft University to write the Relaxed scenario. All four perspectives are similar in their attention to the rôle of the water system, the decline of agriculture, the importance of international connections and the transformation of patterns of independent cities into multicentred network systems, urban constellations.

These four scenarios result in four different landuse programs shown in figure 565.

Searching for a sustainable balance in these matters, the four perspectives follow a different policy, resulting in different directions of development. The planners and designers show that quite different attractive and consistent futures can be invented and developed: four perspectives that overlap in many ways, differ according to the political priorities attached to economic growth, social equity, environmental sustainability and cultural identity.

The Careful perspective shows the Netherlands as part of Europe, leaving out state boundaries. This European orientation gives the eastern and southern parts of the country a more central position, whereas the western part is becoming more peripheral. The network of roads and railroads is transformed from the present starlike shape, radiating from the west,

a NNAO (1987) *Nieuw Nederland 2050;* NNAO (1989) *Nieuw Nederland, Nu Nijmegen & Arnhem Ontwerpen.*

into a grid connecting all parts of the country to each other and to neighbouring European countries. The water system is re-designed to enable natural watercourses to retain more water. Agriculture and nature are integrated, farmers cultivating both. Cities, towns and villages grow independently, maintaining a nice provincial air in the urban system while the country becomes ever and ever more densely populated. *Eindhoven* – pride of the south – is chosen as subject of regional design.

The Critical perspective is designed for a society that changed radically in three ways: energy systems are based on sunlight, wind and biomass, working hours are reduced to three days per week and all urban regions are connected to the European network of high speed transport. Combination of less work and better connections extend the job market to Hamburg, Berlin, Frankfurt, Brussels, Paris and London. The western part of the country is transformed into an ecological balance area. The former Green Heart is changed into a huge water-realm and cities and wetlands are integrated into one ecological system. Elsewhere also large areas are transformed into wetlands and nature reserves. Agriculture for the international market is concentrated in the clay areas in the north, middle and south-west. *East-Groningen* – at present one of the poorest parts of the country – is chosen as subject of regional design.

The Dynamic perspective is based on a market-orientated scenario. The western constellation of cities is strengthened via three interventions in the transport system: a new international combined seaport / airport in the sea, high speed railway connections with the rest of Europe and a new circle line to inter-connect the main cities in the west. The country as a whole is in a way considered as a 100 Mile City, still having its CBD in the west and living areas on higher and drier grounds in south and east. The lower parts of the country are transformed into large scale wetlands for water-management. Farming has become large scale factory farming. *Amsterdam* – international trade centre – is chosen as subject of regional design.

The Relaxed perspective combines all technological and political breakthroughs one can think of. The essence of this perspective is that all these breakthroughs put together will not lead to ongoing urban dispersal but just the other way round, to a new period of urban concentration. This is exactly the same conclusion Manuel Castells drew in his book on the Informational City[a] and Saskia Sassen in 1991 in her book on the Global City.[b] The central technological breakthrough will be the availability of cheap energy by nuclear fusion and by harvesting sunlight, for which 2000 SqKM are allocated. Energy being no problem anymore, speed of transport can be multiplied. The political breakthrough (envisaged a few years before the fall of the Berlin Wall) is that technology of communication will be the driving force to break through old world political boundaries. This will have geo-political influence and change the traditional political decision process into interactive policy development. In this perspective of a full energy economy and trans-continental magnetic train systems, *Rotterdam* is the region to concentrate on. It will no longer serve only as a mainport for Germany, but also for Central Europe and Russia.

56.5 MAJOR IMPACTS OF THE EXERCISE

The impact of this exercise in using spatial design as a method to explore the future may show on different levels. One of them will be assessed here: its usefulness to clarify political options and its impact on everyday politics. The contribution to strategic planning and the influence on design methods has been treated already in the theoretical introduction to this case history.

The political events of the day are that a year after the exposition *'Netherlands 2050'* the fourth policy document on spatial planning appeared in 1988. Central government in the Netherlands is legally obliged to produce such a policy document every ten years.

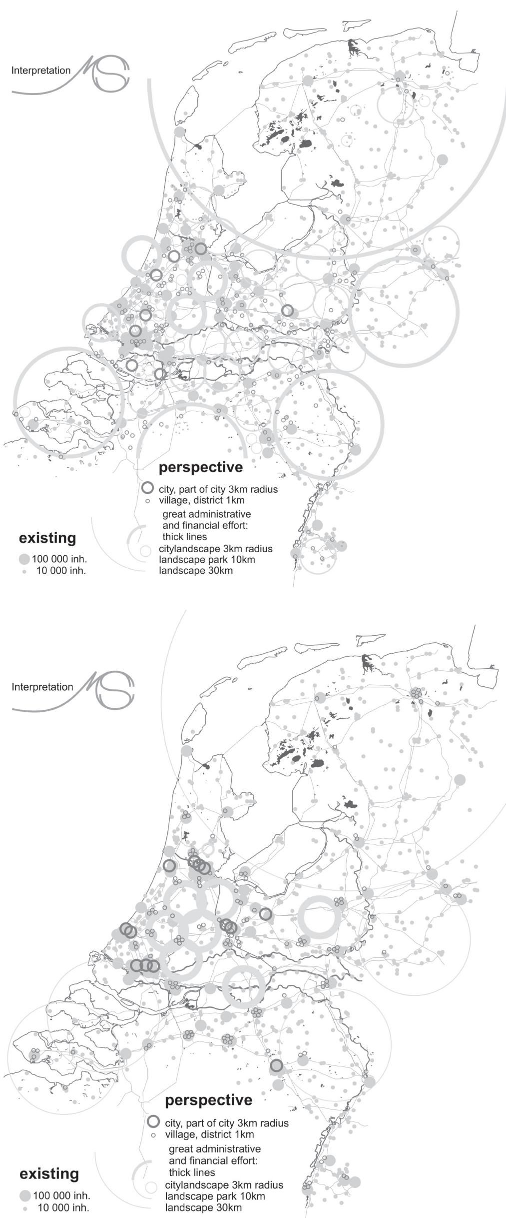
A year later again, in 1989, the foundation Netherlands Now As Design published an investment strategy[c], based on this policy document, financed by the main pension funds and

