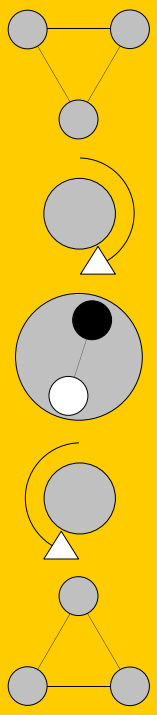
STELLINGWERFF

VIRTUAL CONTEXT

virtual context

investigating the characteristics and opportunities
of digital visualisation media for situated approaches
to architectural design in an urban environment



Marnix Constantijn Stellingwerff

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Contents

to my dear parents, family, friends and colleagues

Summary

This research initiative addresses the issue of Design in relation to Virtual Context.

Central to this study are the innovative potentials and instrumental opportunities of computer based media techniques, capable of generating interactive models and changing perspectives for the benefit of urban and architectural design.

The ambition was to not only make a contribution to the existing body of knowledge concerning digital technologies and their applications, but explore theoretical conditions which might help define and stimulate further study.

From the outset, the focus was on furthering the opportunities for *computer based representation media in creative design*. On the basis of a series of explorative studies the subject of this research was targeted: the issue of Design in Context, or more specifically: Design(ing) in a *Virtual Context*.

During the process there was a marked shift in the conception of the subject from – more or less *immersive* – VR technologies in the direction of approaches which might be expected to become readily available in practice and education and could be effective in actual design processes. This insight also brought about a shift in emphasis from *realism per-se* towards creating a *sense of situatedness*.

The design representation system which was developed was intended to not just allow for one type of model view, but to afford an *array of different views*, from which the designer would be able to choose freely, depending on the phase and focus of design as well as personal preferences. A series of *interface prototypes and support tools* were developed especially and successively tested experimentally.

For the intended final *design driven experimental study*, different *virtual context models* were considered. Eventually, an integral – purely fictitious – design 'environment' was constructed in the computer, so that the workings of the proposed system and its components would be tested systematically.

A conscious choice was made for an *in depth study*, on a relatively modest scale, which would a certain amount of *mutual involvement* between designer and researcher, to confront the participants with the finer aspects of the proposed system in a relatively short time and to gather detailed data. A half dozen design professionals were invited to participate in a closely monitored experimental exercise.

The results of this study therefore do not offer straightforward, indisputable *facts*, to be considered representative for the design community as a whole, but indicate that the *working methods* of the individual designers – when discovering aspects of the site, developing and presenting proposals and reflecting on the qualities of represented designs – tend to vary considerably. For this reason the interactive representation system proved to be of value. Participants could express *different view preferences*, with more or less *realistic* image modes being used in *different phases* of their design developments, with varying *experiences of situatedness*. Some of the design professionals participants were very appreciative of the system's opportunities, others tended to be more 'set in their ways'.

The results of this experimental study indicate that there may particularly be opportunities for interface applications which are able to function *interactively*, offering individual designers – as well as others involved in evaluating design proposals – a *variety of tools* with which to approach specific *design artefacts in their changing contexts*. Virtual models can play not only an important role as a 'reminder' for the designer but also to other parties playing an active role in the design and implementation processes. Interactive environment models are not only promising as exploration tools for *existing sites*, but could be valuable to test the impact of a design on its location. This could be especially interesting if the site is difficult or impossible to visit or as yet *a virtual construction*. In addition such an approach might be beneficial for objective comparison and evaluation of design proposals in competitions and in education as well as in on-line collaborative design projects where the context is still in the process of being developed.

Structure of the Thesis

The dissertation is divided into five main chapters:

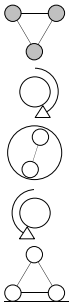
- Chapter 1: Introduction;
- Chapter 2: Spirals of representation and interpretation
- Chapter 3: Set-up of the experiment
- Chapter 4: Evaluation of results
- Chapter 5: Conclusions and recommendations

Furthermore, there are *intermezzos* between the chapters, in order to clarify and illustrate the development, realisation and evaluation of the research, as is addressed in the main texts. Such intermezzos cover several related *case studies* or provide transcripts of *explorative essays* related to the research domain. The *design representation prototypes*, which form an essential part of the main experiment, are also described in the intermezzos.
The intermezzos can be recognized by their grey toned backgrounds. At the end of the book an overview is given of the publications which are referred to in the texts.

This thesis, the interview transcripts (in Dutch) and the experiment system are available at the website: http://www.bk.tudelft.nl/users/stelling/internet/thesis/

No one, wise Kublai, knows better than you that the city must never be confused with the words that describe it.

Italo Calvino — Invisible Cities



Chapter 1

Introduction

Humans possess special skills which enable them to respond to impressions, brought about by a variety of surprising, threatening, familiar and pleasing stimuli.
An individual can *observe* specific features of his or her surroundings, whereby environmental information can be mentally stored and subsequently retrieved in an *imaginative* way from memory in the brain.
In design, such qualities of contextual awareness and the abilities of mental reconstruction are of great importance. Although many of the *contextual features* with which one is encountered can be memorized, designers are inclined to also rely on collections of *representations*, concerning the *existing context*, when working on proposals for new *interventions*, which will lastingly change an existing situation.
On the basis of such representations of 'place', the designer's *imagination* may be triggered, a process bringing about new ideas. Developing design *visions* and testing their viability in the existing context, can essentially be considered as an *imaging* process. Data concerning the environment as it is and the *imagined* realities the designer is considering are *communicated*, both with oneself and with a variety of others involved in the design and effectuation processes, via specialised *design media.*
Design images, created through the skilful use of such media, are intended to give insight and to generate responses, on the basis of which the intermediate design *concept* can be altered or refined until a fitting proposal for a new building or built environment in its urban or landscape context has been generated.
Collected data allows for contemplation and reflection in the working environment of the designer. The reflective design environment can take on different forms, ranging from (re)drawing on paper in the safety an architect's office to a fully interactive *CAVE* environment.
In such a design environment, the architect can prepare for real actions in the field.

Design ideas and *sketches* – noted down via physical or digital means – are translated into a 'V*irtual Context'* allows those involved to 'foresee' what may come to be in the future, whereby constructions can be anticipated and prepared successfully.

For centuries the architectural profession has relied on *pencil and paper* to draw maps, plans and projections, to jot down design ideas, to outline constructions and to render new perspectives.
At present, computers have been used extensively in architectural design practices for about three decades. Architects have learnt to use computers to prepare *building documents*, such as plans, sections and elevations. Based on such drawings, they frequently make *three-dimensional (3D) models* which can be evaluated visually or by computational methods. Working 'the other way' might prove to be a more interesting method. By immediately sketching and refining in 3D, the architect would be able to derive all sorts of evaluations from one central model, from the start of the design process and begin to expand this model environment in a *constructive* way.

Architecture is clearly being influenced by the possibilities generated by computer based representation platforms. New software, new tools and the changing working methods which are the result have already led to innovations which can be recognised in innovative building approaches, the search for new expressive forms of architecture and expanded possibilities to handle complexity in form and program. Contemporary architectural movements and particularly the futuristic ideas of trend-setting architects, often expressed through *seductive imagery* from the latest data-representation software, influence the changing conceptions of architecture in this era.
In this light, many *fundamental and practical questions* remain to be solved: issues of creativity; computer supported collaborative work (CSCW); parametric design; Human Computer Interfaces (HCI); Rapid Prototyping (RP) and the potentials of Automation in the Construction Industry need to be studied and developed further. Preoccupations, observations, perceptions, views, ideas, expressions and ways of communication, issues which are difficult to comprehend, but need to be addressed objectively.
At the same time, *human factors* are essential to each of these research topics, it is of paramount importance for a technical developer of new media applications to *review* and *focus* carefully on the human aspects of digital design media.

Over the past several years digital imaging and virtual reality techniques have begun to support the architect with the introduction of powerful tools for design in relation to a *represented building site as such* and in *a larger urban context*.
This research takes this development a step further by actually involving architects in a design media experiment in which they are required to design purely on the basis of *digital impressions*.

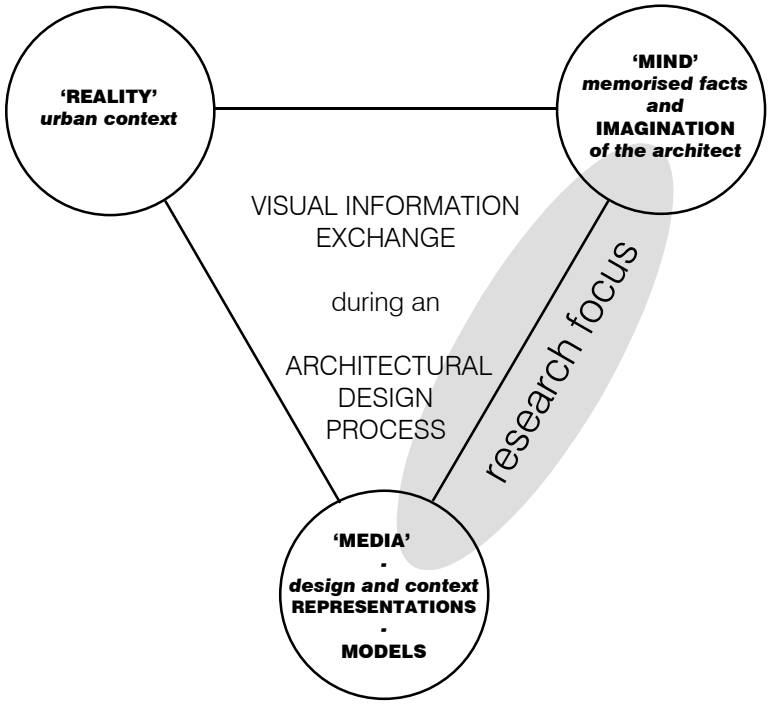
This research project was intended to contribute to a greater understanding of the implications of '*Virtual Context*'. Points of view and viewpoints (both mental and on screen) are the central subjects of study.
This thesis presents a documentation of this exploration which was carried out by means of several smaller case studies and one larger final experiment. It began by focusing on emerging techniques, but gradually all sorts of human aspects gained prominence and began to play a considerable role in the research project as a whole.
Besides the relationships: man - media, architect - researcher, object – subject, this study attempts to address new ways to carry out research, to evaluate data and to draw conclusions.

Recurring themes in the research initiative concern interactions between:
- representations and interpretations;
- the outlook and the way to look in and out;
- viewpoints and points of view;
- visions and vistas.

The goal of this research is to acquire greater insight into the way architects use visual information to represent design ideas in relation to the urban context of a building site. Greater insight is needed because of the large variety of modes of representation and the way different visual information is needed for different tasks and phases during a design process. Furthermore, the preferences, roles and effects of specific types of 3D (three dimensional / spatial) visual information media are still unclear and need to be further understood in order to develop more useful design media and 3D urban / architectural models.
These insights should extend the current knowledge about architectural design as a process, about the effects of design media and about the potentials of 3D models for design. This research is intended to lead to more efficient and creative use of existing tools and to developments of new types of design media with new features, in accordance with appropriate modes of representation. The gained insights should also lead to a more effective organisation of 3D urban models so that during the design process, different needs for information could be better supported with accurate visualisations.

This chapter starts with a review of the research field (section 1.1). Three cornerstones confine the triangular field: *reality* (the urban context), *mind* (the architect's imagination) and *media* (contextual and design representations). Problems from several areas in the research field are presented in section 1.2. As not all of the indicated problems can be faced at once, the research concentrates on part of the field (see grey toned area in figure 1). The focus is on *architectural impressions and expressions, which are represented in different ways (through media)*. The initially broad research field, can be summarised as a project that focuses on *the use of a limited but diverse set of urban context and design representations that are tested in several design experiments with architects.*
The research questions are discussed in section 1.3 and the general approach and methodology in section 1.4.
Section 1.5 describes how the research was framed and positioned in such a way that the results are related to changing techniques and how the research distinguishes itself with respect to parallel developments and innovations. The chances for this kind of research - in general - are explored. The last section of this chapter summarises the research *problem*, the *goal*, the *expectations,* the *benefit* related to *the field of architectural design* and *to the use of design media* and *design research*.

Figure 1. Scheme of the research field.



Terminology

Reality, mind and media are wide ranging terms that label meaningful cornerstones of the research field. Actually, in the research experiment, these labels get specific meanings:

reality → urban context, part of a city / the given case environment,
mind → memorised facts / imagination of the architect,
media → experimental system for representation of design and urban context.

The research field is in motion

Due to fast moving technological developments of computer science, i.e. ICT (Information and Communication Technology), CG (Computer Graphics) and CAAD (Computer Aided Architectural Design), the research field is obviously a field in motion. Therefore innovations in the many related fields were monitored constantly during the course of the research.

1.1 Research FIELD

Three cornerstones define the field of this research:

• REALITY - The design process, conducted by an architect, starts and ends with a focus on reality. At the start, when a new commission is acquired, the architect explores the site and its surroundings. The contextual information from the built environment informs the architect in a partially restricting and partially inspiring manner. The collected information from the site is brought back to the design office, where it is used as reference information during the whole design process. Finally, when the design is ready, the whole design is laid down as building documents. These drawings, specifications and calculations describe how the design has to be built and how it relates to the specific context. Based on these building documents, the actual building is constructed. In the end, the new building and its surroundings form an altered environment. The place has new characteristics, there is a new 'image of the city' [Lynch, 1960], with updated utility and different patterns of use.
Reality is the place where the design comes to realisation. Reality demands a good fit for a new design, because reality includes people with habits and expectations. Reality has a past and a future and reality is the final check for design. Reality confronts with unforeseen facts and unexpected effects. The multiple aspects of reality become manifest in a COMPLEX URBAN CONTEXT.

• IMAGINATION - Architects are trained to 'read' drawings. The skill of dealing with images can be called the architects' *'visual-literacy'* [Cullen (see p226 in Gosling 1996), Stellingwerff, 2002] or *'graphicacy'* [Cross, 1982]. When visual-literate designers read maps, plans, sections and elevations, they are able to empathise with the represented design. With some effort, they can build a mental model in their mind. Architects can *imagine* the building or the city. Ideally, this mental representation can be explored as if it were a real environment. However, it is well known that the memory and imagination tricks with facts in several, partially uncontrollable ways. Facts in the short-term memory are estimated to be limited to seven, plus or minus two, 'chunks of information' [Miller, 1956] and we know that imagination can be biased by wishful thinking and forgotten conditions. The characteristic features of memory in the human brain, which has limitations, also brings powerful advantages. Memories are linked in a way that allows association. *Whereas*

facts might be lacking, interrelated thoughts could be looming. The 'visionary power' to integrate facts and thoughts into 'mind-blowing inventions' relies on the IMAGINATION OF THE ARCHITECT.

- MEDIA - Relatively new means of design representation, such as Architectural Endoscopy (AE) and Virtual Reality (VR) have become available to assist the architect to pre-view a design in 'virtually' all its visual aspects. The scale model or the design database represents the design in a specific, more or less detailed, way. *Faults out of limited awareness and biased imagination can be bypassed by visible facts*. The 'visual cues' from scale- and digital models make AE and VR very helpful tools in a design process. The 'virtual realism' of 3D models can be beneficial in design development and for mutual understanding between architect and client [van der Does, Giró, 1999]. On the other hand, one can question this need for visual directness as further imagination might be pushed aside by seductive impressions. The quality of media could be found in choices of 'appropriate' REPRESENTATION.

Thus, in short, there are three couples of terms, which outline the subject of the research:

- *reality* characterised by a *complex urban environment*,
- *the architect* with the power to *imagine and*
- *media* that can *re-present* images from the architect's design ideas and images from reality.

These terms and related problems are further discussed in the following paragraphs.

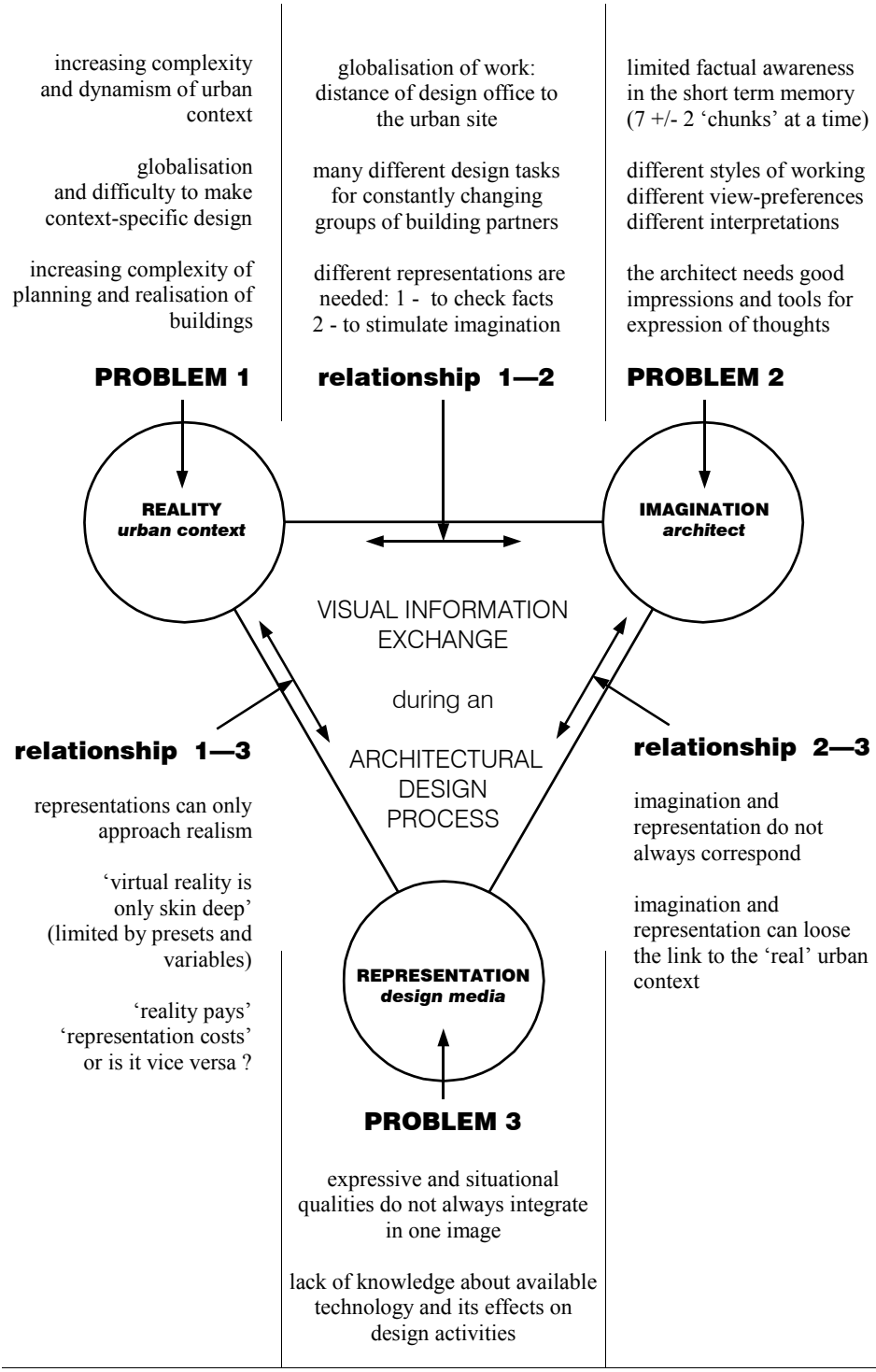
1.2 Definition of PROBLEMS in the research field

In the present day, we have to deal with increasing amounts of information. It is obvious that not all of this information can be kept solely in the head. We have to note things down and look things up in agendas, notebooks, databases and documents. The same applies for the work of architects. However, the problem of information management in architectural design has specific aspects and unused chances that need to be further understood.
During an architectural design process, a lot of information is represented in the form of images and models. The problems that are faced in this research can all be related to the exchange of visual information between the three realms of imagination, representation and reality (see figure 1 and 2). Therefore*, images* and *3D models* play an important role in the research.

Considering the complexity of cities, architects have a difficult but interesting task fitting a new design into the already existing urban context. In order to make it fit, it is necessary to make both the urban environment and the design ideas *'virtually realistic'. This virtual realism is defined here as representation in a direct, passable and visually recognisable form.* For example, perspective drawings, scale models and 3D-computer models are kinds of representations that are considered 'virtually realistic'. A list of building sizes and descriptions of applied materials are also very useful representations in a design process. These might be called *'factual realistic'*. However, such representations are not studied in this research.

Virtual realism is a way of trying to foresee the real future, in which built-design and existing-context come together. The *'superimposed image*' of the design within its urban setting gives the architect feedback for further development of the design and stimulates communication with the client. New media enable the architect to pre-view the consequences of specific design options. However, the architect's preferences for different *'virtual realistic' representations are not yet linked to specific activities* during the design process. Moreover, the *effects and the exact roles of such representations are not yet clear*.
The problem of relating design to its context becomes more urgent if we consider that currently cities change rapidly and become more and more complex. We can speak increasingly of the *dynamic complexity of cities*: whilst one building is planned and designed for a specific site, the surroundings of that site can change simultaneously.

Figure 2. Scheme of the problems that can be indicated.



'*Design in Context*' implies that, apart from buildings that will become the neighbours of the design, often structures and ideas from the past have to be respected, or at least recognised. Future developments also have to be taken into account. With so many details and so many possible changes in the real world, it becomes very important to *keep models up-to-date*.
A totally opposite but equally relevant problem might be that *'virtual realism' can become so convincing that it competes, fakes and distracts from reality*.
With all the interesting features of 'virtual realism' that are available, it is difficult to decide how the detailed and complex reality can be represented in the most useful way. The available 3D-models and drawings, maps and facts play an important role in the thought processes of architects and clients. It is considered that we should rather focus on *'models for...*' than on *'models of...*' [Glanville 1996]. The 'models for' indicate *a possibility*, a chance to design, whereas 'models of' depict one *confined end situation*. The aim in this research was to have an experiment with *a model for conversation with the designer*. The 'virtual realism' could be made adaptable in order to be reflective to the designer's thoughts.

The research problems will be further described in relation to the cornerstones of the research field: imagination, representation and reality.

PROBLEM 1: REALITY and COMPLEX URBAN CONTEXTS

- Representation and understanding of reality - a general problem.

If you wander and just surrender yourself to the overwhelming beauty of the stars at the firmament, clouds in the sky, landscapes, paths and people, castles, farmsteads, houses, villages, cities, skyscrapers, boulevards and … shopping malls, then there is no problem. The problem arises when we want to do something with our environment, want to say something about it, want to make images, or want to change it. Then, understanding the environment becomes a problem. The problem of understanding and re-presentation is a problem for artists, scientists and architects.
This problem is too general and too large to be covered in one thesis. Possibly, this problem can only be covered in a philosophical tract. However, beginning to understand the reality of our built environments is an important starting point for any academic design study. Understanding has to do with perceiving, describing, recognising, sub-dividing and making abstractions of attributes. All such operations generally have one thing in common; re-presenting what was perceived. Re-presentation has to do with creating visual information that will afford greater understanding.

- Experiences of context and design are subjective

Architectural design is involved with the development of ideas that are intended to be 'realised' in an existing phisical and cultural context. Although a design can be studied as an independent artefact, it is in most cases designed for a specific site. After a building or urban plan is realised, it will be used and perceived within the context of landscape, nature, the city, in relation to other new buildings and existing urban structures. An important task of designers is to fit the design into the given situation in an appropriate way. They work in mental constructions using design media to check and refine the design in relation to its context. It is not straightforward what *the* appropriate way is; we cannot point towards one single design paradigm. The designer has to act responsibly and creatively and discover his own criteria and solutions for a specific task. Both the context and the design that responds to it are multi-interpretable, culturally biased and subjectively perceived by individuals. However, when the design is presented, or when it is realised, *the fit* of a design in its context can be evaluated based on situational and functional criteria. A recent PhD study showed how multiple subjective criteria can be used to investigate different design proposals, by incorporating fuzzy logic into analytical techniques [Durmišević, 2002]. Before such enquiries can be made, the architect has to deal with uncertainty and has to value the many different influences that could direct design ideas.

- Theories to understand and approach reality are very diverse

There are different starting points to approach the issue of context. To mention just some conceptions relating to such approaches: People, Paths and Purposes [Thiel, 1997], Cohesion, Fragmentation, Networks [Bekkering, 1998], Public-, Collective-, Private- space [Heeling, 1998], Pattern Language [Alexander, 1977], Elements and Types [Krier, 1983], Complexity and Contradiction [Venturi, 1977]. Each set of conceptions may have its own underlying theoretical basis, rationale and often ideology. It is beyond the scope of this research to venture deeply into such design issues, but it should be clear that there are very diverse ideas and approaches concerning the complex relationship between context and design intervention. This research is not specifically based on a particular method or set of convictions concerning the design of the urban environment.

- DYNAMISM of urban context, BIGNESS and GLOBAL trends

According to the theory of 'genius loci', each place possesses its own characteristics that as it were ask for specific solutions and specific designs

[Norberg Schultz, 1979]. Currently, the force of globalisation is strongly felt. The face of the earth is being changed drastically by human activities such as by agriculture, mining, transport and especially by explosions of urbanisation. Metropolises are faced with constantly changing infrastructural demands, new types of city cultures, new patterns of use and 'added', 'recycled' and 'deleted' buildings. In one theory the influx of ICT will bring people to areas where it is less crowded, in another theory ICT developments bring even more congestion [VROM-raad, 2001]. The increasing complexity of cities forces designers to adopt totally new approaches that sometimes neglect or overwhelm the smaller scale regional aspects. We can question if Critical Regionalism [Tzonis, Lefaivre (1981,1990,2003); Frampton (1985)] can endure the global trends such as 'sprawl' [Xaveer de Geyter Architecten, 2002]. Can we speak of Uncritical Globalism, or is there a new pragmatism that tries to use each available aspect in any appropriate scale, or from any other reference to ground architectural concepts and narratives?

Koolhaas presents 'Bigness' as a development that ridicules the notion of context and urban place: *'Bigness transforms the city from a summation of certainties into an accumulation of mysteries. ... Together all these breaks-with scale, with architectural composition, with tradition, with transparency, with ethics - imply the final, most radical break; Bigness is no longer part of any urban tissue. It exists; at most, it coexists. Its subtext is: fuck context'*. Everything that does not belong to the Bigness concept, is pushed aside ironically: *'Not all architecture, not all program, not all event will be swallowed by Bigness. There are many 'needs' too unfocused, too weak, too unrespectable, too defiant, too secret, too subversive, too weak, too 'nothing' to be part of the constellations of Bigness'* [Koolhaas, 1995].

The urban context used in the main experiment of this research project has nothing to do with Bigness… Here the characteristics of 'the given' are intended to provide stimuli to reveal the participating architects' thoughts about design in context. It is one of the underlying ideas of this research that even the smallest 'constellations' of visual cues may be valid to start thoughts and to let design ideas emerge.
There are arguments that support this approach to the urban fabric: *'the need for an awareness of history in general counts for town planning (stedebouw) in particular, as in most cases, design tasks are situated in areas where much more remains the same than changes'* [Bekkering, 1999 (in Dutch)], (translation by the author).

Any existing built environment needs to be valued, to be criticised, to be related to, before it is to be re-composed. Neglecting, *that* is neglecting the cultural dimension of the profession and the responsibilities that architects and urban designers have.

PROBLEM 2: ARCHITECTS and IMAGINATION

Imaging, imagery, imagination, 'seeing with the mind's eye', are terms which are popular with designers and design theoreticians to indicate that, to a certain extent, they have to see a design in their thoughts and rely on their sketches to get a hold on these mental constructions [Arnheim, 1996, Goldschmidt, 1994]. However, among design-researchers and psychologists, there has been some controversy as to whether images reside in the mind or if they are instantly redrawn from separate memories [Liddament, 2000]. Through the years psychological literature has made a distinction between visualisation based on imagination and visualisation based on memory [Perky, 1910, Kosslyn, 1994]. *Memory visualisation* refers to events or occasions that one has personally experienced or observed, while *imagination visualisation* creates a new, never before experienced event [Perky, 1910].
The problem is to relate psychology and perception research, to the much more embedded issues of design and design decision making.

In perception research, there has been much research concerning how designers perform different design activities. Some researchers have tried to reveal the most detailed mental processes in order to understand parts of 'the design process' as a bigger whole. Comparisons are made between laymen, novices and senior designers, in order to understand the role of design skills that have been learnt [e.g. Kavakli, Gero, 2001, 2002]. In a direct link to mental, behavioural and perceptive aspects, some researchers have drawn conclusions about processes that in reality may be embedded in various external influences or distracting circumstances.

Through Protocol Analyses (PA), some researchers try to get a grip on the mental processes of designers, as they design. Research has been undertaken to get a better understanding of designing in order to develop computer-based support tools [Gero, McNeill, 1998]. Many participants are needed to reach statistically grounded insights. In such research it is not easy to find or develop a good coding system to separate the expected mechanisms from the actual thoughts expressed through the documented utterances and behaviours of the participants. Such research is intended to provide ‘reproducible results, which are capable of characterising designing’ in contrast to ‘literature, which is

based on anecdotal evidence or on personal introspection' [Gero, McNeill, 1998]. It is my opinion that anecdotal evidence is inevitably relevant, that it is reproducible and that it may provide valid knowledge on the level of hints, suggestions and impulses for further, possibly more precise, follow-up research. This opinion will be examined further in chapter 5. *A fruitful approach to analyse 'how designers design' could lie in protocol analyses in combination with quotes of their 'anecdotal' reasoning.*

Although it is interesting to study imagination as a mental process, it can also be treated as a 'Black Box' that delivers 'unlimited associations' to the designer, in an iterative and constructive design process. This principle is followed in this research project. The subject of the research is not imagination itself, but creating the *conditions* for imaginative reasoning. Specifically, the potentials of *different modes of representation* are studied.

Still, when the conditions for stimulating imagination are the subject, it is useful to know more about characteristics of human perception and memory. For this research, at least three aspects are crucial. An established notion is that we can only keep *seven plus or minus two 'chunks of information'* in the short-term memory at a time [Miller, 1956]. Another insight is that 'points of view' can be *framed* in such a way that other thoughts come to mind only with difficulty [Schön, Rein, 1994]. A third idea is that media and reality are very directly accessible sources that allow one to rethink framed thoughts (i.e. to be inspired) and to *change the 'point of view'*. This idea may become clear in the description of sketching as a '*reflective conversation with materials of a design situation': 'A designer sees, moves and sees again. Working in some visual medium - drawing, in our examples – the designer sees what is 'there' in some representation of a site, draws in relation to it and sees what has been drawn, thereby informing further designing.* [Schön, Wiggins, 1992].

In other words, we cannot constantly keep all design ideas or aspects that we want to remember in mind. We are limited, even fenced off and focused in what we think. However, the hints from reality or through media, can make us 'hop' from the one idea (chunk of information) to another.

PROBLEM 3: MEDIA and REPRESENTATION

Hitherto, much research effort has been focussed on the methods and techniques of producing 3D digital city models. A recent overview of essential 3D-City Modelling Research was given during a special session at the 19th eCAADe conference in Helsinki [Dokonal, Martens, 2001]. Papers in this session focussed on diverse and important issues like: *'Developing Standards for the Creation of VR City Models'* [Bourdakis, 2001], *'On Building a 3-D City Model with Students'* [Dokonal, Martens, Ploesch, 2001], *'Modelling the City History'* [Kós, 2001], *'Making and Using a City Model: Adelaide, Australia'* [Pietsch, Radford, Woodbury, 2001], '*Welcoming multiple visitors to the Virtual City'* [Ennis, Maver, 2001] and *'The 3D-City Model – A New Public Space'* [Holmgren, Rüdiger, Tournay, 2001]. Despite the important work on conceiving and deploying existing 3D-city models, many questions on the topic of city model applications and the direct preferences and effects concerning the imagery of 3D-city models remain unanswered. None of the papers in the conference session or any other consulted publications on the subject of 3D-city models focussed deeply on the actual view-preferences expressed by an architect, while using such models. Neither were the direct effects which 3D-city models might have on design thinking investigated in a methodical way. Most studies were linked to real cities, which is straightforward but undesirable when trying to address architects' visual literacy, where recognition of qualitative aspects of a represented city plays an important role. After all, knowledge about the real aspects of the case-city could bias the judgements in an experimental study.

Research into the impact of media on design thinking seems to have jumped from fundamental research mainly targetting the initial design phases (hand-drawn sketches) [Schön, Wiggins, 1992] and architects' reasoning [Arnheim, 1970], to topics about the concrete use of 3D-city models in very specific applications such as historic studies [Alkhoven, 1993], or in collaborative design research [e.g.: Stellingwerff and Verbeke, 2001]. Other recent research has tended to focuses on technical issues of high-end interfaces for the benefit of immersive-VR [e.g.: Kruijff, Donath, 2001] and special projection methods in e.g. a CAVE-system [e.g.: Klercker af, Henrichsén, 2001]. While new and more advanced digital media give occasion to further investigate the impact of design images, most research is currently focussed on the direct benefits of techniques and on the immediate production of advanced models and systems. Specific focus on the impact of fast evolving virtual representations on ordinary desktop computers seems to be disregarded. After the traditional design-media research by Schön, Wiggins and e.g. Hamel (1990), the

preferences and effects of media in relation to architects, appear to be neglected in current research.

Research about the preferences and effects of newly available technologies is indispensable. Lack of such research is reflected in recurring mistakes in the way some techniques are used. Several presentations (of undeniably interesting efforts to make attractive 3D-city models) show models from unnaturally high viewpoints just above the building blocks that move at enormous speeds. Research and common sense should have directed the view to either a well-chosen bird's-eye view or a normal person's eye height. It has to be said that many 3D-city models look extremely good with respect to their materialisation and their extensive use of photos for texture mapping. However, most 3D-city models get their quality from a special team of modellers that act as self-educated craftsmen. None of the surveyed research indicates whether architects might actually want to see much realism in models. We do not know how impressions from different models and different representational techniques, may distort or support our perception of reality.

Currently, there is growing criticism about the quest for realism in computer-generated imagery. Dutch architect Fons Verheijen: *'Ideas and concepts are so realistically presented that it seems as if the design is finished. One forgets that after this conceptual design phase, there will be a whole world of architectural and building technological work and feedback. There even seems to be a tendency to shape architecture in such a way that it conforms to the virtual image from the computer. One misses chances to deepen the concept. ... The whirlwind of ICT developments should lead us to simulation of reality, not only in image, but also with respect to physical laws and legal requirements'* [Verheijen, 2002 (in Dutch)], (translation by the author).

1.3 Research QUESTIONS

This research project started with many questions. At first, questions were invoked by the emergence of a new and tempting medium: Virtual Reality. In the wake of the initial enthusiasm surrounding VR, which was supposed to offer 'limitless possibilities', questions were being raised of a primary technical and practical nature. How can we best get the existing world represented and available in 'real time' via a digital model? How can architects design within a represented context? How can we reduce the virtual model's data-size in order to get more rendering speed? These questions were 'most interesting' before the research started, around about 1998. The answers and insights to such questions which were being put forward at that time, can be found in the work of e.g. Bourdakis, Ennis and Donath (2001).

Gradually the research questions changed. The focus moved to 'desktop VR', which in principle is more 'connected' to the daily practice and technical facilities in architecture offices. VRML became generally accepted as the core technology to build a laboratory test-system. The aim of this research shifted to finding potentials in the use of VRML as a non-immersive visual representational medium. The questions became much more focused on the choice of impressions and the effects of different kinds of visual representations in design. What is the effect of colour, compared to black and white-representations? What is the effect of a particular angle of view in a perspective rendering? How does the rendering of 'fog' and 'transparency' help in the understanding and appreciation of spatial images?

Eventually, the focus of the research became much more human related. The search for the 'right view at the right time' about architects' view preferences and their visual literacy was inspired by the 'right tool at the right time' PhD research of Ellen Yi-Luen Do (1998). The preferred views of architects, represented via the computer screen, are supposed to have their impact on the architects' 'point of view'. When does a designing architect require a view from above and when is an eye level view preferred? When and how do the design ideas 'surface' during a design process? Are the ideas and the flow of thoughts directly linked to the way a design is viewed? Can we speak of a visual literacy of architects? How can the interaction between a designer and the applied design-media be understood? With such questions, the development and understanding of new visual language aspects became the final goal of the research.

1.4 Research APPROACH and METHOD

The research draws on notions of design as a cyclic process in which design ideas emerge through a kind of ‘conversation’ with the applied media. This approach would allow designers to design while they are being observed. This research is not set up as a confined experiment in which the research participants get a limited set of tasks and materials to which they can react in a limited set of ways. The research is conceived as 'design driven research' [Breen, 2002/1], not cognition or behaviour research. The outcomes and findings of the research are thereby not 'measurable' in a statistical way. The scientific results are interpretations of design artefacts, design narrative and of a monitored and (re-) constructed design process. Chapter 2 describes the interlinked cyclic aspects of design and research.

It is postulated to be fundamental to technical research that prototypes should be treated as 'technical hypotheses'. Only by building and testing prototypes, can the technology be put to the test and improved.

Hypotheses and prototypes are methods which respectively involve the theoretical testing of conceptions and the technical testing of constructs. A hypothesis is a testable thesis that requires a theoretical proof. A prototype is likewise a testable type (a ‘construct’/system/proposal, e.g. a machine or a production method) that requires a technical proof of its qualities and performance. Both hypotheses and prototypes differ from final theses and real products in the fact that they are proposals, which might lack in verity and utility. Even, for the sake of a vivid theoretical discussion and better technical insight, one could advocate that they *should* initially lack in verity and utility.

Before hypotheses and prototypes can be tested, they need to be developed based on the state of the art knowledge in relation to imagined possibilities and truths. Descriptive research analyses existing situations and data. Explorative research is intended to reveal possibilities.

In this research, both theoretical and technical research methods are used for the benefit of descriptive, explorative and empirical approaches.

Table 1. Research types and their methodological objects.

research typology		
	THEORETICAL	TECHNICAL
DESCRIPTIVE	references	models *of*
EXPLORATIVE	scenarios	models *for*
EMPIRIC TESTING	hypotheses	prototypes

Each of these distinct methods proved to be useful and relevant for the completion of this research as a whole. Without references, one would be obliged to start each research from scratch. Without exploration, one would be confined to and focused on existing conceptions and solutions that are already at hand. Without testing of physical and mental constructs, one would stay fundamentally hypothetical. Without theories, one cannot be expected to make predictions for practice. Without technical research (such as it is performed, for example, by a playing child), one cannot approach and change the real world of people, animals, plants and things.

In this research, empirical testing is not just used in an experiment to find if hypotheses and prototypes are valid and functional, it also includes a broader interpretation on the basis of observation of existing and new information [see also Priemus, 2002].

1.5 Research PLACE, ROLE and CHANCES

As was mentioned in the paragraph of research questions in §1.3, there has been steady shift away from technically focussed issues towards human—computer interface (HCI) issues related to design.
In all of the phases of this research there has been contact with other research groups, which have a more or less technical focus in their research. Virtual Reality research laboratories with high investments (e.g. for CAVE systems or a complete model *of* the city where they are based) often rely on commercial and community reasons to exist. However, such laboratories and high-end facilities do not suit less ambitious, yet powerful equipment available to most design offices. The focus of this study tries to get closer to requirements in design practice. Nowadays, most research experiments related to architectural design and computer interface / representation issues can simply be carried out on a desktop computer, in a quiet office room.

Besides developments to use ordinary equipment and to have the focus on design in relation to representations, there was another important change in research approach. This development, inspired by publications by Donald Schön and Ranulph Glanville, changed the research approach from ‘rigid and cautious in order to be scientific’ to ‘eagerly explorative; to innovate design research and to understand aspects of representation in relation to design’. This shift in the emphasis of the research needs more explanation.
Schön’s ideas influenced the content and approach of this study by the value

that was laid in his careful description of design processes [e.g. Schön, Wiggins, 1992] as compared to, for example, policy controversies [Schön, Rein, 1994]. A careful description is a necessity to reveal the precise considerations of an observed designer.
This was seen as a useful analytical method, opposed to a more traditional (and rigid) scientific approach, in which data is weighed and presented in figures. A protocol analysis, in this respect, appears to be a much more scientifically controllable method of research. However, the actual design issues, the narrative and the intentions of the designer (his/her personal considerations) can in principle come across much more revealingly in Schön's descriptive approach.
Glanville claims to be interested in design because it is constructive and uses 'second order cybernetics theory' to describe design research and design. He considers that the different roles of the experimenter and the designer are often forgotten, disregarded and excluded from reporting in research and design. Cybernetics originally was about the control of systems. Second order cybernetics actively involves the controller, the observer of the system, in the understanding of the system as a whole. This makes a difference because the often excluded (ghost) person is nonetheless present as a force to be reckoned with. He or she can set the conditions for an experiment and is often biased (or 'framed' as Schön would say) in the way the responses and findings are perceived.
The impact of Glanville's writings has led to a practice whereby 'I' sometimes use the first person in my reports to indicate that there may be some real influence by me, in the design and the findings of the research. It is often considered unscientific to use the first person in research reports. However, there is a trend to allow for personal thoughts, as it may resolve boundaries to curiosity, sometimes goes beyond the questioned, encourage innovation and allows for failure when theories become replaced by new insights. Especially in technical and design related research applications, there are always elements of straightforwardness, pragmatism, control and embedded requirements that make each case special. Such issues need to be recognised are not necessarily in contradiction with the search for scientific truth.

Both Schön and Glanville approach design as a 'constructive' process that needs reconsideration, is iterative and should allow mistakes in order to be innovative [Schön and Wiggins, 1992, Glanville, 1995]. Each design step generates new results, new representations and new understandings that in turn lead to new unpredictable design problems, new approaches and new directions. This implies that for design research the topics to be researched are

intrinsically so complex (i.e. embedded in real life) that findings of one single paradigm or understanding through separation in completely consistent (design) steps is not feasible. Therefore, it was expected to be fruitful to see and describe the findings of design experiments as *constructive explorations.*

Another aspect in which both Schön and Glanville have a common approach is *the view of media as a conversational partner* [Schön and Wiggins, 1992, Glanville, 1995] as a particular application of the Conversation Theory by Gordon Pask [Pask, 1975]. Design media (sketches, CAD drawings, etc.) 'have an open ear to the designer' to record and represent the ideas of a designer, but also give occasion for reflection. If an architect is trained to use design media, he/she can as it were have a productive conversation with the design ideas through representation.

Not all of the approaches mentioned above were familiar to me at the start of the research. Especially in the main experiment of the research, notions of design as being conversational and constructive were instrumental in determining the 'design' of the experimental approach.
Particularly in the last phase of the research, while writing the dissertation, did the understanding of second order cybernetics (i.e. the impact of my role as developer of the experiment, programmer of the software prototypes, interviewer and as analyser/reporter of the findings) become of utmost importance. The deeper understanding of above mentioned conceptions allowed me to present VRML prototypes (see the intermezzo at the end of chapter 3) as technical research results, with a distinct role to produce useful sorts of representations. Moreover, findings from conversations with architects and the study of their process results, using the provided prototypes, led to results which could be suitably articulated due to my involvement in the experimental process.

In view of the above, this research consciously broke with some aspects of traditional design methods research and 'design science' [Gregory, 1966] [see also Cross, 2002]. The opportunities of this research involved taking some risks to find identifiable preferences and effects through a constructive conversational design process, whereby the designer is exposed to adaptable represented information of an urban environment, as a context for thought.

1.6 Research BASIS

This chapter considered the general field of research, the related problems and the quest for the development of fitting research questions. The 'setting' of the research was considered in relation to other design-research approaches.
To conclude, the research is summarised in a concise overview.

Problems:

- urban environments change rapidly, designers need to get and maintain a good information about the current situation,
- in the design office, the design team depends on collected data which is often cumbersome to retrieve and visualise,
- the way context is represented has considerable influence on factual awareness and inspiration during a design process,
- available and emerging technologies potentially allow designers to get answers through vivid, changeable and personalised views,
- when using the new technologies, the designer's preferences and the effects of different representations are not clear, the design media are still far from optimal in providing required representations, responding to vivid changes in information needs during the design process.

The goals are:

- to find a set of relevant visual representation types using perspective projection in accordance with specific information needs of a 'designer in action',
- to develop a prototypical design representation medium that would be able to respond to the changing needs of a 'designer in action',
- to create formats to inform architects and students about the use of visual representation systems for design and to offer guidance for collecting of useful data for design in context
- to contribute to the evolvement of new insights concerning research methods addressing design and design media research.

The expectations are that:

- the research will have longer term effects on design related media use and will stimulate the developments of new research approaches,
- instead of drastic changes to available design media, the recommendations will direct to education with an emphasis on the relationship between urban context and design and stimulate creative

use of new media;
- new research questions may come to surface.

The benefits to the field of architectural design are that:

- the importance of the urban building site as the context for design is given prominent attention,
- next to factual information about a building site, other insights, such as more and less visually realistic representations, are expected to be of importance to study the impact of design in its future context,
- new insights will be gained about inspiration, from unexpected thoughts triggered by re-presented visual information.

The benefits to the field of design (media) research are that:

- research in effects and opportunities for traditional media (e.g. architectural enthescopy and sketching) will be extended into the fields of newer (digital) media, which are to a certain extent similar but also have wholly different operational characteristics,
- design research will be set up as a 'conversational constructive design study', which benefits from protocol analysis methods, but also from more narrative approaches allowing for 'influences from the research setting' and discussion of findings.

1.7 Research Relevance

The *societal relevance* of this research is that it addresses the characteristics of working with a visually adaptable urban environment model that allows the architectural or urban designer to choose specific views on demand. The new insights are intended to lead to more purposeful urban context models and more accurate methods for the use of such models.

The *scientific relevance* of the research is twofold.
First, the 'design' of the experiments and the way of observing and concluding should allow for broader insights and understanding of representation and imagination in design. This method of research contrasts with approaches that narrow their view to single specific (e.g. behavioural or perceptual) aspects in the design process.
Second, this research is intended to provide insights into dialogical processes

between architects (*imagination*) and their design media (*representation*) through which ideas are expected to build up. This part of the research draws from a philosophical theory called 'radical constructivism' [von Foerster, 1973], [von Glasersfeld, 1997], [Segal, 2001] [Riegler, 2003], which points to the creation of subjective realities by observers. In relation to this theory, the double role of the researcher, observing and intervening, will be taken into account. The development of the experiments, accentuation of specific findings, formulation of conclusions, are all expected to play a significant role. The whole undertaking is expected to bring 'constructed understanding' on the research topic.

Case Study 1

ROME: then and now

When I visited Rome for participation in the 5th EUROPAN design competition congress, I heard a lecture about current large-scale changes in many European, American and Asian capitals. The influence of large traffic infrastructure was a special theme for the 6th EUROPAN design contest. The next day, I decided to explore the theme and walk outward from the tourist centre of Rome, in order to find out about conditions in the Roman suburbs. To my surprise, the image of the city changed drastically each mile I walked. I took many pictures and considered that they might serve as inspiration for my research.

The overwhelming power of urban developments, lack of planning and the force of urban transport infrastructure, as experienced during the walk through the Rome outskirts, puts the small scale focus of the main experiment in this research in a modest perspective. It is considered that the full experience of a site visit can never be completely covered by a representation of any sort. Nevertheless, this Rome case study brought together two historic examples of representation that in fact do succeed in bringing across a partial image of the city.

Rome has always presented a challenge for representation. The etchings of Nolli and Piranesi show that representation can cover different aspects of our real-life experience. Through abstraction and by a deliberately chosen viewpoint, an image can tell more then a thousand words.

Nowadays, with new media available, it should be possible to make models for representations that cover both factual and ambient characteristics of a building site. Multi(ple)-Media can capture and keep the impressions of a site-visit so that the designer can bring back the information to the office and have a continuing inspiration of the relevant design context. However, this should never lead to the situation whereby an architect is content if only the (scale)models and representations are available. It is my conviction that a serious architect should not refrain from a site visit, but should make several visits, preferably taking different views at different moments.

Figure 3. Part of the ‘nuova topografia di Roma’, Nolli, 1748.

Figure 4. ‘Veduta della Piazza della Rotonda’, Piranesi, 1751.

ROME THEN:

Nolli - Piranesi, Overview - Insight

In 1741, Giovanni Battista Nolli was commissioned by Pope Benedetto XIV to make a map of Rome. He used the strength of abstraction to tell a subtle story of object and space in the complex city of Rome (see figure 3). He used the medium of ink on paper in its ultimate form: the blackness of the ink was used to indicate the built and private / inaccessible area; the white of the paper was used to indicate all public / urban spaces. In fact, he used both ink *and* paper. Before the Gestalt Theory introduced the words 'figure' and 'ground' [Rubin, 1915,1958], Nolli swapped them for his urban map. Nolli's invention was to use the paper as 'ground' for space.

At about the same time, Giovanni Battista Piranesi (1720-1778) used the contrasts of ink and paper in a different way. In the Vedute di Roma / Antichità Romane, Piranesi took advantage of the whiteness of paper to show the bright light on architectural monuments (see figure 4). The etchings offer insights into the impressive architecture of ancient Rome through the imagination of Piranesi.

For Nolli and Piranesi, the implication arises *that it requires more than a medium to bring across a message* [compare McLuhan, 1964/1994]. The inventiveness of the artist and the temptations of the observed reality, play an equal role. It is as if both the rationalist and the romantic artist have freed themselves from the supposed limitations of their visualisation media. Nolli used rational abstraction in order to depict the complex spaces of Rome; Piranesi used skilfulness and romantic imagination to depict historic qualities of Rome. Nolli's map gives overview and detailed information. Piranesi's vedute give insight and create atmosphere. Both Giambaptistas knew (each in their own way) how to master the problem of representation.

Figure 5. meeting the highway, 1997

Figure 6. 'città spontaneo', 1997

ROME NOW:

Giro a piedi attraverso Roma - di Termini a Ribibia

Imagine … you are outside, walking in the streets of Rome. You walk in order to understand. From the centre, eastwards along the railway, you observe changes in the city-shape: the streets become wider, the buildings become more autonomous and spaces flow more easily into each other. You pass by the ring road, walking to the 'spontaneously arising' outer areas. The shape of objects and spaces is not coherent with the shape of streets anymore. The roads acquire the meandering shape of rivers. Groups of flats stand in abandoned agricultural areas like bushes in a meadow. You feel ‘one’ with history and future, you experience distance, sound, huge billboards, cars and a lizard between some rocks. How could you ‘capture and keep’ all these experiences? How could an architect keep the consciousness of a site visit vividly available at the ‘drawing table’?

I went out of the Rome city centre to the north-eastern subway station of Ribibia. I took a picture approximately each 250 meters, during a 12 km walk (See figure 5 and 6). The resulting 50 pictures indicate the drastic changes along the path. I once again became aware that the city is a layered composite of historic fragments. Many thoughts and interpretations were triggered by the constantly changing impressions. From the northeast side of Termini central station, I walked in an easterly direction until I met the highway and saw how high it was (figure 5). At the north side of the Viale Scalo S. Lorenzo, I was trapped between the concrete highway walls, a railway emplacement and the Cimitero Campo Verano. I became aware that such large-scale elements in a city could really become new boundaries that cut off a pedestrian's intentions. By following the old town wall, I found a way through, near the Porta Maggiore. Then I followed the main road, Via Prenestina. Further on, in the east, I was attracted by the open spaces and linear structures on my map. When I approached Borgata Gordiana, some distinct changes took place. There were some abandoned farmhouses and there was no streetscape anymore. Instead, there was a massive 'domino row' of flat-blocks (figure 6). This had to be an example of the 'città spontaneo', a result of illegal building practices [M de Vos, 1992]. The roads meandered around the buildings. Infrastructure was obviously not planned before the buildings arose. High fences surrounded the school buildings and shopping malls. There were huge billboards. A sense of security and human scale were not considered. I went north and found another

old ring structure: the Ex-Forte Prenestino and Ex-Forte Tiburtino. After seeing the historic layered structures of the 'tourist-Rome', it was not so remarkable anymore to see such big defensive structures embedded in peaceful suburbs. The city developments became more scattered. Near Ponte Mammole it seemed to me that the river Aniene (Teverone), the massive flat buildings and the new winding streets were equal forces, each with their own rules that did not seem to take care about 'making a composition' anymore. Increasingly, from the city centre to its outskirts, Rome seemed to forget the orderly urban logic that was so typical all over its former empire.

The walk brought up several questions in relation to the research:

- How can an architect get a grip on such overwhelming complexity in current cities?
- At what level should we try to relate new design interventions to the existing context?
- What is the potential role of a representation model (scale-model or VR/ CAAD data-model) related to the ‘real’ image of the city?
- What might be the added value of a model, compared to the real experience of a city?
- Could I use the *concept of a walk* to trigger the creative processes of research participants in such a way that I could learn from them?

case study 2

CONTEXT in ART / ART in CONTEXT

Architects and artists can relate to each others' work, they can learn from each other, they can partially teach each others' students and they can find common goals in the creation of new experiences in public, private, urban, architectural and interior space. Art and Architecture are not the same and should not be mixed up. On the other hand, Architecture, by not mixing it up with Art, should not be reduced to a craft.
The Sint-Lucas Architecture Schools in Brussels and Ghent (where I have worked in recent years) use the motto *'Architecture is Art, or it is not Architecture'*. In my opinion, the word 'is' should be rather read as 'comprises' then as 'equals'. This means that the qualities or values that can be found in Art should be part of Architecture as well. This thought was appropriate when I assisted and observed the processes of two artists who developed ideas and subsequently presentations for sculptural work for a specific urban environment. It was assumed that the thought processes and choices of these artists could give hints for the research hypotheses and for the characteristics of new media that might help architects and artists to relate design to context. As the artists bother less about distracting requirements, of which architectural practice is full, it might be that considerations of form and material, in relation to the context of the art-site, become more manifest then in the study of designing architects.

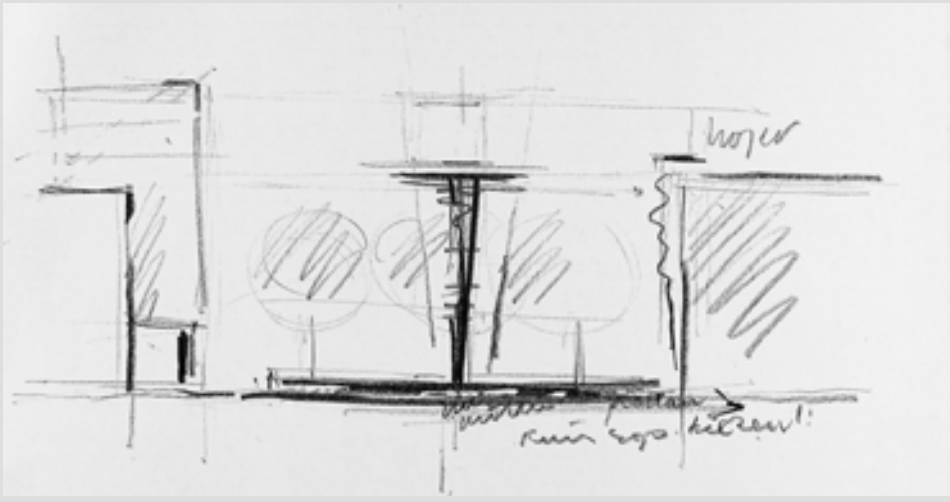


Figure 7-10. The sketch 'ruim sop kiezen!!', perspective studies of exact placement and a metaphoric illustration: 'the pivot of directions'

CONTEXT in ART

Just two weeks after the start of this research project, Bernard Olsthoorn asked me to be involved in his design process for a sculpture at a specific urban site. We both benefited from this collaboration: I got the exclusive experience of an artist in action; Bernard got my assistance in the visualisation of his ideas. The case study provided new ideas for the research and showed that 'art in context' (partially) raises similar issues as 'architectural design in context'.

Bernard showed how the study of urban patterns and the scale of surrounding buildings influenced the theme and the shape of his 'pivot-column'. He indicated the unclear shift of parallel roads and an arbitrary overlap of urban spaces. The placement of his sculpture and the metaphor of a 'pivot of directions' commented and restructured the image of the place.

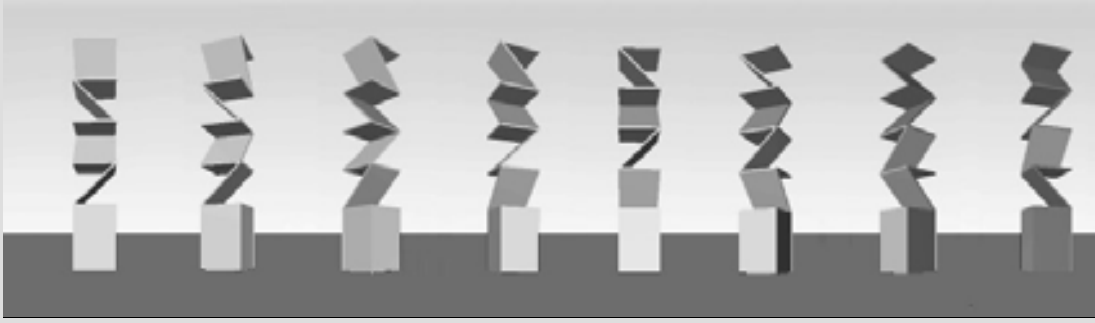
We visited the site and took digital photographs from several viewpoints. Then we made maps, elevations and montage/collage images during a one-week process. The result was an A3-size booklet with a carefully directed presentation of texts and colour prints. The proposed sculpture has a kind of ‘Brancusian corporeality’. As situated, it becomes a landmark for the place. The presentation was a first proposal in which several subtle design features were included.

It was not an easy collaboration process. For Bernard, it was difficult to know what was technically possible and how much effort his specific wishes involved. Personally, I found it most difficult to control the colour and the perspective of the collages, by means of mouse and screen.

The process gave insights into the work-process of an artist. The interference of new technical visualisation methods should not be underestimated in such a process. The sometimes intuitive, but purposeful expressiveness challenged the new software and the old hardware. The approach to combine high-resolution digital images with rendered 3D-information claimed several 'system overflows' and disrupted a real 'creative media interaction process'. On the other hand, the use of colour printouts of intermediate results gave good opportunities to take time for reflection on the design and for adjustments of the images.

Figure 11. Sculpture by Bernard Olsthoorn.

Figure 12. Sculpture by Jeroen van de Laar.



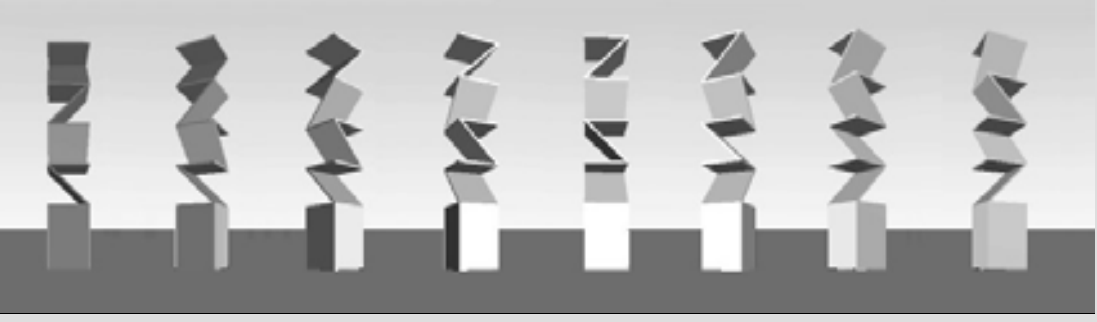
ART in CONTEXT

In 1998, there was another opportunity to see what considerations go into bringing art and context together. The 'ZZZZ-sculpture' of Jeroen van de Laar refers to its dynamic context and is a reference metaphor for the client: publisher Zwijsen in Tilburg. As the image of the ZZZZ-shape changes constantly according to the point of view, it has a very dynamic impact on an already dynamic site. A 3D-model and four different photomontages were made in order to check and present how the sculpture would fit in the environment. Similar to the process with Bernard Olsthoorn, several adjustments were made in the area near the sculpture. Trees in the image were photo-edited, as they should be treated by a gardener. Hedges and new lawn were placed. It can be concluded that there always has to be some final adjustments to fit newly added elements into existing areas.

An interesting difference in the approach of Jeroen van de Laar, compared to Bernard Olsthoorn, is the treatment of 'context'. While Bernard showed how context-aspects impacted on the idea and the shape of the 'pivot column', Jeroen showed how the 'ZZZZ-sculpture' impacted and fitted into its surroundings. The 'pivot column' includes and reorganises the shape characteristics of the context. The 'ZZZZ-sculpture' expresses its own shape characteristics in each direction of the context. However, both sculptures are carefully related to the context.

Figure 13-15.

Studies of placement
and
illustration of changing impressions
while going around the sculpture



Case Study 3

3D MODELING - new means available

At the start of this research, several new Internet related techniques became available. The success of HTML, as a text and image based descriptive language, was only part of a whole range of new languages using the common set of Internet communication protocols known as TCP/IP. Programming languages such as Java and JavaScript, data streams for sound, video and 3D modelling languages could all be transported over the same network. The 3D Virtual Reality Modelling Language was available from 1995. It was a standardised language for exchange of three-dimensional models. These models could be shown and walked-through by means of a special VRML-plug-in that made renderings within an Internet Browser screen. I remember my excitement when, on Monday, 5 August 1996, I was able to download the 'moving-worlds specifications': the second and much improved version of VRML. The specifications of this 3D descriptive language allowed developers to change the spatial representations with programmed effects and to make it react to users' actions. This created possibilities to build 'virtual reality models' that could easily be distributed over the Internet and could be used interactively. Eventually the VRML specification was approved by the ISO (the International Organisation for Standardisation) and IEC (the International Electrotechnical Commission). VRML'97 was published as an International Standard (ISO/IEC DIS 14772-1) on 4 April 1997. At the same time, graphic processor chips became capable of rendering VRML scenes in an acceptable number of frames per second. Exactly in time for this research.

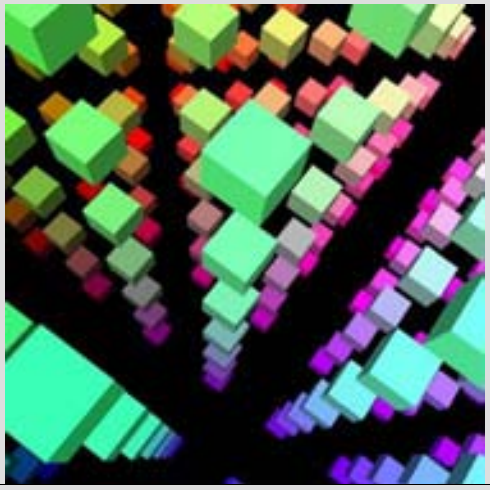
The VRML'97 language provides a thoughtfully chosen set of 'nodes' that can be useful to build al sorts of digital 'prototypes', 'environments' and 'tools'. A node is 'the fundamental component of a scene graph in VRML. Nodes are abstractions of various real-world objects and concepts. Examples include spheres, lights and material descriptions. Nodes contain fields and events. Messages may be sent between nodes along routes' [web3d.org, 1997]. Nodes remind me of playing with sets of objects in toy-systems, like Lego and

Figure 16-18.

VRML and JavaScript code, describing a grid of coloured boxes illustrating the RGB colour space.

```
#VRML V2.0 utf8

NavigationInfo {headlight TRUE type ["EXAMINE","ANY"]}
DEF boxes Transform {children []}
DEF PlaceScript Script {
 eventOut MFNode new_box
 eventOut SFString string
 eventOut SFVec3f point
 field SFNode box USE boxes
  url "javascript:
   function initialize() {
    point[0]=0;point[1]=0;point[2]=0;string = (' ');
     while (point[0]<200){  point[1]=0;
      while (point[1]<200){ point[2]=0;
       while (point[2]<200){
        string=string+('Transform {translation '+(point[0]-100)+
         ' '+ (point[1]-100) +' '+(point[2]-100)+' children['+
         ' Shape{appearance Appearance{material Material{'+
         ' emissiveColor '+(point[0]/400)+' '+(point[1]/400)+
         ' '+(point[2]/400)+' '+'diffuseColor '+(point[0]/200)+
         ' '+(point[1]/200)+' '+(point[2]/200)+' '+
         ' shininess .5 transparency 0}'+
         ' geometry Box{size 9 9 9}}]}');
        point[2]=point[2]+33.3;}
       point[1]=point[1]+33.3;}
      point[0]=point[0]+33.3;}
    new_box = Browser.createVrmlFromString(string);
   }"
}
ROUTE PlaceScript.new_box TO boxes.addChildren
```



Fisher-Technik. Such systems make it possible to build very diverse ‘constructs’ from just a limited set of basic objects. The usefulness of VRML-nodes can be understood by investigating a broad range of applications. VRML is used as an illustrative medium in several sciences; it is used as a presentation medium for architecture and as an art medium on web pages. As a useful help for people working with VRML, an ‘Internet community’ of very engaged people is ready to advise and to exchange questions and answers about VRML (the gathering place is the Internet newsgroup: comp.lang.vrml).

In media research, it is useful to see new means as additions to the traditional. New techniques should not be feared, as they are additions-to rather than replacements-of the trusted techniques. The existing architectural design media (such as drawing, scale-model making and the use of collages) are useful in order to understand how VRML could be used. The navigational aspects of VRML browsers can be compared to possibilities of a moving enthescope in a scale-model. The expressive features of VRML, such as the application of fog and texture mapping, the use of colour, contrast, light and shade, can be related and compared to traditional rendering techniques. But then again: additions to the traditional design palette should also lead to progress!

VRML was chosen as a starting point for the research. The set of 55 nodes and further language characteristics (such as human readability, openness, standardisation, availability and object orientation) provided a potential medium for architectural design, as a ‘toolbox’ to build a laboratory for design research. The 'moving worlds' of VRML corresponded to the 'dynamic perspective' of the Media Research Program [Breen, 1994].

In this paragraph, three modelling exercises are presented. The insights, gained during these studies were applied further in the modelling of the main research experiment.

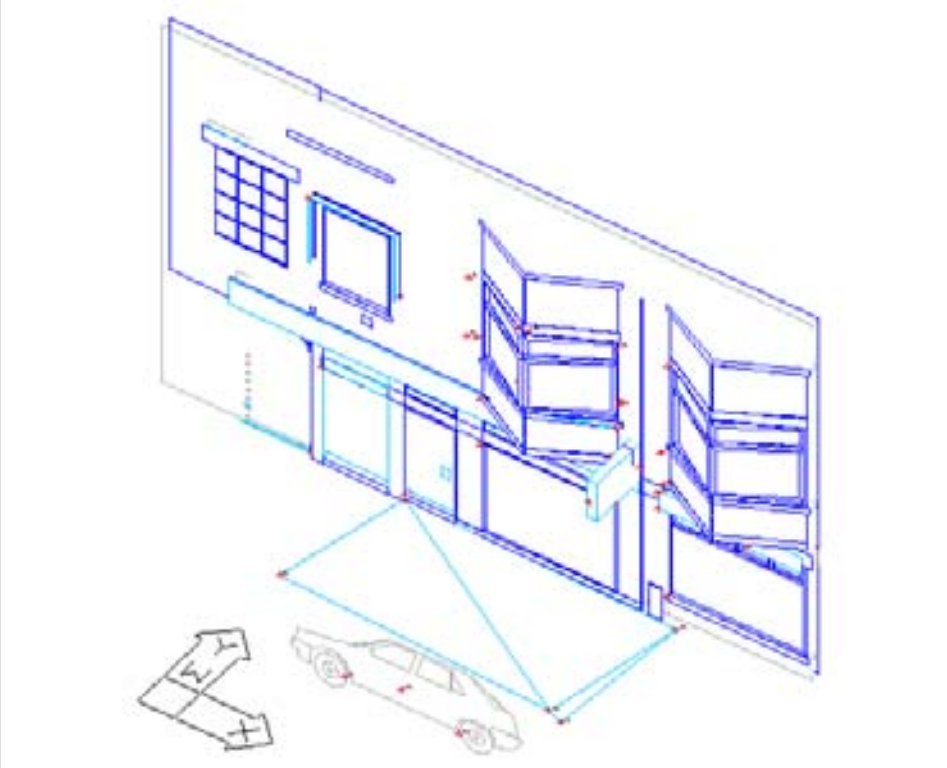
Figure 19. Frontal façade picture, one of the two source images for the photogrammetric model.

Figure 20. Resulting model with source image projection.

Delft Geodesy projects: Photogrammetry

Several experiments were carried out in collaboration with the faculty of Geodesy of the Delft University of Technology using digital photogrammetry.
Photogrammetry is a technique that allows one to compute geometric data from pictures. The technique is often used for measuring in aerial pictures, but the close range variant of the technique focuses on measurements of smaller objects, buildings and façades.
In a small case study, a digital façade photo (figure 19) was used to compute several points. Enough points were gathered to build a 3D-model (figure 21) of the façade. By means of a 'slide projection' option in the software 3D-Studio, the original photo information was projected onto the model (figure 20).
Photogrammetric algorithms become increasingly smart and many geometric features can be collected on the basis of repetition, rectangularity and primary form aspects in many parts of buildings [van den Heuvel, 2001].
After several joint experiments and exchange of experiences concerning approaches and needs, it was concluded that the technique should become increasingly fruitful for production of the kind of city models which were the

Figure 21. Reconstructed model from computed 'point cloud '.



subject of this research.
However, like the rendering technology, photogrammetry was not the central theme of the research, so for some time there were no new collaboration experiments.

The knowledge of the photogrammetry group again proved to be valuable in my research when I needed an algorithm for a difficult rotation in the interactive map program (see p165). Such vector formulas are typical in photogrammetric software. Group members helped me with this:

```
rotation[3]= -Math.atan2(
                    value[0]*value[2]*
                    (1-Math.cos (value[3])) +
                    value[1]*Math.sin(value[3]),
                    value[2]*value[2]*
                    (1-Math.cos(value[3]))
                    Math.cos(value[3])
```

VRML - Delft railway area model

Another explorative study involved an area to the west of the historic city centre of Delft. The current railway area was the subject for an urban context-model of the research test. The area was assumed to be a good subject case, because in the next ten years, the area will change drastically. The railway will go underground and the area will be totally re-developed. This was considered as a good opportunity to serve as a context-model for experiments with designers.

Later in the process, after some critical advice of Prof. Ir. Wim van den Bergh, it was understood that because such an area is so well-known, it could easily influence the results of the perceptive understandings of the participating architects. Therefore, a new fictitious urban model was developed and the railway-area model was left in its unfinished state. However, many new

modelling skills were gained by performing this case study.
The model was based on scanned maps, scanned aerial pictures and straightened digital photos of all facades. Many scale cues in the façade images made it possible to estimate the building heights. The façade width was found in the map. Thus, a big façade décor was erected on top of the maps and the aerial images.
In order to give the VRML model enough rendering speed, all texture maps were placed in 256x256 bitmaps. It became apparent that the aerial images could only be recognised from sufficient height, otherwise the pixels would give too abstract a pattern. A VRML script was made in order to switch from aerial information to map images, based on viewpoint height.

Figure 22, 23. Facades were 'straightened' for texture mapping.

A problem had to do with the quality of the rendering hardware of 1998. The distinction between planes with different distance to the viewer was computed in '8 bit' (256 distance-steps). This was not enough for the large scale of the model: details got rough jagged edges, as the distances could not be adequately distinguished.

Figure 24. Jagged edges.

Soon after the problem of jagged edges emerged, new, better, cheaper and more powerful rendering hardware became available.

A lot of effort was made in the collection of digital pictures of all facades and in the CAAD construction of the city-model. However, the decision was made not to continue with this virtual environment model, which may be considered as a test case for the definitive experiment model. The model might be useful in the further design process of the Delft railway area.

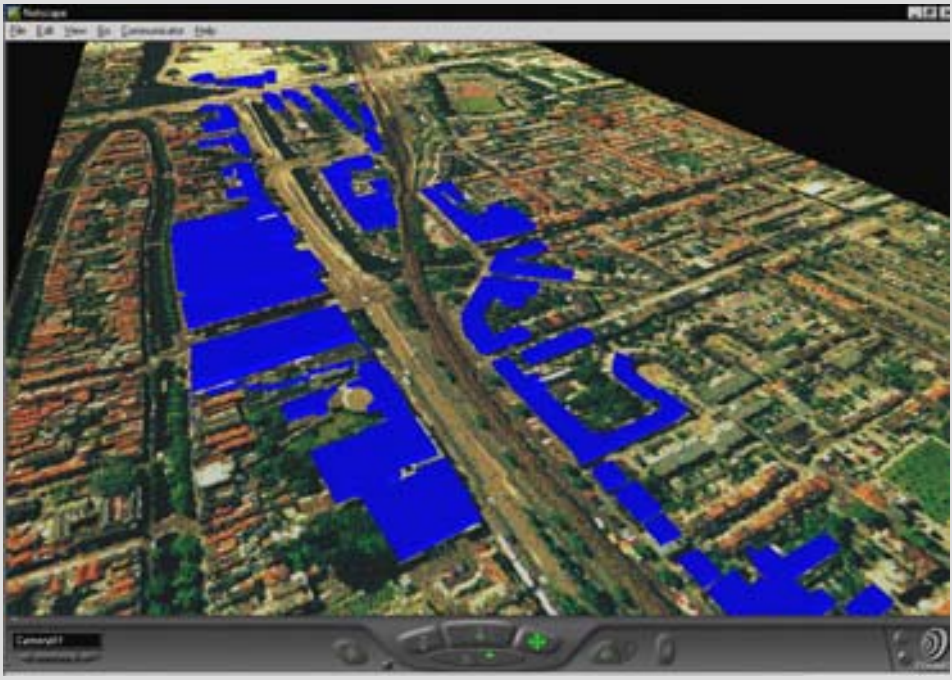


Figure 25. Delft railway area model with aerial picture base.

Figure 26. Delft railway area model with façade texture mappings.

VRML - Lelylaan Model

In collaboration with the Building Management group of the Delft faculty of Architecture, a digital model of the Lelylaan area in Amsterdam was made. The model allowed students to sketch and test different building proposals, in order to combine cost and quality considerations. This model was made on the basis of a 2D AutoCAD file and a number of digital pictures of surrounding buildings. The students made use the CAAD model, Excel spreadsheets and the VRML model in order to explore the cost and quality of several urban design variants.

Figure 27, made by ir. Sjoerd Bijleveld, shows an interesting way to link the map of the building site and photos on the website. These images were also used to make texture maps for buildings in the VRML model. Figures 30 and 31 compare the real image and the model in VRML.

Figure 27. Website of site-investigation-images.

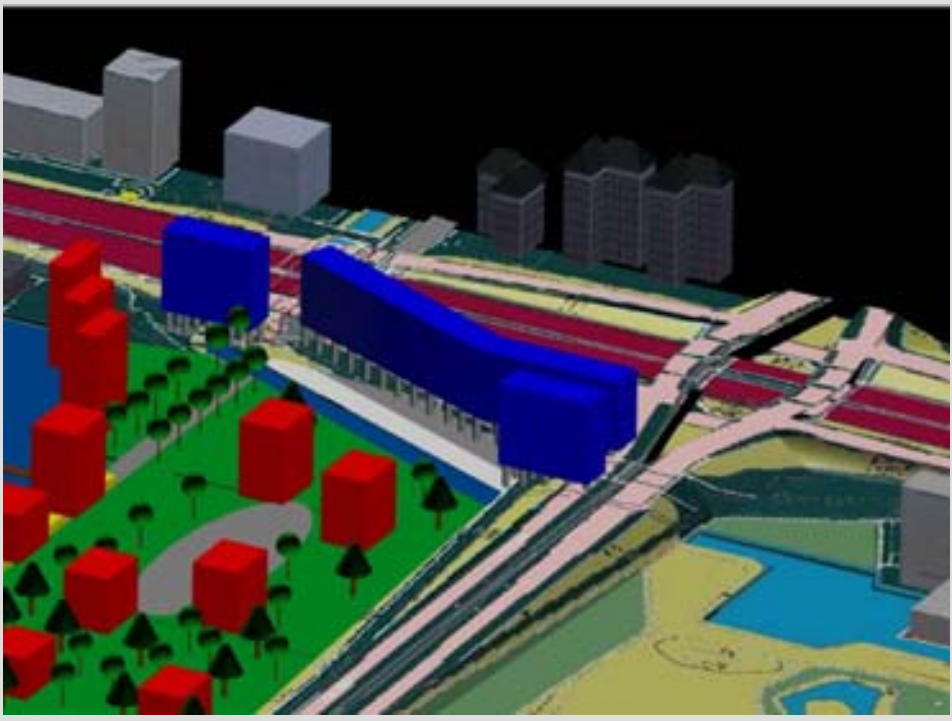
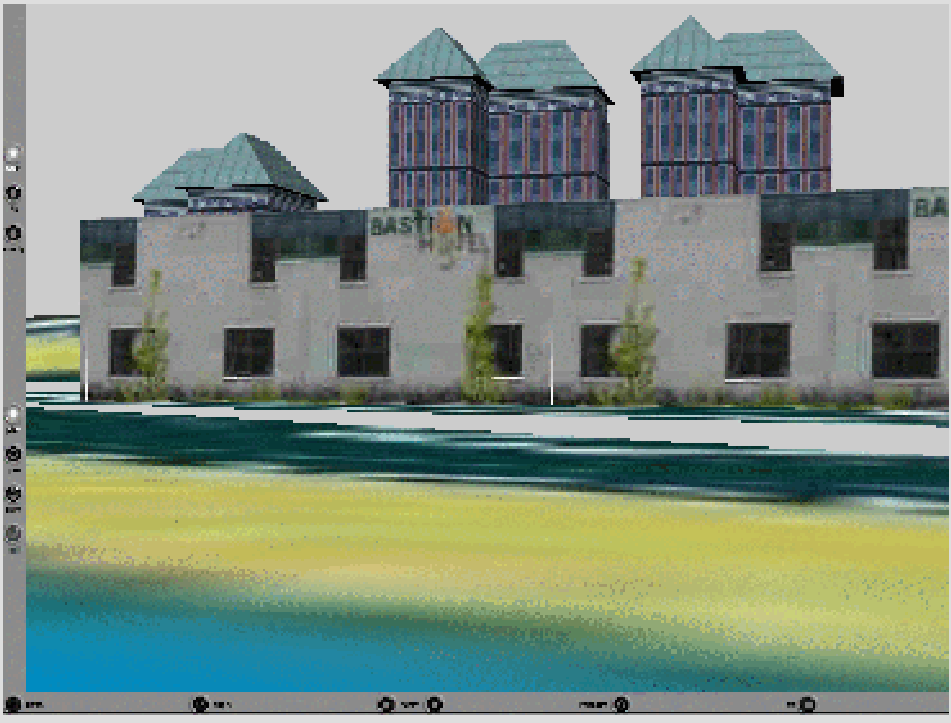


Figure 28, 29. Cost & Quality variants by the 'quantum'-student group.

Figure 30, 31. Comparison of the real situation and the VRML model.



Essay 1

Changing APPROACHES to the Real World

In chapter 1, the field of research was situated between three cornerstones: reality, mind / imagination and media / representation. Three case studies were used to elaborate on the themes of the cornerstones. In the case of 'ROME then and now', the problem of representation of a complex urban experience was discussed. The case of 'CONTEXT in ART / ART in CONTEXT' illustrated approaches to design for a specific site. The third case '3D MODELING - new means available' brought several 3D-modelling experiments.

Chapter 1 concludes with an essay in which each cornerstone is presented again and evaluated in a different way. This basis of this essay is first published as a paper in *'CAAD - Towards New Design Conventions*' [Stellingwerff, 1997]. The paper is reused in this thesis, in order to further explain and position the research field, as described in §1.1.
'Changing APPROACHES to the Real World' explores relationships between designers and the existing built or natural environment. Different kinds of design media change the approach to the 'real world' and can have an important impact on the design process and its results. Six main directions are described and evaluated:

- design through contemplation,
- design by means of traditional media,
- design using desktop computers,
- design within a virtual reality environment,
- design with ubiquitous computers and
- design through augmented interaction.

After seven years, several of these directions are still developing. Changes such as the ubiquity of computers and augmented reality have impact on the way we live and work. These themes appear to remain relevant for further research and design.

In Dennis Potter's science fiction sequel "Cold Lazarus", the interplay between *the real-*, *the imagined-* and *the virtual reality* is a central theme. This story inspired me to explore different design approaches within a framework of the same three phenomena. Set in the year 2368, Potter describes the ethical and economical fight over the thoughts and feelings of a 20th century writer named Lazarus. The frozen head of Lazarus has been preserved for centuries until a research team of psychologists and neurologists connects the brain to a TV screen. This results in the monitoring of mental images from the writer's past, by means of stimulation with neural chemicals. When a commercial TV channel wants to buy the mental images, the story develops into an ethical fight between different members of the research team. A radical group, the RONs, fights against the virtual- and the newly introduced mental- reality brought by the commercial TV stations. They call for 'Reality Or Nothing'. One member of the research team appears to be a RON as well. Finally, he attacks the laboratory and Cold Lazarus is disconnected and freed from his mental exploitation. Lazarus dies and enters heaven's reality. [1]
In this fascinating story, Potter describes tension between three important 'information aspects' of our modern society. Fundamental to the film is the mental information in the writer's brain. By means of the connected TV screen, the mind can be viewed uncensored and shows the writer's thoughts, full of passion, fear, anger and other feelings. A second aspect of Potter's film is the presence of reality; which is directly perceived and not simulated 'here and now'. This is what the RONs fight for. The third source of information comes from commercial TV channels. These 'mass media' transmit Virtual Reality as a kind of entertainment. For the RONs this represents an ultimate lie and is a distraction from the 'real world'.

Besides my excitement over Potter's story, telling and thinking about it does indeed focus the theme of 'realism'. Architectural design involves the same three important aspects: *functioning of the mind* (thoughts, ideas, dreams and feelings of a designer), *opportunities of media* (which include pen and paper, (scale-) models, the World Wide Web, Virtual Reality and even 'the mass media') and *characteristics of reality* (the material world in which the design should fit). Below, I will explore different design approaches and media developments, by means of a theory that interrelates information on the levels of the mind, media and reality.

An information co-ordinate system

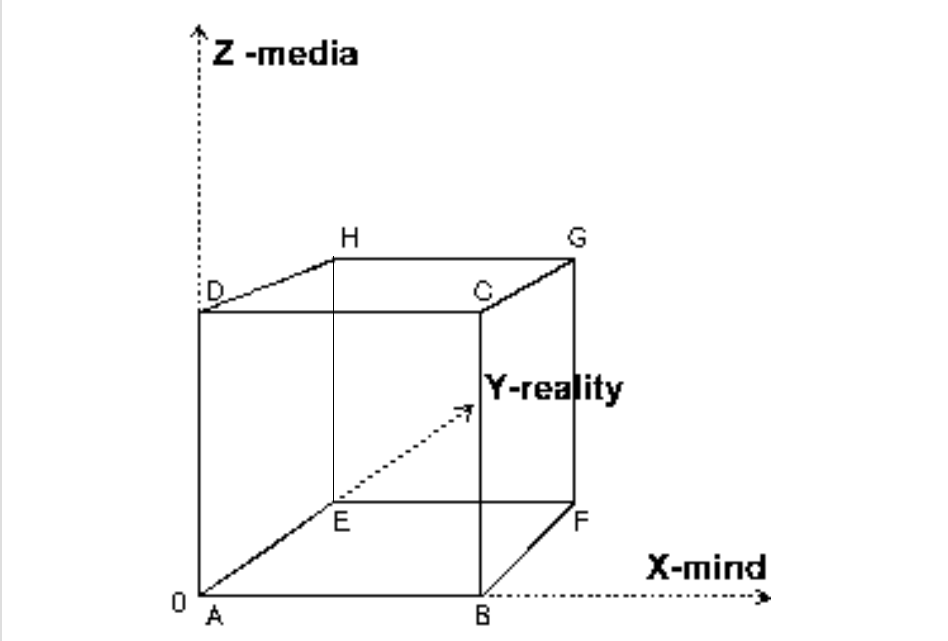
The geometrical co-ordinate system of René Descartes is used to explore different phenomena. Here, it is useful to introduce Descartes' system, for the exploration of design approaches. Therefore, each axis of a co-ordinate system is set-up for the ranking of a specific kind of information involved in a design approach. In order to describe and use this system of *theoretical information axes,* I will first mention the different axes. Then I will describe the corners of a cube within the depicted information space. Finally, I will try to identify six different design approaches as areas within the cube. See diagrams 1 and 2.