a Castells, M. (1989) *The Informational city*.
b Sassen, S. (1991) *The global city: New York, London, Tokyo*.
c NNAO (1989) *Nieuw Nederland, proeve van een investeringsstrategie*.NNAO (1989)

life insurance companies. This investment strategy originated a public-private committee on spatial investments chaired by a former minister of Housing, Planning and Environment and consisting of departments, burgomasters of Amsterdam, Rotterdam, The Hague and Utrecht and representatives of private sectors.

The arguments for metropolitan development are quite pronounced in the Dynamic, Critical and Relaxed perspectives, although for different reasons: economical in the Dynamic worldview, ecological in the Critical, the outcome of technological breakthroughs in the Relaxed perspective. The designers mis-interpreted the Labour priorities however. Labour allied with the Christian-Democrats in an anti-metropolitan policy. This became clear by the difference between the fourth policy document on spatial planning[a] and a fourth policy document 'extra'.[b] The original report, issued by a conservative minister of planning, had as its main issue metropolitan development in the west. Three years and a cabinet crisis later, a socialist minister issued an extra report in which the three main cities in the west are replaced by thirteen cities all over the country. That minister now is the Queen's Commissioner in Groningen.

The committee on spatial investments commissioned a study on a high speed / high frequency transport service between the main cities in the West and Schiphol Airport. By reducing travel-time the separate cities would be integrated into one urban system that would improve overall efficiency and hence its earning capacity. By the time the report was published in 1992, the tide of metropolitan development was out already. The four perspectives all had been orientated on Europe. In political reality however, not the international future, but the provincial present did win the day.



566 Two out of four perspectives, see also page 457.

Summing up these experiences one may conclude that the political impact of the project has been pretty thin as far as direct influence on landuse policy is concerned. On a deeper level however, design has been discovered as a method to explore the future. Many political issues on top of the political agenda today, like water-management of the delta, decline of agriculture and the need to rethink the transport system were imagined fifteen years ago. The designs made all sorts of expectations visible, publicly debatable and subject to planning and decisions on investment priorities. But to change potential into practice, the focus of research has to be directed to the decision processes themselves.

56.6 DESIGN TO DECIDE ON INVESTMENT STRATEGIES

The research project that followed the line set by *The Netherlands Now As Design* and preceded the Deltametropolis declaration[c] originated in the Faculty of Architecture of the Delft University of Technology. For years it had been clear to professional planners that the loose pattern of urban centres in the west was rapidly transforming to a collection of cities with overlapping spheres of influence causing interference, competition and a general loss of competence to promote common interest. For that reason research was done to find means to generate a next transformation, in which this collection of separate cities would integrate into an urban system, an inter-connected constellation of urban centres, a multi-centered metropolis.

At a Faculty of Architecture, research is mainly study by design. To be able to focus on decision processes, partners were found in the University of Amsterdam and the National Institute of Planning and Housing, a private association of planners and local politicians. With financial support of the main cities in the west and several departments, a foundation was created: The Metropolitan Debate. The aim of this foundation is to experiment with new methods of decisionmaking to get better decisions quicker. The idea is that metropoli distinguish themselves from other urban concentrations by being able to do just that: take better decisions quicker. The method conceived to improve the decision process on planning policy distinguishes between perspectives, projects and strategies.

Perspectives are general and integrated long-term policy statements illustrated by designs to indicate different directions of development.

a VROM (1988) *Vierde nota over de ruimtelijke ordening*.
b VROM (1992) *Vierde nota over de ruimtelijke ordening Extra*.
c Amsterdam, Den Haag, Rotterdam and Utrecht (1998) *Verklaring Deltametropool*.