As a first axis, I mention information in the *mind* of the designer. This mental information represents knowledge and vision for change and innovation of the existing situation in reality. As in the mind of Cold Lazarus, the information does not have to be censored or refined. On the contrary, design thoughts should be free and vivid, in order to formulate new ideas.
At right angles to the information axis of the mind, the information content of *media* is introduced. Media are used to represent and communicate information extracted from reality and from the human mind. Media apply abstractions as a consequence of which certain aspects are brought in focus and others may be turned down or even neglected. Drawings, (scale-) models, texts and images are design media, which can represent both ideas of designers and aspects of reality. Media are able to *reflect* and *mediate* information of *real world objects* and of *objects of thought*. That is why writing, talking and sketching can enlighten or refine a process of thought and explains why some photos or documentaries can give us a clear insight into a certain real situation. Media extend the *'now and here'* of perceived reality to a much wider range and may include the impossible, the past, a future or an 'elsewhere' (e.g. in fiction and television). As far as the human mind is concerned, media can extend the short- and long- term memory and media can play a confrontational role in conversation with one's own thoughts (e.g. via design sketches or by reading in your own diary). Media offering the ability to reflect can become a partner in a design process [2]. In contrast to 'the mass media' (especially television) these reflective media can exchange information in two ways. You can, for example draw an image on paper and at the same time or later, re-view the image. This 'reflection' gives insight in mental images, which are noted. This enables an iterative design loop [3] in which ideas can be tested and refined.
The third axis, signifying completion of a theoretical space of information exchange, consists of *real-world* information. The often-complex compound of a building site, the physical context and changing social and economical

aspects of a neighbourhood, can be seen as a source of *reality* information. This information can both inspire and constrain the designer. It might be clear that reality is an important aspect for design, because every materialised design is immersed in a context of everyday users and in other designed or natural objects.

In order to provide a sense of scale, a cube is projected within a co-ordinate system. Although information on each axis cannot be defined in a uniform unit, the cube indicates the boundaries of information involvement in a certain design approach, (see diagram 1). This means that the most, or the least involvement of, for example, *realism in sketching,* can be roughly indicated. Therefore, the purpose of this co-ordinate system is exploration and phenomenological comparison of different processes, which are involved with one or more types of mental, media, or reality information. It is an indicative system for development of thoughts and opinions about the interplay of different information in the design process. [4].
Describing the corners of the cube in a narrative way can give more clarity to the meaning and the use of the information in the co-ordinate system. The corners represent extreme situations in which 'reality' gets different meanings. On the corners of the information space, the previously mentioned 'real world' gets its equally realistic counter worlds of the mind and media.

Diagram 1. Information axes and cube.



Point A, the zero of each information axis can be described as the unconscious state of a deep sleep, from which the world and different kinds of media are excluded and where even your dreams are forgotten when you wake up. Point B represents pure fantasy, without relation to reality. After creation of information in point B, so to speak after 'getting a strange new idea', this information can be useful as an input for particular experiments, which relate free fantasy to more demanding facts from reality. Point D is the maximum of media information involvement and can be seen as the set of media, which challenge for unintentional use and casual creation. For instance, the throwing of paint on canvas can be seen as a non-specific and free starting point for an evocative painting. Point E is pure reality, as it appears when you awake. It is fresh air streaming through an open window; the sunlight on your pillow. This 'point E reality information' is perceived when you are not yet aware of your full agenda for the day to come and it might be felt before you turn on the television; which collects for you all nasty things from the same reality.

While point A is a zero state without information, point B, D and E are 'pure realities', unrelated to other kinds of information. B is the mental world of our fantasy, D is the evocative world of a medium and E is the not interpreted material world (which is called here the 'real world').

The next described points are full mixtures of two kinds of information. Point C represents the full interaction between mind and media, without consideration for reality. For instance, if you doodle around with a pen on paper, what forms the image is both the character of the media and the influence of your imagination. Surfing on the Internet, or designing a fantasy building (without a place or function in the real world), can also be seen as a selective and creative information process related to point C. The information cube makes it clear that the virtually created information world of point C is opposite to the real world in point E. Similarly, point F is opposite the evocative media in point D. If a contractor and his or her architect investigate a site, they can sense the 'genius loci' and the future building appears in front of their mind's eyes; that is in fact exactly the type of information that - theoretically at least - belongs to point F. It is a mixture of pre-realistic imagination and real world experience. The third mixture (point H) is the real world represented on media (for instance a photo of a house) or media within reality (for instance an amplification or live broadcast of a concert). The 'photo realistic' represented information of point H has nothing to do with the fantasy information of point B (on the cube, point H is opposite to point B). For an architect, point H represents the gathered information of the site and the design assignment. It can be a combination of models, photographs and descriptions related to the design task, as how it would be sent to all applicants

of a design competition.
Then, finally to be described, point G represents the full mixture of real world information, mental imagination and information on media. Point G could seem an ideal state for (some) architects and other human beings that want to be innovative, spiritual, expressive and realistic at the same time. The quest for 'state G' can be seen as the process to find the best solution in a design process. I am really curious to see a gadget, medium, or a machine that can offer the point G kind of information integration (though it might be just as simple as drawing the sunset in beach sand). Until that time, we are confined to different design approaches, which stress their attention on one or two types of information, while they neglect or disadvantage the third [5]. These approaches are explored next using this model.

Design through contemplation

At a time when design media did not yet exist, people would be limited to conceptualising and refining ideas in their mind, or to make something from scratch. In those days, people would be dependent to serendipity for their new inventions and would need a trained mind for empirical approaches. I fantasised the two previous sentences, like we sometimes have to fantasise about pre-historic life due to the lack of written sources. Nevertheless, with the help of my father, I found one reference in which a design was conceived through pure contemplation of the mind, without the use of media.
Philo of Alexandria (approximately 15 BC - 40 AD) describes in his book 'Opificio mundi' the creation of the world. In the 17th until 20th paragraph of his book, he compares this Creation with an architect's design process for a city: *" ...When a city is founded, in order to express the prestige of a king or a leader who strives for absolute domination and wants to stress upon his vision and successes, sometimes a well educated expert, an architect by profession, appears and starts to investigate the local situation concerning the climate and the orientation in the landscape. Then, in his mind, he roughly 'sketches' all parts and functions which have to take place in the city, such as: the sanctuaries, the sport accommodations, the city halls, the markets, the ports, the shipyards, the main- and side-streets, the construction of walls, the residential arias and further public buildings and spaces. When he collects all these models of each category in his mind, as if they were drawings on a wax-tablet, he takes the 'intelligible city' with him. Then he recalls the images of these mental models, with his innate memory function and refines the specific features of each part of the city. Then he materialises the city as a good artisan and refers as much as possible to his un-material mental model.*

Similarly, we have to assume that God, when he decided to make the Big City (the visible cosmos), first made models inside his intellect, from which the 'intelligible cosmos' was composed and from which afterwards the visible cosmos was created. As the city was previously modelled in the architect's soul and did not exist somewhere else, but printed in the soul of the artisan, similarly the cosmos of ideas will have existed nowhere but in Gods 'logos'. Since, which other place would exist, where his forces ('dynameis') could be stored in their purity? ..." [6].

Philo wanted to categorise 'reality' in two parts: mind and matter. The mind could produce ideas and detailed designs, which could be materialised into a man-made (or God-created) reality. The ideas of God and of an architect were estimated to be so perfect that they could not exist in the realm of media, but immediately had to be fulfilled in reality.

Still, sometimes an architect says: 'wow, I have such a good idea, we are going to build that…'. Unfortunately most buildings, their surroundings and regulations are so complex that the 'good idea' has to be checked and refined by means of media. This process makes the initial ideas more realistic and prepares the design for materialisation. On the other hand, it is often good to refer to the clarity of one's first ideas, until the end of the design process. Media should not disturb, but support, the process of design through contemplation. If media do support and represent both the information of the material- and the mental world, the 'new design approach' comes nearer to point G in the information co-ordinate system.

Design by means of traditional media

Before writing about 'traditional media', I want to make two remarks. First, 'traditional media' should not be seen as outdated, or as dead media [7]. I just use the word 'traditional' to indicate a difference with new digital media, which distinguish by their coded information that is not bound to one certain material object (e.g. paper). Secondly, a new invention should not be seen as a replacement for something still existing. Inventions and designs are additions to the existing 'real world' and do not replace, by definition. So, traditional media are still in use and prove their usefulness in everyday (design) tasks. They still compete with many new digital media in aspects of directness, (multi-) functionality, portability, levels of detail and clarity of use.

It is not my intention to offer an extensive overview of characteristics and comparisons of different kinds of media. What I especially want to indicate is the change of approach in design, as media become increasingly sophisticated.

Initially, news and knowledge was communicated orally. The art of writing

and later the printing technique, enabled the storage and distribution of that information. For art and design, the technique for drawing perspective was one of the most important media inventions. By means of the linear perspective projection, the image of a building could be put on paper, in order to show it elsewhere in a more or less realistic way. A design could be presented even before it was built. The image in the mind's eye of an architect could be shared and discussed. The existence of design media made a change in the organisation of the building industry. First, the architect was head of the artisans and worked 'on site'. Later, existence of drawings made it possible to work from an office. As to realise the design, the drawings were handed over to a building contractor and served as a legal document. The use of traditional design media also made it possible to foresee the costs and the problems in materialisation of a design. Furthermore, the existence of documented buildings made it easier to design changes to an already existing building.
The introduction of perspective drawings and photo-realistic media like photography, film and video changed the world-image of architects and other people drastically. The knowledge of other cultures and styles increased, when these media where developed. In conclusion, we can speak of a roughly global formal language in contemporary architecture. This impact of media was already obvious in the inspiration for classicism by, for instance, the 'Antichità romane'-images of Piranesi.
Traditional design media, especially 'pen and paper' are quite diverse in their use. They are open to the fast documentation of mental information, almost undisturbed in your thoughts. You can put some keywords and simple schemes on paper, with the paper becoming a medium for storage and refinement of those 'great ideas'. Pen and paper can be used for the direct notation of the material reality; you can for instance draw a perspective or write down the name of a street. The information can be (a combination of) text, drawings, diagrams, or other code. Therefore, paper is applicable to a full range of information, from the most conceptual to the most realistic. Nonetheless, the precision and content of information is highly dependant on the skills of the user, where the users 'starting skills' do not need to be high and the 'learning curve' can be quite steep. A big advantage of the use of most traditional design media is the fact that they are skills almost naturally acquired during childhood.

For reasons of its 'openness' to notation of mental and real world information, the traditional design media may be located near point G in the information co-ordinate system. On the other hand, compared to digital design media, the structure and adaptability of data on traditional media is not so enhanced.

Therefore, I would place traditional media somewhere in the middle of the cube in diagram 2. The group of traditional media is so diverse that it is difficult to argue my decision for this central place, but as said before, it is indicative. The advantage is that other approaches can be compared with traditional media, based on this position in the diagram.

Design using desktop computers

In traditional images and scale-models, there is still a certain physical relation between the media, information and reality. In digital media, this direct relation does not exist. The information is coded and can be compared with abstract, but structured, sequences of letters in language. The existence of code, which represents information, makes it possible to represent any kind of information, as long as it is previously declared how the code works. The information can have many more structural levels, attributes and attachments, than information on traditional media. The information is also easy transportable and can easily be transformed and copied. This creates many advantages, which are not yet fully explored.

The full structure of information in one or more computer documents can be seen as a model of the real world and mental information. By means of graphical user interfaces on desktop computers, the user can interact with the model. When the computer is not connected to a network, the interaction between user and computer can be seen as a one-to-one relation, isolated from the surrounding world. Despite existence of good facilities for interpersonal interaction (e.g. videoconferences, e-mail and shared design environments) and data connections (e.g. for Product Data Management and on the World

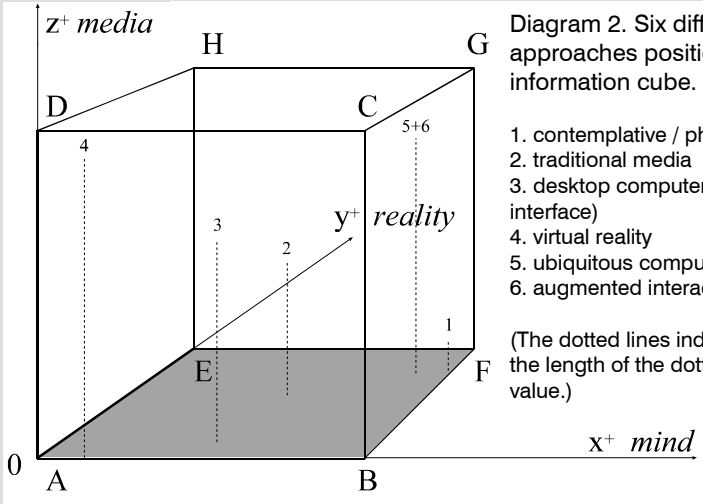


Diagram 2. Six different design approaches positioned within the information cube.

1. contemplative / philosophical
2. traditional media
3. desktop computers (graphical user interface)
4. virtual reality
5. ubiquitous computers
6. augmented interaction

(The dotted lines indicate the x-y placement, the length of the dotted lines indicates the z value.)

Wide Web), the computer-represented world has a limited connection with real world data. Compared with design via traditional media or design through contemplation, the direct perception of the real world is cut off by the metaphorical desktop on the computer screen. Especially, where real world data for architectural use is concerned, most data in computers is represented in a highly abstracted and reduced form. In a full CAAD equipped office, it could be possible for a designer to not visit the building site and its surroundings. Instead, he or she would deal with representations of both the context of the site and representations of the building materials used for creation of the design. Although precision, realism and efficiency of this working method could be excellent, the architect would be missing the sense of the region and the 'genius loci'.
Especially if the 'interaction' with the user and the quality of the information structure are concerned, desktop computing might serve as a good medium. The commercial term 'multi media' tries to indicate this as well. On the other hand, if desktop computing is compared with traditional media and contemplative design approaches, it has a less direct relation with the real world. See diagram 2.

Design within a virtual reality environment

In the development of design media, from traditional- to digital–representation modes, we can see a distraction from 'real world' information. The designer has to rely increasingly on representations and previously digitised information. In fully immersive virtual reality, the gap between the real world and the simulated world is complete. All information is presented in the best possible realistic way and potentially replaces awareness of the material world. Virtual realists speak about full immersion in the data space. By the use of a 'head mounted display' or a 'projection cave', the real world cannot be seen and all senses are focused on the digital model. Therefore, all design decisions are based on previously collected information. Although simulation techniques have become increasingly realistic, all senses are based on 'second hand' (mediated) information. A lot of research should be invested in the anomalies and reliability of simulated information so that design decisions and creative ideas can be based partially upon findings from virtual reality simulations.
Collecting, digitising and modelling 'real world data' for use in virtual reality is a cost intensive and time concerning technique, by which many simplifications have to be made. By means of digital photogrammetry and texture mapping techniques, a rather detailed model can be made, but these

techniques are still in development. They need a lot of planning and are not fully automatic.

Another issue is the question whether it is useful to model all existing built environments, to have them within arm's reach. My considered opinion is that it is (in political language) *not un-useful* and that, similar to the deciphering of the human genome, certain people will always strive to model the whole world as detailed as possible. We can already see some projects in which whole cities are modelled with a 'level of detail' from several meters to about 20cm with near realistic texture mapping [8]. Although these models can be used perfectly within a virtual reality environment, they still tend to be more applicable for presentation than for precise design tasks. In the next years, if the models become more reliable, acquire more levels of detail and are attached to other useful data, this might change.

From virtual towards augmented reality

In recapitulation, the four previously described design approaches form a historic media development in which the designer's relation to the real world becomes smaller (more detached) and the represented media 'world' takes its place. Furthermore, there will be fewer reasons to visit a certain place. Instead, the information of that place would travel to you. These developments take place since the introduction of computer networks. In fact, the developments are so immense that the French philosopher and urban planner Paul Virilio [9] made a major change in his futurology about the impact of speed on human behaviour. In his book *'l'Esthétique de la Disparition'* he describes the development of speed in history by means of defence and civil technology examples. He concludes that by increased speed, of for instance trains and aeroplanes, the world appears to become smaller and smaller, the human becomes a nomad again and is always 'on the way'. Place is no longer an item, the topic is movement and the front window of a car becomes a television.

In a subsequent book *'L'inertie polaire'* he describes almost the opposite: it is not the human body that moves, but information. With the same eloquence, he concludes the opposite: human nature will become totally motionless and people can perceive and communicate anything without movement. Essentially, space is not deconstructed by speed, but becomes irrelevant when everything can be mediated and simulated - virtually.

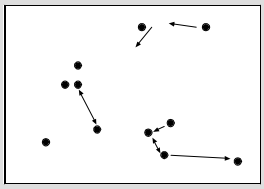
I have illustrated these developments in worldview in diagram 3 [a-d]. In the past, [see a] there were no media and no means of long distance transport. People lived in isolated communities, which barely interacted with each other. People went to the 'agora', the marketplace, to communicate with each other. This would have been a typical setting for my description of design through contemplation; people did not use media, but discussed with each other about how the new building or city extensions should be made. News and history were exchanged through oral communication. It was the time for stories and imagination around the campfire. There was no global worldview and cultures existed separated from each other.

Then [in b] people met each other in theatres, the news was distributed by means of e.g. newspapers and the world was perceived as a globe. People started travelling and they brought their stories home. Traditional media were used for many different cultural and organisational functions. Artists made sketches in nature and worked on paintings in their ateliers. Similarly, design did not take place on site, but in an office. Design media helped the architect to make realistic designs, based on both inspiration and constraints from reality and on mental dreams and ideas for a new world. Of course these descriptions continue to be valid for much of our current daily life and work.

Some time after the development of electronic mass media such as radio and television, the digital media were introduced [c]. The daily news items and other world information entered each individual room. No longer was the agora or the theatre 'the place to be'.

Now, if you want the 'information on your fingertips', you should stay at home *behind* the TV and *in front of* the PC. The TV is the new campfire for globally narrated stories and provides an overload of images. The PC is a mirror-medium on which ideas can be composed and refined.

Still that is not enough. Reality is being copied and diversified into models. Stories become interactive and we become 'on line'. I can fly between virtual New York skyscrapers [this was written before 9/11/2001] and at the same 'multi-tasked time', buy a CD in Tokyo [iTunes/MP3 in 2004]. Why should I go outside in the hostile world, if I can kill all avatars (virtual representations) of my friends in our 'multi user dungeon', while eating my 'pizza-on-demand'… ?



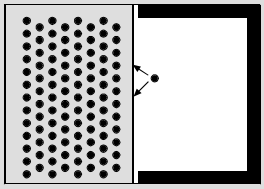
real 'interaction' between people on the Agora

one to one

narration by the campfire

a

isolated communities



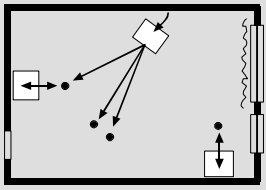
theatre

one traveller explains to many immobile

linked communities,

b

exchange of knowledge and goods



behind the narrative TV

many zapping the channels

satellites,

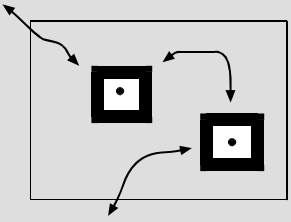
globally distributed information

in front of the PC

graphic user interface

c

one pc to one user



personal media

simulation

isolation

representation

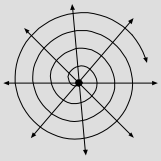
many to many

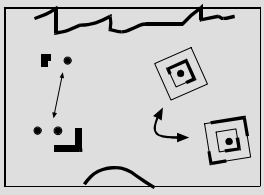
d

global interaction

space and world dimensions are irrelevant

modelled world





ubiquitous gadgets

portability

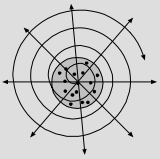
e

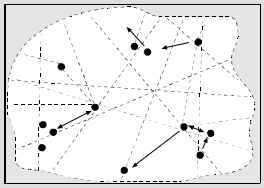
web

cyber communities

digital cities

calm technology





on the agora with superimposed data

identity

location

added information

user-state-specific

f

value of the place

data atmosphere attached to the real world

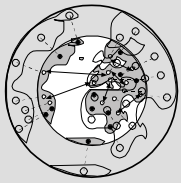


Diagram 3. Historic / futuristic overview of developments in social relations and ways of communication (left) and changes in worldview and perceived world measurements (right).

In principal, we can make a choice for a virtually perceived world in which design can exist without a real world context. The design artefact just needs some links and there is no need to materialise it. The perceived world dimensions shrink to the size of a hard disk in our 'world server' and we are in reach of anything and all our x.colleagues@y.places. We have a new skin of data and do not feel or see reality. Is that the end of all futurologies? I hope not.

Fortunately, I found new developments on the Web that can bring the design process back to the reality of the material world. Although these techniques are very new, I am convinced they can be transformed into useful 'design approaches'. The strength of these developments is in the strong relation they lay between the material world, the mediated world and the interaction of a user. They can become design approaches near point G in the previous described information cube. This means an equal and strong combination of the three information components.

The first recent development is called *'ubiquitous computers'* [10]. This means that computer chips are integrated in many products in order to make them smart. Information is not exchanged on 'user command' in a modelled virtual world or on a metaphorical desktop, but by action in the real world. So, if we open a door and enter a room too dark for the work we want to do, the light switches on automatically (and we call that a smart building). Of course a chip in every 'real world object' is quite expensive and not necessary. Only things that can change their physical state (e.g. switch on and off), need some intelligence. A car is a typical thing that should be made smarter.

All things that have an internal consistent state that cannot be changed automatically and their sub components, can just get a label that links them to a database. The technique of *'augmented interaction'* [11] uses identity labels on objects and looks up certain linked object-data by means of a database connection. For example, books from the library have ID-labels. When you lend a book, the book-label and your client-label are scanned and the book's state is changed in the library database. Another example is the barcode on products in a shop. If the prices change, the shop owner just changes one field in a database, instead of all the bar-code labels.

Design with Ubiquitous Computers and Augmented Interaction

I have been thinking quite a long time about what could be the impact of ubiquitous computers and on augmented interaction for the design of buildings and their materialisation. The application of these techniques in the production of buildings is quite clear. In a factory or on the building site, small chips in tools and machines can provide a more specific use of building components and complexity can be dealt with more easily. The components could be labelled and monitored during the building production, the whole lifecycle and reuse of the building. Smart buildings can become more pleasant and more cost efficient.
For centuries we have been using media, which provide information concerning buildings and building sites. We use that information in design offices, the design is not made 'on site'. This situation is similar to that of soldiers who mainly exercise in simulated war areas. They are shut off from reality. For the instruction of cold-blooded warriors, that might be an advantage, but an architect needs to feel and perceive the context in an uncensored and realistic way. We are now used to this separation of the building site and the design office. It is difficult to imagine that such new techniques might enable us to design 'in situ', with all our design tools virtually available at the building site.

The idea of a design approach with the use of ubiquitous computers and augmented interaction has an opposite concept compared to the virtual reality approach [Lagendijk, 2000]. The material reality is perceived directly and all yet developed CAAD and sketch tools can in principle be used for 'design on site'. In one possible future, vr-gadgets get a semi-transparent screen through which the design image is superimposed over the directly perceived reality. Surrounding buildings are identified and linked to their database of a Geographic Information System. Through a Global Positioning System, the location of any object can be measured. By means of an advanced solid modeller, the spatial design can be made while it is immediately checked and refined for materialisation. Finally, the moment of point F, where the contractor and his or her architect investigate a site and sense the 'genius loci', gets a more realistic image of the future building in front of their mind's eyes. The image is shared and based on realistic data. Then, we do not need the dark caves of virtual reality anymore.

With these developments, the future - as Virilio saw it - is changing again. The world gets back its normal material dimensions and becomes a newly added, super imposed, data atmosphere [diagram 3 e and f]. Real world information,

information of databases and projections on screens and mental imagination get equal chances. Newly developed technology can provide methods that enable us to combine fantasy, design and refinement without distraction from reality.

I hope, this essay gives insight into current developments in media technology and its influence on design practice and worldviews. I tried to do this by means of a theoretical co-ordinate system, which interrelates different sources of information, relevant to design. With a historic / futurologic overview in little images, I tried to sketch developments in social relations and ways of communication (diagram 3, left) and changes in worldview and perceived 'world measurements' (diagram 3, right). Although I cannot foresee the future, I mentioned two promising developments that can become relevant for design. At least these developments can shift our current global focus on virtual reality to a wider range of possibilities concerning Information and Communication Technology.
Returning to the story about Cold Lazarus, I would not say 'Reality Or Nothing' for I am not one of Potter's radical RONs. My preference would be 'Reality And Refined Imagination' (RARI), for that is what research and design is about.

Notes and References

[1] *'Karaoke and Cold Lazarus'* by Dennis Potter (1935-1994), Faber and Faber 0-571-017478-7, April 1996. Respecting the final requests of the author, these films where broadcast respectively on BBC and Channel 4, starting from 28 April 1996. I could not find the original name of the 20th century writer in Potter's story, so I use the story's title 'Cold Lazarus' when I refer to the writer and his frozen head.

[2] At the Symposium 'Models of Human Action' at the Sixth International Congress on Cybernetics, Systems Research and Informatics, Baden Baden, August 1993, Ranulph Glanville mentioned 'Conversation' as one of three metaphors depicting design: *'Design is (like) a conversation -it IS a conversation- in the simplest case, held with oneself through the means of paper and pencil. The marks left on the paper (the drawings) talk back to you - giving you ideas- if you'll let them. (This is an act of listening.)'*

[3] In *'Inquiry by design: Tools for environment-behaviour research'* (Monterey, Cal.: Brooks/Cole) J. Zeisel presents a 'design development spiral' consisting of empirical knowledge which is refined in a circle of *image-*, *present-* and *test-actions*.

[4] Generally the Cartesian co-ordinate system is used for exact placement of mathematically described (deducted) phenomena in a numerically exact space or area. In this case, I used the system for a less exact comparison of 'approaches' and can only give an indication of 'few' or 'much' information involvement. Still I hope this comparison helps to offer more insight into the different kinds of information involved in design.

[5] Although specialisation in design-research often makes us look at one single approach (e.g. CAAD, Simulation or Optimisation), it is clear that most design processes consist of many subsequently performed approaches from which the results are combined or compared. A change of approach can bring new developments in the state of information in our mind, via media or into reality. For instance, if I get stuck with this text while sitting in front of my word processor, I can change my approach. I can take a walk, in order to confront my mind with reality instead of a 'graphical user interface'. Therefore, none of the described design approaches can be seen as the best solution compared to the others. We will always need combined approaches in order to see a problem from a different angle.

[6] *'Opificio Mundi'*, Philo of Alexandria, translated into English from a Dutch translation by A.P. Bos in *'Geboeid door Plato'*, Publ.: Kok, Kampen, Netherlands, 1996.

[7] The *'Dead Media Project'* is an interesting collection of obsolete media, presented on the Web by Bruce Sterling and Richard Kadrey. See: [http://www.deadmedia.org/ August 2002]

[8] See for instance the VRML models on the Internet at:
http://www.bentley.com/modelcity/ (ModelCity Philadelphia by Bentley Systems) and http://www.planet9.com/ (several Virtual Cities)

[9] Paul Virilio, *'l'Esthétique de la Disparition'*, Paris, 1980.
Paul Virilio, *'Het Horizon Negatief'*, 1989, translation in Dutch.
Paul Virilio, *'L'inertie Polaire'*, 1990, 2-267-00887-4, Christian Bourgois Editeur.

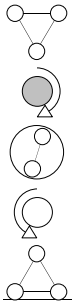
[10] For ubiquitous computing, see the homepage of the late Mark Weiser: [http://www.ubiq.com/hypertext/weiser/UbiHome.html August 2002] or [http://sandbox.parc.xerox.com/ubicomp/ August 2002]
'Ubiquitous computing is roughly the opposite of virtual reality. Where virtual reality puts people inside a computer-generated world, ubiquitous computing forces the computer to live out here in the world with people. Virtual reality is primarily a horse power problem; ubiquitous computing is a very difficult integration of human factors, computer science, engineering and social sciences.' See also: Mark Weiser, "The Computer for the Twenty-First Century," Scientific American, pp. 94-10, September 1991.
[11] *'Augmented Interaction is a style of human-computer interface that tries to make computers as transparent as possible. Using this style, a user will be able to interact with the real world, augmented by the computer's synthetic information. The user's situation will be automatically recognised by applying a range of recognition methods, allowing the computer to assist the user without having to be directly instructed by the user. The user's focus is not on the computer, but the real world. The computer's role is to assist and enhance interactions between human and the real world.'* See: Jun Rekimoto and Katashi Nagao, "The World through the Computer: Computer Augmented Interaction with Real World Environments", User Interface Software and Technology (UIST '95).
See also: [http://www.csl.sony.co.jp/person/rekimoto/navi.html August 2002]

'Augmented reality refers to the combination of the real and the virtual to assist the user in his environment. Applications include telemedicine, architecture, construction, devices for the disabled and many others. Several large augmented reality systems already exist (for example, the Interactive Video Environment system), but a wearable computer with a small camera and digitizer opens a whole new set of applications.'
See: [http://www.media.mit.edu/wearables/ August 2002]

This essay was first published as a conference paper:
Stellingwerff, M.C. (1997) *Changing approaches to the Real World*, Published in the book : 'CAAD - Towards New Design Conventions', Technical University of Bialystok, Poland, Edited by Aleksander Asanowicz and Adam Jakimowicz.

But how can you look at something and set your own ego aside? Whose eyes are doing the looking? As a rule, you think of the ego as one who is peering out of your own eyes as if leaning on a windowsill, looking at the world stretching out before him in all its intensity. So then: there is a window that looks out on the world. The world is out there; and in here, what is there? The world still - what else could there be? With a little effort of concentration Palomar manages to shift the world from in front of him and set it on the sill, looking out. The world is also there, and for the occasion has been split into a looking world and a world looked at. And what about him, also known as "I", namely Mr Palomar? Is he not a piece of the world looking at another piece of the world? Or else, given that there is world that side of the window and world this side, perhaps the I, the ego, is simply the window through which the world looks at the world. To look at itself the world needs the eyes (and the eyeglasses) of Mr Palomar.

Italo Calvino — Mr Palomar



Chapter 2

Spirals of representation and interpretation

In the first chapter the field, problems and concepts of design-media-research have been introduced. The reality of a building site with its urban context, the mind of a designer and design-media with their content were placed in a relationship of information exchange.

Problems of architectural design, related to information exchange, can be explored in experiments, where the expressions and impressions of designers are observed. The set-up of the experiment, the experiment's participants and the experimenter himself play different roles in the research. The whole undertaking of experimentation, observation and the drawing of conclusions is seen as a complex conversational system, where the tested prototypes, the design ideas, research findings, conclusions and recommendations are connected together.

One should be aware that answers can be partially hidden in the way questions are asked and in the questions themselves. Answers from research do not only come from the actual tests; the whole process of preparation and completion also brings deeper understanding of an issue. In technical research, the actual state of prototypes during a test influences the findings. In fact, the prototypes are the subject of the test. The prototypes are 'possible answers' to technical problems. Those possible answers are questioned in the test.

In design-media-research, a number of participants design in a certain imposed way or by using specifically given design-media prototypes. In such research, the participants react to the specific conditions and prototypes. The experimenter observes the reactions. The participants' reactions are 'indirect answers' to 'possible answers'. Such 'second order answers' can become valuable information in design-media-research, if the manner of questioning is taken into account.

The aspects of questioning and the influences of the research set-up are described in this second chapter.

First, in section 2.1, the focus is on the design process as a cyclic iterative system where the (initially vague) ideas develop into (ideally) strictly defined building instructions. This conception of the design process leads to a design-media experiment. The differences and resemblances between a real design process and the design-media experiment are described.
In section 2.2, the focus is on aspects and theories of 'design creativity' that are considered to be important for this particular study. These aspects are addressed via the examination of theories and formulation of hypotheses.
In section 2.3, case studies and prototypes are described. Major expectations about the preferences and effects of the prototypes are identified.
In section 2.4, the design-media experiment is explained using a scheme that indicates the different phases of research. The scheme also reflects the structure of this thesis.
Section 2.5 gives an enumeration of how the main problems of the research field have contributed to the 'design' of the experiment. The actual experiment itself is described in the third chapter.

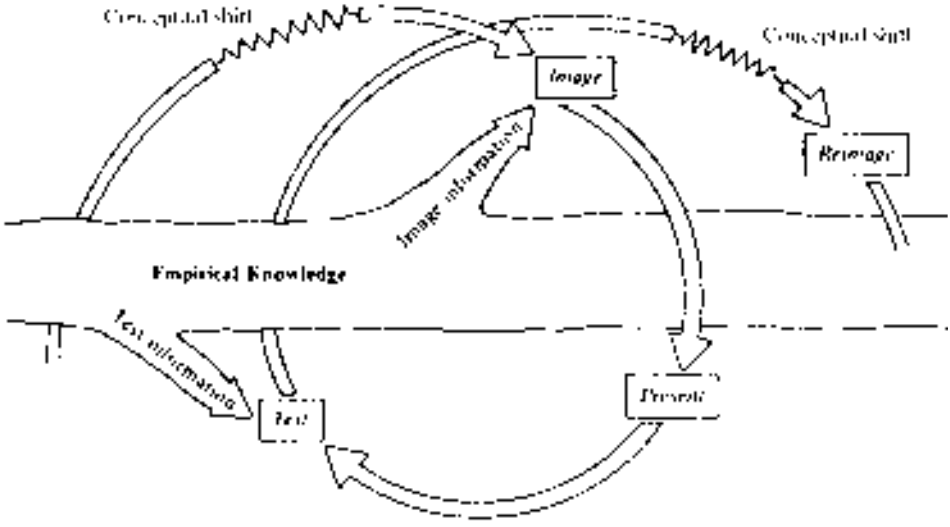
2.1 Design Practice versus Research Experiment

Architectural Design : spirals of different realities

A design process seldom develops straightforwardly. A single recipe 'how to design' cannot be given. Design is mainly learned 'by doing' [Breen, 2002/2, van den Bergh, 2002], by gaining experience and under supervision of a teacher who already has gained experience. Rather than the actual perceptions, considerations and actions in a particular design, many tracts of design research describe the process from a certain distance.

In *'Inquiry by design: Tools for environment-behaviour research'* J. Zeisel (1984) presents a 'design development spiral' involving empirical knowledge which is refined in cycles of *image-*, *present-* and *test-actions* (see figure 32). The cycles become fruitful if they lead to distinct conclusions and decisions. In such a casen the design develops in controllable iterative loops. The empirical knowledge increases. However, this is a general and theoretical concept of the designing in process.

Figure 32. Design development spiral [Zeisel, 1984].



In practice, the design process can be quite ponderous; involving cycles that keep returning. If the cycles return to the same situation, the process gets stuck. At other more fruitful moments, a designer seems to skip Zeisel's neat and spiralling process and the design develops with one enormous leap forward. Crises and inspirations come seemingly unexpected.

Some designers claim to ‘always’ be busy with their design, day and night, anywhere [Kurokawa, 2000]: *"Likewise, to build impressive architecture deserving of praise, the architect must put all of her or his whole soul into the project, down to the most minute of details. I sketch 24 hours a day. In the past 40 years, I believe I have made around 100,000 sketches. In my head, I am always designing, always building, always walking around inside this idea as if in some virtual reality. After walking around and around inside the 'building', the design becomes the plan and from there, the actual building. By laying out the sketches on the floor of the exhibit, I hope to offer the guest the chance to walk around in my 'virtual reality'."* A certain mystery around designing is never un-useful when you have reached the top.

Others say they need specific conditions: a very tidy or very messy atelier, or they claim that they need to be surrounded by inspiring artefacts and images from study trips all over the world. Hertzberger, for example, always carries a small sketchbook to collect thoughts and experiences for further reference and reflection [Bergeijk, Hauptmann, 1998].

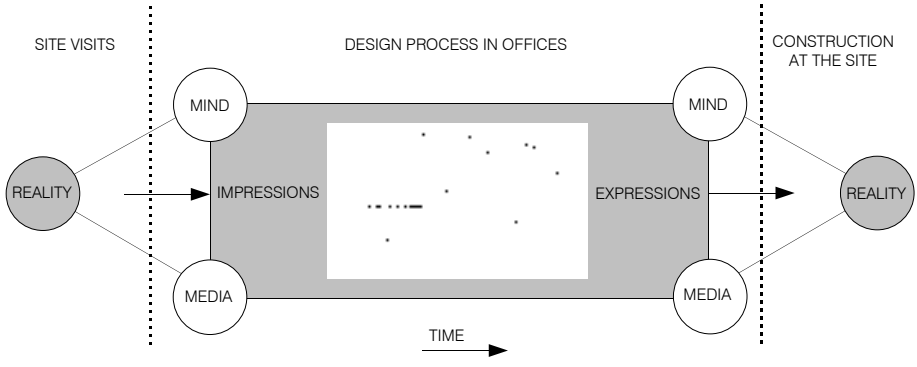
In design-(media)-research such claims can be interesting starting points for the development of hypotheses and prototypes. Experiments, interviews with architects and own experiences can reveal details in Zeisel’s rather generalised design development spirals.

An example of closer observation is given by Schön and Rein (1994, p166): *“A designer works with materials to produce an intended object and discovers that the materials resist, more or less, his attempts to impose his intentions upon them. In this process, the designer’s intentions evolve. Design moves inevitably produce some unintended effects, which the designer may see either as flaws to be corrected or as happy accidents that suggest new opportunities”.* While Zeisel described the *image-*, *present-* and *test-actions* in a ‘macro view’ of design development, Schön and Rein indicate smaller aspects. They propose that there can be ‘resistance’ and ‘unintended’ effects, which can be motivations for new opportunities. This description is also close to the emotions of designers when constructs are used like: ‘flaws to be corrected’ (annoying) and ‘happy accidents … opportunities’ (excitement, ambition).

On closer observation, a particular phase of a design process seems to reveal an *own reality* that consists of a dialog with the design media, producing design moves that can be influenced by circumstances in the atelier as well as the designer's moods. The process is a different reality where the designer meets (im)possible and (un)desirable design options.
This closer observation of design processes can be described in a narrated or a coded way. A combination of the two methods can also be used. Several specific coding system can be distinguished. The one is tuned for research of sketching, the other for comparisons in usage of different sorts of design-media. The codes are used in the attempt to pinpoint the different actions of a designer at work. Goldschmidt (1989, '91, '92, '94, '95) uses the terms 'moves' and 'arguments' in descriptions of the design process. The designer makes moves in his/her understanding while solving the design problems at hand. The arguments for the moves can be considered as follows: 'seeing as' (code: SA) and 'seeing that' (code: ST). Other research explains the design process more interactively in series of 'seeing – moving – seeing' actions [Schön, Wiggins, 1992]. Research of 'visual thinking' distinguishes three behaviours: seeing (S) imaging (I) and drawing (D) [McKim, 1980].

As described in section 1.1, the closest relation to the *(real) reality* of the existing built environment is at the start and at the end of the design process. At the start, the site and the urban context is visited in order to check the contextual conditions of the design. At the end, the building is built: the design and the real context are confronted with each other in an definitive juxtaposition. In the whole in between process, the design is produced in the virtual space of computers, offices and in the dreams of architects (see figure 33).

Figure 33. RELATION TO and SEPARATION FROM URBAN REALITY

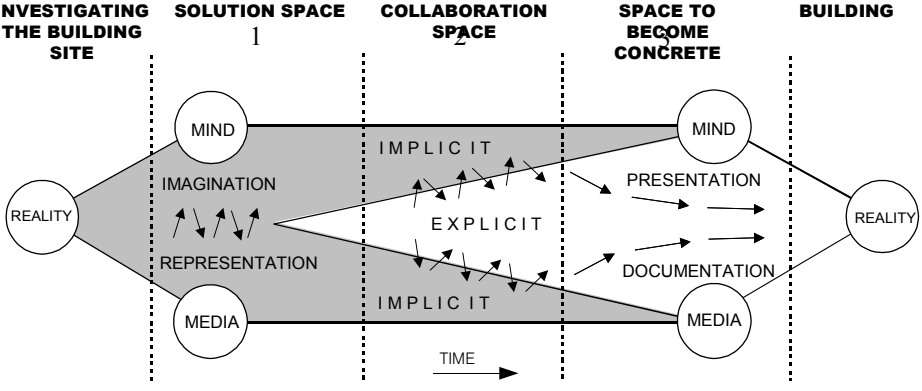


Zeisel's design spiral can be seen as a useful representation of the process of design. However, during such a process, the character of the design spiral changes. Cross (1989), Jones (1970) and Goel (1995) mention different 'stages' of the design process: analysis of the problem, concept generation, preliminary design and detailed design. A general overview of design research publications reveals three main phases where the focus is on: design in early stages, collaborative design and design concretisation (see numbers 1,2,3 in figure 34).

After the investigation of the building site, the early ideas and solutions concur with one another in an explorative phase. Unlike solving (for example) the mathematical equation: {x element of the positive rational numbers | x^2=4}, many problems of a design task are 'ill-defined'. More then one solution is possible. The designer, or in most cases a whole team of different experts, works (metaphorically) in a 'solution space' that develops from initially 'dream-like' ideas and unresolved visions, into a more definite set of documents. These specify the design 'object' as precisely as possible. This 'solution space' encapsulates all ideas and wishes in the minds of the design team, the client and others involved and the collection of sketches, models as design media.

At the start of the design process the solution-space seems unlimited. Later, useful solutions might be distinguished and specified. At a certain moment, a design concept can become 'generative' and solutions seem to fit according to the 'rules' of the design itself. In this respect, Goel (1995) identifies two types of solution-moves or transformations: lateral and vertical transformations. Lateral transformations are real changes from one idea to a different one (from

Figure 34. Phases of the design process.



a to b), vertical transformations are developments of one single idea (from a to a+). In general, it is beneficial to the design process if lateral transformations are made before the vertical transformations take place; first exploration, then concretisation.

In the early stages of design, the design solutions are still open to debate, the design representations should be produced and exchanged in an open way without prejudgements and without too many constraints. Later, a phase of collaboration can take place. Each member of a design team influences the ideas with personal knowledge. The most promising alternatives can be selected. The design representations in this phase become loaded with domain specific information (e.g. from an engineer or a building cost calculator). After selection and adjustments, the implicit aspects of the design become explicit.

At the end of the design process, ideas must become (sometimes literally) concrete. The focus is on production and presentation of definite images and clear documentation for the builders. The final phase of the design process is interesting for research since it is focussed on practical issues like standardisation of documents and optimisation of collaboration between building partners. This phase can benefit from research that helps to streamline and control the refinement of design information.

Thus, in each phase of the process, the main tasks of architects and their collaborators change. Likewise, it can be assumed that the tools and design-media to create and manage the design should adapt to the changing needs of the designers. Therefore, distinct research in addressing the role of design media and working methods should focus on one phase at a time.

In contrast to the final phases, the early phases of the design process are interesting because of the potentially different points of view in the solution space. Contradictions, different perceptions and alternatives are the objects of research. Here we speak of different ‘realities’ that can live in the minds of designers or … on the back of an envelope. Such ‘virtual realities’ can have a lifespan of a few seconds or up to years. These different concepts are often used as generative models for further activities that construct and influence the final design.
Apparently the design process (in the office) can benefit from the withdrawal/separation from the real site and all constraints in the built environment. It allows freedom to think about the (im)possible and (un)desirable alternatives.

A balance should be found in adequate sorts of representations and media, so that the inspirations and limitations from the real building site are well available at the designers' desks.

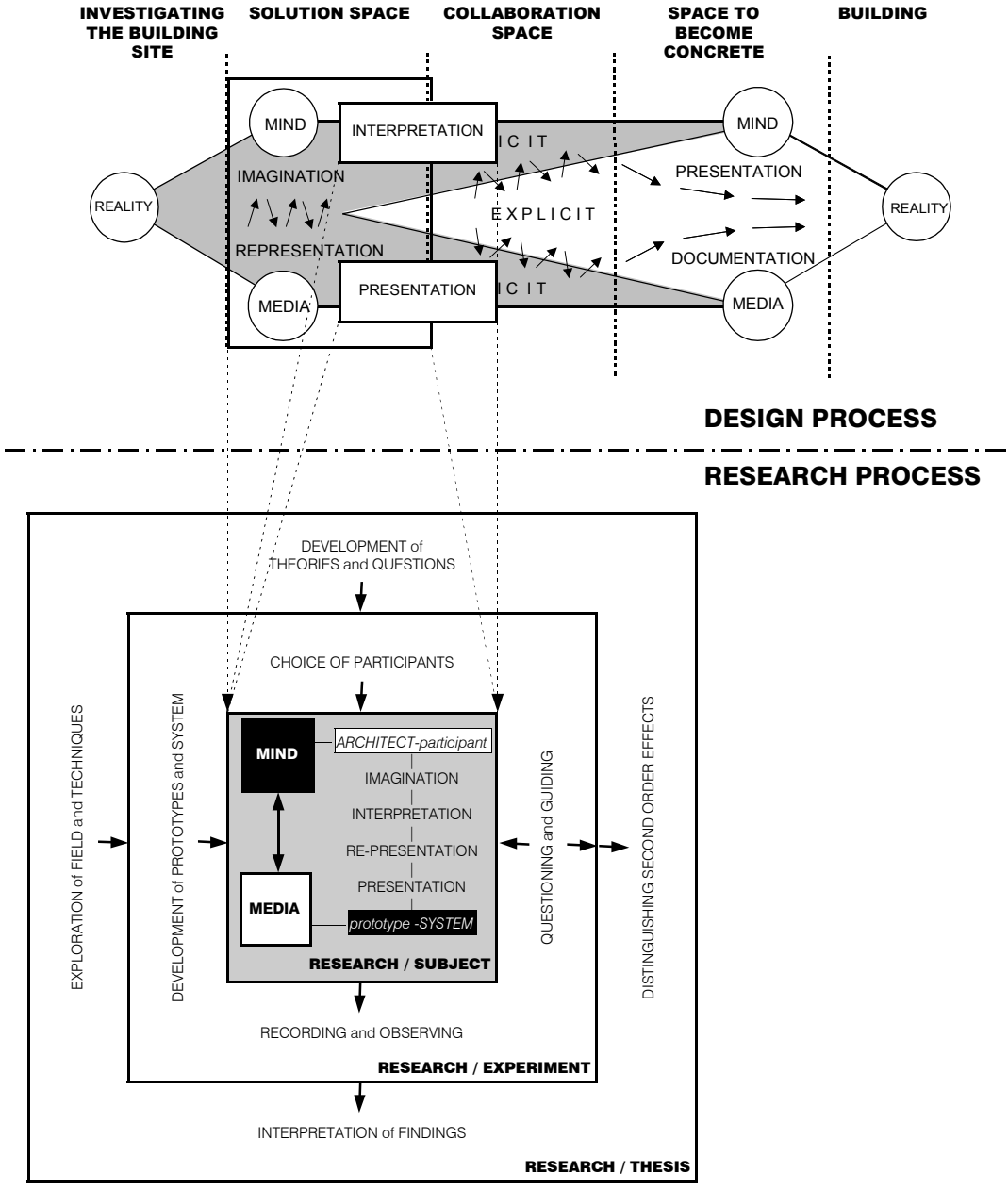
Design Media Experiment: spirals of influence and observation

In order to understand more about processes of representation and interpretation in design, it is worthwhile to investigate such aspects via an experiment. The experiment, which was carried out in the course of this research project is described in chapter 3. It involves a number of invited architects who react on representations from a computer model of a given building site and its surroundings.

The focus of this research was on the early stages of the design process. Figure 35 shows the relations between the design process as described above and how it transformed to the research experiments.

As in biological research, the terms 'in vivo' and 'in vitro' can be used to situate the research. 'In vivo' means that the research observations are done in real life. That implies a view rich in contextual influences. The results however, might be so rich that it becomes difficult to draw conclusions and to control the findings. 'In vitro' means that the research takes place in a confined (sterile) environment. Literally in vitro means in glass, the glass of a test tube, but in general it means 'in a laboratory'.
The main experiment of this research took place 'in vitro'. The glass was actually a computer screen; the 'laboratory' was a faculty room. A main theme of the experiment was the way the invited architects would perceive and react to the 'context' as it was presented (the building site model and its direct surroundings). The context 'in vivo' as such was not the subject of research, but the re-presentation of an urban context 'in vitro' (on screen) was. Direct influence of a real urban context was deliberately excluded from the experiment. The real context did not exist. In order to eliminate biases from memory images, the context representations came from a hypothetical city created especially for this experiment.
Figure 35 shows how imagination, interpretation; re-presentation and presentation are the essential themes of the study. Those themes are important in both the real design process and in the experimental setting. Impressions from the urban environment and influences of other people are kept out of the experiments. Instead, the results from the experiment are directly related to the setting of the experiment, to the actions of the selected architects and the further interpretive steps described in this thesis. This refers to the 'second

Figure 35.
Relations between the design process and the research experiments.



order effects', which were mentioned in the introduction of this chapter. All words in the schematic blocks of the experiment and the thesis (such as 'development of theories and questions', see figure 35), describe the different influences that (partially) colour the experiment. The reason to reflect on these 'second order aspects' has to do with the consideration that design research partially bring its own conditions and conclusions, while normally design is not bothered by external research questions which are different from the particular design questions.

Black and White Boxes

Glanville (1997): *"We communicate in a circle. This is the form of communication between the simple Black Box and the observer, appearing to be a "Black Box" to the Black Box. Black Boxes do not have to be simplistic systems. For instance, I really have no idea what is happening in your head and I can see none of your ideas, nor (therefore) can I share them. If you represent them in some way, it is still not your ideas I see, but my interpretation (building my understanding) of your representation."*

The mind of the designer, who works with the representations of an urban context and indefinite ('sketchy') expressions of ideas, is seen here as a 'Black Box'. The representation and interpretation of his or her ideas can only partially construct understanding of the 'struggle' to find the right solutions to the ill-defined design problem.

Contrarily, the media used and partially developed for this experiment are treated as a 'White Box': everything is known about the possibilities of the medium. After all, the medium is a system of prototypes that were designed and developed by the researcher, for the research. However, the point of view of the participant, the prototype system and the experiment as a whole is perceived as a Black Box.

The way, to approach the 'Black Box' of the designer's mind, is through conversation. The conversation is triggered by the provided experimental system and the researcher. The research is intended to enquire what kinds of sketches the designer produces and what he or she says (opinions about design, about the undertaken methods, questions and insights) and what he or she undertakes (taking a view, testing a certain option in the system).

The aim of the experiment is to learn about the kinds of preferences and effects in relation to representations that are provided through the test system. Any necessary (guiding / instructing / questioning) involvement of the researcher is not excluded from the experiment. This involvement is neither excluded from the transcripts of the experiment. Questions are asked during a

free exploration of the represented urban environment. Influences from instructions that are given or from the direct way in which some questions are asked, are regarded to reveal more details; biases are not feared because they are either subsumed within the observations, or they are relevant.

2.2 Discussion of Theories and the Formulation of Hypotheses

This research experiment is set-up to examine different aspects of re-presentation. In order to approach this broad subject, several specific hypotheses and prototypes were developed. The prototypes relate to technical issues of representation to support the visual needs of the participating architects during the experiments. The hypotheses are based upon theoretical notions from scientific sources and from personal thoughts and insights gathered during the earlier case studies. The hypotheses are tested in an

About the Black Box

The Black Box is a construct invented to explain how some perceived "signal", observed to change, changes. It is, metaphorically speaking, placed over the signal so the signal enters with one value and emerges with another (the observed change in the signal). The relationship between the in- and outputs can be tested by the observer (who invoked the Black Box), who can modify the input in the light of the output by feeding the output back to be the next input.

The observer determines what relationship holds between these two signals and treats this as if there were some cause functioning inside the Black Box itself to make the observed change. In this way, the Black Box acts like an interface. Note that not only is the Black Box constructed by the observer, but the whole explanation is, also. You cannot see inside the Black Box (there is nothing to see: there is nothing there—it is an explanatory principle). Nor can you assert that because you have proposed a working relationship between in- and output, it will always hold. There is no true causal connection, no mechanism. The Black Box embodies Wittgenstein's principles (and pre-dated them by about a quarter of a century). It allows us to handle our ignorance by building relationships and by pretending there is a causal element at work.

To achieve this, there must be communication between the observer and the Black Box (including the in- and output signals). That is, the observer must be able to distinguish the input and the output (which must have different values on at least one occasion) and communicate with or through them. This is how the "functional description" works, which describes how the observer understands the action of the Black Box, comes to be constructed. The observer compares the signals, builds his functional description and then takes an output and making it the input, predicts what will happen by using the functional description and then testing whether the prediction is upheld. Thus, the observer controls the Black Box, recycling signals (changing the input) and communicating with the Black Box. And the Black Box, for its part, equally controls the observer, who responds to the signals the Black Box emits. Each controls the other in an endless loop. The control (and the communication through which the control is exerted) is circular.

It is this mutualism, this reciprocity of interaction in the building of the (observer's) functional description, that leads us to insist the structures and qualities attributed to the one (most often the observer) must, for the sake of consistency, also be attributed to the other—even though (in the case of the Black Box) we cannot see into it and it is a constructed fiction! This is why we come to assume that the Black Box also makes a functional description of its interaction with the observer. [Glanville, 1997].

experimental setting through close observation of the design activities of the participating architects.

The study draws from the following list of research themes and researchers:

2.2.1 situatedness

Situatedness is a term from cognitive psychology. It can be understood as knowledge that is structured, based on real places or real applications. Situated learning was indicated in fundamental psychology research (in a comparison of people and mice) and showed comparable results for 'occasion setting' and 'context dependence' in learning aspects [Dibbets, 2002].

Situatedness is described as '*where you are, when you do, what you do matters*' [Gero, 1997-1998].

The phenomenon of situatedness is studied in Artificial Intelligence (AI) research, in order to supply knowledge to learning systems [Clancey, 1997]. A perceptive system builds a 'mental map' of the environment in which it is placed. Such an environment can be physical (e.g. a room where a robot should work), can be language based (e.g. for a learning dialogical system), or can be a 'construct' of cases or precedents (e.g. for a case based advisory system). Each learning system needs to collect, or be fed 'situated knowledge'.

The AI approach is to situate learning systems, in order to teach them rules and to let them make decisions. The approach in this thesis is opposite: to let people make decisions and let (intelligent) media 'situate' the people with suitable and preferred visual information.
Originally, situatedness comes from the site itself. Visits to a building site are relevant for an architect to observe and absorb all characteristics of the context in which the design should fit. Media can be used to bring the impressions of a site visit back home (to the design office). Moreover, it has been a conviction from the start of this research that media can provide 'extra' situatedness in the design process. Media can help evoke new ideas [Stellingwerff, 1999/1]. The images created and communicated via media can stimulate imagination [Breen and Stellingwerff, 1997].

As digital media can provide adaptable views, situatedness can likewise be adaptable to momentary needs of a designer. Situatedness is a keyword in the search to adapt media to personal needs.

2.2.2 reframing

In 1997, eight months before he died, Donald Schön visited the Delft faculty of Architecture to give a research-course for starting PhD researchers. The 'Donald Schön course-week', initiated by professor Alexander Tzonis' Design Knowledge Systems group, was truly inspiring and influenced specific aspects of my research insights. Schön encouraged me to focus on the theme of design in context and on the impact of framing by taking different points of view and by utilising different sorts of content representation. Later, I realised that my research themes tightly corresponded with his themes of 'reframing' and 'reflective conversation'.

Donald Schön and Martin Rein used framing in their study of policy controversies. People and parties with different ways of framing of an issue cannot resolve their conflicts. Being confronted with each other's frame, or introducing a new and common meta-frame, can lead to shared insights and can help solve the controversies. The authors [Schön, Rein, 1994, p.178] compare reframing of political issues with reframing in collaborative architectural design: *' ... the actors may be struck by their different views of a policy issue; and when they are so struck, they have an opportunity to test their construction of one another's views. This is very much like what goes on in an architectural design studio, where different designers can reveal, by their visible design moves, both how they understand the design situation and how they interpret the meanings of one another's utterances.' ... 'The concrete situation, the materials and the object in transition give the actors hooks on which to hang their attempts to invent adjustments that may resolve their differences - at the limit, synthesising elements of their conflicting frames.'*

While Schön and Rein use reframing metaphorically, i.e. as a conversion of framed thoughts, in the context of design I am inclined to take the theme of reframing more literally. In this sense, reframing can be considered as moving the point of view, changing position and making alterations in the composition of a design within its context. *The frame holds what you see; reframing leads to seeing something differently.*

2.2.3 serial vision

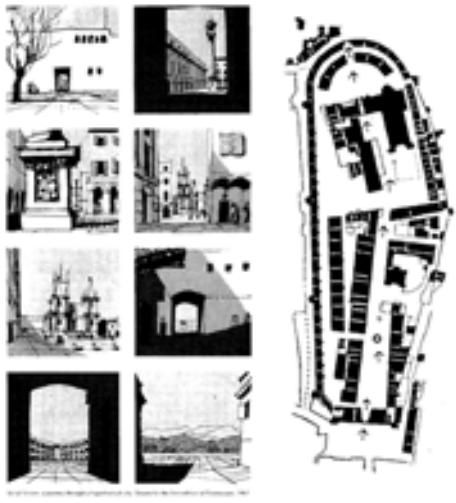
By means of his famous hypothetical city, Gordon Cullen (1961) explained the concept of the serial vision: *"To walk from one end of the plan to another, at a uniform pace, will provide a sequence of revelations which are suggested in the serial drawings opposite, reading from left to right. Each arrow on the*

plan represents a drawing. The even progress of travel is illuminated by a series of sudden contrasts and so an impact is made on the eye, bringing the plan to life (like nudging a man who is going to sleep in a church)…" .

Serial vision is a linear way of story telling. It is a fixed sequence with a beginning and an end. The application of serial vision is a typical example of traditional presentation: the story to be told is fixed in static images, the audience gets the 'story' through the sequencing of these images that illustrate the story. The architect can thus communicate the qualities of the 'good design' in the 'interesting environment'. The impressions can lead to questions from the 'audience', however the environment cannot be appreciated or explored interactively. As such this form of serial representation clearly has its limitations, as Cullen himself notes: *"... the slightest deviation in alignment and quite small variations in projections or setbacks on plan have a disproportionally powerful effect in the third dimension."* Most probably, Cullen selected what he thought were the most 'interesting' viewpoints and the most picturesque villages to underpin his urban analyses.

Serial vision is clearly a valuable invention. Through the link of maps to perspective views, a good insight and understanding of a design can be communicated. However, the audience nowadays does not want to be nudged. In public urban debates, it seems as if laymen do not exist, everyone has his say. People like to test and interact. In order to meet the wish to participate, architects' presentations should allow prompt visual answers to questions of

Figure 36 : The hypothetical city, Gordon Cullen, 1961.



the audience. In this respect, serial vision is too static and too 'finished'. In a design process, the images should not be fixed, but dynamic and the images should not be finished visions but interactive views from a digital- or scale-model.
With the opportunities of 'new media', *the presentation concept of serial vision* can be extended with *the exploration concept of dynamic views*.

2.2.4 reflective conversation

By sketching, a designer makes a personal notation concerning certain contextual aspects of a problem that has to be solved. This can be seen as 'noted situatedness'. Re-viewing the sketch makes it easier to understand the problem. The design problem is externalised by the brain and can be reflected on in a more relaxed and competent way.

Schön and Wiggins (1992) mentioned a "*reflective conversation with materials of a design situation."…"A designer sees, moves and sees again. Working in some visual medium - drawing, in our examples - the designer sees what is 'there' in some representation of a site, draws in relation to it and sees what has been drawn, thereby informing further designing."* .

Sketching is interaction in optima forma. The medium is filled with represented knowledge and relevant information for a specific problem. While the sketch is being produced, the information generated via the medium is read and interpreted, the designer can take creative steps and re-draw, reflect and refine the 'sketchy' ideas.

Where serial vision is an end product of a designer, reflective conversation is the process in which designerly insights can become visualised visions.

2.2.5 design cycles

The design spiral of Zeisel (which was described before, see p77) is considered as a schematisation of a practically much more complex and tedious process. Therefore, one cannot speak of neat design cycles anymore. This research opts for a system that should help the designer to concentrate and focus on a problem by providing a certain extent of situatedness. A system that raises the designer's context awareness and can adapt quickly to different information needs of the designer. A system that stimulates re-thinking and remembering, in order to complete the interrupted creative spiral.

2.2.6 models of / models for

Models play a key-role in this research. A clear distinction can be made between 'models OF…' and 'models FOR…' [Glanville, 1996]. In the vision of Glanville, models OF... are relatively rigid and descriptive, models FOR… tend to be more open to exploration and invention.
The development of models OF can give new technical understanding of an object or method. An example of a model OF is for instance a simulation program to illustrate the way a combustion engine or a schematisation of a negotiation process. In the scheme of research types (see table 1 on p23), the models OF are placed next to the references, whilst models FOR are placed next to scenarios.
Scenarios are theoretical ways of thinking to explore particular subjects. In order to start a process of 'scenario thinking', one could ask 'what – if' questions. As in a film scenario, the flow of events in each part is created before the full details are determined. Scenarios are explorative because steps are made before they prove to be sufficient. The opportunity of stepping into an unknown direction can evoke creative ideas.
Models FOR are characterised by the same kinds of 'uncertainty' as scenarios. This uncertainty depends on the amount of risk that a researcher takes in the explorative research. A model FOR may involve similar mechanisms as scenarios. The 'what – if *questions'* in *theoretical* explorative research, can be replaced by 'what – if *mechanisms'* in *technical* explorative research. Such mechanisms can be explored by means of, for example, changeable parameters and preconceived rules in the model's 'system'.
Whereas a model OF is primarily a depiction of something that already exists, a model FOR allows for new investigation. To make the difference even bigger: a model OF is something that is extracted and abstracted from its environment, while a model FOR only works if it is situated in a (new) environment. The same applies for the theoretical counterparts of both sorts of models: a reference is mentioned apart from its original context in order to be re-framed and reinterpreted, while a scenario creates a new context in which the new thinking steps can be made.
In this research, models OF and models FOR are combined in one complex test system. The VRML models of the urban context (see section 3.5 p.145-149), the building site and the design proposals can be denominated as models OF context and design characteristics. The JavaScript tools, the adaptable parameters and the set-up of the test as a whole, can be denominated as a model FOR exploration of view-preferences and effects in a simulated architectural design process.

2.2.7 think aloud

The think aloud method [Van Someren et. al., 1994] is often used to get insight into the thoughts of a research participant. For instance, in order to find out how a designer thinks during the process of sketching, the researcher can instruct and train the participant to directly speak out what he or she is thinking [Hamel, 1990]. Although this method provides a very direct report of the participant's thoughts, it is difficult to reveal new preferences based on new prototypes and techniques. The think aloud method is most suitable in cases that test the working methods and the common practices of participants without much interference of the researcher.
As this research involved many new aspects and prototypes, it was an important consideration to find a good combination of 'think aloud' methodology and a more direct way of interviewing and instructing.

Hypotheses

The seven approaches, which were described in the previous paragraphs and the experience gained in the earlier case studies, have contributed to the formulation of the following research hypotheses:

1. *There is a feeling of situatedness in digital 3D-models that represent a design context. (theme: 2.2.6)*
2. *Digital media offer the opportunity to generate dynamic views and adaptable representations in a variety of ways, thereby creating different experiences of situatedness. (theme: 2.2.1)*
3. *Different dynamic forms of situatedness, created via digital means, can stimulate concentration, focus, the reframing of thoughts and conversation in design, whereby design cycles may be shortened. (themes: 2.2.1/2.2.2/2.2.4)*
4. *Adaptable models OF a design context can inspire the designer in such a way that they become models FOR creative design thinking. (theme: 2.2.6)*
5. *Dynamic views and adaptable representations using digital means are more effective to evaluate the impact a design concept will have in its context than serial visions using fixed images. (theme: 2.2.3)*

6. *Being separated from the real site with all its intrinsic constraints, can stimulate a measure of freedom in the design process, allowing for the consideration of (im)possible and (un)desirable alternatives, which may actually lead to improvement of the design concept. (theme: 2.2.5)*

7. *Combining the 'think aloud method' with intermediate instructions, conversations and questions by the research is a useful way of gaining results in design driven studies. (theme: 2.2.7)*

2.3 Case studies and representation media prototypes

Parallel to the development of hypotheses, a number of explorative case studies and experiments were carried out. The insights from the cases, combined with the theoretical study and the formulated hypotheses, directed to the design of the main experiment. Nine VRML-program parts (four prototypes and five support tools) were developed for the experiment system. The case studies are described in the (grey toned) intermezzos between the chapters as follows:

After Chapter 1: Research Field Exploration Cases

- *Case study 1 [p.37] ROME then and now*
  REALITY - The city as tempting context
- *Case study 2 [p.43] CONTEXT in ART / ART in CONTEXT*
  MIND - Design approaches related to the urban context
- *Case study 3 [p.51] 3D MODELING - new means available*
  MEDIA - Model making experiments

After Chapter 2: Design and Modelling Exploration Cases

- *Case study 4 [p.105] Vienna WORKSHOP - Virtual Aspern*
  Research methodology
- *Case study 5 [p.107] TEXTUREMAP collections*
  Model making experiments
- *Case study 6 [p.109] Delft WORKSHOP: Imaging Imagination*
  Research methodology

After Chapter 3: Explorations for Technical Implementation

- *Case study 7 [p.153] VRML/HTML/JAVA/JavaScript*
  Trying out different user interface variants and new HCI concepts

Experiment Prototypes

1. *different representation layers [p.157]*
2. *model extensiveness layers [p.159]*
3. *fog and transparency sliders [p.161]*
4. *switching between eye level and bird's-eye views [p.163]*

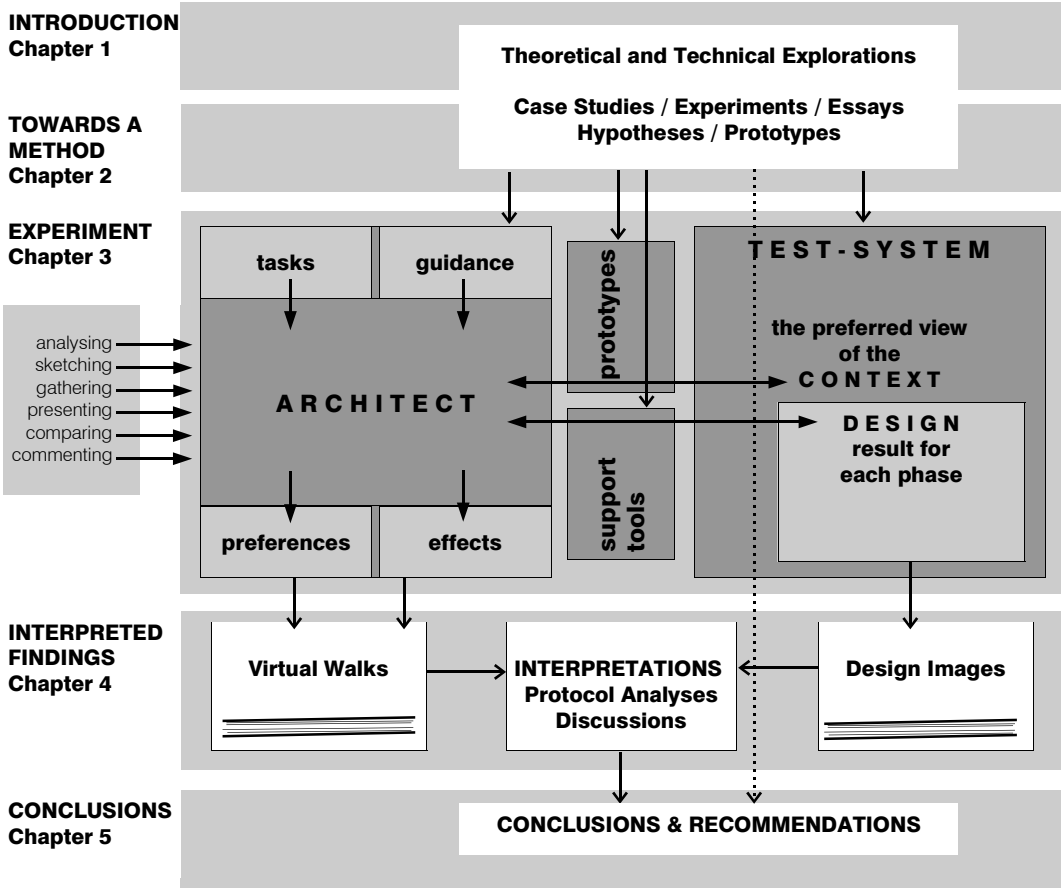
Experiment Support Tools

1. *virtual site analyses [p.165]*
2. *constructive sketching [p.167]*
3. *drag and drop sketching [p.169]*
4. *surface sketching [p.171]*
5. *the interactive map [p.173]*

2.4 Design of the experiment

The diagram of figure 37 gives a general overview of the research experiment. Theories and explorative studies, discussed in the first two chapters and in the intermezzos between chapters, led to the design of the experiment as described in the third chapter. The role of the participating architect and related aspects are shown on the left hand side of the diagram. On the right side, there are the system aspects. The interaction between the architect and the test-system is subject of research. Design sketches, models, images and interviews were utilised to reveal the preferences of the architects and the effects of the prototypes. The results are documented and interpreted in chapter four, in relation to hypotheses and expectations formulated prior to the experiment. Final conclusions and recommendations are presented in the fifth chapter.

Figure 37. Research scheme.



2.5 Considerations for the experiment

To conclude this chapter, a short recapitulation of some important aspects is given.

Design is a highly personal undertaking to solve an often ill-defined problem. Only close observation and cautious description of momentary insight can reveal information about the different realities in the design process.
Design activity *and* design research are ways of searching that spiral around different prototypical and hypothetical 'realities'. Concepts are tested, learned from and rejected, refined or extended.
In the set-up of this research, there is an interplay between:

- the reality as imagined in the architects' mind,
- the design representations of thoughts and contexts via media,
- the research understanding of observed actions and expressions,
- and (not to forget) the 'reality' of the experimental setting.

Design processes include different phases and circumstances in which ideas emerge. To get better understanding about the potentials of new design media, a test making use of prototypes can be carried out.
The test in this research is intended to reveal effects of design representations. In order to carry out a study in this field, the participation of a number of architects, designing in an experimental set-up was needed. The think aloud method and protocol analyses was considered to be a useful approach, but the many issues and actions also needed to be valued 'as such' in a qualitative way.

In order to focus on the use of different digital representations of urban context and design, the experiment positioned individual design processes (in vitro) in a laboratory environment (in vivo). The participating architects would be confronted with a fine-tuned system of digital media to test theories concerning representation techniques. The theories were laid down in seven hypotheses (see page 100), the digital media techniques were made testable through four prototypes.

The experiment is considered successful if:

- it clearly supports or rejects hypotheses,
- if it proves the effectiveness or weaknesses of the prototypes.
- if it provides new (unexpected) insights and
- if new theories, new techniques and new questions are generated.

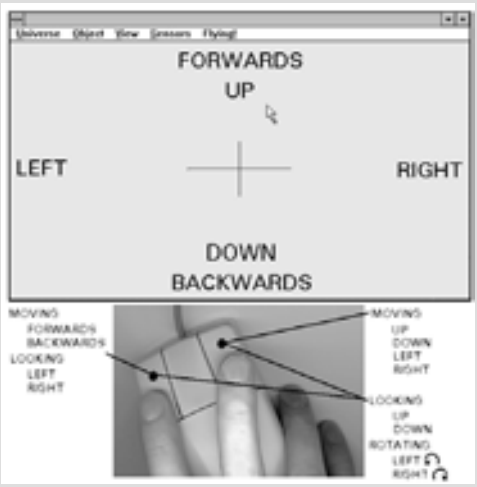


Figure 38, 39. Images from the Aspern workshop model. Bird's eye view and pedestrian view of the interactive model.
Figure 40. Method of navigation through the VR model by means of different mouse direct and click combinations.

Figure 41. Study in which the Aspern model functioned as an urban context for educational design and modelling exercises.

CASE STUDY 4

Vienna WORKSHOP - Virtual Aspern

The 2nd European Architectural Endoscopy Association (EAEA) conference in Vienna helped shape a number of my research prospects. A special design simulation workshop was part of the conference. The '(in)visible city' workshop challenged all participants to use their own laboratory capabilities and approaches. Later, the idea of such workshops proved to be successful during the third EAEA conference in Delft and at the AVOCAAD conferences in Brussels.

In the Virtual Aspern workshop, each participant received a scale model and a set of CAAD drawings that had to be used to visualise a design for a new urban extension in the Vienna district.
For the TU Delft contribution, Jack Breen and myself worked simultaneously on enthescopic and 3D-Studio animations and had our first experiments with sets of façade texture maps. *"If one wants to simulate design options, then a model has to be made relatively quickly and this must be flexible in use. This means such a model will be relatively abstract. We asked ourselves how abstract or realistic a model should be. We started with elementary, graphic patterns which were applied as texture maps and subsequently, some sampling techniques which offered a more realistic image were tried out."* [Stellingwerff, Breen, 1995, 1].
We compared the use of 'optical- and digital- endoscopy' [Stellingwerff, Breen, 1995, 2], this resulted in collaborative use of texture maps on both scale models and digital models and brought joint developments in 'overview cameras and virtual maps'.
Another experiment in the '(in)visible city' context was a first VR application that allowed one to wander through Virtual Aspern, making it possible to change facades images interactively (see figure 38-40). The Aspern model was later used in an educational setting for the D11 presentation module in Delft (figure 41) [Breen, 1997].

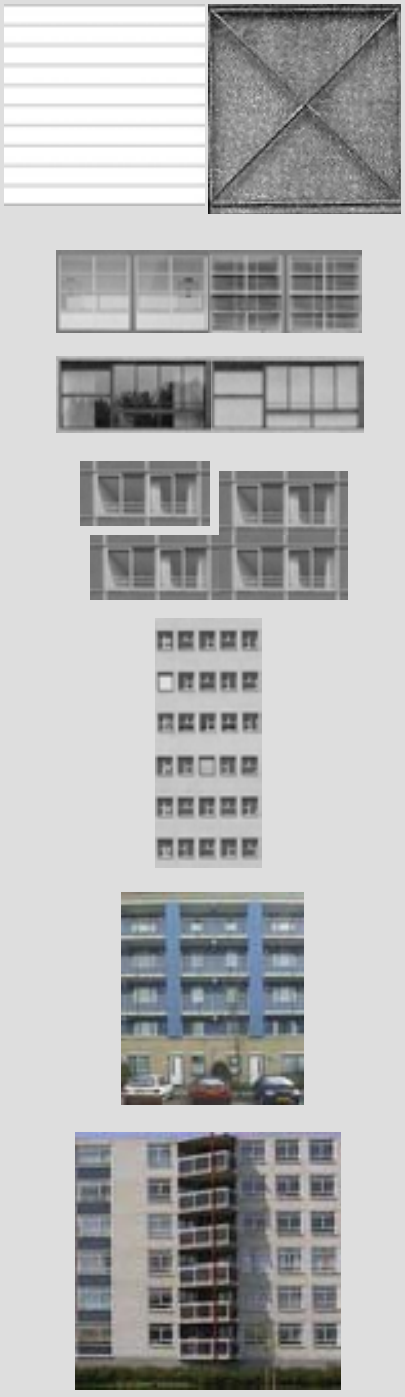


Figure 42. Some different sorts of façade texture maps.

CASE STUDY 5

TEXTUREMAP collections

Back from the Vienna conference we started to collect all sorts of texture maps, in order to use them in other tests and in educational projects.
Different sorts of textures can be distinguished.
Simple line patterns already provide a good impression of the scale of a building. Each line can indicate a floor or a structural division. The line pattern already gets architectural importance, if the effect of line directions (horizontal or vertical) and contrasts is considered.

If the patterns become slightly more detailed, an image of architectural identity emerges. Connotations of offices and residential buildings can be made based on size and type of window patterns and colours.
Façade colours can be used as a legend, or as a reference to material.
Types of textures can be chosen depending on the steps of the design process. One can start with less-definite patterns and change them whenever a more detailed representation of planning ideas is required.
A virtual model of a real existing environment can also be 'textured' with less realistic textures. This might give a clearer image of the main sculptural and spatial features of the environment. The realism, the colour and the general choice of the textures can be used to express contextual ideas and interpretations by an architect.

The production of textures involves several techniques.
A texture can be drawn in a CAAD program, or in a photo edit program. It can be scanned from an architectural publication, or one can take a digital camera and go on a ‘façade-hunt’ in the city. When a picture of a façade is taken, one should try to get as little perspective as possible in the picture. The perspective can also be eliminated with a photo-editing program (see figures 22 and 23, p.57), but if there is much 'depth' in the façade (due to balconies etc.) this method can give strange effects.

A façade texture should preferably be 'tile-able' if it is to be applied in a repetitive pattern.
If the edges of the façade are not straight, the texture image can have partially transparent areas. This technique is available in images with an 'alpha channel' (the information layer in digital bitmaps that codes for transparency).

It is useful to keep a 'texture-map library' in order to quickly 'dress up' an abstract geometrical model.

Textures that need to be used in VR applications should preferably be in sizes that fit tightly in the memory of render-hardware cards; at the time the experiment was carried out, sizes of 256x256 image-pixels performed well.

CASE STUDY 6

Delft WORKSHOP: Imaging Imagination

Inspired by the Viennese '(in)visible city' Aspern Workshop, Jack Breen and I developed a workshop. Once again each EAEA member would be invited to show and exchange digital and optical endoscopic experience. This time the model was conceived as a context for design. Fifteen participants received either a textured VRML / 3D-Studio model, or a textured cardboard scale-model. Each team explored the model in their own visualisation laboratory. Fifteen different designs were brought to the conference. The workshop assignment, the digital model and a great variety of images and opinions can still be seen on the special website: 'IMAGING IMAGINATION - Exploring the Impact of Dynamic Visualisation Techniques in the Design of the Public Realm' at: http://www.bk.tudelft.nl/media/eaea/imim/

The workshop generated many new insights for the further exploration of 'design in context', 'dynamic visualisation techniques' and 'the value of questionnaires'. Lessons: the relevance of a tightly prepared experiment, the need to involve architects instead of visualisation experts, the importance of open questions, the quality of mixed media (e.g. a scale model with digitally manipulated, colour-printed textures) and the need to study the process-data instead of just the results.

The findings of the workshop questionnaires had an impact on the methodology of the experiment in this PhD study concerning the investigation of the architects' points of view.
The following is a quote from the questionnaire findings [Breen, Stellingwerff 1997]: *'In general, the texture-mapped models were received positively. This can also be seen in the various designs, which attempt to fit in and react to the surroundings. During certain decisive moments in the design process, some participants would have preferred a less detailed model, with only the abstract forms of the building blocks (without facade textures) in order to focus on the matter of the form of masses and proportion of spaces. The facade textures*

give a lot of information although the projection is totally flat. More 3D geometric details could be provided in the balconies and the gardens, because these elements are most distorted when projected on a flat facade 'face'.
The question "which view, 'eye level view', or 'bird's-eye view' is most appropriate for several visual checks", gave a lot of insight and a confirmation about the use of endoscopy and certain graphical user interfaces of computers. Most 'primary urban design decisions' like the 'placement of masses' and 'finding an appropriate urban scale' are done in bird's-eye view.
The more detailed decisions (visual checks) and decisions about height are made in eye-level view (e.g., details on the ground, choice of texture and material, light adjustments, camera placements, finding the appropriate human scale and proportions of spaces).
The comparison, after taking the average of the answers in all questionnaires and for all design tasks, shows some preference of the use of eye level views (60%) over use of 'bird's-eye views' (40%). Remarkable was the consistency of this outcome among 8 participants (all between 54 and 64% for eye level use). Only two participants seem truly dedicated to perspective eye level views with their score of only 25 and 10% for the use of birds eye view. Very important though, is the simultaneous combination of both views. In most endoscopy laboratories this combination is almost natural, as the designer is standing next to the scale model and looking through the endoscope pipe or looking at a video monitor. When the views are separated through enhanced technology (such as happens when electronic camera navigation tools are introduced or in most 'full immersion' Virtual Reality applications) the need emerges for the insertion of a second view-frame in which an overview is provided. In a video or a previously rendered computer animation of a route through a model, the same need for an overview can occur.
If a small overview image is not offered, one can easily become disorientated.'

When reading back this report on the questionnaire findings (after five years), the insights are still relevant, but the given percentages appear a bit arbitrary as they were based on only eleven forms. Most of the participants were endoscopy researchers, not architects or clients of architects. Apart from that, it is not so relevant to find how many views were of a certain kind. What is of interest are the thoughts and preferences during the whole design or presentation process. It is interesting to hear what designers are looking for when they undertake specific actions and try to get a specific view. In general the questionnaire did touch some of these issues, but the need arose to hear much more from architects who are actually monitored while they think and act. Nevertheless, the experiments and questionnaires of the Imaging

Imagination Workshop pointed the direction towards a better method for investigation of different *views* and their effects in a design process. Moreover, the expressed preferences to have '*less detailed models during certain decisive moments in the design process'* encouraged me to further explore the effects of different *representation* modes during specific design actions.

Workshop **Delft EAEA Conference 1997**

I M A G I N G
I M A G I N A T I O N

Exploring the Impact of Dynamic Visualisation Techniques in the Design of the Public Realm

Q U E S T I O N N A I R E

E A E A

3. Imaging Imagination

The workshop is about visualising design options within a given context model.

Two important aspects in this 'imaging imagination' process are:
(1) the way one looks at a model and
(2) the development of the model.

Ways to look at the model.

3.1 **Which view, 'pedestrian view' or 'birds eye view', is most appropriate for visually checking the following design decisions within the given context model:**

	pedestrian view (view of endoscope or perspective rendered eye level view)	**birds eye view** / (standing next to the scale model or rendered axonometric viewport of computer)
placement of masses	☐	☐
height of masses	☐	☐
proportions of spaces	☐	☐
finding appropriate urban scale of masses	☐	☐
finding appropriate human scale of space	☐	☐
placement of secondary elements (e.g. trees)	☐	☐
camera placement	☐	☐
colour adjustments	☐	☐
light adjustments	☐	☐
design of details on the ground (e.g. sidewalks)	☐	☐
choice of texture / material	☐	☐

3.2 **Which view did you use most while working on the design model:**

☐ pedestrian view
☐ birds eye view
☐ both, changing now and then
☐ both, (almost) simultaneously

3.3 **Did you use 'dynamic visualisation techniques' during the modelling process in order to get a better insight?**

☐ yes ☐ no

Which technique:
☐ by moving my eye along the sides of the model on a low level above the model groundplate
☐ endoscopic movement
☐ video recording and playback
☐ rendering an animated camera in a computer program
☐ by using an instantly rendering CAAD program and computer with hardware rendercard
☐ by making and viewing a VR model (e.g. in VRML format)

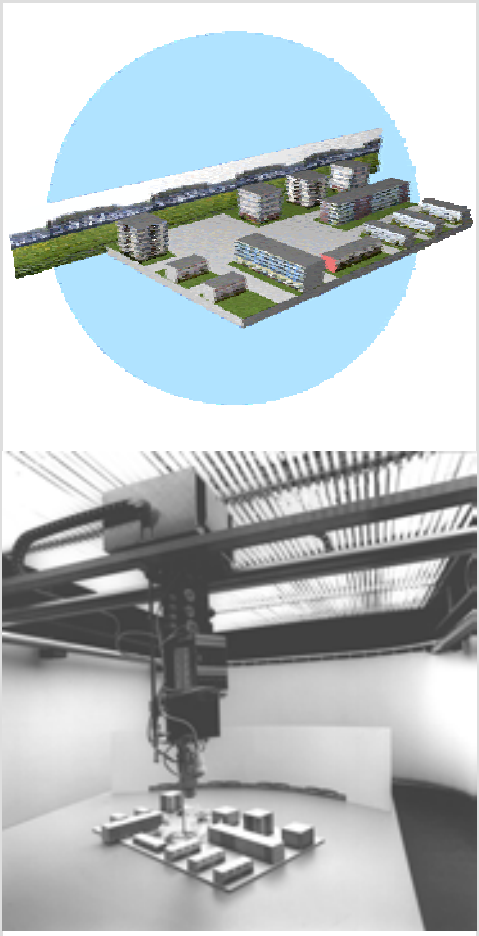


Figure 43.