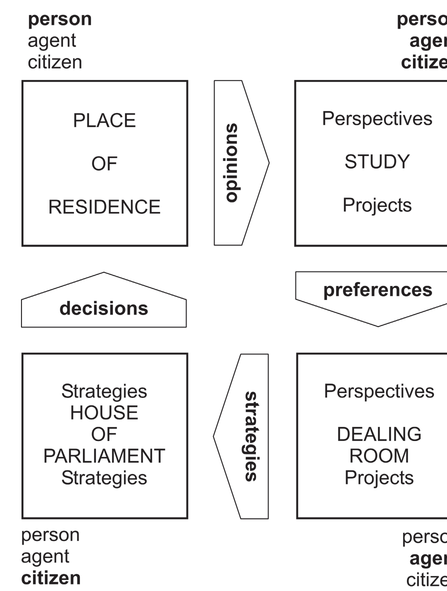
Projects are direct interventions in existing situations. Strategies are a combination of one perspective with a portfolio of projects that will contribute to realisation of that perspective.

The decision process addresses participants in three rôles: as individuals deciding on their own place of residence, as agents in initiating and realising projects and as citizens in defining and selecting perspectives.

The decision process itself consists of decisions in a series of four steps, starting at home where everybody cherishes his or her own opinions. The next step is to study available perspectives and projects and to decide on personal preferences, eventually preparing an individual strategy. The third step is confronting all these personal preferences in a dealing room, facilitating transactions and trade- offs between participants. This will lead to a hybrid strategy combining features of several perspectives and a mix of projects. The fourth step is evaluation of the results of the dealing room by parliament. Their decision will then trigger a new series of decisions by private citizens either to move or to stay.

The method was first tried out in 1997, sponsored by the four main cities and a government research programme managed by the Interdepartmental Commission on Economic Structure (ICES). Later that year a second try-out was held on a regional level, sponsored by four cities in the eastern part of the country. In 1998 the Minister of Housing, Planning and Environment commissioned the foundation with organising a debate on a recent department study called 'The Netherlands in 2030'[a] Four metropolitan debates were organised, for the north, east, south and west of the Netherlands respectively. Later in the same year the Minister of Agriculture, Nature Reserves and Fisheries commissioned the foundation with a debate on the future of rural Netherlands. In slightly more than twelve months the new method was tested seven times. To be sure, all these were laboratory tests. Perspectives were more or less realistic, in the debate on The Netherlands in 2030 even formally so, but no real projects and investments were involved.

567 Projects



568 Decision process on planning policy

56.7 MAJOR IMPACTS OF THE EXERCISE

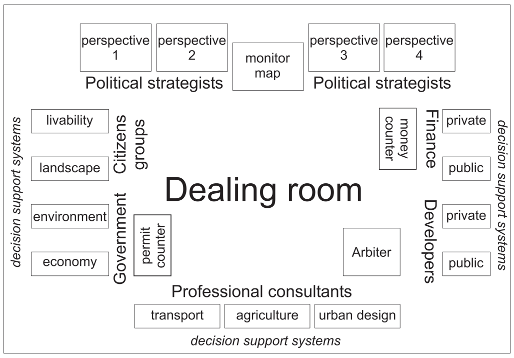
Since the testing of the method did not involve real perspectives and projects and participants did not represent all actors participating in reality, the direct impact on political reality has been zero. The aim of the foundation is to develop a method that parliament might use in deciding on the fifth policy document on spatial planning that had to appear in the report "People desire dwelling, dwelling in the 21st century".[b] The tests did show two weak spots in the method. The most important one: there is no decision support system available that can evaluate perspectives and projects with the same speed participants need to support their decisions. The second weak spot: projects tend to be too detailed and complicated when nearby in time, or too vague and superficial when far off. A format specific enough to make real decisions, and general enough to be useful in strategic planning was developed at the last moment for the debate on the rural system of the Netherlands.

Politically there were also reasons not to engage in experiments of this kind. First of all, a new Minister of Housing, Planning and Environment postponed the fifth policy document on spatial planning. Second, parliament decided they would prepare for the debate on the fifth policy document by evaluating the experiences with and results of the fourth policy document first. Third, the planning institutes of central government for the environment (RIVM), the economy (CPB), society and culture (SCPB), traffic (AVV) and spatial planning (RPD), commissioned by the ICES to develop an ex ante evaluation system for major public investments, did not come up yet with an operational method to be used publicly.

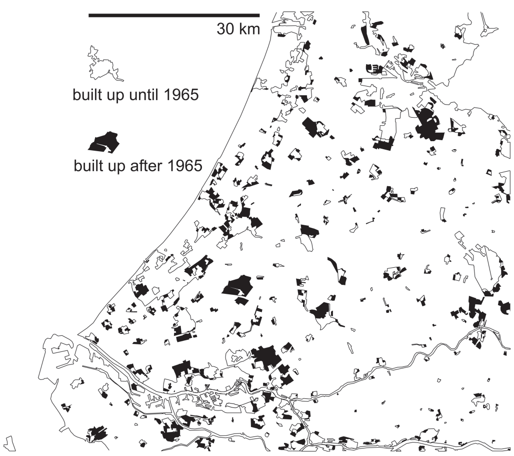
So the proposal of the foundation to organise for a change in parliamentary exploration of the future, after several parliamentary enquirements of the past, has to wait.

a VROM (1998) *Nederland 2030, Discussienota Verkenning Ruimtelijke Perspectieven*.

b VROM (2000) *Mensen wensen wonen, wonen in de 21e eeuw.*



569 Lay-out of dealing room



570 Dispersal

The contribution to strategic planning of this exercise in improving decision procedures can be summed up in a lay-out of the dealing room used in testing the method, the centrepiece between the private study for personal positioning and the assembly hall for collective evaluation. The influence on the design methods have been described (see figure 561, 562 and 564).

56.7 DESIGN TO FORGE SOCIAL ALLIANCES

To analyse the difference in perspectives you need a uniform legenda. This legenda has been developed by Taeke de Jong of the Delft Faculty of Architecture.[a] It consists of four main units (water networks, transport networks, rural and urban fields) differentiated according to size, with quantum leaps in land surfaces of 10. With this tool he analysed 25 perspectives of different public authorities and private associations, published in 1995 and 1996.[b] He then could show that indeed all of them were planning ongoing dispersal on a national scale (R=100km), in line with the fourth policy document on spatial planning report extra of 1991.

This analysis convinced Aldermen responsible for the municipal planning policy of Amsterdam, Rotterdam, The Hague and Utrecht that if they wanted to reverse this policy of dispersal, they had to join forces.

The first thing you do if you want to reverse a policy that was followed successfully for forty years is to change the concept on which it is based. The politically ‘correct’ concept is that there are independent cities developing independently. The reality is that the fields of influence of these cities in the west overlap and interfere and that this mutual interference weakens them because they spend energy in irritation in stead of saving energy by co-operation. Joining forces is the answer. Another politically ‘correct’ concept is that the Netherlands is the most densily populated country of the world and that the western part is the most densily populated part of this high density country. So the Aldermen said: “stop thinking of the delta as high density land and start looking at it as a low density city.”

Starting from there, a period of a year and a half has been used to develop a perspective on the transformation of the loose collection of independent cities into an integrated urban system, to be called deltametropolis. The four Aldermen commissioned the University of Amsterdam to write them a scenario and to organise a two week combined design studio of their best designers, commission the ING-bank with a research of concentration by integration, invited David Rusk from Washington D.C. to advise them on metropolitan development strategies and spend a series of eight sessions to formulate the declaration Deltametropolis. This declaration states in 21 articles that in a European perspective the need arises to transform the cities in the delta into a deltametropolis. This declaration was issued just before municipal and parliamentary elections in 1998.

A few months later, after being re-elected, these four people – three men and a woman – convened to decide on further action, to wit: to broaden the political base; to start a research and design programme to convince the supporters of the dispersal policy that in a European field of action concentration may be more desirable and maybe even necessary; to be active in public discussion as well as in everyday negotiations on policies and projects. In February 2000, the Association Deltametropolis was formally established. The association has institutional members only. At the moment this Chapter is being written, the Association has thirty-three members: twelve cities with more than a 100.000 inhabitants, five chambers of commerce, six waterboards, four ‘green’ members (two farmers’ associations, the Associations for Monuments of Nature and the National Recreational Association), four housing corporations, The Employers Association of Holland and a transport company. The idea is that the Association creates the opportunity to discover and invent together how this metropolitan transformation may be realised.

a Jong, T.M. de and M. Paasman (1998) *Een vocabulaire voor besluitvorming over de kaart van Nederland*.
b Jong, T.M. de and J. Achterberg (1996) *25 plannen voor de Randstad*.

The research and design programme concentrates on seven issues:

1. improving the water system of the delta that is now being used up to and beyond its capacity;
2. re-thinking the transport system to overcome the negative influence of low density and dispersed urbanisation on the efficiency of the transportsystem;
3. urban diversity, to use the opportunities of metropolitan development to widen the range of urban environments the delta has to offer;
4. economical synergy, analysing which clusters of economical activity establish themselves where and why, to be able to improve conditions for their earning capacity.
5. defining urban growth boundaries to conserve the water realm in the centre of the Deltametropolis and to guarantee its ongoing agricultural use;
6. the development of Leiden, of strategic importance as a node in the metropolitan transport system and
7. scanning cultural facilities and events to assess the cultural production of the Deltametropolis and its quality level.

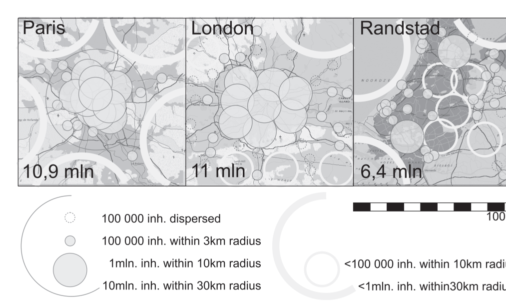
Several reports have been published;[a] seminars on the results are held with a frequency of two per year. Findings of the studies on the water and the transport system are finding their way in research and design of others, just as the Association also uses knowledge and ideas from elsewhere.

56.9 MAJOR IMPACTS OF THE EXERCISE

The Association has been unexpectedly successful in its everyday political action on policy matters. Policy documents of the Minister of Transport and Water Management and of the Minster of Agriculture state explicity that they agree with the concept of Deltametropolis. The Minister of Housing, Planning and Environment has adopted Deltametropolis as a main issue of his fifth report on planning.[b]

The proof of the pudding will be if he accepts that in this low density and rather dispersed deltametropolis, motorways and railways have to be connected to raise the efficiency of the transport system. A political preference for railway systems may lead to a policy that pays lipservice to the Deltametropolis but stays fixed on traditional notions of public transport by rail as if the Deltametropolis had the density of Paris or London.