Handling the enthescope and the scale model provides a useful sense of interaction.
The direct overview of the scale model and the pedestrian view on screen, gives a direct view concerning the features of the design at hand.
By providing a digital version of the same model in VRML, the interaction and overview / insight qualities could be compared with the cardboard scale model.
It was concluded that the VRML viewer needed several additional programmed 'tricks' in order to compete with the physical model qualities. This was the start of the development of several prototypes for the research experiment.

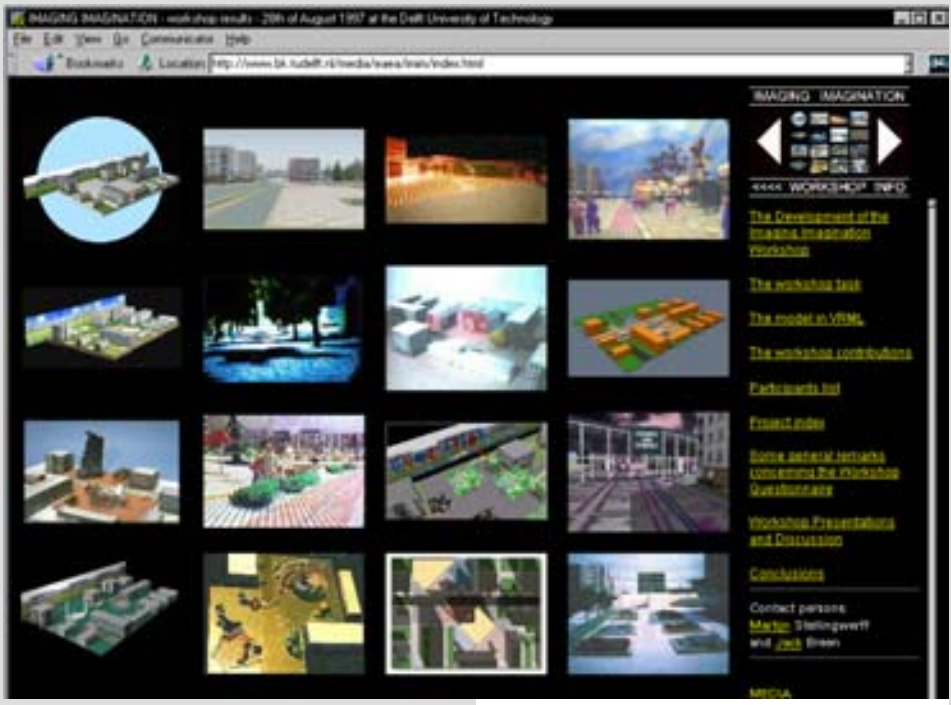


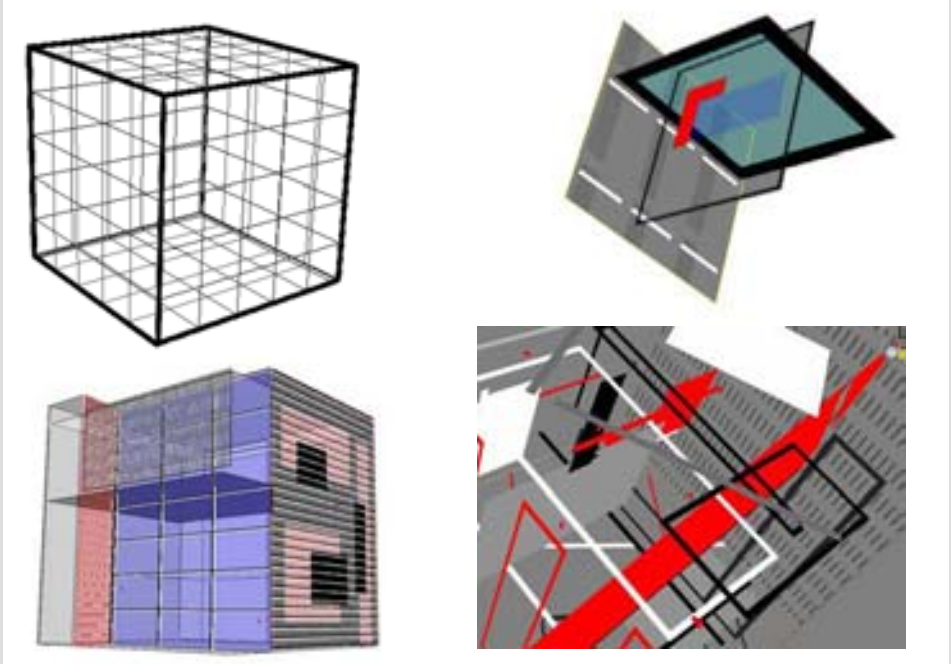
Figure 44.

Another thing which was learned during the Imaging Imagination workshop: pre-defining the workshop deliverables, structuring the presentation of results and organising the review of findings is necessary in order to get clear insights.

Such a process takes time and needs much effort, but in the end, it is much more rewarding then an improvised ad-hoc process. Organising the workshop, with Jack Breen, was rewarding and showed that both research and education need careful preparations that lead to concise and clear instructions and effective guidance.

Figure 45.

The idea for the SketchBoX program came slowly, in steps, after I experimented with the spatial effects of different texture-maps on rows of boxes. Especially the semi-transparent textures added to the spatial feeling in the perspective renderings. I started to program a pixel draw program that directly showed the sketches on the surfaces of geometric elements. From that moment SketchBoX developed further, mainly triggered by my fascination for the transparent colours and changing views.



Essay 2

SketchBoX

Most Computer Aided Architectural Design software suits the engineering aspects of design quite well, but is lacking as a design medium. As far as sketching is concerned, many architects still rely on traditional media such as pen and paper and scale models. This paper presents a theoretical exploration concerning design media and the application of typical media aspects in a spatial sketch program.

SketchBoX was conceived as an experimental 3D version of a sketchbook. It could be used for the notation of primary forms and structures in 'architectural' space. The program consists of several transparent drawing surfaces that can be placed in relation to one other and in relation to models of design or different design contexts. Thus, architects and students of architecture would be able to explore more adequately spatial configuration of the built environment and can comment using models of their designs. SketchBoX would enhance architectural group discussions and collaborative work because visual annotations can be made directly in relation to a 3D model. This paper describes the design considerations and possible use of the SketchBoX program.

The SketchBoX project was first published in *Architectural Computing from Turing to 2000 - eCAADe Conference Proceedings* / Liverpool (UK) pp. 491-497 for the eCAADe conference which took place 15-17 September 1999.

1. The nature of Design Media

At the Media department of the Faculty of Architecture in Delft, both traditional and digital design media are taught and explored. The potentials of new and existing design media are tested and new prototypes for design notation and representation are developed. We see computer programs, such as photo-editing software and spatial Computer Aided Design (CAD) software as important, but still limited in creative design applications. The expression and communication of ideas and other considerations such as collaboration and evocation are beyond the scope of most CAD software. In CAD, most 'true media aspects' are not supported. CAD is primarily useful in the creation of documents, databases and for the refinement of sketched ideas.
We educate students to develop their ideas in a spatial way, by means of pen and paper (van Haaften 1997) and scale-models (Breen, Olsthoorn 1993, 1996, 1999, 2002). Another important role in design and presentation of architectural design is played by our renewed endoscopy laboratory (van der Does et al. 1998). By means of an endoscope, you can get an eye-level image of an architectural scale model. New medical optic endoscope tubes and small video cameras, good scale-models and direct interaction of movements can make architectural endoscopy comparable to advanced Virtual Reality (VR) systems. Simultaneously we carry out research that searches for better digital media applications. Such media should benefit development and communication of spatial architectural design ideas.

1.1 Media versus Instruments and Tools

Instruments are different from ordinary tools because they are precise and are refined for a specific task in a specific domain. Media can be distinguished from tools, because they are open to different and even unintended uses. Unlike instruments, media are applicable to any domain. Media can represent content and they acquire meaning by the way in which we interact with them. 'A medium is something which, whereas a tool does as demanded, does not always do as demanded but may, as it were, "kick back".' (Glanville 1994). Design media can add something through the way in which they reflect ideas we invoke by our actions.
Back to the topic of CAD software, we consider CAD as a useful tool. CAAD, which stands for a domain-specific kind of CAD (A is for Architectural) can be considered to be applicable as an instrument. The many utility tricks of a modern CAAD program, can be very helpful in the production process of building documents. The influential book 'Digital Design Media' (Mitchell, McCullough 1991) does, in this sense, not cover its title, but it gives an

extensive overview of computer functionality and available tools. The book is not about openness or evocative and reflective true-media aspects of certain computer programs. Future research should focus much more on the aspects of design media that can enhance creativity, instead of tools that can enhance productivity.

1.2 Creativity through Evocation and Situatedness

Innovation is more of the same, except that it is improved. Creativity is one or more steps beyond innovation and goes further than improving the established solutions. Design media can help to make creative steps and they can give insight into what was not yet considered. Media can evoke new ideas. The images created via media can stimulate imagination (Breen J. and Stellingwerff M.C. 1998).
Creativity is dependent on several contextual conditions. Amongst others, this has to do with 'situatedness', a term introduced by Clancey (Clancey, W.J. 1997). Situatedness is described as 'where you are, when you do, what you do matters'. Most people have experienced the phenomenon of situatedness if they have had a good idea and suddenly lost it again. They can go back to the place where they first had their idea and then remember it. This is an indication of the power of situatedness.
In order to stimulate the conditions for creativity and situatedness in a design process, media can be used to visualise contextual information in different ways. Presenting the right view at the right time can help to evoke ideas and can aid one to make creative steps.

1.3 Sketching and reflective conversation

By sketching, the designer can develop and note down certain aspects of a problem which needs to be solved. This can be seen as 'noted situatedness'. Re-viewing the sketch makes it easier to understand the problem. The design problem is (as it were) 'externalised' by the brain and can be reflected on in a more relaxed and convenient way.
Schön and Wiggins mentioned a 'reflective conversation with materials of a design situation'. 'A designer sees, moves and sees again. Working in some visual medium - drawing, in our examples - the designer sees what is 'there' in some representation of a site, draws in relation to it and sees what has been drawn, thereby informing further designing.' (Schön and Wiggins 1992).
Sketching is design interaction in optima forma. The medium is filled with represented knowledge and essential information for a specific problem. While the sketch is produced, the information on the medium is re-read and

interpreted, the designer can take creative steps and re-draw, reflect and refine the 'sketchy' ideas. Through a series of iterative loops, the sketching designer might be able to create an innovative design from scratch.

1.4 New approaches

From the time of Turing to 2000 (the conference theme), a variety of tools have been developed to the benefit of the building industry. In terms of document production and project management, IT achieved a lot. Generally, the CAAD industry has brought very robust and useful tools. Many of these were developed in a metaphoric reference to real world phenomena (e.g. desktops, cut-copy-paste, layers and magnifying glasses). Such metaphoric software aspects do enhance the original tools, but they do not create new phenomena. Looking ahead, we should not only go on with making such enhancements, but we should create deliberate new applications without the mimic-like reference to what already exists. A non-metaphoric approach can lead us to new and useful developments that are not possible or thinkable without computers.

As far as sketching is concerned, the metaphoric approach would result in a mimic of pen and paper on a computer screen. The result might include all brush strokes and paint effects and many other drawing enhancements, but it is not revolutionary. In contrast, for example, the Electronic Cocktail Napkin program (Gross,1994) provides truly new 'intelligent sketching paper' by adding trainable recognition and pattern matching to the mimicked drawing process. Such an approach transforms the initial tool into a new medium with unprecedented possibilities.

Table I. A new approach for CAAD after 2000.

Turing to 2000	Beyond 2000
keyword: robustness	keyword: creativeness
Many metaphors for existing tools enabling better ways of :	What has been achieved PLUS unprecedented Instruments and Media for :
• Document production	• Multi-disciplinary collaboration
• Data / File Management	• Synchronous group interaction
• VR-viewing	• Situatedness and Evocation in VR

2. SketchBoX development

The initial idea for the SketchBoX program derives from two considerations through which metaphoric sketch-paper in a computer could be transformed into powerful new concepts. In the first place, sketch-paper in a computer can be placed in relation to 3D-space. The sheets of paper are not exposed to gravity and do not hang askew. Secondly, paper, which is mimicked in a computer, can be perfectly transparent. This makes it possible to trace and draw in a good relation to 3D represented objects.

Besides these two aspects of 'paper' in a computer, there were some beliefs and views about the phenomenon of sketching which weighed in the design of the program. In the first place, sketching should not be hindered by too many drawing limitations. In CAD programs, it is often an advantage to have limitations like snapping effects and collision detection. However, in sketching, such programmed limitations only bother the designer in expressing his or her ideas. Secondly, sketches should evoke further ideas by the quality of their images. This is still difficult in some cases. In the SketchBoX program, the drawing speed is reduced substantially because of high-resolution drawings. On the other hand, the evocative value of semi-transparent colours in sketches could be valuable.

The first prototypes of the SketchBoX program resulted from an ongoing programming exploration in which several ideas were tested, refined, rejected, or combined. After a year of experimentation, more programming experience was gathered and certain goals could be reached. Implicit questions relating to new media for design within a 3D-environment were asked. This resulted in three program variants, which can be introduced by headings of explicit 'What—IF'questions. Each variant potentially brings new aspects and added value to computer-aided design.

2.1 WHAT IF … I could draw on the walls of the city?

The answer to this question was explored with the first SketchBoX program variant in which one can put semi-transparent ‘wallpaper’ on the faces of a 3D model and draw on it.

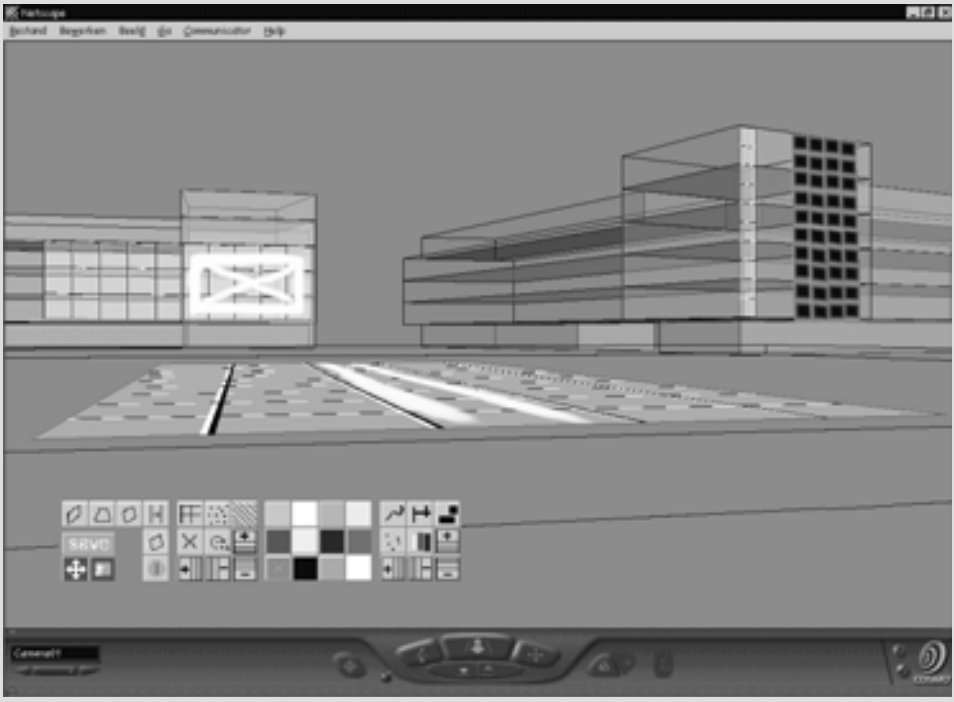


Figure I. SketchBoX Wallpaper

The program makes it possible to have a VR walk through a 3D city-model, a street or a building and add ‘planes’ on walls and on the ground. The planes consist of three adaptable image layers. First, there is a background with a plain surface of a semi-transparent or opaque colour. This helps to distinguish the ‘wallpaper faces’ from the wall or floor behind. Then a texture map layer represents a grid, a dot, or a hatch pattern. The pattern can help you as a guiding layer for a freehand sketch. Finally, on the top layer one can draw with ordinary bitmap drawing tools (e.g. freehand line, straight line and filled area). The combination of the three layers provides a wallpaper where it is possible to draw and trace in relation to a context model depicting parts of the built environment or a design.

2.2 WHAT IF … I could relate my sketchbook pages spatially ?

The program variant linked to this question makes it possible to put drawing planes in 3D relation to each other and in relation to context of spaces and objects represented in a 3D model.

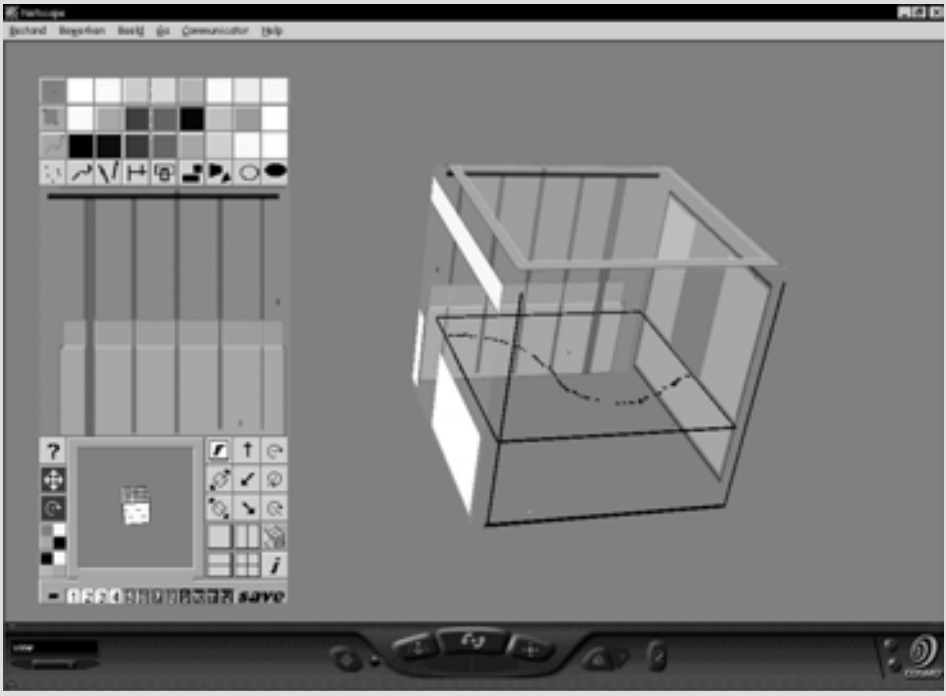


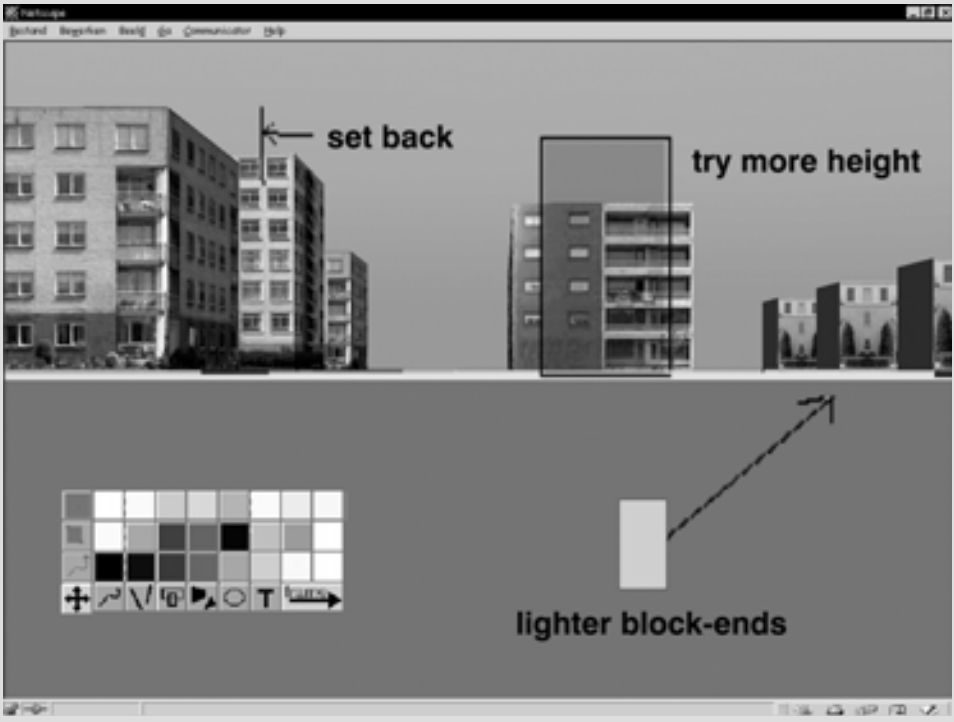
Figure II. SketchBoX Surfaces

Similar to the wallpaper program variant, one can draw on semi-transparent surfaces, but in this case the surfaces can be placed free in space. This variant provides 12 drawing surfaces that can be moved and rotated in relation to each other. Thus one can create and explore spaces that exist between the drawing surfaces. As one can draw lines and rectangles in many colours and in filter-like transparent colours, one can easily get the impression of doors and windows in a wall, without difficult Boolean operations. The difficulty of this program concept is the fact that the drawing can be obstructed by other surfaces which are situated in between. How to draw on a surface not immediately in front of you? This has been solved by the user interface that provides a planar projection of a selected surface. While you draw on the planar projection, the drawing also appears on the surface placed in 3D.

2.3 WHAT IF … I could place a sheet of tracing paper over the screen ?

Of course it is possible - and efficient - to sketch on tracing paper over printed computer images, but a more integrated way of doing this would be provided by the third variant of the SketchBoX program.

Figure III. SketchBoX Tracing Paper



While exploring a VR model, one can activate a semi-transparent drawing surface between one and the model. On the drawing surface one can make annotations similar to the way one would do with a marker on a plotted architectural CAD drawing. The annotations will be stored together with the viewpoint co-ordinates. This makes it possible to exchange the drawing and annotations in an exact relation to the model. Thus a shared point of view is created and remarks based on a complex 3D model can be understood less ambiguous.

All SketchBoX variants have been programmed in Java-Script and the Virtual Reality Modelling Language (VRML). The information of sketches can be related to a VRML model placed on an Internet file-server. For future versions of the program, it is envisioned that the information of the sketches themselves and their spatial placement in relation to the model can be exchanged, using direct Internet protocols, or as an attachment to an E-mail. This enables the program to be used for synchronous and a-synchronous collaborative sketch sessions and virtual annotation work. For further information about the development and use of the program, see:
http://www.bk.tudelft.nl/users/stelling/internet/programs.html

3. SketchBoX in use

Essentially in all variants of the SketchBoX program one can place a drawing surface in relation to a 3D VRML model. This allows one to draw in reference to a simulated context. The context of the drawing can be a representation of the real world (e.g. the surroundings of a building site), or it can be a 3D-CAD model of a design option.

Each program variant has its own characteristics and utility in the design process. The 'wallpaper variant' (2.1) allows direct drawing actions related to the surfaces of a model. This is assumed to be useful for analyses of built environment and building design and makes it possible to sketch over the form and structure of virtual spaces and objects.

The second variant in which drawing planes can be placed in relation to each other, makes it possible to evaluate bigger 'design interventions'. By placing a drawing surface within a represented urban space, it could becomes possible to explore the impact of certain forms, structures and colours in that space. By moving the drawings in relation to each other, one can explore the influence of height, depth and width of a space in relation to the surface characteristics.

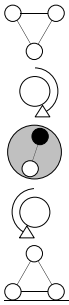
In the third variant of this sketch program, several 2D-sketch surfaces can be placed over a 3D model. Each surface is related to one single point of view. This is assumed to be useful for making annotations related to a design proposal. By binding the viewpoint to the sketch, the annotations of, for example, a contractor can be understood in direct relation to the model. Actually, this is a way to bring more objectivity in the communication of comments to design, because the subjective point of view is shared along with the comments.

The concept presented here of sketching in three dimensions, refers to the above described media aspects. On the one hand, development of the program was an attempt to introduce transformations to the concept of sketching. On the other hand, it tried to adhere to the typical quality aspects of sketch media, which can be summarised as related, direct and unrestricted.

The SketchBoX experience prompted further study and the development of prototypes for the benefit of the design driven experiment in this PhD research.

REFERENCES

- J. Breen and B. Olsthoorn, The Table, 1993, The Bench, 1996, The Bridge, 1999, De Wand, 2002, Publicatiebureau, Faculteit Bouwkunde, Delft, the Netherlands.
- J. Breen and M.C. Stellingwerff, Imaging Imagination, workshop held during the 3rd EAEA conference in Delft. 1998, Results and descriptions at http://www.bk.tudelft.nl/media/eaea/imim/
- W. J. Clancey, Situated Cognition; on human knowledge and computer representations (Cambridge University Press, 1997).
- J. van der Does, Architectural and Urban Simulation Techniques in Research and Education - Developments of analogue and digital eye level visualisation, 1998, Delft University Press, the Netherlands.
- R. Glanville, Representations Fair, Honest and Truthful" in Materialy Konferency Jne, conference proceedings on computers in architectural design, 1994, Technical University of Bialystok, Poland.
- M. D. Gross, The Cocktail Napkin, the Fat Pencil and the Slide Library, in: Proceedings, Association for Computer Aided Design in Architecture, National Conference, St Louis, 1994, 103-113.
- A. van Haaften, Uit de hand, schets-vaardigheden in de bouwkundestudie. Publicatiebureau, 1997, Faculteit Bouwkunde, Delft, the Netherlands.
- W. J. Mitchell and M. McCullough, Digital Design Media, van Nostrand Reingold, 1991, New York.
- D. A. Schön and G. Wiggins, Kinds of seeing and their functions in designing. Design Studies, Vol. 13 No 2 April 1992. 135.



Chapter 3

Set-up of the Experiment

The main experiment combines theoretical considerations from chapter 1 and 2, with technical, visual and behavioural findings from the case studies. Based on the experiences from the case studies, four representation prototypes were made. These prototypes are tested in the experiment. The results of other programming exercises became support tools as part of the Virtual Context system. These also have certain prototypical features, but were not tested as such.

The first section of this chapter outlines the general aspects and ideas behind the experiment. Successively the *what*, *why and how* of the experiment are described. This should give insight into : the hypotheses forming the basis of the experiment and the expected qualities of the prototypes as integral part of the research instrumentation. Furthermore, the chosen research method and the set-up of the experiment are outlined.

In section 3.2 and 3.3, the research protocol and the design phases are described. These paragraphs emphasise the procedural aspects of the experiment and the subjects participating in the experiment, the instructions and design tasks at the start of each phase and the sorts of questions asked.
In section 3.4, the urban model is described. This adaptable virtual model serves as the context for the design tasks which were set. The considerations for the design of the context model are described, followed by an overview of the features and the production process of the context model .
In the last section (3.5 'the test on track') subsequently the VRML-system, human factors, the monitoring-system and the analysis methods are described.

The documentation and evaluation of findings follows in chapter 4.

3.1 What is tested ?

A conviction from the start of this research was that the image characteristics of visually represented information can drastically influence the interpretation and usefulness of that information. This idea can be applied to the modelling methods and ways of representing an urban context, to improve architects' sense for an environment and to enlarge their understanding of the characteristics of a building site via a computer screen.

In the main experiment of this research project, several ways of representation are tested and judged by architects. Their judgements of different representations are studied via a series of tasks, within a simulated design process for a hypothetical urban building site. The test is intended to provide insight about the effectiveness of representation methods of contextual information by investigating the architects' view-preferences during phases of an architectural design process. These two aspects are coupled in a search for the optimum: 'the right view at the right time'.

The experiment is based on several case studies and theories. The ambition was to gain more insight concerning the relations between representation of information and ideas, decisions and actions as a result of such information.

During the evaluation of the case studies, a broad range of representation aspects was considered. At the same time, it became obvious that, during the design process as a whole, there is often the need for these different sorts of representations in successive phases and from case to case. Informal talks with architects and observations based on their design presentations even showed that the need for a specific informing image or view can sometimes change in a split second. At one moment, for instance, nearby pavements and the arrangement of vegetation next to a building can be evaluated, immediately followed by considerations about the structure of roads in the broader surroundings of the building site.

The test evaluates view-preferences of architects in a 'confined simulation of a design process'. The view-types from which the participating architects could choose were limited to a programmed range of settings concerning viewpoint and representation parameters using a VRML model. The phases of the design process were also limited, in order to get specific insight about view-preferences at specific/different moments.

Six phases were distinguished (see a detailed description in section 3.4):

1. analysing the context,
2. sketching over the context,
3. gathering essential context images,
4. presenting a design within the virtual context,
5. comparing different designs for the same specific context and
6. commenting, making annotation and arguing about design in a virtual context.

The specific view-preferences of architects, changing during these design phases, are considered to be pivotal for the understanding of initial design ideas, for adjusting the design to the context and for making design decisions.

The experiment was set up in such a way that theories and suppositions might be addressed, but also as an exploration in which unexpected events might occur. The essence of the experiment is *checking if* the prototypes perform as predicted and if the suppositions are correct. The essence of the explorative part of the experiment is *finding out how* the prototypes work in 'practice' and how certain design processes might be triggered, guided, or directed by the range of representations and images produced via the prototypes.

The answer to the question 'what is tested' can be described as a combination of two topics: *visual representation tools* and *architectural design related to an urban context*. Phrased another way: the question 'what is tested?' can be described as a *theme* (adaptable visual representation), explored in one *domain* (architectural design for a specific site, within a given urban context), while many technical and procedural *aspects* are taken into consideration (as suppositions, in prototypes and by means of protocol analyses).

In the first two chapters, the field of research and the specific domain of architectural design have already been addressed. In the next paragraphs the Theme, the Domain and the considered Aspects will be described in relation to this experimental study.

THEME: emerging media technologies as a driving force for innovative applications and visual representation developments.

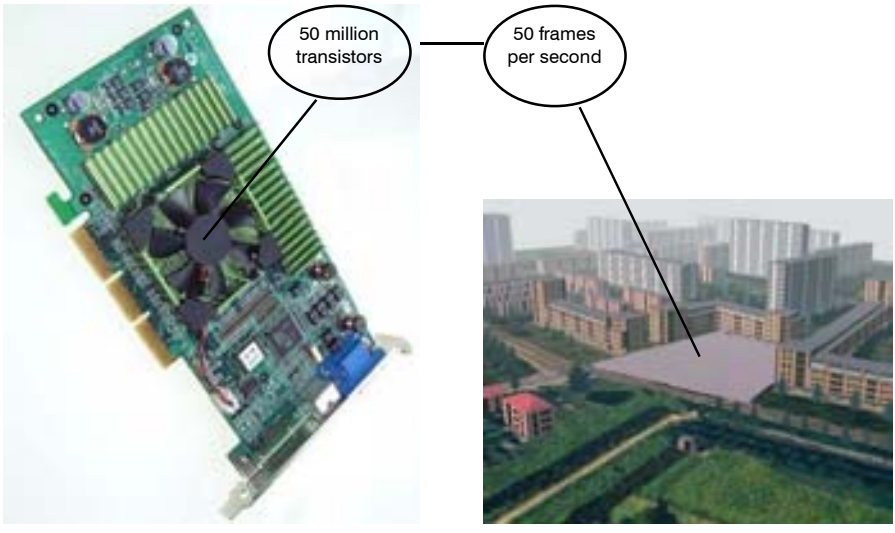
In chapter 1 and in the first three case studies, the general need for the development of new visual representation aspects was coupled to tempting city-shapes and new technical possibilities. The expressive qualities of the Piranesi and Nolli etchings and the complexity of Rome, are typical examples that pinpoint the issue of representation. A trigger for the development of new visual representation aspects comes from technological inventions and new techniques on the market.
At the beginning of the 21st century, dramatic developments in the Computer Graphics Industries (CGI), are the driving force for domain-specific research into 3D-interactive (collaborative) design environments. Most themes have to do with the representation of 3D content and perspective rendering via computer screens. Other aspects concern non-linear image interpretation (navigation, serial-vision, the dynamic perspective) and interaction.
Three layers of fast evolving technology are used as a basis for aspects of visual representation:

- Graphic Processor Units (GPU's) [Nvidia, 1999] (from 1999 the rendering speed of newly available graphic cards for computers has doubled each six months for several years),
- the OpenGL 3D Application Programming Interface (API),
- the Virtual Reality Modelling Language (VRML) standard and the forthcoming X3D specification.

Typical of these technologies is their focus on rendering speed, combined with good image quality. One important deficiency of the rendering techniques (around 1999) was the inability to render cast shadows. The 'Gouraud shading' was limited to smooth object shadows based on light distribution to a facet.
For the experiments in this research, the above-mentioned standards have been used in a pragmatic way: 'as they are'. Positive aspects were exploited, the lack of cast shadows has been taken for granted. No extras such as stereo-views or ray-traced shadow textures have been used. Especially 'texture mapping', 'alpha blending', 'Z-buffering' and 'fog' are taken to be promising features for this research.

There are many sorts of visual representations. The function, the system, the domain and the experience of the user determine the characteristics of a representation. The public's 'general literacy' for visual representation is greatly influenced by different media domains such as: film, music television, military-, game- and space-simulation technology and all sorts of commercial applications.
Some aspects in the experiment share visual representation characteristics with other domains. For example, the interactive map is ubiquitously used in flight simulators, 3D-computer games and GPS navigation systems. However, testing its use and utility in the domain of architectural design is relatively new [see e.g. Bridges, 1997] particularly when it concerns a direct relation between a dynamic perspective (virtual walk) and the overall outline of a city (map image). Several other visual aspects of this research are frequently used in relation to architectural design representation, but a comparative research effort coupled to different design phases, should be expected to give much more insight in their utility and their impact. Hidden line rendering and gouraud-shaded images, which are also tested in the research, are examples of commonly used representations in CAAD software.
In this research, the visual representation of 3D urban context has been the subject. Items of study included Graphical User Interface Design for 3D (3D-GUI), 3D content representation, 3D navigation and 3D tools.

Figure 46. It is not the first time in history that technical developments had impact on artistic and utilitarian expressions.



DOMAIN: Architectural Design in an Urban Context.

Many application domains benefit from innovations in the Computer Graphics Industry (CGI). The games industry is currently the driving force behind new developments. The quality of the 'new means available' has become the norm for specific applications in architectural practice. The domain of 'Architectural Design in an Urban Context' determines the research theme of visual representation aspects in relation to specific questions about preferences and effects of 3D models and the various types of 3D visual representation. The study of 'Visual Literacy', is considered to be very relevant for the future practice of architects.

In order to focus the experiment, all technical representation aspects included in this test deal with the question of how design relates to a given context. The urban context is used as reference for the design and could be visualised in an adaptable way. The designers, who took part in this experiment, could adapt the model in such way that they were able to get a good impression of the urban context. On the basis of their reactions I hoped to get an indication about the communicative properties of different types of representation. As such, the 'artefacts' in the form of intermediate sketches of the architects form the counterpart of the proposed visual representation system: it's their visual answer, their vision.

The question 'what the research experiment is about', can further be explained by the *aspects* that have been considered:

ASPECTS : Themes, Hypotheses and Prototypes

The first aspects to be considered in the experiment are the theoretical considerations in section 2.2 and the seven hypotheses that are based on theoretical considerations. Furthermore, the prototypes developed on the basis of the afore mentioned case studies, are the main issues in the research experiment.

ASPECT 2: Protocol Patterns

The explorative part of the experiment relies on the large variety of results that came from the test. The test couples the range of possible representations to a specific set of tasks that are implemented in a simulated design process. Many aspects of the design process are monitored carefully. All image changes on the screen are captured in a video-file and the spoken texts of the participant and the researcher are recorded as well. Before the tests started, a method for protocol analyses was developed. The protocol analyses give insight into patterns concerning view-preferences during the design phases.

The Protocol Analyses consists of three methodological procedures:

- the monitoring of actions and reasoning of the participants during the virtual walks,
- the schematising of relevant actions (the actual translation of the virtual walk transcripts into protocol codes) and
- determination of patterns and logic behind processes in which relevant choices and successes occur, or where the initial intent has ceased.

As the Protocol Analyses introduce an abstract interpretation layer, this method makes it possible to look rigorously at the research findings. On the other hand, it was experienced that Protocol Analyses leave out many subtleties. Therefore, results and conclusions in chapter 4 are in some cases coupled to more direct interpretations of the original virtual walk transcripts. The design images are also involved in the conclusions. Thus the architects' view preferences and the effects should be revealed.

ASPECT 3: The Unexpected

It can be expected that a good test gives clear test results. After analysing the test results, the hypotheses should be proofed or disapproved and it should be possible to outline a number of protocol patterns. Because of the considered breadth of this test and the still quite loose confinements of the possible outcomes, there will be a certain information overload on top of ‘what is tested’. Considering this overload of information, there are two aspects that must be taken into account*: the obvious and the curious results*.
From the start of the research, there was a concern that a test just proves what is already evident. Sometimes, results can be curious to outsiders and obvious to the insiders, sometimes the opposite can occur. However, in general, a prototype is not tested in order to hear that it is 'nice' or to hear that the 'dis-functioning functions' obstructed the judgement of real functionality. An

assessment of 'niceness' is relatively irrelevant or even distracting to a test. Dis-functionality should be eliminated before a test starts. The obvious result is less tempting in research. The curious result is worth noting in research. Therefore, the unexpected insights are welcome in the test. It is a test with a quest for the curious and a fear for the obvious.
The test is specially focussed on getting more insight into the uses of new digital image/ VR media and the impact of different context representations. The conclusions of the test need not be generalised. Conclusions from the experiment, need not be applicable as 'rules' for design processes and tools. Rather, it is the intention to learn from the test and its outcomes and to find fruitful directions for designers and researchers to explore.

3.2 Why is it tested ?

There are several motivations to carry out this research. Research questions are the driving force. A division can be made in pragmatic, scientific and environmental / architectural questions. Most issues have already been mentioned in the first chapter.

PRAGMATIC ASPECTS

- Multipurpose city models need to have suitable characteristics.
- What are fitting characteristics?
- Do designers primarily require factual information?
- Is there need for more pictorial information?

SCIENTIFIC ASPECTS

- What is the potential of a digital 3D model in the information exchange between architect and reality?
- How can images influence thoughts?
- How can thoughts be reflected in images?
- What is the relation between viewpoint and point of view?

ENVIRONMENTAL ASPECTS

- How can we optimise the way in which new design fits into the existing environment?
- What is the impact / role of the juxtaposition of design and context?
- How can we merit the qualities of urban space in relation to the vast pressure of building activity and infrastructural developments?

3.3 How is it tested ?

The experiment involves a simulated design process, in which an adaptable context model is tested during different design phases. In order to manage the whole experiment, every aspect had to be designed thoroughly. As the simulated design process was tightly structured and focussed on the research aspects, the process cannot be denominated as 'natural'. The participating architects were instructed to follow the specific steps. They had to use the provided tools and were confronted with the virtual site model. They could not rely on their familiar design-media and could not visit a real site. The simulation had *aspects of a realistic design process*, in order to test the new prototypes.

The research preparations involved software development, the set-up of a test-computer and the selection and invitation of research participants. A research protocol played the role of script in order to keep track of all preparations and the execution of the research. The whole experiment was developed and scheduled in eight steps which were structured as follows:

1.PRE ACTIVITIES: Choice of participants, invitation and scheduling
2.First Session: *analysing, sketching, gathering information (see §3.4.)*
3.Handout of the design brief and gathered images
4.Design-task at home *(see §3.4.)*
5.Merging the design result into the test system
6.Second Session: *presenting, comparing and commenting (see §3.4.)*
7.Unannounced request for a memory drawing
8.POST ACTIVITIES: Documentation and evaluation of results

Each step is described in detail in the next eight sections, the actual tasks and tools of the design phases are described in §3.4.

3.3.1. Choice of participants, invitation and scheduling

The choice of suitable participants for the test was crucial. The research entails new techniques and the design tasks were quite demanding. Therefore, the following participant profile was made: the participants should work as architects, or should work at an architecturally related firm (such as a visualisation office, or a school of architecture); they should regularly work with CAD programs or other kinds of visualisation software; they should be unbiased by detailed knowledge of this research and should be willing to spend about one day of their time for the benefit of this study. This participant profile corresponds with the target group for the tested hypotheses and prototypes. It could be expected that such participants would be willing to spend time for the tests and understand the issues addressed in the research.
A schedule was made in order to place all appointments within a four-month timeframe. This included two visits to the Faculty of Architecture for tests at the research laboratory and a 'take home' design task.

3.3.2. First Session: analysing, sketching, gathering

Each participant visited the research laboratory twice for sessions involving the virtual urban context model. The participants were confronted with a computer model of a hypothetical urban context. In order to get familiar with the architectural aspects of the site, they were asked to 'interact' with the model as much as they could. This interaction was structured by means of tasks linked to three design phases: analysing the context, sketching over the context and gathering essential context images. These phases are described in more detail in §3.4.

The three design phases and accompanying tasks formed the core of the first session at the research laboratory. Necessarily these tests were embedded in a range of 'rituals', by which the participants were guided and observed. Before each of the tests actually started, the subject was given instructions and the opportunity to try out the special tools and aspects of the system. During the test, a short checklist was used in order to investigate intermediate opinions of the participant. Questions were not asked in a strict order, but at what seemed like an appropriate moment during the design process.

3.3.3. Handout of the design brief and gathered images

During the third phase of the first research session, essential images had to be gathered. These images were printed and handed out as a reference for the actual design session at home. The design task was kept very simple: the

architects had to formulate a proposal to a local municipality about how an open area in an existing neighbourhood might be developed. The hypothetical ‘suburb’ was said to be in need of some new communal functions. These could be small and large functions (such as possibly shops and schools) and there was a lack of outdoor space for the inhabitants, for markets and for youth. The architects had to propose 'something' that was appropriate and useful for 'upgrading the neighbourhood'. This design task was kept general, in order to fully facilitate the freedom of the participant to react freely to the visual cues from the test system.

3.3.4. Design-task at home

Between the first and the second test, the participants had to carry out a design-task at home.
Although this part of the experiment took place without the direct control of the researcher, there was no concern about biasing effects. The given urban context was fictitious, so the impression of the site could not be influenced by real impressions from a site visit. All impressions came from the interaction with the model during the first session and from the gathered images.
As design ideas tend to have a certain incubation period [Branzell, 1993], the time given for the design task at home was intended to lead to a more balanced views of the participants. The participants were asked to note down what they thought about the urban context and how it was represented in the test system. Afterwards, they had to provide all sketches they made during their design sessions. The results of the design-task should indicate if the perceptual understanding of the context-model approaches the architect's demands for contextual information which might inspire creative design.
The focus of the research was on the primary visual investigations of an architect in order to understand the characteristics of a site and in order to be able to judge the appropriateness of a specific design for that site. Therefore, the design creation activities, as they developed at home during this phase, are considered as a suitable preparation for the sessions at the faculty.

3.3.5. Merging the design result into the test system

Before the second test session at the faculty started, the result of the ‘home work’ of each participant was merged into the context model by the researcher. This provided a model with combined information, in which the impact of the design proposal on its surroundings and vice versa, could be evaluated.

3.3.6. Second Session: presenting, comparing and commenting

During their second visit, the participants once again had to perform several tasks in three phases: presenting the design in its context, comparing different design proposals for this context, commenting and discussing the qualities of the design in context. These phases are described in more detail in §3.4. Similar to the tests in the first three phases, the tasks were accompanied by instructions and monitored using a checklist to document the intermediate opinions.

3.3.7. Unannounced request for a memory drawing

At an unannounced moment, some weeks after they had been confronted with their design proposal in the virtual model, each participant was asked to try to remember and re-draw his or her design in relation to the urban context. They were asked to present, in a single image, the main characteristics of their design in relation to the context. During the previous occasions, they had never been required to remember the aspects of their design or the environment; they thought the experiment was finished after the second session. The memory drawing was requested because it could possibly tell more about the most important visual aspects.

3.3.8. Documentation and evaluation of results

The recorded interviews were interpreted and 're-presented' using three sorts of documents. The collected information altogether consists of a set of 150 pages with illustrations in colour, it was decided not to include the complete transcripts in this thesis. However, this thesis, the interview transcripts (in Dutch) and the experiment system are available at the website: http://www.bk.tudelft.nl/users/stelling/internet/thesis/

3.4 Design tasks and tools

In the first phases of an architectural design process, the surroundings of a site are explored for their potentials and constraints. The site needs to be visited in order to understand its real characteristics. The important features of the site can be documented by means of photos, notes and sketches. The collected information can be brought back to the design office and can be processed further as design documents. One commonly used procedure for exploration of the site makes use of annotations on a map. Iimportant formal and functional features of the site can be visualised by means of schematic notations on the map.
In this research, an interactive process between the participating architect and the 'virtual building site' replaces the exploration of the site. The above-mentioned methods (making notes, sketches and pictures) are transformed into tools and procedures relating to an adaptable context model. In this case, the first introduction to the site was split up into three phases: analysing, sketching and gathering images. In each phase, the participating architect was guided by instructions and directed by tasks.

3.4.1. Analysing the context

The support tool for virtual site analysis (p.165) is intended to provide ways to interact with a virtual model. The different tools incorporated into the system allow for the emphasising of typical aspects of the site and can provide additional background information such as height, distance and area size.
The analysis tools were designed with a specific uses in mind, but this was not told to the participating architects. The instructions only explained the workings of the tools and how they could be used to note down and investigate spatial aspects of the context model.
In *Management of Sequential Space Experiences*, Arne Branzell introduced a graphic notation method for spaciousness, paths, nodes, edges, districts and landmarks [Branzell, 1995]. These kinds of notations can also be created using the analysis tools in this system. For instance, the red box and the line of sight can be used to pinpoint landmarks. Nodes can also be noted using this red box. A white line was considered to be most suitable for notation of paths and districts; the straight line can be used for paths as well as for edges. The 'spider web lines' seem to be most useful for indicating spaciousness and districts. The outcome of the test will show how the participants actually use these tools.

The main question, in each phase of the experiment, was: *'what is your preferred view whilst carrying out the specific tasks in this phase?*' The

participating architect could choose a number of optimal viewmodes by means of viewpoint navigation and with icons and sliders on the 'adaptable view menu' (p.148).

Research questions:

- What is the preferred representation of the model when trying to understand and analyse the site?
- How to understand the characteristics of the site?
- What differences are there between the preferred representation aspects of a bird's-eye view compared to a pedestrian's eye-level view?
- What is the opinion about each of the test aspects?
- How does the understanding of the site and the context progress?

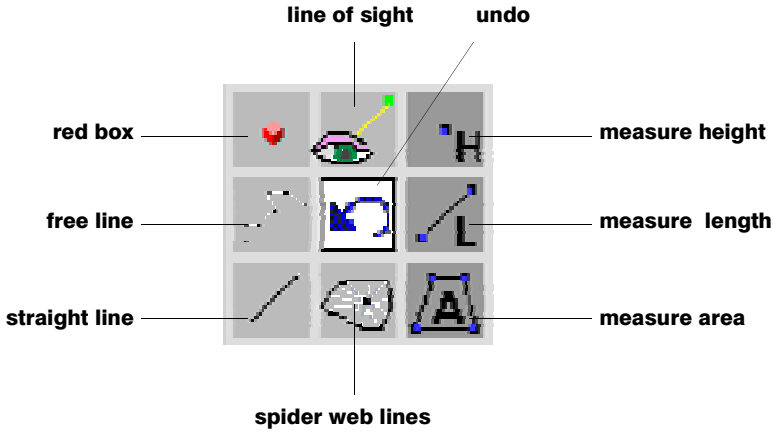
Analysis tasks:

- Look at the model from different viewpoints, as if the model is an object, which you can turn around and as if the model is an environment through which you can walk at the eye-level of a pedestrian.
- While looking at the model from different points of view, try out the effects of different representation modes using the view menu.
- When you get more confident in working with the system and get more familiar with the context model, try to understand the building site in relation to its surroundings.
- Mention the features of the surroundings and characterise the neighbourhood.
- Try to guess the real scale of buildings and urban spaces.
- Check your guesses by means of the measurement tools in the menu.
- Try to make relevant notes on paper or by using the analysis tools in the menu.
- Try to emphasise the spatial features of the site, by means of the analysis tools in the menu or by talking about them.
- It does not matter if you do things incorrectly. Misunderstanding is also a result.
- Evaluate your understanding of the site and its urban context.
- Give your opinions about usefulness of the different tools and qualities of adaptable representation of the model.

Available tools:

- Prototype tools for setting the model representation (p.157-163).
- Tools for navigation (p.173).
- The analysis tools (p.164-165).

Figure 47. Tools for analysing the context.



3.4.2 Sketching over the context

Sketching in this experiment is considered as a process of trial and error. It is used to visualise ideas and to explore their impact. While the analysis tools are assumed to make an interpretative layer over the model, the sketch tools can create a 'layer of hypothesis'. In the process of sketching, things are tried out repeatedly. Each try comes with a judgement wether it is good, has to be improved or has to be rejected. In this experiment, the sketches are mainly judged on the basis of their spatial impact and their appropriateness within the given context. The representation of the context should also be appropriate for the process of sketching. It is assumed that the context should look different in the sketch phase than e.g. in the presentation phase. This test phase should give more insight in the use of computer sketch tools and the represented context in which the sketches are placed.

Research questions:

- What is the preferred representation mode of the model for the creation and evaluation of your sketches?
- How do the sketch tools help to generate ideas?
- What spatial impressions do the different sketch tools give?

- What kinds of perspective images (bird's-eye view or pedestrian's eye level view) are preferred in the process of sketching?
- What is the opinion about each of the test aspects?
- How is the activity of sketching within the digitally represented context?
- How long does it take to make useful sketches related to the site and what obstacles are encountered?

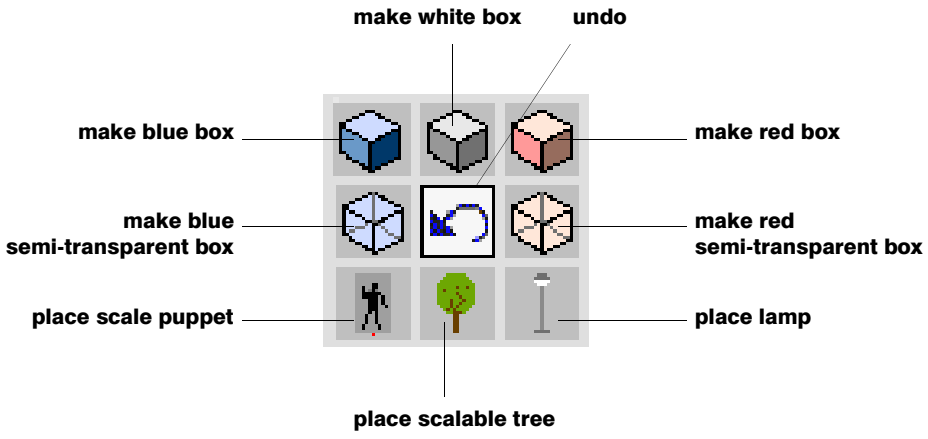
Sketch tasks:

- Try to formulate a spatial proposal for the redevelopment of the open space in the given urban context model.
- Try to use the available drawing tools to make sketches.
- Evaluate the sketches and try to adapt the model characteristics in such a way that your sketching process is correlated with contextual background data in the best possible way.

Available tools:

- Prototype tools for setting the model representation (p.157-163).
- Tools for navigation (p.173).
- The sketch tools (p.166-171).

Figure 48. Tools for sketching over the context.



3.4.3. Gathering representative context images

As a conclusion of the analysis and sketch tasks, the architects were asked to collect a series of images, which they expected they would need during the actual design process.
This test phase was intended to give more insight concerning the preferred views as the architects would be dependent on their collected images when they would design at home or in their office. Then they could only rely on the images in their memories and those that they collected in this phase. The first analysis and sketch phases were explorative. The view preferences were still influenced by a limited understanding of the possibilities of different modes of representations and viewpoints. In this third phase, it was expected that the site would be known reasonably well. Therefore, it was an opportunity to find the 'really' important and preferred images.

Research questions:

- What kinds of images are considered essential as a source of information for the further design process?

Gathering tasks:

- Look at the model from different viewpoints, as if the model is an object, which you can turn around and as if the model is an environment through which you can walk at the eye level of a pedestrian.
- While looking at the model from different points of view, try out the effects of different representation modes using the view menu.
- Make about ten 'optimal views', which have to be printed in order to inform you for the 'take home' design task.

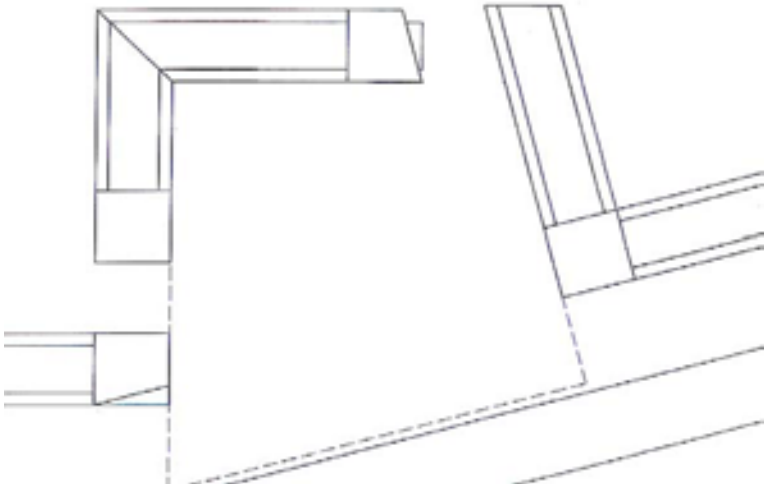
Available tools:

- Prototype tools for setting the model representation (p.157-163).
- Tools for navigation (p.173).
- The 'store image' button on the computer keyboard. This key executes a 'capture program' that grasps the current screen image and stores it as a numbered file on a computer.

3.4.4. Design tasks at home

After the first explorative design sessions at the university, the participating architects were asked to prepare a design proposal for the open space in the centre of the context model. The design had to be made at home, or at the own design office of the participating architect. The images gathered in the first test session were printed and could be used as a source of information for the design task. Other sources of information provided were the design assignment, some guidelines for deliverables and an elementary plan drawing of the site (figure 49).

Figure 49. A simplified drawing of the site (provided in scale 1: 200).



3.4.5. Presenting a design within its context

Before the second test session at the faculty started, the result of the design task of each participant was received and merged into the context model. This provided a model by which the effect of the design 'in situ' could be explored.

Research questions:

- In what way do the expectations and considerations of the designers correspond to the impressions generated by the design model in the context?
- How is the design explained by the designer?

Presentation tasks:

- Look at the model from different viewpoints, as if the model is an object, which you can turn around, as if the model is an environment, through

which you can walk at the eye level of a pedestrian.
- While looking at the model from different points of view, try out the effects of different representation modes using the view menu.
- Tell about your expectations and considerations for the design.
- Does the model fulfil your expectations considering presentation aspects? What is wrong, good, better, worse, different than expected? In what way is it different?
- What is your preferred narrative order, if you were to present this design?
- Create / choose one particular view which you would like to use if your design were to be published in a newspaper.

Available tools:

- Prototype tools for setting the model representation (p.157-163).
- Tools for navigation (p.173).

3.4.6. Comparing, commenting, discussing options and their effects in the given context

After each participant's design proposal was presented, the merits of the proposals by the other participants and one 'disputable' design created by the researcher were discussed. The 'disputable' design is a large volume that quite drastically confronts the urban context by introducing a slightly larger scale object (see figure 50). Furthermore, this design is deliberately presented with expressive features that might raise questions whether the image shows the building as it will appear in reality.

Figure 50. A 'bridge' building was shown to bring up discussions about different scale and different representation within the given context.

Research questions:

- How are other designs perceived and appreciated?
- Do arguments put forward about the different designs relate to what is actually seen on the screen?

Tasks:

- Explore and tell about what you see.
- Discuss the best and worst features of the alternative designs and the way they are represented in the model.
- Give your opinion about the best / favourite design proposal.
- Tell more precisely why you consider it is good / bad design? Give reasons.

Available tools:

- Tools for setting the model representation (p.157-163).
- Tools for navigation (p.173).
- A '►' button that, when it is chosen, shows the next design model or prototype within the context model. This button successively shows: The design of the participant. Designs of other participant. A 'disputable design' Drag and drop sketch tools (p.169).

3.5 Context model characteristics and adaptable aspects

This research project has roots in the three sections of the Media Group, at the Delft Faculty of Architecture: Form Studies, Freehand Drawing and Presentation Techniques. The educational approach of the Form Studies group was beneficial in the choice and set-up of the context model and the formulation of design tasks. The Form Studies staff formulates each of its student assignments in a very precise way. All exercises are introduced by an eloquent text about related architectural and artistic aspects and all exercises start with a 'given'. The given can be: a set of precisely chosen elements, proportions, materials, graphics, a functional requirement or a mathematical sequence. Most of the exercises are guided by a protocol that directs the process of designerly study. The students are required to keep a file of their sketches and considerations and document their spatial work. A curriculum in which the diverse ideas of many students (for each exercise about 100-400 design results each year) can flourish, while the results remain comparable.

The central part of the model in this test comes from a Form Studies exercise for first year students. The students are confronted with the scale 1:200 model in wood and are asked to develop and situate a design proposal in it. (See figure 51). The assignment asks for a strategic composition of volumes within an exterior space. "*The edge of the residential area is 'indented' with a large open space between the building blocks. Formerly this was intended to interweave the cityscape with the landscape. The city council wants to build, but there is no space to extend the city. Then she decides to give the commission for a professional study about increasing the city density. The open space at the edge of the city is the site, which is assigned for this study."* [Translated digest from the form-studies guidebook 'MORV' by Bernard Olsthoorn, 1998]. The students have to make a mass study for the given open space. What is required is not a worked-out plan, but a study of form on a relatively abstract level. These could be used by the fictitious city council to get more insight into the capabilities of the site.

The model of the form-studies exercise was extended to an area 25 times larger. The design for this larger model was based on structural analysis of an aerial photograph of Delft. With a technique that can best be compared to 'sampling' in modern pop music, several parts of the aerial picture were recomposed into a new urban fabric (see figure 50, photo). The 'samples' were

edited together into a new aerial picture of the hypothetical area. The area is characterised by the meeting point of two orthogonal urban structures at 15 degrees to each other. The edge of the city resembles a typical Dutch residential area with a mixture of fifties to nineties housing buildings and the typical high level of 'organised space'. The area just outside this city border is filled with some greenhouses, a villa area, a long road with a mixture of free-standing houses, company buildings and a park. The hypothetical context is specially designed for the research experiment. The aim was to realistically mimic a Dutch neighbourhood, with enough interesting features for an architect to relate a design to this given context.
The aerial image was then imported in AutoCAD to trace over the building geometry. The outlines of the buildings were 'extruded' to the appropriate height and further processed in 3D-Studio Max. Then the models were exported to VRML. The VRML models were edited using a text editor, in order to give them the right structure of layers and to add specific adaptable representation aspects. The final model consists of several parts, which can be switched on and off in order to get the right view. The view settings can be chosen by means of an icon menu (see figure 53). The object transparency and the amount of fog-effect in the model were made parametrically adaptable. The empty building site was represented as an unarticulated flat grey area within its urban context.

Figure 51. The student exercise context model and a design study.

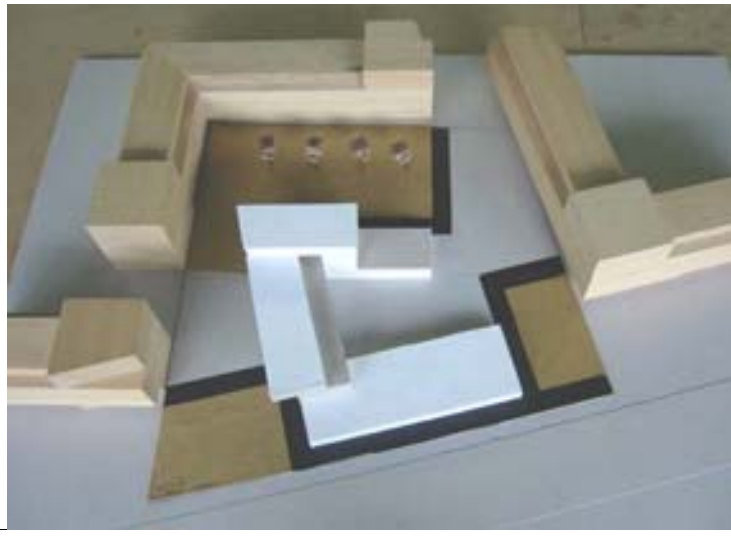


Figure 52.

Development of the context model based on the Form-Studies exercise model.

a: the student exercise model was used as the center of a neighborhood, the wider context was composed by using Delft aerial picture samples

b: the aerial picture composition was then used to draw a 3D CAD model

Figure 53.

The Virtual Context model can be navigated by means of mouse movements and by pressing keys on a specially prepared navigation keyboard.

The 'adaptable views' can be composed by means of a Graphic User Interface consisting of icons and sliders. The menu functions as a 'head's up display' and can be positioned on the computer screen.

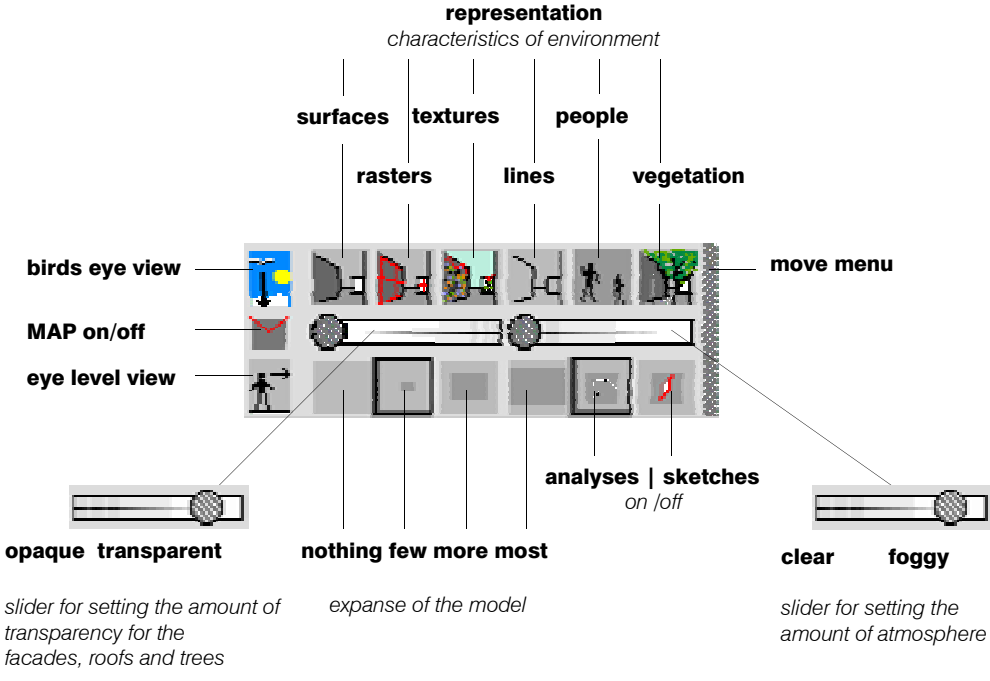
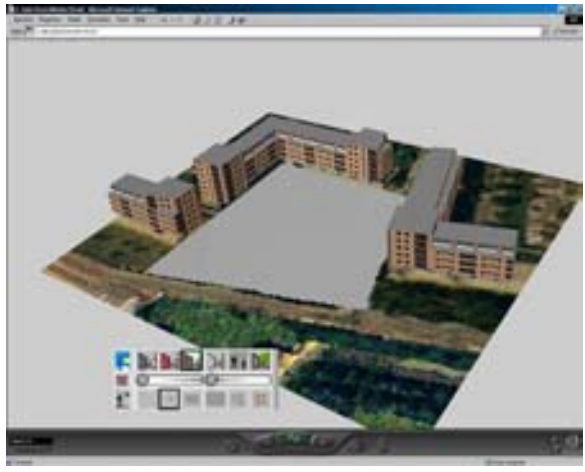


Figure 54.

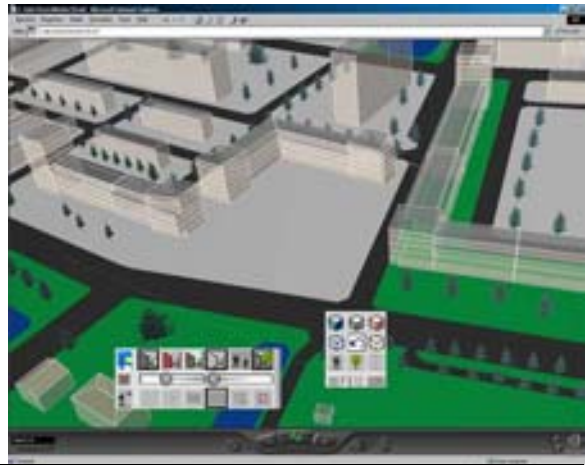
Three examples of representation settings:

Small area with textures.



Large area with textures, more details in pavement and trees.

Large area with lines for indication of storeys, 40% transparency of building surfaces, trees and simplified indication of street, lawn and pavement.



3.6 The test on track

The VRML-system

From initiation to production and execution, the whole test took some three years ('bruto time'). First of all, in 1997, I started experimenting with the new Virtual Reality Modelling Language. Many of the case studies were the result of such experiments. Then, in separate developments, the prototypes were developed and the virtual context model was created. Finally, all of the prototypes and the context model geometry were integrated within one complex JavaScript/VRML program. This was possible because different VRML entities can be treated as objects. The system actually is a manageable composite of these objects. The models of the design proposals of the different participants were also added to the whole. By means of the VRML 'switch node', the different layers of representation, the prototypes and different design model information could be switched on and off interactively. Case study 7 about user interface aspects (p.153) determined the choice of JavaScript as the overall programming language. The user interface is based on a virtual Heads Up Display (HUD) and enables the use of icons and sliders found in WIMP (Windows Icons Menus Pointers) user interfaces.

Human factors

The test sessions involving six architects took place from 3 March to 3 October 2000. The flow of the test was arranged by means of a research protocol. This resulted in six interviews in which view preferences and their effects were investigated.
In order to keep the research clear and as unbiased as possible, it was carefully considered what instructions, hints and tasks should be given and what should not be told to the participants. The final question, in which the participants were asked to draw their memory image of the design and its relation to the context, was carefully kept a secret until it was asked.
The first participant provided feedback about his general feelings about the experiment, about the pace and the comprehensibility of instructions and tasks. It was important to tell the participants that they should not worry about doing things wrong; 'any result is interesting'. After all: it was the researcher who made such 'blunt facades' on the one hand and who persisted in asking ‘nitty-gritty’ questions about what they thought. Afterwards, I could only express my gratitude for the very interesting answers and designs they made. Nothing went wrong!

The monitoring-system

A freeware frame-grab program was used to record the spoken interviews and save a screen-image every 3 seconds. The program produced large audio-video files that were completely transcribed. The resulting 'virtual walk transcripts' were then combined with the accompanying screen-captures in order to give a clear overview of the interviews.

The analysis methods

A first analysis of the 'virtual walk transcripts' was carried out by putting typographic emphasis on specific 'interesting' phrases and remarks. This was a personal undertaking in which some subjective choices may have been made. Subsequently. For the sake of objectivity, an analysis round following a process of Protocol Analyses was undertaken. Finally, a mix of both methods led to the evaluation of results.

Reconsideration time

A first version of this thesis was written, but despite all the work a feeling of discontent about validity of conclusions could not be suppressed. In other research using Protocol Analyses and the Think Aloud Method, the results were based on a large number of participants, following proven statistical methods and presented with graphs and 'compelling percentages'.
A time-out was needed. Other research work was done and in the meantime a focus shift took place from 'digital design media' to 'human factors research and collaborative design theory' [e.g. in Stellingwerff and Verbeke, 2001]. Design Research paradigms were studied, notably by grasping Glanville and by appreciating Schön. In retrospect, I see this development as very useful because I acquired a better view concerning the scope of this research initiative. Conclusions may be drawn in different ways. Conclusions can be based on insights and findings and do not always need quantification.
Finally, the thesis was re-written. Many texts were reviewed, decomposed and placed in a clearer order. The first two chapters were changed completely because of the new notion of the role of context, not just as (urban) context in design but also as a research context. The evaluation of results, as presented in chapter 4, was extended with a more precise check of the hypotheses. The fifth chapter was extended with methodological conclusions. So, …the test had already run its track when the research found a better course… .

Marco Polo describes a bridge, stone by stone.
"But which is the stone that supports the bridge?"
Kublai Khan asks.

"The bridge is not supported by one stone or another,"
Marco answers,
"but by the line of the arch that they form."

Kublai Kahn remains silent, reflecting.

Then he adds: "Why do you speak to me of the stones?
It is only the arch that matters to me. "

Polo answers: "Without stones there is no arch."

Italo Calvino — Invisible Cities

CASE STUDY 7

VRML/HTML/JAVA or VRML/HUD/JavaScript

The goal of this case study was to find a good set of programming tools and a programming language, to ultimately make a virtual simulation system for the main research experiment. The problem was to adapt standard VRML files (which can be exported by commonly used CAD modelling and authoring software), to the specific needs during an interactive test experiment with participating architects. The experiment required a system that would allow testing of different prototypes at a high level of performance. The test was not *whether* the prototypes worked, but *how* they could be used; therefore, they *should* work. This involved a lengthy exploration process during which insights, programming skills, modelling skills and available techniques were developed step by step. The final goal was a system that would make it possible to have ‘a pleasant virtual walk with an invited architect', without blue screens, bugs, or hiccups.

At the start, there were several programming options available. It was not yet possible to say which option would be preferable. However, the requirements were known:

- good real-time rendering of a city model,
- adaptability of the model in a way that looks like the on and off switching of layers in CAD software and
- an interface that shows the state of the layers in a clear way

The first tested set of available techniques was a combination of VRML, HTML and Java. This combination allowed one to link a 3D-environment part in VRML with a 2D-interface part in Java. Both could be combined on an HTML web page. This system was tried out and worked well, but eventually the JavaScript language was preferred as it was less abstract and could be better integrated within the VRML code.
The VRML/HTML/Java experiment resulted in a simple application with switchable VRML layers. The layers made it possible to switch on and off

different sorts of façade representation (face-photo-functions-patterns) and the extendedness of the 3D-model (see images below).

Another experiment involved a 3D-model with ‘hot-spots’ that triggered an HTML browser screen to show associated ‘local information’. Therefore, if you walked trough the model, at a certain place, a text could pop-up that showed the street-name, or at another location, a screen would show a picture of a specific building. A very first example of the system is shown on the next page. A good example of such a system that relates multimedia city information, is http://www.vrglasgow.co.uk/ [Ennis, Lindsay, 2001].

Figure 55.

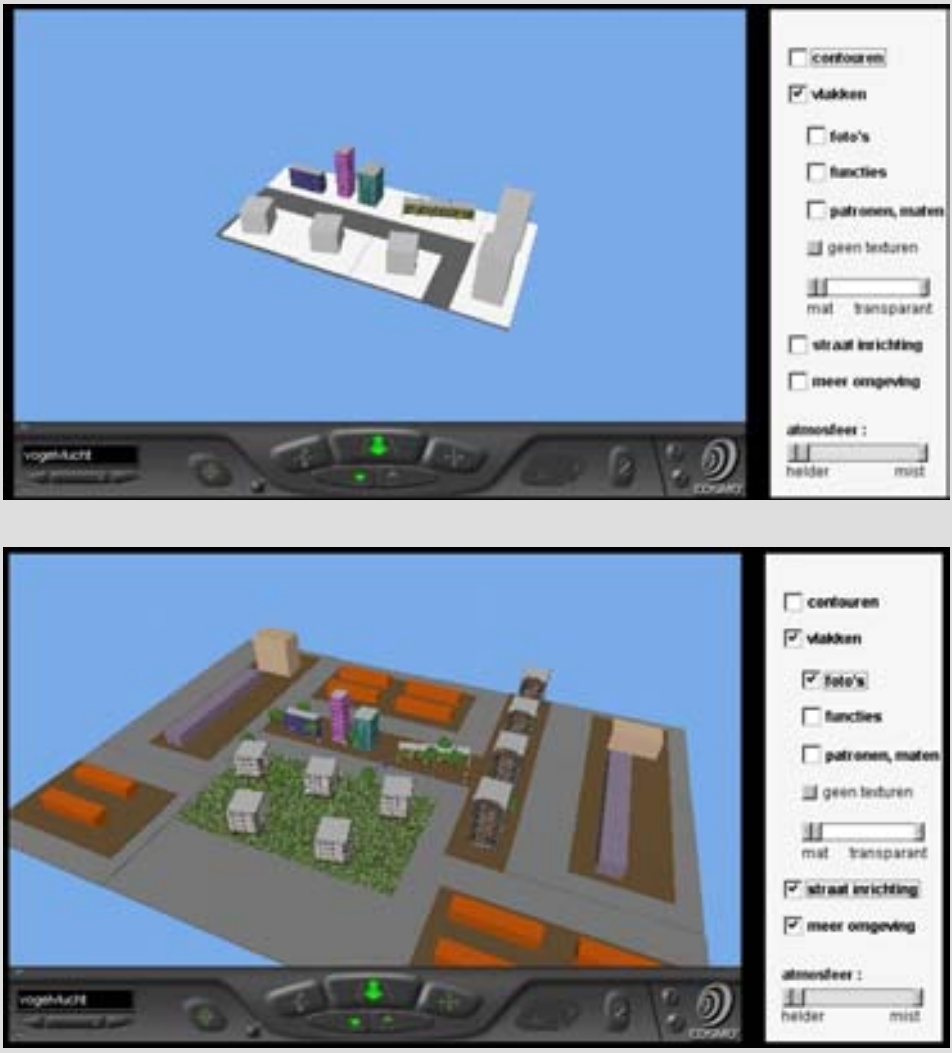
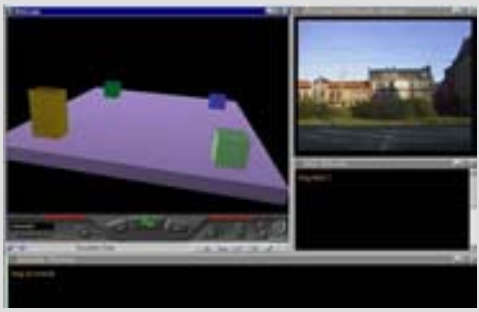
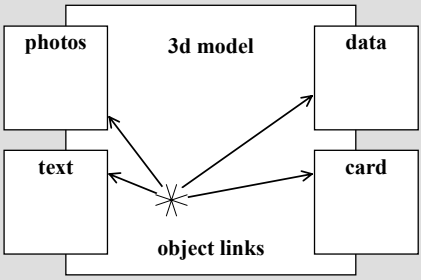


Figure 56.





Finally, a combination of VRML and JavaScript was chosen for all further experiments. The JavaScript language can be easily incorporated into the VRML code. Aspects of the 3D environment can be changed directly by using the JavaScript code. The problem however was that there was no 2D-interface available, while in Java, the buttons and sliders for such an interface are directly available in previously defined classes. In the VRML + JavaScript combination there are no external links to HTML, or to standardised user interface items. Therefore, a trick was used: the user interface was made like a virtual Heads Up Display (HUD). The HUD is a 2D or 3D interface placed immediately in front of the viewpoint in the VRML world. When the viewpoint moves the HUD moves accordingly and it seems like the interface is part of the viewer, like a car dashboard (the car interface) that moves with the driver and the moving car. The HUD was used for many WIMP (Windows Icons Menus Pointer) interfaces (see some examples below). Several concepts were developed in order to get clear and informative interfaces for the experiments with architects.

Figure 57.

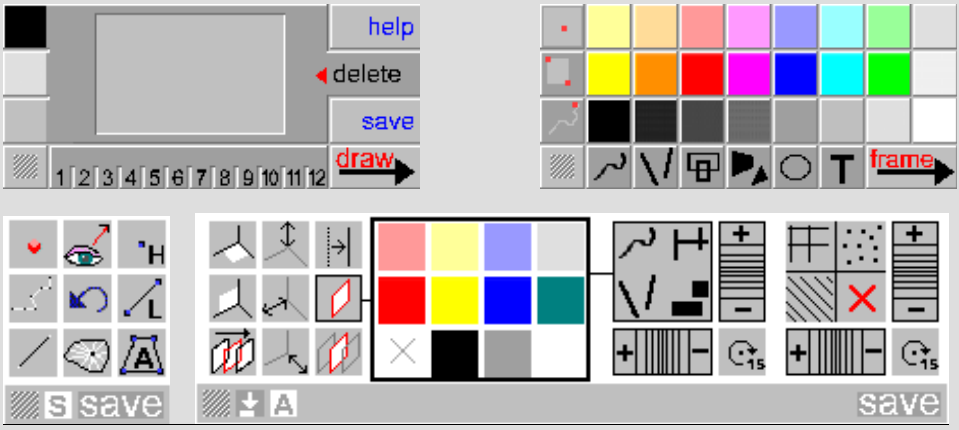


Figure 58.

Model settings: façade drawings without outlines and aerial pictures on the ground faces.

Model settings: plain faces with outlines and a more abstract ground drawing.

MEDIA PROTOTYPE 1

different representation layers

The façade textures of the context model can be changed in order to test the architects' preferences during the design process. The representation can be set to plain faces, to gridlines or façade textures, combined with or without outlines. Furthermore, there is an option to bring more detail for the benefit of an experience of 'human scale' and there is a switch to turn all trees on or off. The setting of façade textures is combined with an aerial picture on the ground while the option for plain faces comes with a more abstract ground drawing.

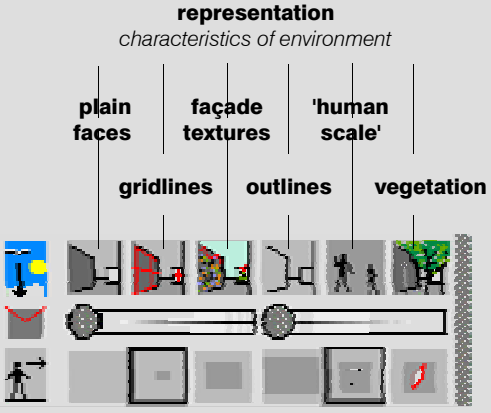


Figure 59.

Model settings: the square with its immediate surroundings.

Model settings: the whole area.

MEDIA PROTOTYPE 2

model extensiveness layers

Four icons on the representations menu allow the user to choose how much of the context is shown.

1: nothing
2: the square and immediate surroundings: 145m x 160m
2: the wider neighbourhood: 435m x 480m
3: the whole modelled area: 745m x 800m

During the test there were questions if the participants wanted / needed to see even more.

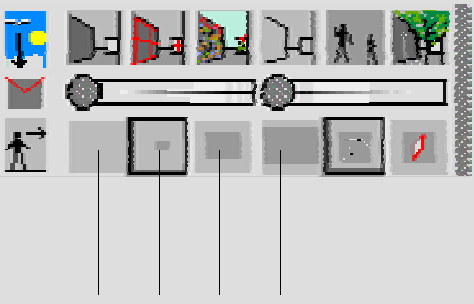
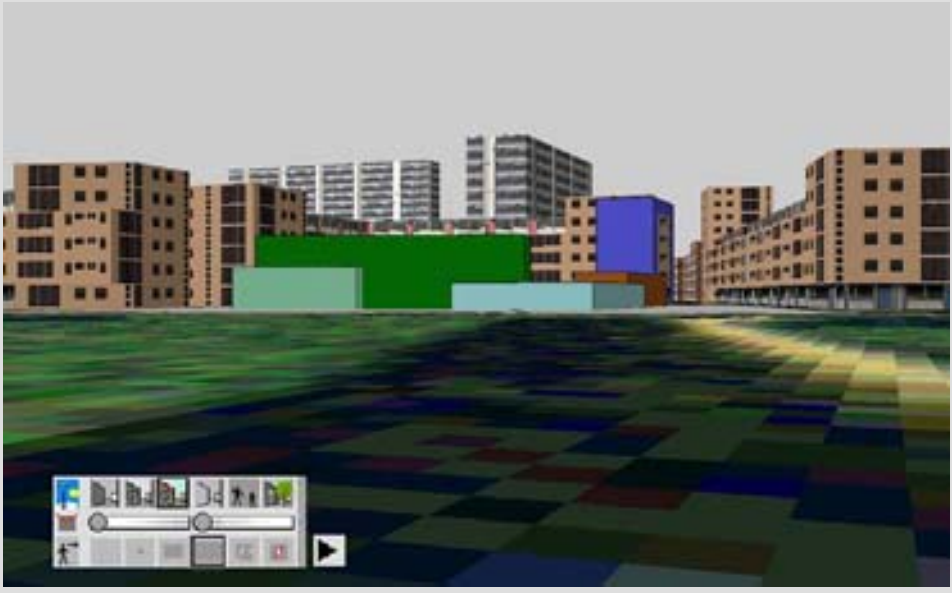
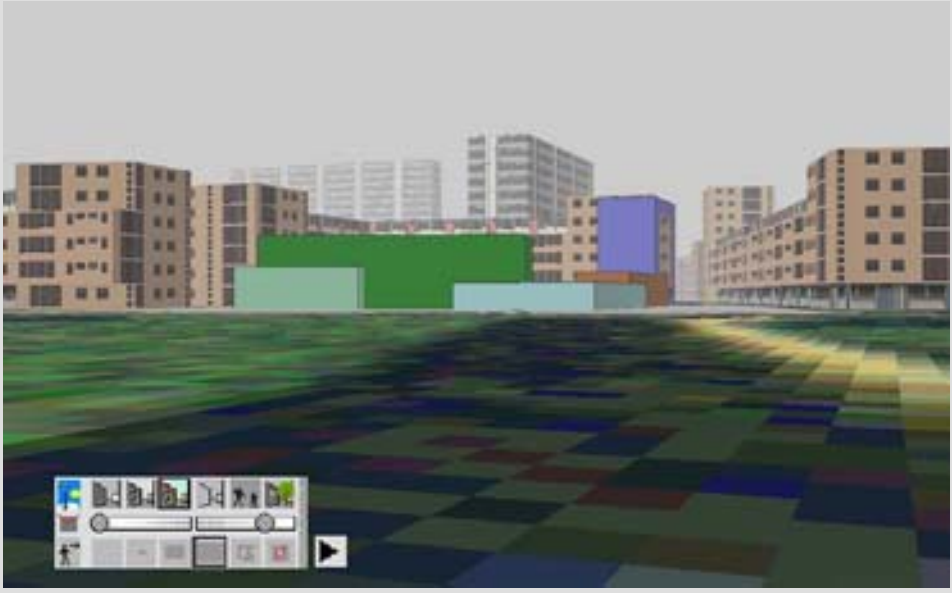


Figure 60.

Model settings: no fog, no transparency.



Model settings: some fog, no transparency.