The Association Deltametropolis aims at reducing travel time within the metropolitan area to a maximum of one hour. This norm is only attainable if cars and public road transport with taxi's, vans and buses take a fair share in total mobility.



571 Density of Paris. London and Deltametropolis

The contribution to strategic planning of the Deltametropolis Association has been quite impressive, keeping in mind its relatively short time of existence. From the start, 1996/97, the initiators knew they should be very selective in their choice of strategic projects, leaving the bulk of decisions where they traditionally belong. There are three criteria to select strategic projects:

- The project directly supports the main aim of the strategy: to improve integration of the metropolitan system and enlarge synergy.
- The project is conditional to many other projects and for that reason certainty should be attained about its realisation.
- The project is directly related to the metropolitan level and this level is the only right one to conceive, design and realise the project.

The first criterion refers to the importance of a strategic project, the second to the urgency of it, the third to the opportunity to take action.

In 1996 it was decided that the water-system and the transportation system should be considered strategic projects. The water system is chosen not only because of its existential

a Deltametropool, Vereniging (1999) *Personenvervoer in de Deltametropool;* – (1999) *Planning Metropolis, urban growth and social patterns;* – (2000) *Wonen in de Deltametropool;* – (2001) *Waterrijk Deltametropool.*
b VROM (2000) *Mensen wensen wonen, wonen in de 21e eeuw.*

importance for the Deltametropolis, but also because the water system is considered to be the main structural component of the delta landscape and the cities in the delta. The water system expresses identity and image of the Deltametropolis. This identity and image is internationally recognised.

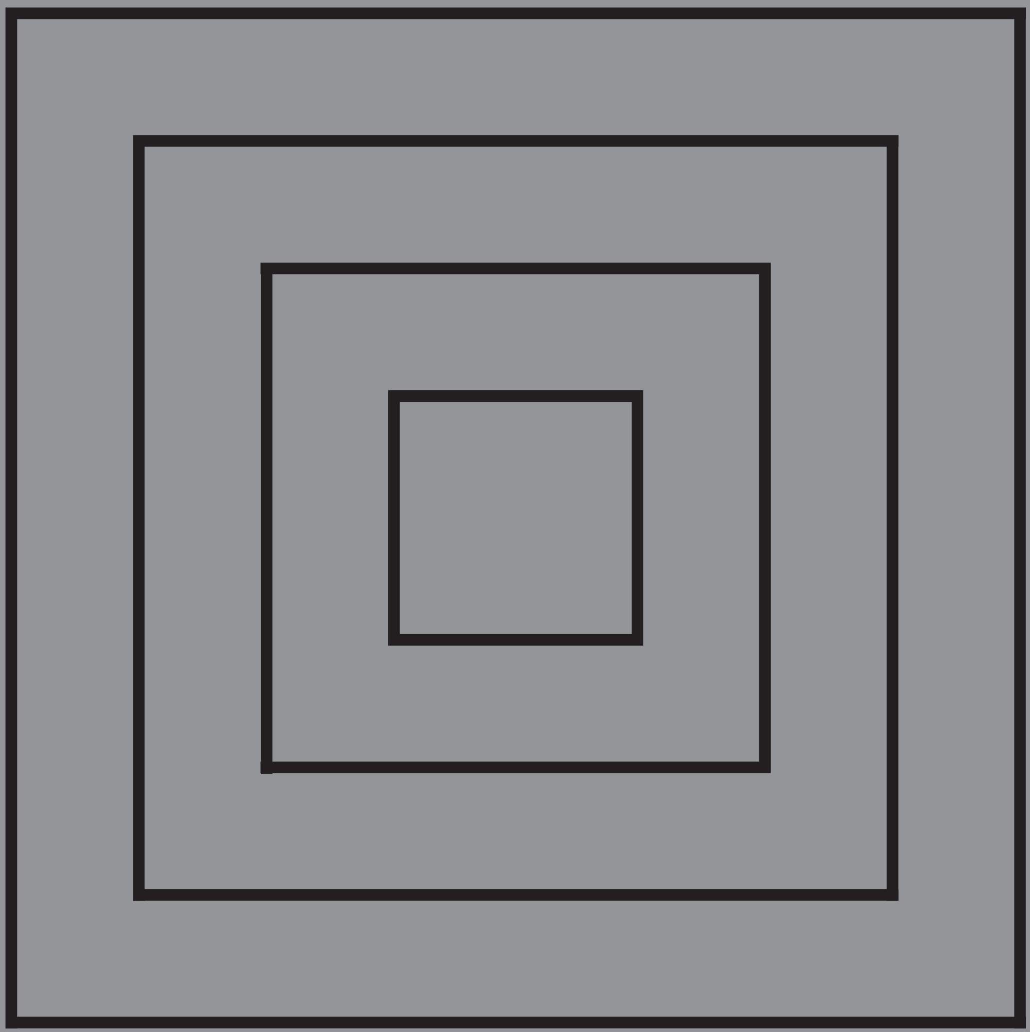
The transportation system is chosen for its direct contribution to improved integration of the metropolitan system, the need to organise the system on metropolitan level and the urgency of a major system improvement by integrating the roadsystem and railsystem that are still rather segregated.

The influence on design methods is not yet clear. The fact that the Deltametropolis Association offers a platform for informal policy discussion on perspectives has made it into a refuge for representatives of political and public and private bodies to discuss openly about quality criteria and to comment on explorative designs of transport systems and landscape transformations. By and by exploration by design is being accepted as a method to articulate an agenda for the future.

56.10 CONCLUSION

Where does the Netherlands stand today and what difference does the Deltametropolis concept make? The most important change, needless to say, is emergence of the European Union. With state boundaries having lost their rôle as economical boundaries, competition is no longer between countries, but between city-regions. Deltametropolis first and foremost is an answer to that new market-situation. The dependence of the Dutch economy on trade, transport and finance is a strength in an economy where wealth is based on worldwide exchange of material goods and Dutchmen happen to be gatekeepers of the main entrance to the European continent. Hoewever, in an economy based on information and services, the game has changed. If you are not an original source of information and if your service level is not up to world standard, you have got a problem.

Deltametropolis is a strategy to tackle this problem. The Dutch ideal of tolerance, solidarity and egalitarianism is dear of course to Dutch hearts. We should like to maintain this cultural identity as a characteristic of the European Union. The Deltametropolis declaration explicitly states that growth in size or wealth is not our biggest problem, nor foremost concern. It states that the city is an emancipation machine, a method of adding value and a school of civic culture. The Association Deltametropolis can serve as an example of this civic culture. It is an example of broad institutional participation in planning Deltametropolis; a serious endeavour to join forces to sustain, strengthen and enlarge the freedom of choice for those who live here.



57 EPILOGUE

THEO VAN DER VOORDT
YPE CUPERUS

57.1 THE ANATOMY OF THE BOOK EX-POST

The initial objective of this book was to write a text book on research methodology for architecture, urban planning and technical design students, with a particular focus on *research by design*. As such it aims to offer an extensive follow-up of earlier discussions of the so-called Methodology Board of the Delft Faculty of Architecture on types and methods of design related research. One member proposed that design driven research applying to be labelled as science should meet the methodological principles of A.D. de Groot's *Methodology: foundations of inference and research in the behavioural sciences* (1969). Other members disagreed and suggested that there are hundreds of 'scientific' research methods. After long discussions the committee published a short report on eight types of design related research, leaving out of consideration its methodological approach. From time to time new debates flared up on whether and when designing and research by design may be labelled as scientific work and a design as the output of scientific research. The present book has been initiated to reflect on these questions and to discuss methods and criteria for 'scientific' design and design related research. Over time a number of new objectives were added. One of these was a comprehensive overview of design related research and study at the Faculty of Architecture in Delft. Another wish of many in the Faculty was to raise the academic status of design, developing a basis for equivalence between certain design outputs and other, more traditionally recognised scientific activities. Yet another objective, though not universally supported, was to develop a more rational basis for design. Multiple objectives often lead to a hybrid. Some people may find this book *is* a hybrid. But, it is much more! As far as we know it is unique in presenting such a rich blend of many different perspectives, methods, and ideologies. In essence, this is really a book on methodology in the sense that it explores a range of methods!

56.2 SHARED OBJECTIVES, DIFFERENT APPROACHES

This book shows that a considerable part of study and research at the Faculty of Architecture at Delft is centred on the description and analysis of plans. Such analyses and the comparison of designs with reference to concept, intent, function, form, structure and technique are the focus of the research programme in architectural and urban design. Objectivity, intersubjectivity and interpretations subject to personal preferences, are weighed differently per project. Pre-design research and the evaluation of existing buildings also represent an important field of study, as does the study of the way in which design solutions are generated. Exploring new construction techniques, product-development, IT and other tools to support and optimise briefing and design and complex multi-actor decision processes in the field of real estate and housing are included as well. Some of the questions being examined are:

- How does a designer generate a concept?
- What is the rôle of typology, model development, hypotheses and forecasts in this process?
- Is evaluation '*ex ante*' able to provide timely indications of strengths and weaknesses in a design?
- How can empirical research '*ex post*' contribute to the improvement of briefing documents and optimising of design?
- What are the (dis)similarities between design research, typological research, design study and study by design with reference to objectives, methodology, object and context, applicability in design processes and scientific character?

As this book has shown, many faculty members are searching for a better appreciation of design tools and of the effects of design decisions, as well as for the optimisation of the briefing process and of design itself. However, some clear differences in approach and strategy were identified.

Empirical research usually starts with a conscientious identification of the problem and objective. It is strongly focused on a careful description of reality, the exploration of theories and the testing of hypotheses. It also tends to develop practical recommendations for designers, planners and policy makers based on the pillars of reliability, validity, desirability and probability. All this is centred around general knowledge and the further development of a body of 'true' knowledge.