MEDIA PROTOTYPE 3

fog and transparency sliders

Two sliders allow for the changing of general aspects in the perceived context model.
The amount of 'fog' can be adjusted in order to find out if the atmospheric perspective has an added value for the perception of depth.
The semi-transparency of the facades can be changed in order to find out if it is useful for the spatial understanding of the building blocks.

opaque transparent
slider for setting the amount of transparency for the facades, roofs and trees

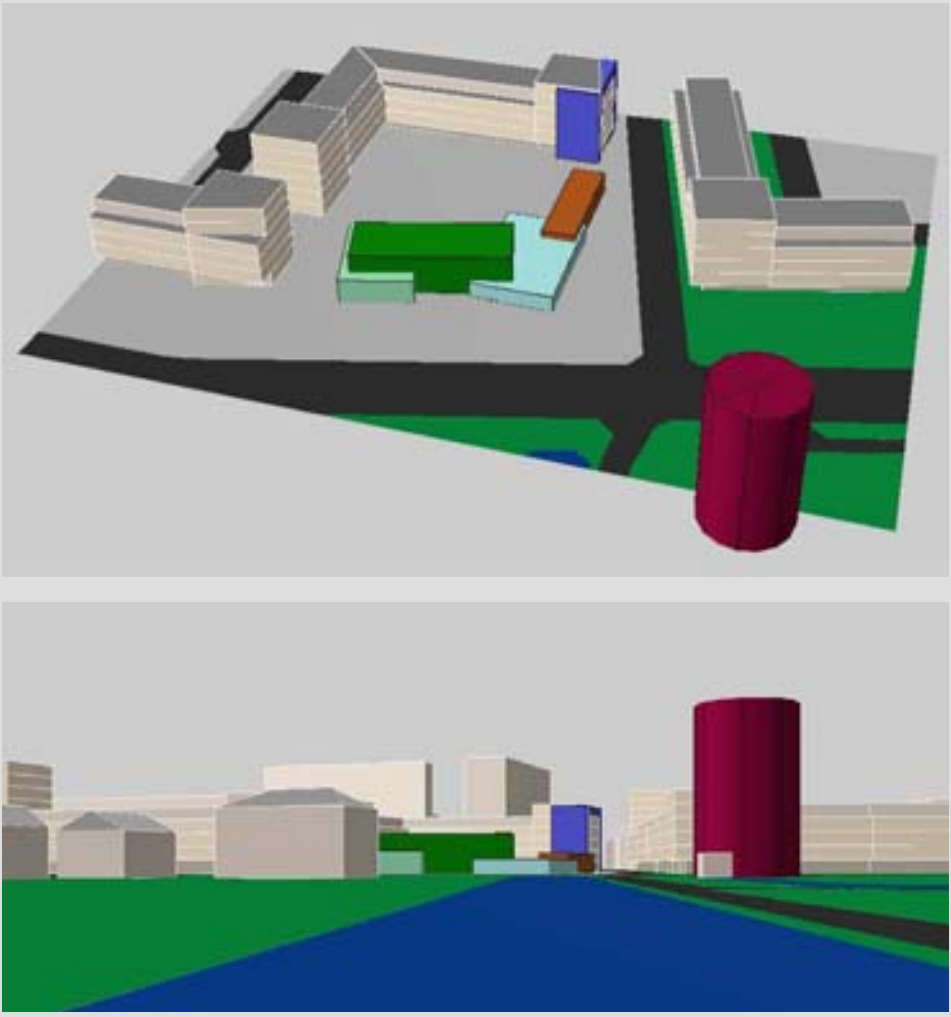
clear foggy
slider for setting the amount of atmosphere

Figure 61.

Model settings: no fog, some transparency (no textures).

Figure 62.

Bird's– eye view and pedestrian eye-level view.



switching between eye level and bird's-eye views

In many normal CAD systems, the viewpoint defaults to the zero level.
In CA*A*D systems, which have an extra ***A*** to indicate that they are optimised for ***A***rchitecture, the zero level should be replaced by a normal average eye-level of about 1.65m.
A quite simple but very useful prototype automatically moves the navigation system to eye level and makes it possible to instantaneously switch between bird's-eye views, straight-down views and pedestrian's eye level views.
Whenever the eye level button is chosen, the view direction is corrected to a horizontal, 1.65m high plane, while the orientation is kept the same.

Figure 63.

Pedestrian's eye level view and a straight-down view.

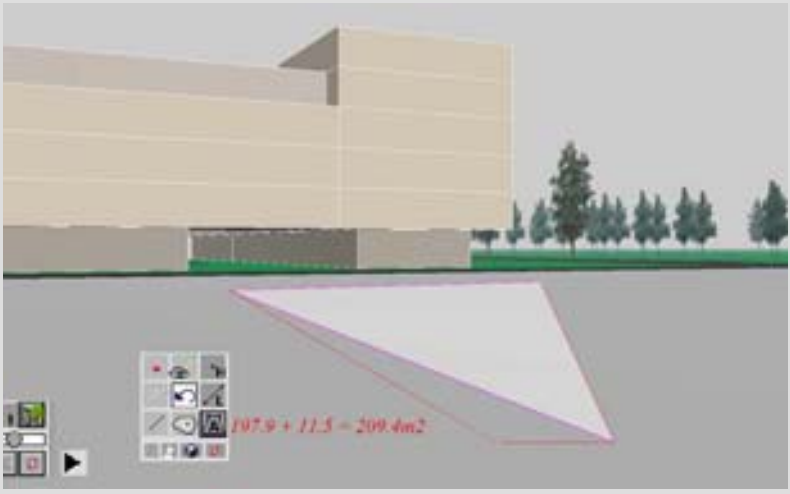
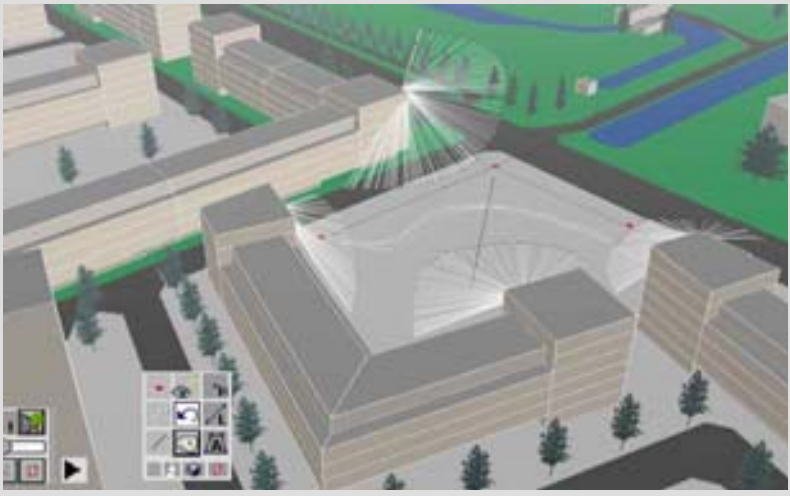
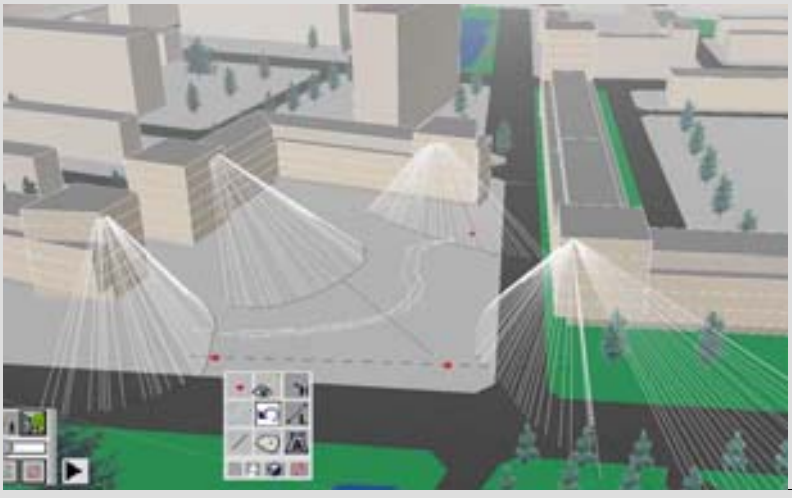


Figure 64.

Measuring an area.



'spider web' lines



'spider web' lines from another point of view

SUPPORT TOOL 1

virtual site analyses

The analysis tools provide a way of interacting with a virtual model. The different tools allow one to emphasise typical aspects of the site and they can provide the user with additional information such as height, distance and area size.
In *Management of Sequential Space Experiences*, Arne Branzell [Branzell, 1995] introduced a graphical notation method for paths, nodes, edges, districts, landmarks and spaciousness. The first five notations are Kevin Lynch's well-known orientation signs [Lynch, 1962]. This kind of notations can also be created with the analysis tools. The red box and the line of sight can be used for pinpointing landmarks. Nodes can also be noted with a red box. The white free line is assumed most suitable for notation of paths and districts; the straight line can be used for paths as well as for edges. The 'spider web lines' seem to be most useful for indicating spaciousness and districts.
This tool and the other sketch tools had the status to be 'available if needed' during the whole experiment. The participants were not instructed to use the tools in specific ways. The outcome of the test would show if and how the participants actually needed these tools.

Figure 65.

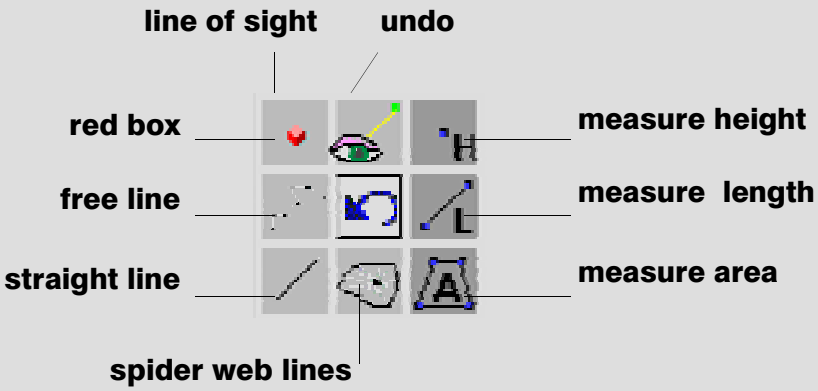


Figure 66.

Sketch with some elementary objects and semi transparent volumes, seen in relation to a building with and without façade textures and from different points of view.

SUPPORT TOOL 2

constructive sketching

Sketching in / with the computer has only recently become a more standard procedure. When studying people's attempts to sketch using a computer, one can find similarities to non-digital sketch processes. If sketching is defined as 'a way of creating in a free but possibly iterative way', then there should always be action and opportunity for adaptation and refinement in sketching. Thus, the theme of sketching is defined in a general way. As an example of the concept of sketching, one can see sketch aspects in improvised speech or in a discussion. Speaking can contain sketch aspects, if one is allowed to rephrase and clarify initially spoken statements.

In architectural sketching, several approaches can be seen. Constructive sketching (as a way to model with mass representing objects) is introduced here as a tool whereby place boxes and pre-set objects can be placed in the given context model. The architect can then see the result and the impact of such a 'sketch' action.

The prototype consists of a set of eight objects (see icons). Boxes can be drawn using four mouse clicks. The height can be related (clicked) to the height of surrounding buildings. Trees, people and a type of lamppost can be placed in one click. The objects are assumed to be quite design-independent. The boxes allow the user to make simple and quick checks about placement of masses. The other objects are made available, in order to find their usefulness for the benefit of judging scale and size in such 3D representations.

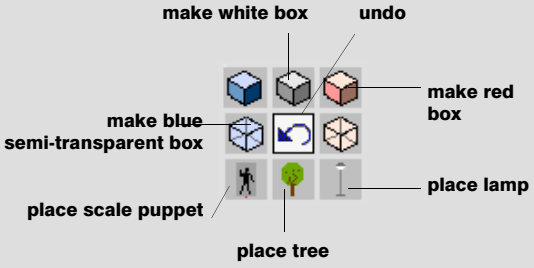
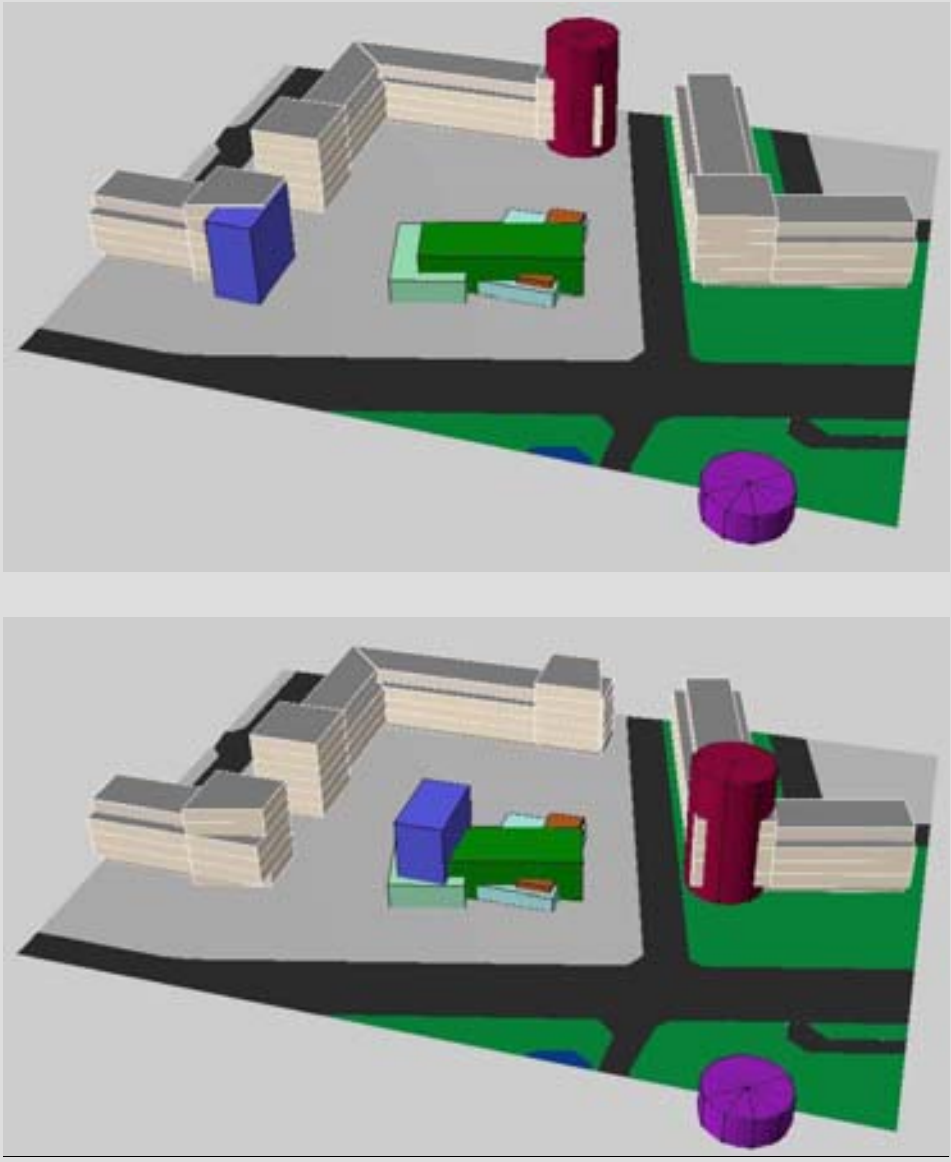


Figure 67.

Figure 68.

Drag and drop sketching with available objects.



SUPPORT TOOL 3

drag and drop sketching

Besides constructive sketching, another more adaptive way of sketching has been included into the experimental system. In physical modelling, this way of sketching works well by using all kinds of 'objects trouvé': pieces of paper or remaining blocks of wood from the bin in the studio. The arbitrarily placed objects can be moved quickly in order to try things out. One should see this kind of sketching as 'learning by doing', without the stress of keeping everything under control, but at the same time, one should keep the eye open for sudden inspirations and inventions. Each test, each option, might potentially inform the designer about what might be and what is not appropriate within the given urban context.

A new tool that was made after the experiment of this research allows dragging and dropping arbitrary VRML models from the Internet into the scene. This development draws from recent additions to the nodes of the standard VRML language. Such developments support the further evaluation and sharing of design within its context over the Internet.

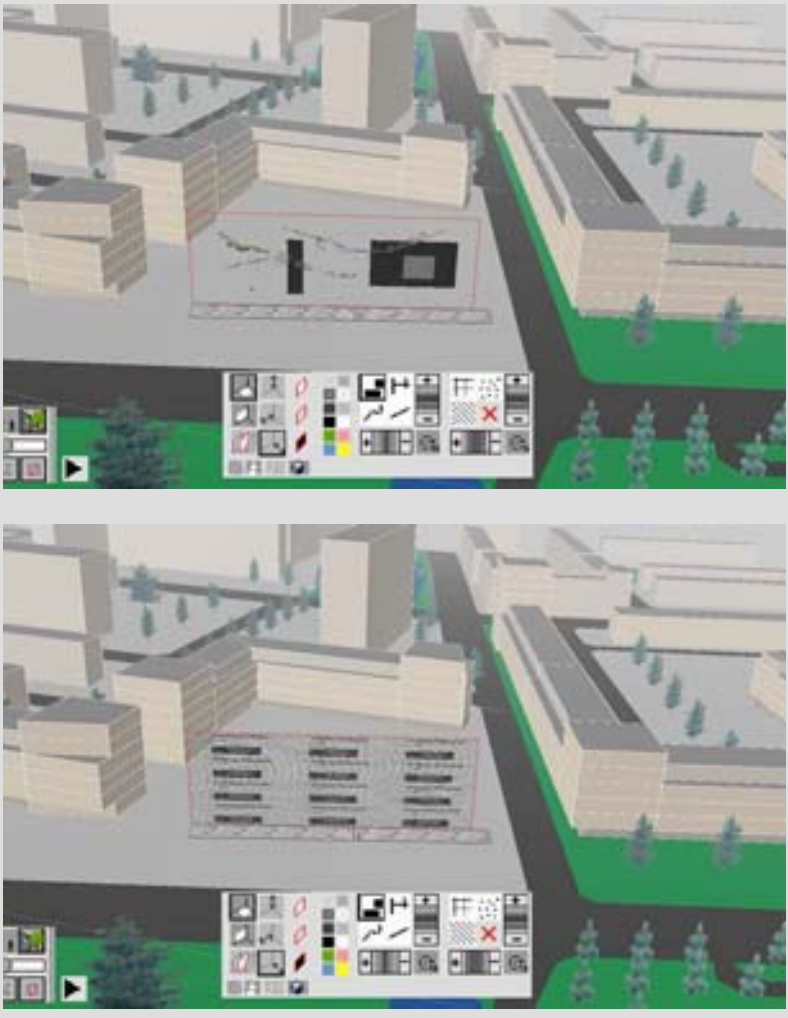


Figure 69.

Sketch with different pixel based drawing tools on a surface that can be placed in relation to the surrounding urban context.

SUPPORT TOOL 4

surface sketching

A third way of sketching is compared to drawing with ink on paper. If one considers the paper as a transparent canvas that can be placed in the space of the context model, one could draw and sketch there directly in the model.
Sketching with pencil and pixel gives a lot of freedom, because the medium is not pre-defined. A pixel can become the edge of a rectangle, or it can become a twinkling star. Ink on paper and pixels on a screen allow images to be re-interpreted repeatedly.
SketchBoX (see p.115) is a program that was used to explore different alternatives for sketching within a 3D-environment. Different from most CAD drawing tools, (which in most cases work with 3D primitive objects and curved surfaces), I wanted to try 2D drawing aspects within a virtually represented 3D-world. The conference paper and the case study of 'SketchBoX' were used to further develop a prototype for 'space related sketching within a 3d model'. The SketchBoX experience was thus made instrumental in this study.

Figure 70.

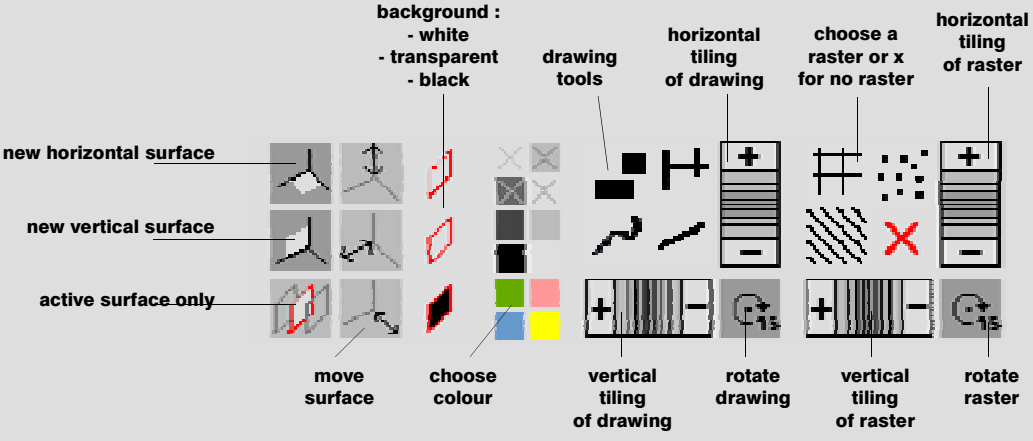
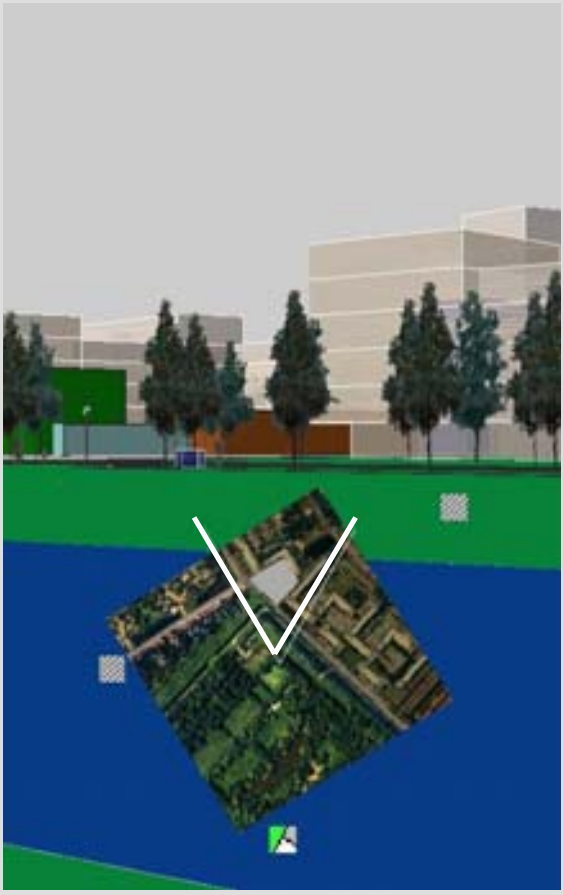


Figure 71.

Two eyelevel images of the final context-model with the 'interactive map prototype' activated.
The map could be used with a map image or with an aerial picture on it.



SUPPORT TOOL 5

the interactive map

Using an interactive map is like reading a map in a virtual world. It is comparable to a visual navigation system for a car, a plane, or a ship. Interactive maps change when the user changes his or her position or orientation. Two essentially different approaches exist: a static map with a moving arrow and a static arrow with a moving map. The prototype described here is of the latter type and scrolls and rotates interactively according to the user's movements. The map can be changed into an aerial picture and the map-scale can be changed while it is in use. Another option is dragging the map, which leads to a related movement in the viewpoint.
The map was made available during the experiments, in order to help the participating architects regain their orientation after they got lost. It was expected they would better understand the environment if they used the map.

The idea of an interactive map was also explored by students who made an enthescopic video and inserted the map by chroma-key techniques (see pictures below). The interactive map metaphor was also made instrumental in the renovation of the Faculty's endoscope facilities, which combine an eye-level-viewing-camera with an overview-orientation camera, used when 'driving' the instrument.

Figure 72.
Superimposed video overview in a student design presentation.

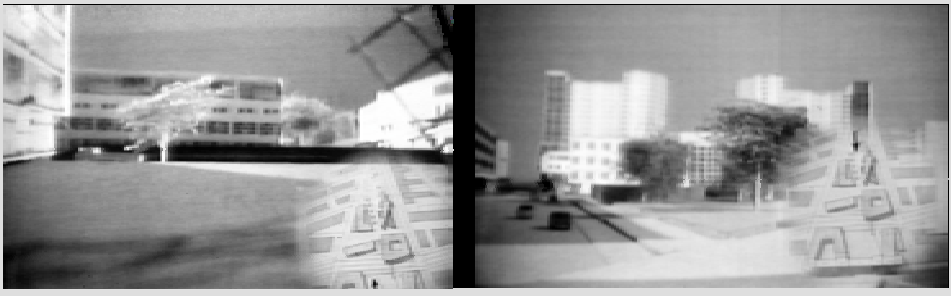
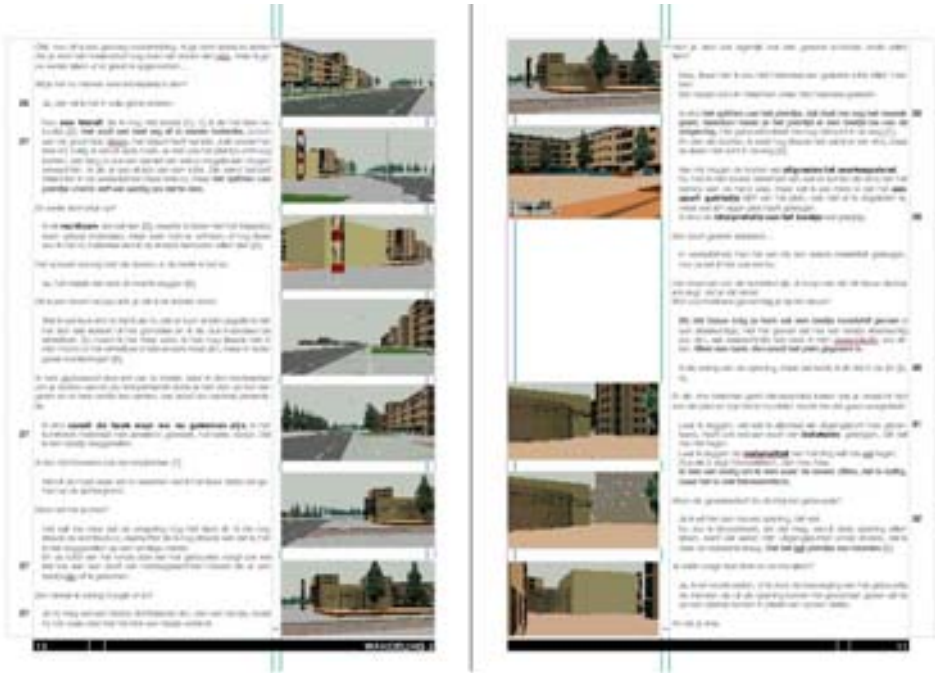


Figure 73.
Two pages of the interview transcript in Dutch.

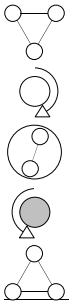


"Sire, your mind has been wandering. This is precisely the city I was telling you about when you interrupted me."

"You know it? Where is it? What is its name?"

"It has neither name nor place. I shall repeat the reason why I was describing it to you: from the number of imaginable cities we must exclude those whose elements are assembled without a connecting thread, an inner rule, a perspective, a discourse. With cities, it is as with dreams: everything imaginable can be dreamed, but even the most unexpected dream is a rebus that conceals a desire or, its reverse, a fear. Cities, like dreams, are made of desires and fears, even if the thread of their discourse is secret, their rules are absurd, their perspectives deceitful and everything conceals something else."

Italo Calvino — Invisible Cities



Chapter 4

Findings and evaluation of results

This chapter provides insight into the research data collected from twelve interview sessions. Six architects were interviewed in two sessions each. All findings documented here have come from what they did and what they said in reaction to the provided experimental situation.

In order to make the interviews manageable for further interpretation, the following procedure was followed:

- First, all interview recordings were viewed. Spoken text was transcribed and corresponding screen-images were placed in a parallel column of the page layout. References to specific images on the page were placed in the text (e.g.: [1]) . All texts of the interviewer were set in an italic typeface. Names of the participating architects were replaced by neutral indicators (e.g. Architect 1 or short: A1). This was done to make the research report independent from possibly known names.
- Each tenth row of the text was numbered in the margin. The texts were then read several times and noteworthy aspects were emphasised in a bold typeface. This resulted in a separate 128-page supplement of 'inter-view-transcripts' (see figure 73).

Further interpretation of the transcript was undertaken in two ways:

- Protocol Analyses resulted in coded lists that proved useful as indices, to quickly find back specific themes. These analyses were not used for quantitative evaluation but for the pinpointing of qualitative considerations.
- Specific quotes with references to the line numbers (e.g. [@1220]) were translated and used for the evaluation of prototypes, hypotheses and for reconstructing the development of design ideas in each process. Quotes and a close observation of each design process provided qualitative answers and indicative insights into the research questions.

For reading convenience, the hypotheses and the contents of this chapter are provided on the next two pages.

Hypotheses 1 till 7 (see also pp. 94-100).

Situatedness

1. *There is a feeling of situatedness in digital 3D-models that represent a design context. (theme: 2.2.6)*

Dynamic Views

2. *Digital media offer the opportunity to generate dynamic views and adaptable representations in a variety of ways, thereby creating different experiences of situatedness. (theme: 2.2.1)*

Design Stimulation

3. *Different dynamic forms of situatedness, created via digital means, can stimulate concentration, focus, the reframing of thoughts and conversation in design, whereby design cycles may be shortened. (themes: 2.2.1/2.2.2/2.2.4)*

Models OF - Models FOR

4. *Adaptable models OF a design context can inspire the designer in such a way that they become models FOR creative design thinking. (theme: 2.2.6)*

Effectiveness

5. *Dynamic views and adaptable representations using digital means are more effective to evaluate the impact a design concept will have in its context than serial visions using fixed images. (theme: 2.2.3)*

Taking Distance

6. *Being separated from the real site with all its intrinsic constraints, can stimulate a measure of freedom in the design process, allowing for the consideration of (im)possible and (un)desirable alternatives, which may actually lead to improvement of the design concept. (theme: 2.2.5)*

Combining Methods

7. *Combining the 'think aloud method' with intermediate instructions, conversations and questions by the research is a useful way of gaining results in design driven studies. (theme: 2.2.7)*

4.1 FUNCTIONAL ANALYSIS OF PROTOTYPES

4.1.1 Prototype 1: different visual representations

about plain faces without texture
about outlines of the geometry and floor-lines
about raster textures
about colour façade images
about black and white façade images
about more details
about trees

4.1.2 Prototype 2: model extensiveness

about extensiveness

4.1.3 Prototype 3: fog and transparency

about fog
about transparency

4.1.4 Prototype 4: eye-level and bird's-eye views

about eye-level views
about bird's-eye views

4.1.5 Some remarks about movement and orientation

about wandering
about animation
about using an interactive map

4.2 FINDINGS PER ARCHITECT

4.2.1 Architect 1

tracing the design ideas
indicative passages to ground the hypotheses

4.2.2 Architect 2

4.2.3 Architect 3

4.2.4 Architect 4

4.2.5 Architect 5

4.2.6 Architect 6

4.3 ASSESSMENTS

4.3.1 Assessment concerning the prototypes

4.3.2 Some remarks about Protocol Analyses

4.3.3 Assessment concerning the hypotheses

4.3.4 About the developing design ideas

4.4 TOWARDS A CONCLUDING CHAPTER

4.1 Functional Analysis of Prototypes

4.1.1. Media Prototype 1: different representations

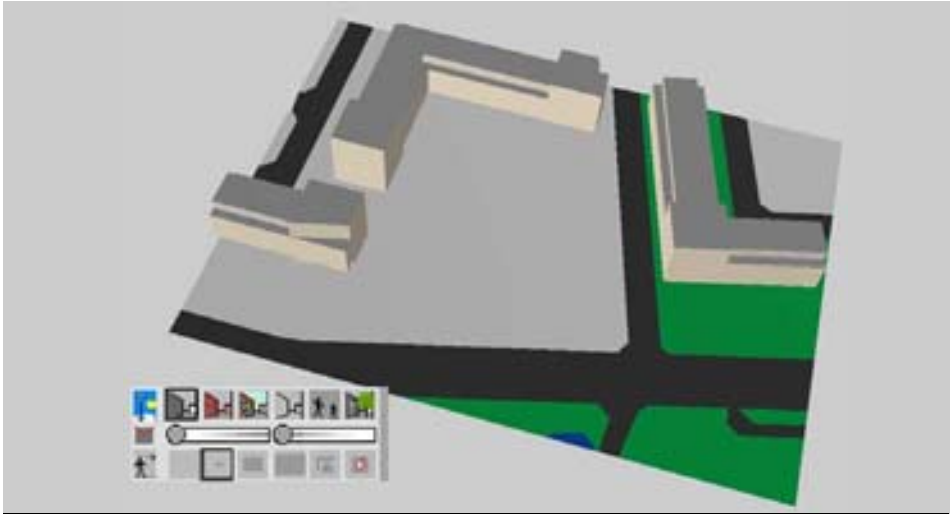
about plain faces without texture:

A1: I always want to start by studying the masses. I want to draw instead of taking pictures. I prefer to start with 'less information' because then it is about spaces in the city. I want to see it from above again. [@47] On the other hand:
A1: Such a blocky model triggers me to think in blocks, it makes me think and compose in blocks, while in reality, this would be made muddy by trees and… So this influences me and makes me use a more detached design method [@310].

A3, at the start: Maybe these façades are already too much now. Initially, I prefer to think in masses [@3960]. First the study of form, faces, transparency and lines of sight are important. Maybe that is what is good about such a model: the fact that you can forget the bicycles, the children and everything [@4003].

A5: I can only recognise the building-types by the way they are parcelled out [@11532], I want to see more of the façade arrangements [@11540].
A4: The danger of the foam-model! You can partially see the atmosphere, still, houses (at the south-west corner of the model) could accommodate either the mayor, or it could be for persons seeking political asylum: you just cannot interpret such a model [@6945].

Figure 74. Example of plain faces without texture.



about outlines of the geometry and floor-lines:

A view with these lines proved to be 'too much' in combination with the façade textures, but they were often used with the plain faces. In that combination, the lines provide a reference to the scale of the buildings as the floors could be counted.

A5: Can you add a person on the square. A scale. I cannot connect with those blocks, can you add shades or a line? [@9110]. The lines make it easier to draw on [@9958].

A3: In comparison to the façade images, this one is friendlier. That might be because of the closed doors and black windows. You do not see reflections, no weather, many aspects are missing [@4525]. If you do not see the façades, you will imagine the architecture by yourself [@4540].

A1: I would like to have such a model of a project site, but then options that are more realistic would also need to provide 'less information'. Then I would like to be able to go back to the reduced images of ‘blocks’ and then preferably to lines.

Figure 75. Example of outlines of the geometry and floor-lines.

about raster textures:

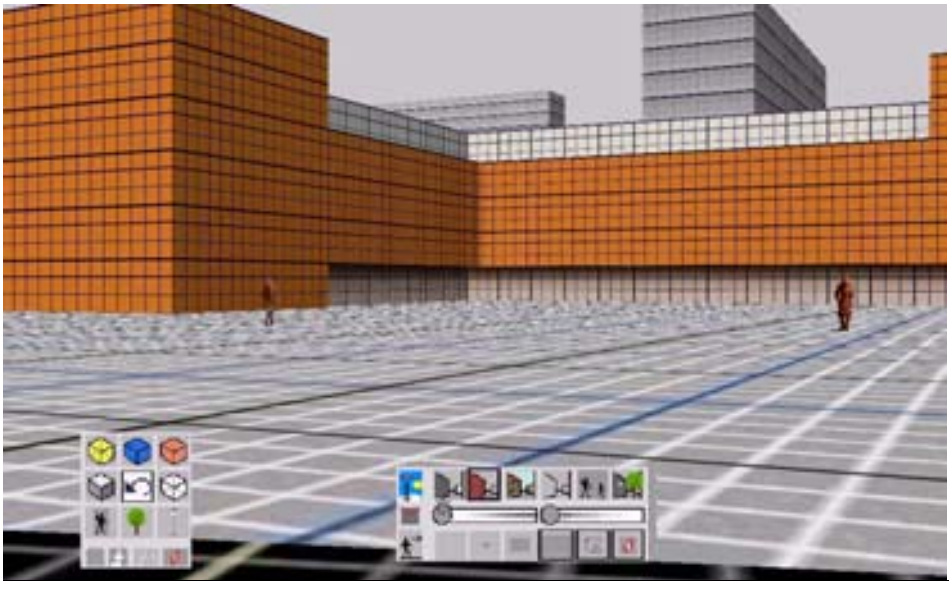
Raster images, with different gridlines every 1, 5 and 10 meters were introduced in the research in order to see if they gave useful cues of building sizes and distances. However, they were consequently neglected, or misunderstood by each research participant!

A6: I see different colours, why is it that it is part orange and not just white? Is it an indication of material? [@11550]

A5: I would never use that! It gives the wrong association to the people and office buildings. [@9510] However, the grid might be useful if you want to design the façades [@9520].

One positive side remark of A1: Ground floor façades that set back, have some darker tint and some shadow. This gives a better impression of the plasticity of the façade [@120].

Figure 76. Example of raster textures.



about colour façade images:

A2: I want to start from an eye-level view, immediately with all available textures [@2513].
A1: After seeing the plain faces, the façade images give a surprising effect [@135]. On the basis of the overall building shapes the architectural image was not expected.
A1: You can see where 'the eyes' of the building are situated. This influences the design decisions (the line of sight to the polder-ditch) [@615] If I come closer to the square, I want to know some more about the façades. When I have to decide about the colours and materials of my own design, I really want to know exactly what the colours and materials of the surroundings are. Then I would also want to visit the site again, in order to feel and experience the colours. Then I want to know 'how granular the bricks are'. That is not possible with this image… [@2344].
A6: If it would cost a lot to model all the façades, I could use just a map with the floor plans, but at first sight, this is valuable information. It is useful for both the analyses and for the presentation [@11633-11642].
A3: Still, you cannot form an opinion about the functioning of the building in the environment. I cannot see if these are kitchens, storage rooms, or shops. If they are shops, they will have great impact because of the delivery trucks. That is a completely different ambience than if they were kitchens, then you would indeed see children playing. Here, it is still not clear if there is a stairwell [@4020].

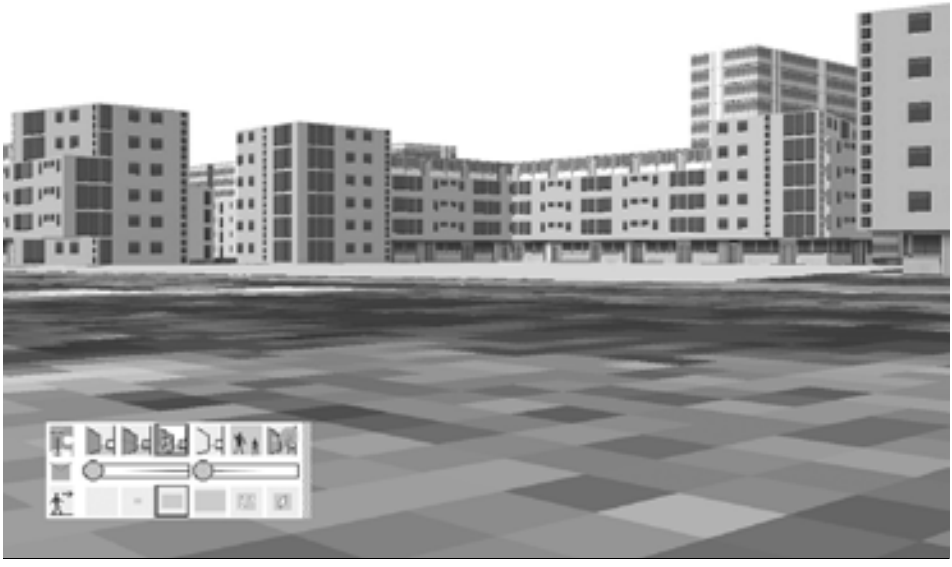
Figure 77. Example of colour façade images.

about black and white façade images:

The option to see in black and white was raised by A1: I would prefer to give them something that is obviously not reality (e.g. a hand sketch) instead of giving something that pretends to be realistic but is not. Like my appreciation of black and white photography. The colour film is not fully realistic, while I can imagine colour in a black and white image [@1330-1335].

A5: I doubt if I want to give so much information (presentation). I think it works if you do it in black and white, as long as you still have a scale association ...[@9645].

Figure 78. Example of black and white façade images.



about more details:

A3 appreciated the tiled pavement, as it works as a natural reference to scale. In several circumstances, she asked to "put the pavements on" again. There is a stunning unity in most sidewalk tiles in the Netherlands: the 30x30 cm size. This type is used in the system layer of 'more details'. This realistic reference to scale seems to be appreciated much more than the meter raster. A3: In reality you can either see what a meter is [@4734].

Figure 79. Example of more details.

about trees:

Figure 80. Examples of trees along the road.

A5: Trees in drawings are seldom right [@9640].

A3: That tree helps ... [@4930].

While A4 is gathering images for the design, she asks to see the same representation with and without trees. She comments on the important difference this makes for the image of the street, but then for the design process she prefers to have an image without trees. A4: Can I stay here, or are there trees in front. Look, this is essential!, although they are 'model-trees'. Trees 'off' please, then I can have a better view of the situation [@7720].

Table 3. Quantification of Protocol Analyses about all representation types (media prototype 1). See also §4.3.2.

number of outspoken preferences for representation types								
		A1	A2	A3	A4	A5	A6	∑
pP	PLAIN	4	0	1	3	3	1	12
pPL	PLAIN + LINES	1	0	2	0	2	0	5
pR	RASTERS	0	0	0	0	0	0	0
pF	COLOUR FACADES	1	2	0	2	2	3	10
pB	BL. & W. FACADES	1	2	3	0	4	0	10
pD	MORE DETAILS	0	1	3	1	0	0	5
pT	TREES	0	2	1	2	0	0	5

4.1.2. Media Prototype 2: model extensiveness

about extensiveness:

A1: if I would see this in real, things near me would influence me much more. Now, because I can easily oversee the rest of the surrounding city, I include that in my thoughts as well [@320].
A4 about the smallest model: Now I see just a place where something should be done. I would focus to this scale after defining a concept. However, for the definition of a concept I need to know what kind of place it is: I cannot see that! I cannot see what is opposite nor can I see if the street is lively and if this is a block end [@6740].
A4 about the medium extensive model: Now I see that it is a kind of Delft extension. It has a double centre, surrounded by a bigger scale ring. I cannot recognise the time (style) in which it is built. … In the smaller model, I could not see this crossing point of urban structure, now there is clearly: green, small scale, large scale. But still you do not know if there is something big here [@6755]… A more extensive model than this does not need to be shown in 3D, but in a plan, you can see if it is a village or part of a ring-shaped city. This has to do with function. Is this a centre area or is this a suburb? You cannot see all such aspects [@6810]. Even if the design is just about a small-scale change (a façade), I need to see the site until about 200m. around the design [@6825].
A6: what you need to know is: 'what makes such a place specific'. I doubt that that is about the 'micro', because if you zoom in, it is all the same. However 'macro' is important: is it near the sea, next to a motorway. Is it possible to combine work and dwellings? : That's what makes it specific! [@11715].