Design research - often in the form of (comparative) plan-analysis - is usually strongly descriptive and exploratory and less prescriptively. It is generally directed towards interpreting, understanding and explaining designs and the design tools used, both in itself and with reference to site characteristics and the social, cultural, historical, technical, ecological and economical context. It may be instrumental in evoking inspiration and ideas for a particular design.

Typological research is a particular form of design research, whereas it looks back and tries to explore a typology of design solutions, traced from precedents. But, it can also be a particular form of design study or study by design, whereas the focus is on designing new, yet non-existing types. The focus may vary from description to exploration and testing, from empirical and descriptive to normative and prescriptive.

Design study is an integrated part of the design process itself, whether the design is actually constructed or not. In the field of design methodology many authors discussed the well-known cycle of analysis, synthesis, (simulation) and evaluation. This cycle may be applied to the design task as a whole or to a decomposition into sub-problems. Although the focus is mainly on a particular, context-related design solutions, design studies may explore new possibilities with generic applicability, new knowledge and a better understanding of probabilities and desirabilities.

Study by Design – elsewhere called *Inquiry by Design* or *Research by Design* - tries to generate knowledge and new insights by studying transformations of a design or design interventions in an existing situation. Generally, this type of study also features a strong exploratory characteristic. The first step is to generate new design variations using design itself as the process for the study. Hence the term 'means oriented study' is used in contrast to the more common goal-oriented approach. Then the implications of these variations are studied, whether or not leading to adaptations or completely different solutions. As such new concepts may be developed as well as a better understanding of the impact of different design decisions.

Design may differ sharply from study and research with reference to its product aimed at (a plan or building- versus research based scientific knowledge), its focus (searching for new possibilities - versus searching for desirabilities and probabilities) and its character (normative, based on personal preferences, views and ideology, versus empirical, based on facts). However, in practice the difference is often one of degree rather than kind. Particularly in design study and study by design, studying and designing are alternate processes. Both are employed interactively and iteratively, in order to arrive at a solution of high quality. In different phases and to varying degrees, what is possible, what is desirable and what is probable receives thus more or less attention. In the first instance, in moving to an improved design, contextual knowledge is more important than general knowledge. But, the opposite may be true as well. Starting a design process may evoke new problem statements and research questions, merging study and design to a strongly integrated process.

56.3 STUDENTS' WAYS TO STUDY AND RESEARCH

The task of academics is to research and teach. The Faculty of Architecture at Delft has always been a Design School, focusing on design driven education. While the proportion of non-design disciplines, such as real-estate and project management, asset management and the social sciences has increased in the curriculum, a considerable amount of knowledge is still taught in design studios within the master-pupil tradition. In this process, the teacher inspires the student through the demonstration and discussion of design. While the moments shared in this traditional teaching approach are too valuable to loose, it has become clear that there is a great deal to be said about design and the process of designing. This book aims to stimulate such an approach. In retrospect it presents a wide variety of opinions, design strategies and research methods. From strongly contrasting positions it demonstrates how research, study and design may be linked to one another. In this way, the book should become a valuable tool for the teaching of architectural, urban and technical design. Not only to teach students how to include research data and analysis in their design process, but also to guide them to contribute more consciously and effectively through their design projects to the research objectives of the Faculty. By using the book at different stages of their development and working through it with different faculty members, students may reach deeper levels of understanding. By being presented with the juxtaposition of contrasting points of view, students may experience a positive, creative tension, which facilitates learning. However, although the book shows a lot about *how* faculty members are doing research, in a strict sense it is not a text book on research methodology. For a clear understanding and developing of skills in designing research, different types of research (review of literature, survey, case study, experiment, content analysis of documents and plans, secondary analysis of existing data and so on), research methods and techniques such as interviewing and observation techniques, methods of data-collection and (statistical) data-analysis, this book should be used in combination with more traditional textbooks on research methodology. To ensure that this book becomes an effective textbook in itself and to achieve the same high standards as leading books on research methodology and techniques, it is proposed to hone this book on the basis of feedback from our students.

56.4 CONTINUATION OF THE METHODOLOGY DEBATE

The contrasts and complementarities in terms of strategy and methodology presented in this volume will provide a sound basis for further scientific debate in the area. Cross-references will help the reader in finding different opinions on the same subject. Being informed about the goals and techniques of peers will hopefully contribute significantly to the development of understanding and criticism, the deepening of knowledge and the raise of more inter-disciplinary compositions of research teams. For these reasons, it is intended to use the book as the basis of thematic discussion-meetings and study-seminars within the Faculty of Architecture in Delft. But, of course, 'Delft' also wants to contribute to the international debate and to receive feedback from the international peer group. Although this book originates from our inner circle, we are strongly aware of the leading discussions in many other architectural schools, both in Europe and in the United States. There, too, is a request for a stronger clarification of the issue of architectural and design research as a condition to maintain the status as academic institution. See for instance the book of H. Dunin-Woyseth and J. Michl (2001) *'Towards a disciplinary identity of the making professions'* of the Oslo School of Architecture and the ongoing discussions within the Design Research Society. Whereas we hope that *'Ways to Study and Research'* has shown that design as a field of inquiry has matured to an autonomous discipline, international exchange of ideas and methods will undoubtedly deepen our common knowledge and explore new insights. Furthermore, we are very open to inspiring debates with scholars from other fields of knowledge. So spontaneous reactions on the book are most welcome!

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INDEX

In this index an expression like y(x), object(subject) means ‘object y as a working (function, action, output, result, characteristic) of the subject x (independent variable actor, input, condition, cause)’. The sign → means ‘see also’.

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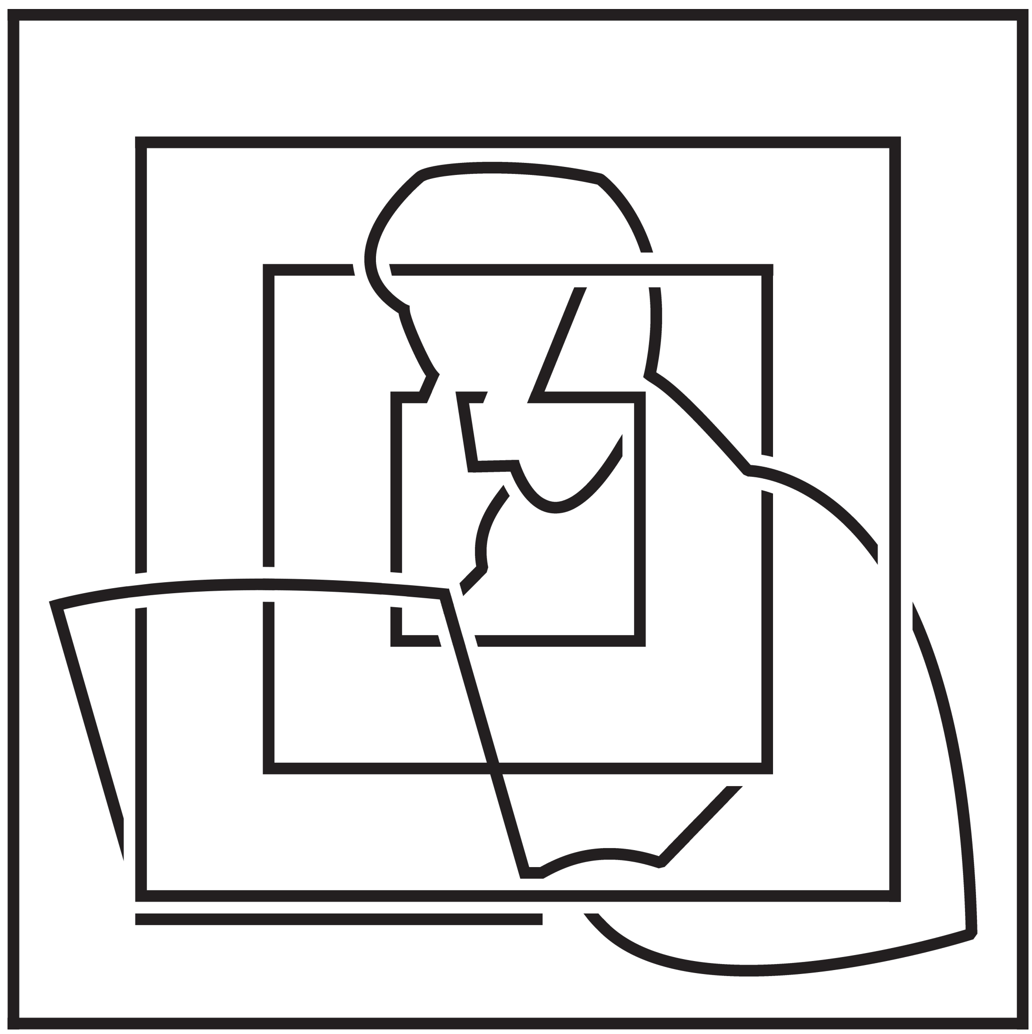
How can we develop a scientific basis for architectural, urban and technical design? When can a design be labelled as scientific output, comparable with a scientific report? What are the similarities and dis-similarities between design and empirical research, and between design research, typological research, design study and study by design? Is there a need for a particular methodology for design driven study and research? With these questions in mind, more than forty members of the Faculty of Architecture of the Delft University of Technology have described their ways of study and research. Each chapter shows the objectives, the methodology and its implementation in search for a deeper knowledge of design processes and an optimal quality of the design itself. The authors - among them architects, urban planners, social scientists, lawyers, technicians and information scientists – have widely differing backgrounds. Nevertheless, they share a great deal. The central focus is a better understanding of design processes, design tools and the effects of design interventions on issues such as utility, aesthetics, meaning, sustainability and feasibility.



To reach a shared understanding of these issues, designers must be cognisant of the goals and methods of their peers. This will stimulate criticism, deepen knowledge, promote the integration of ideas from different disciplines and lead to an improved co-operation between designers and researchers. As a consequence, this book is not only meant to be used in educational settings, as a tool to teach design, research and study, but also to give new energy to the debate about design as a scientific process.

DUP SCIENCE

WAYS TO STUDY AND RESEARCH

URBAN, ARCHITECTURAL AND TECHNICAL DESIGN

EDITED BY: T.M. DE JONG

D.J.M. VAN DER VOORDT