Table 3: Quantification of Protocol Analyses about model extensiveness (media prototype 2). See also §4.3.2.

number of outspoken preferences for model extensiveness								
		A1	A2	A3	A4	A5	A6	∑
p1	SMALL 145 x 160 m.	0	0	2	0	0	0	2
p2	MEDIUM 435 x 480 m.	0	0	2	1	0	0	3
p3	LARGE 745 x 800 m.	1	3	2	0	1	2	9

4.1.3. Media Prototype 3: fog and transparency

about fog:

When the 'fog' slider was set to 80%, some people started to appreciate the impression of distance in the otherwise flat image. More fog disrupts the view of the nearer buildings. Fog could be set between 1200 and 200m. of visibility, with the 80% setting corresponds to a visibility distance of 400m.

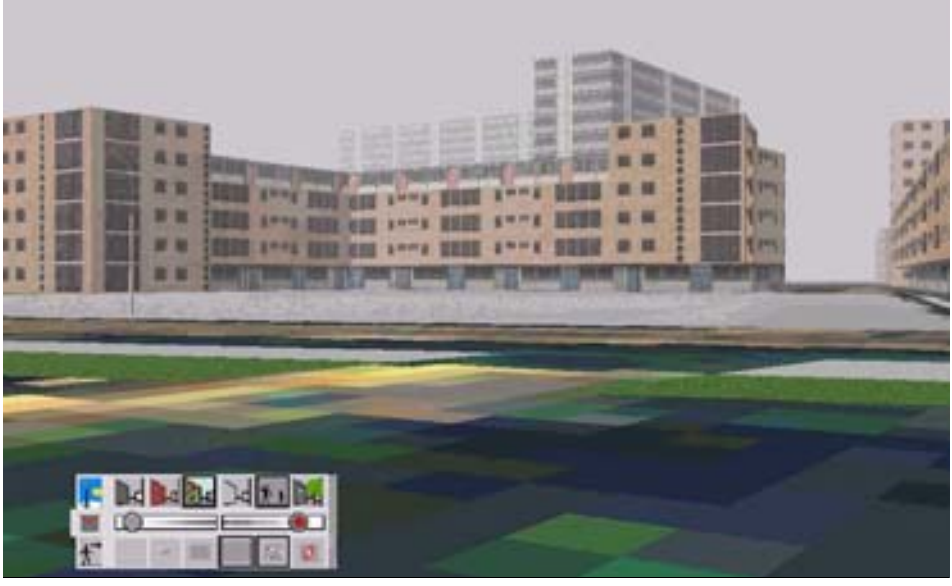
A3: This is useful to estimate distances of the buildings [@4355].

A4: For me the fog does not matter much. I am used to reading such computer images. For presentations it can be useful [@7130]. It does not have as much impact as the effort you could have in a hand-sketch by keeping some distance between structural lines of buildings that are behind other buildings [@7225].

A5: At this moment the fog is not useful for me, because I want to use printouts of these images and draw on the prints, so then I need strong outlines on all of the buildings [@10110].

A6 sees fog and transparency as a means to put the surroundings a bit more in the background in a design presentation [@11920].

Figure 81. Example of fog; atmospheric perspective.



about transparency:

A1: I like this image, because the building blocks can still be understood as shapes, while you can also see something extra. In addition in this representation, the design matches with the environment; they both have the same level of abstractness. This implies that if the environment is shown in a more detailed way, the design needs more as well [@2410].

A3: Now it is too transparent. In reality, you cannot look through it either. A glass façade would have impact on the image of the square [@4845].

Table 4. Quantification of Protocol Analyses about fog and transparency (media prototype 3). See also §4.3.2.

number of outspoken preferences for fog and transparency								
		A1	A2	A3	A4	A5	A6	∑
pf..	fog	0	0	1	1	0	1	3
pt..	transparency	2	0	1	0	0	0	3

Figure 82. Example of transparency.

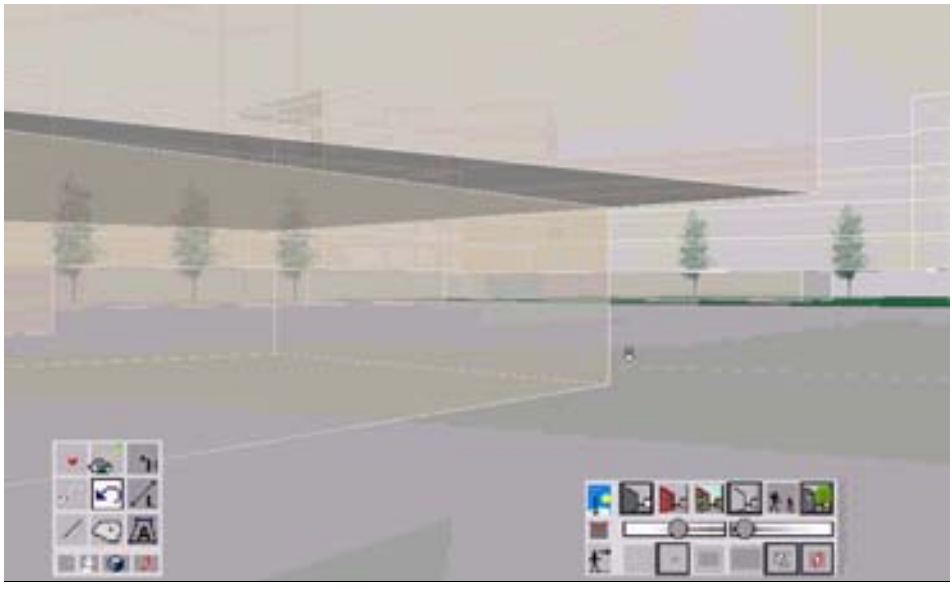


Figure 83. Example of an eye-level and a bird's eye view.

4.1.4. Prototype 4: eye-level and bird's-eye views

A1: I'm someone who prefers to have an overview. Working in plans and sections gives the kind of overview in which insight comes intuitively. The overview involves a system, a pattern. You can compare the overview of an architect with the skills of a tailor: a tailor imagines a dress out of a flat pattern. The perspective view has a communicative role and can be used to check your design. An overview (plan or section drawing) makes that I do not forget things, while a perspective drawing puts things behind each other and that makes me afraid I might forget aspects that cannot be seen. I use colour pencils in order to structure my drawings. Only if something is very complicated, you need to draw in 3D. As such, 3D is to check, 2D is to make! I think: the more information, the more insight. However, the less information, the more overview. So, black and white images give more overview and if more information is added, the more confused I tend to get. [@2100-2260]

A5: After understanding / knowing the site, I took my design decisions in this, more extensive overview. That's where you decide about the proportions. I think that indeed most of the decisions take place based on that level. Then you check the decisions on eye level [@10555].

Table 5. Quantification of Protocol Analyses about the outspoken preferences for specific viewpoints (media prototype 4).
See also §4.3.2.

number of outspoken preferences for viewpoints								
		A1	A2	A3	A4	A5	A6	∑
p|	bird's-eye 90° down	1	1	0	1	1	0	4
p/	bird's-eye 70° high	0	3	0	0	0	1	4
p\	bird's-eye 45° low	2	4	0	0	2	3	11
P-	ground eye level	1	3	3	1	3	1	12
P*	specific point	5	2	2	2	6	0	17
p#	use of a map	1	0	0	1	1	1	4
p~\	preset helicopter	0	0	1	2	0	1	4
p~-	preset walk	0	1	0	0	0	0	1

4.1.5 Some remarks about Movement and Orientation

Study of movement in the 3D model gains from the abstract interpretative layer of the Protocol Analyses. The PA's codes (see also §4.3.2.) show the switches between eye-level (-) and bird's-eye (\ | /) views and it can be checked if a movement is prompted by visual triggers in the image (< >) or by mental processes (*). For the Protocol Analyses belonging to each of the twelve interviews, see the final pages of the Dutch transcript supplement. Based on the PA tables, several conclusions can be drawn:

about wandering

In the first explorative sessions of the participants, there were far more instantaneous shifts from bird's-eye views to eye-level views than in the later sessions. This can be seen as series of \ -* \ -* \ -* (and variations) in the Protocol Analysis tables. Visits to one's own design in the context model (as happened in the later sessions), had significantly more 'ground based' movements, e.g.: - >- >- -*. It sometimes seemed that the participants forgot that they could fly like a virtual bird. They were often attracted to have a walk to the next side of their design and they wanted to look from specific points in order to check their design ideas.

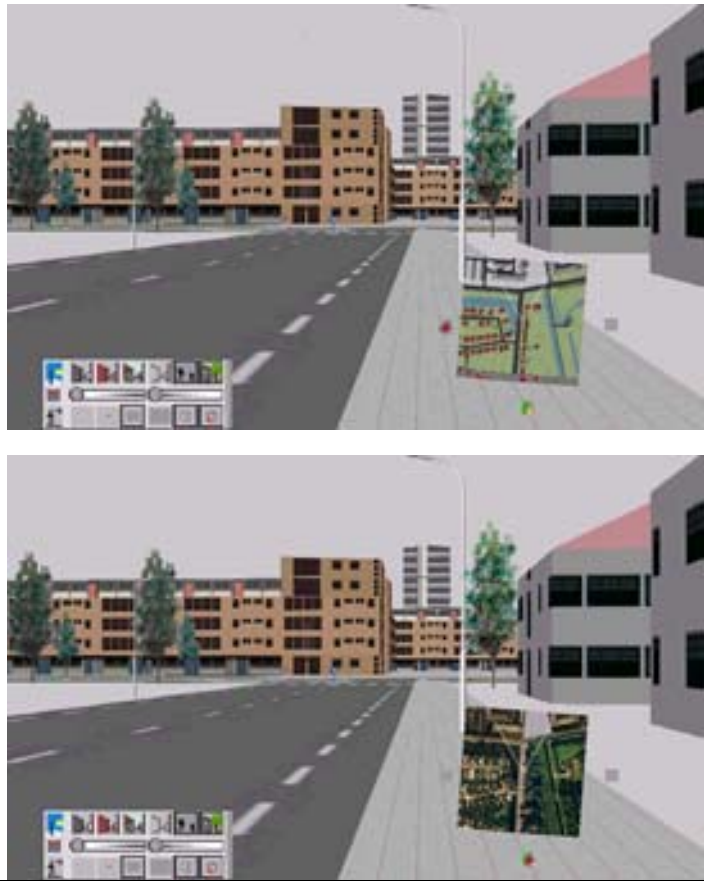
about animation

Several animated paths were shown. One path of a car passed the square along the main road. It was remarkable that everyone wanted to look left, in order to see the square. VRML-animation allowed such movements. Motions (turning, panning, moving) that are invoked by the user (by means of moving the mouse pointer) were added to the already visible movements of the animation. The result is very natural if you turn your head while the car moves. This is in contrast to previously rendered animations and video, that cannot be interactively changed.
The dynamic sequences described above can be found in the protocol analyses as the following combination of codes: ~-- and p* and -* or in the transcripts at: [@428], [@2950] 'I want to look left, while driving. Yes, that's it. Splendid.' [@7500] 'I would like to see a bit more of what is to the left, but I already expect that it would give that movement'.

about using an interactive map

A1: I like it. However, that has to do with the interface of the computer that makes such things necessary. Something else: I like this interactive map also because it is a map! The same thing with an aerial picture appeals less because that gives too much information [@2415].
A4: This would be useful if you can indicate what you want to see [@7710].
A5: I like it but it is too difficult for many people to make the link. Many people cannot do what you do now. They might get confused [@10210-12230].
Testing this tool proved its utility, especially as it rotates according the turns of the user. This leads to a better understanding of the site and means fewer people will 'get lost'. The map-dragging function, to move oneself, proved to be a bit too direct, as the tool did not prevent the user from dragging 'into buildings'. This can create misunderstanding.

Figure 84. Example of the interactive map, showing the map and the aerial picture.



4.2 Findings per Architect

4.2.1 Architect 1

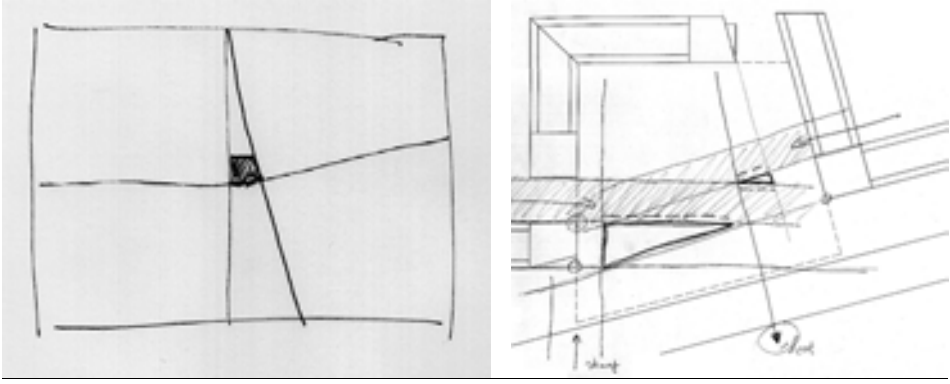
A1 played a double role in the experiment. Not only did he give answers very conscientiously, he also gave feedback on the sorts of questions and tasks during the interview. He was the first of six participants and his responses encouraged me to continue with the chosen method of 'virtual walk interviews'. An important feature introduced at his request was the black and white representation of the context model. Later, when other participants tested this option, it proved to be very useful in the presentation phase.

Tracing the design ideas

A1 takes his time to look around and to thoroughly understand the urban context. He does not want to be hurried and goes to specific viewpoints to check lines of sight. He wants to sketch on paper in order to study the main form of the neighbourhood and to check how much building volume can be introduced on the site without obstructing certain lines of sight. The requirements for new representation media should improve considerably before he would hand in his colour pencils. However, this does not discourage him to use such techniques.

About context – Sometimes A1 translates the spatial form of the context into values and qualities with emotional indicators: the 'embracing surroundings' [@245], 'the eyes' of the building [@615]. At other times A1 translates visual impressions into terms on the level of composition: ‘it consists of four quadrants, landscape lines are used’ [@148], ‘the villas are messily orthogonal’ [@152].

Figure 85. First sketches: the four quadrants and lines of sight.

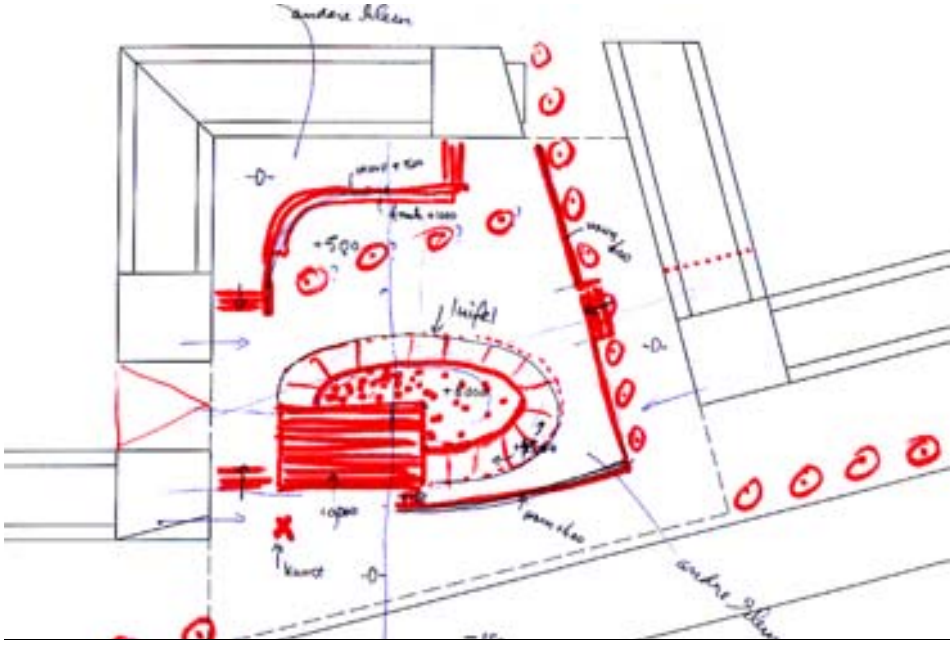


First idea – Right after investigating the main roads and lines of sight, A1 wants to ‘keep open space’ [@55], ‘let space exist’ [@100].

Refined ideas and choices - He sketches ‘what, nonetheless, you could do’ [@219] (maximum masses considering the lines of sight and the idea to keep the space relatively open). Then he wants ‘to play with low and high and scale’ [@400]. He develops a theory based on the two levels of scale in the near surroundings: ‘either something low in the 'embracing' surroundings [@245], or, 'very brutal', something between the low and the much higher building behind’ [@250]. He wants to be able to see out from the building to the polder ditch [@410].

The design that was handed in - The design of Architect 1 shows a precise reaction to the characteristics of the context. When determining the exact placement of building masses, different sorts of views (pedestrian views, views from the main street and views out of the houses) were considered. Use of different heights in the pavement proved to have an enormous spatial impact on relatively small design operations. A feeling of an 'inner court' was established by the placement of a 1.5 meter high bent wall. The other side of the wall provides a comfortable backdrop for a bench.

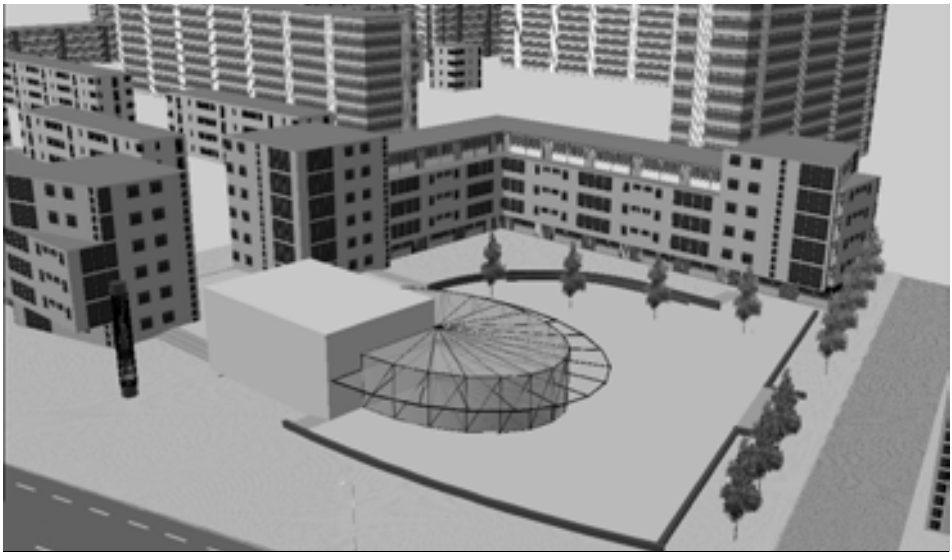
Figure 86. One of the design drawings by Architect 1.



Reviewing own design – A1 wants to check if certain qualities in his design really work as expected. He wants to check the 'hospitality' of the space he made. He also wants to check the lines of sight and the quality of the differences in height and the 'carpet' of the square. The interview passage, starting from @808, shows an interesting succession of situated thoughts while we 'walk'. This succession goes from *seeing and recognising* [@808:] 'well from here I do not see much', to *denomination* [@809:] 'oh, I see the block of course', to *judgements* [[@809:] 'it secludes very much initially, yes still a quite big block', to *moving ahead* to the next aspect of the design that becomes visible [@810:] 'mmm, the object has something'… this process of viewing and judging goes on while we walk around the building. Many exact visual checks are made. This goes on for nine pages in the interview transcripts. All this 'walking around' worked like in the real world when you walk and talk while you are both inspired by what you see. This passage [@808-@1660] supports the assumption that situatedness can actually be experienced during a virtual walk.

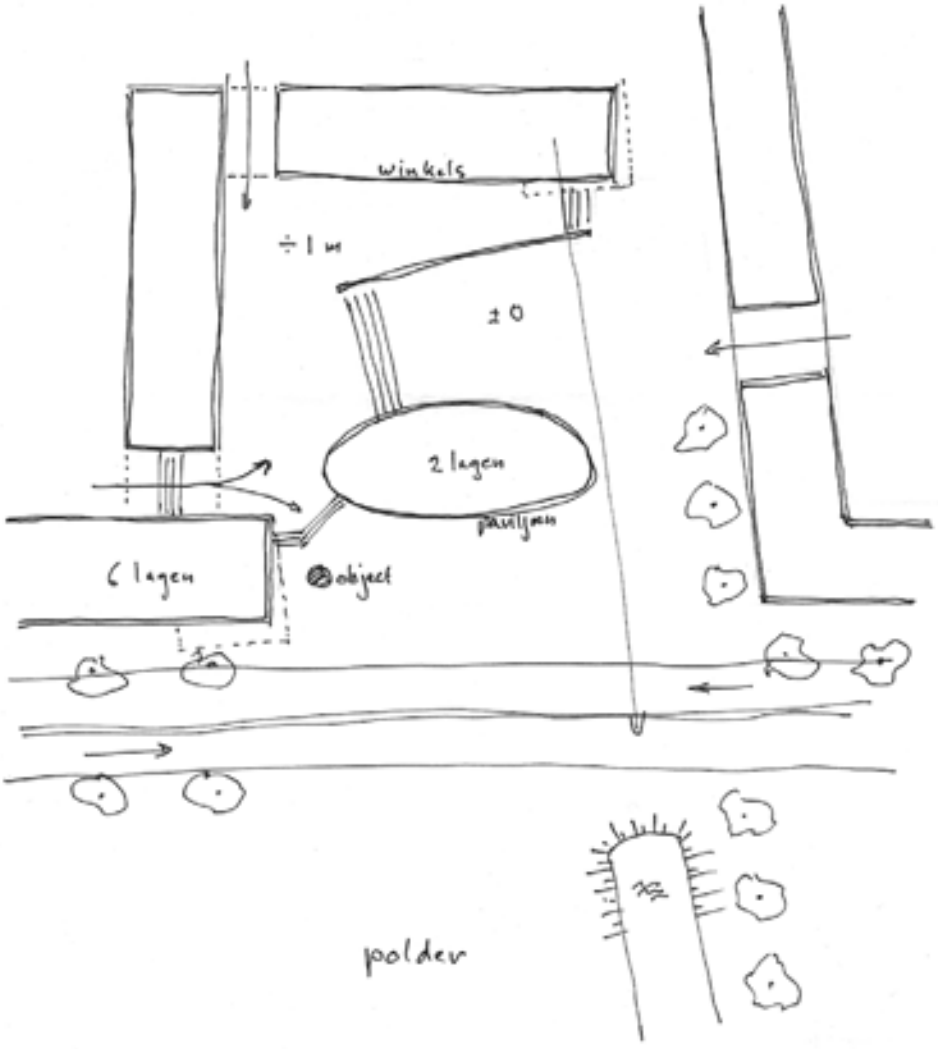
Newspaper image - A1: 'I would like to show it 'from the normal experience', so not from above. I think that it should show what is going on. Therefore, I would choose a point of view with a high angle bird's-eye view. Can you show it. Yes, but this is not as nice as the view through the underpass … but, I want to show the overview to the people. It is a compromise.' [@1641].

Figure 87. Preferred image for publication in a newspaper.



Memory image - Although the memory drawing has several inconsistencies concerning details in the context and the design, main ideas of the free sight and volumes at places where they do not disturb lines of sight, are still recognisable in the drawing. An arrow from a building to the polder ditch, exactly similar to an arrow in one of the design sketches, signifies that the main ideas of the design are remembered. The memory drawing strongly supports the idea that not only the image is remembered but that the driving ideas and characteristics are remembered as concepts and that such concepts are used when reconstructing the idea as an image on paper.

Figure 88. Memory drawing by Architect 1.



Indicative passages concerning the hypotheses

Hypothesis 1 – Situatedness – Almost from the start of the interview, many specific statements indicate the importance of situatedness. E.g.: 'I want to stand on the sidewalk, at the left and the right side' [@39].
A1 switches rapidly between high aerial viewpoints and eye level viewpoints. The contextual model is treated in four ways:

- as an environment, in which you can walk and look around,
- as a model that can be turned around and looked at like you would do with a scale-model,
- as a drawing medium: he indicates that he wants to draw lines on the streets [@32, @46, @109].
- as a 3D computer model, that can be used as source of information, while you make notes and drawings on a sheet of paper. 'I want to go back to my sheet of paper' [@343].

This shows how versatile the 3D-model prototype can be and how the sense of situatedness can quickly change from 'environmental situatedness' to 'object-like situatedness' to 'sketch-like situatedness'. This is in addition to the chosen point of view, representation type and use of available tools.

Hypothesis 2 – Dynamic Views – Different forms of situatedness can be distinguished. The point of view matters for the kinds of aspects that are discussed about. An aerial view provides overview. A1 indicates that he sees orthogonal buildings. He says: 'because I can easily see from above, I am aware that I do consider more of the rest of the city: the bigger composition' [@320]. The eye-level views though [@808-@1660], provide a more direct situatedness in which the architect focuses on details and on dynamic perspectives. 'Less contextual information gives more purity. The surroundings provide atmosphere' [@427].
In addition, the chosen visual representation influences the different sorts of situated thoughts. 'I have the urge to think in blocks when I see a model of blocks' [@310]. When the façade texture mappings are switched on: 'that's a surprise. It is a different kind of architecture than I expected. I can imagine this in the Netherlands; it could exist. So much glass, there must be something to see from these buildings…' [@136].

Hypothesis 3 – Design Stimulation – Changes in situatedness, i.e. seeing in a different way, certainly provide a more vivid reflective conversation. This is indicated by the changing thoughts when A1 shifted from bird's eye views to eye-level views, when textures were switched on and off. Several times A1 expresses his urge to draw and make some notes [@32, @46, @109, @205].

He even wants to use colour pencils in order to note in a coded way [@214]. This shows that he has many impressions that he needs to process and that he wants to reflect upon what he sees.

Hypothesis 4 – Models OF to Models FOR – As hypotheses one, two and three appear to be confirmed by several passages in the interview with A1, the main conditions for the fourth hypothesis seem to be met. A1 does not just see the model as a model OF the urban situation, but he really uses it as a model FOR design activities. The model is used in a 'reflective conversational' way. This means that, using the model representation type and by moving the viewpoint, new questions about the site arise. These questions are answered by the impressions from the model [e.g. @144-152]. The reflective process goes on and on, similar to conversations. This is what actually was expected from the developed model and prototypes.

Hypothesis 5 – Effectiveness – Evaluation of the own design, by means of dynamic views and adaptable representations went well. The design was approached as if it was visited after it was built. This gave the opportunity to reflect further on the design as a whole and on details [@808-@1660]. If this would have been a design presentation in front of an audience, they would have gained much insight about the plan and would be able to participate in discussions by indicating specific viewpoints. By such an approach, the 'vision' of the architect would not be dominant and people could build-up their own point of view.

Hypothesis 6 – Taking Distance – A1 likes reduced information as it is provided in the tested prototype models [@2357]. 'Less surroundings gives more purity. The larger surroundings bring ambience' [@427]. 'In this way (aerial overview), the site in a larger context plays a role. If I was looking at the real site, the larger surroundings would play a less important role [@304].' Seeing and exploring his own design in the represented context almost takes away the curiosity to see the building in real [@1450].

Hypothesis 7 – Combining Methods – this hypothesis sometimes seems to be confirmed and at other moments contradicted in the interview with A1. He told me he felt too hurried by my questions. [@344:] 'I need some quiet; I feel you put me under pressure; then I might take decisions that I cannot overlook.'

4.2.2 Architect 2

Architect 2 had a targeted approach when exploring the virtual urban context. This approach was different from the way the first architect worked to see everything in detail. While A1 wanted to see every feature of the VRML model in small steps, A2 was more impatient and asked to immediately show the model in its best possible way. Later, when the first design ideas came up, the need for much more detailed and specific information did however arise.

Tracing the design ideas

About context - A2 quickly recognised the 'dullness' of the neighbourhood. She decided that some stimulating functions were needed for people in the area. ‘Something spectacular, kind of a pedestal for a sculpture, something must happen there. It is all so monotonous, something different should be introduced. I think if you complete the surroundings with one more block, you will not see that some effort has been made’ [@2652].

First idea - When asked, A1 came up with two ideas: a ‘pedestal’ [@2652] and ‘something with water’ [@2700]. Both ideas were used in the final design. The idea of a pedestal was used as a metaphor and was translated into a raised pond with a heightened basketball field on top of a public Internet room.

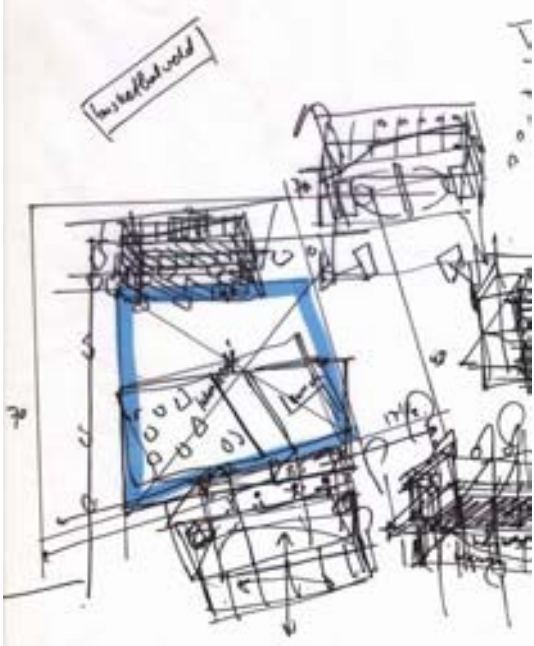
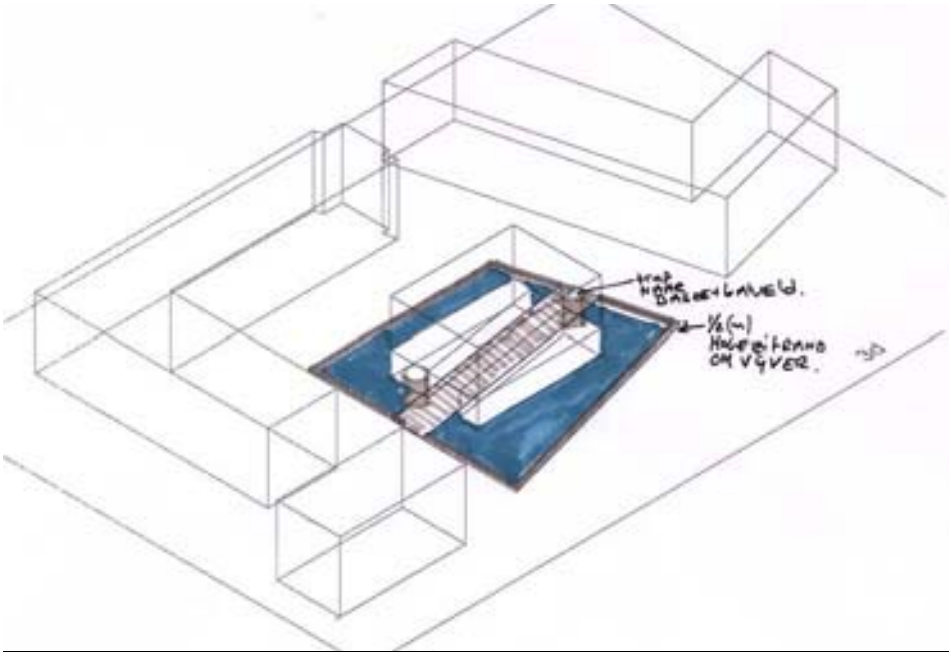


Figure 89.
First sketch: sizes of the site are checked in relation to dimensions of new functions (a baseball field and an internet café).

Refined ideas and choices - Further inquiry showed a more detailed request for information, such as: 'what did the borders of other ponds look like', because: ‘if I also want to do something with water it should not be the same as what is already available’ [@2710]. She concluded that the other water surfaces in the neighbourhood are a small pond and a ditch, both with a somewhat natural border. So her pond should have a border of benches to sit near the water [@2710].
When shadows were discussed, she concluded that new masses should not be too high [@2760]. When I asked her again if there was a certain motive to react to the given context, she repeated that it should not be too high and it should be different in shape [@2830].

The design that was handed in – The design tries to respect the environment. The design contains a new pond and an Internet shop with a baseball cage on top. Existing pedestrian routes are respected by means of a bridge through the building.
The sketches handed in had two different styles. On the one hand, there were design sketches showing many ideas, measurements and shapes on one piece of paper. On the other hand, there was a small booklet with 2D and 3D CAD drawings, which precisely showed how the design needed to be placed in its surroundings and how the space could be used.

Figure 90. One of the design drawings by Architect 2.



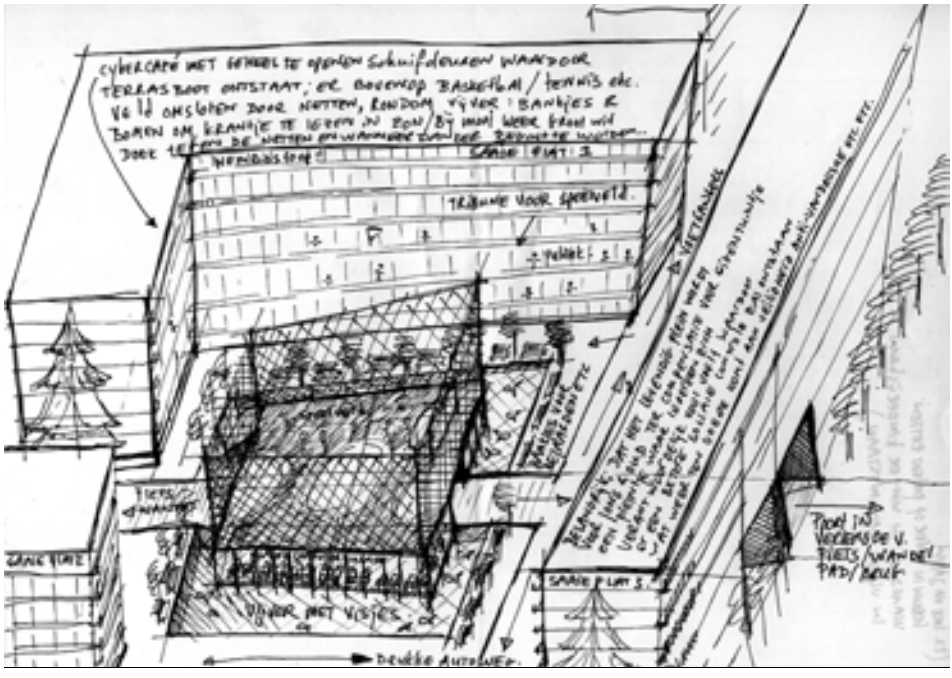
Reviewing own design - 'The (blue) stairs at both sides stand out. In fact, I wanted to change them, let them continue to the inside of the bridge, or do something else. They really catch the eye those spiralling stairs. Or I would make them more transparent, glass, or just open.' [@3320].
'I would really like to "bungle" on with the design for some more days. Right now I cannot tell what to improve…' [@3440].

Newspaper image - She prefers a view in between bird's eye and eye-level. A2: 'The image should also show the trees and some people' [@3627]. The colour of the street is a problem for her; it looks too much like Lego… [@3635]. A black and white image would solve this. A full colour image, with trees and people on it, would be good for a neighbourhood journal.

Figure 91. Preferred image for publication in a newspaper.

Memory image - There are no obvious mistakes in the memory drawing, unlike some of the memory drawings from the other architects. However, the drawing shows A2's feelings about the site in a very straightforward fashion. The memory sketch reveals interesting written side remarks. Each block of flats is numbered: 'boring flat 1', 'boring flat 2' ... The design is described by its functions and qualities: 'cyber café with completely opening sliding doors so that a "terrace boat" is created; on top a baseball / tennis field surrounded by nets. Around the pond: benches and trees, to sit and read a newspaper in the sun. If the weather is good, the nets could have a large white cloth as a projection screen for an open air cinema. The existing houses are like a tribune for the playing field. Important: as the houses do not have gardens, the lively square functions as compensation for both the young and the elderly. They feel responsible and this stimulates better social control and a safer place. The gate is in line with the bicycle/wander route and the bridge through the building'.

Figure 92. Memory drawing by Architect 2.



Indicative passages concerning the hypotheses

Hypothesis 1 – Situatedness – Right at the start of the interview: 'It's as if I am looking into a room, it is not exactly clear where I walk' [@2520]. Quickly, after looking at viewpoints on the ground and from the air, she says: 'Now that I have walked around, at this stage in the design process I think that I have seen the atmosphere and know about the streets and façades [@2622].

Hypothesis 2 – Dynamic Views – A2 clearly prefers to see a rich image: overview textures on the façades, higher viewpoints. She wants as much information as possible in one overview. She indicates there might be a possible bias because everything looks quite chic and new, while in reality it might be an older neighbourhood. She thinks it is because of the bright colour and the width of the sidewalks [@3107].

Hypothesis 3 – Design Stimulation – At first when she has her first 'visit' to the site, she looks rather quickly. Later, when she needs more specific information, she directs the viewpoint to get specific answers, e.g. [@2705] she wants to see the border of the pond behind the big flat.

Hypothesis 4 – Models OF to Models FOR – She says that if you had been to the real site initially, she would expect that the model would be good enough to work with, even if it did not have façade textures [@3008].

Hypothesis 5 – Effectiveness – During a design presentation A2 would first show images of her own choice (e.g. a calm animation) and then if there were questions, she would like to have the prototype system to go to specific places [@3815]. 'If you want to be chosen in a design contest, you should tell everything by showing just two images. People do not take time to study everything, so you need to be clear' [@3557].

Hypothesis 6 – Taking Distance – When façade textures are used, the model is good enough to be used as a contextual information source in a design contest, without a real site visit [@3020]. She indicates that in real design assignments, it is necessary to visit a site, but in certain conditions (if you live far away and if it is not yet for a full assignment) the model is sufficient on its own. This does not completely support the hypothesis.
At another point during the interview, when we talked about software features like gravity, she indicated that such a program should not exclude the impossible. She likes to be surprised by things that at first sight would appear impossible. Software should not exclude potential surprises, but instead should

allow for unexpected eye-openers. [@3740-3755].

Hypothesis 7 – Combining Methods – There were many occasions during this interview where I tried to push a bit in order to get more insight and answers. However, A2 was not influenced in any way to adapt her design approach. The following passages support the hypotheses that interventions, questions and instructions do direct the focus of the interview, but that the real preferences, choices and methods of the architect are not influenced. Sometimes I was aware that a specific word or kind of phrasing might steer to a certain direction. In such instances I would try to talk in different ways to neutralise possible suggestions. At the start of the interview, we took a view from above. While I gave explicit instructions to walk around: '…we are going to walk around the site…' [@2504], I thought an eye level view should not be prescribed, so suggested that she should instruct me about what positions to go to, eye-level or from the air [@2510]. Complying with these instructions she told me: 'I want to start at eye-level' [@2513]. Later: 'and now I want to see more' [@2535] 'a bird's eye view' [@2541]. I gave explicit instructions to think aloud: 'If you are surprised or if you conclude something, you should say that in order to let me know what you actually see' [@2516]. She complied thinking aloud: 'it's as if I look into a room, it is not completely clear where I walk. I do not see a road to follow' [@2520]. She told that she would go and think about the design and would come back later if she needed further information about particular features of the site. I encouraged her to gather as much information as possible during the first design session [@2615-2650]. She got particular interested in the water areas in the surroundings and concluded that actually she needed much more information concerning this aspect. Then she came up with an interesting thought [@2735]: 'I think there is a difference, if you have actually been at the site, you would think the information in the model to be enough, as a reminder. However, if you have not seen the real site, you need much more information'. Such refined insights would not come from a straightforward 'think aloud' design experiment in which the architect is not allowed to discuss with the researcher. Such insights might remain undiscovered if the results would just have been enquired by quantitative methods like Protocol Analyses.

4.2.3 Architect 3

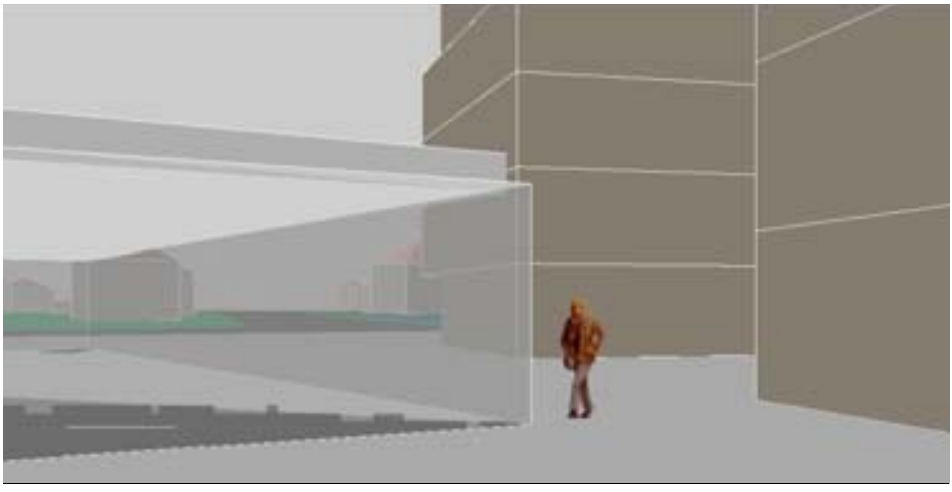
Based on the digital sketch impressions, Architect 3 came up with a 'Ying and Yang sign shaped building' that should respond to and interact with the existing urban environment. She proved to be very sensitive to the representational aspects of the VRML model. On the basis of the images, she indicated that great care should be taken with the introduction of 'not really existing transparency' and other visual cues that do not directly relate to the real image of façades [@5535]. On the other hand, she appreciated the sketch tools and liked to explore the site and the design from different points of view. Another delicate aspect that she mentioned was the representation of a red wall in her design. Representation of materials in the computer can easily fail and should be carefully refined before being shown to a client.

Tracing the design ideas

About context - 'A rather spacious ample site' [@3928]. 'A very empty / bold square, is what it seems. Something needs to happen there' [@4313].

First idea - Lines of sight gave an important direction to the design. Several times, she named the same lines [@3910], [@4930], [@5710] and she recalled them also in her memory drawing. She investigated whether she should follow ('pick up') the line. In order to find an answer, she went to specific places and checked the views [@4930].
A more concrete first design idea was formulated as 'a transparent pavilion-like volume' [@ 4957].

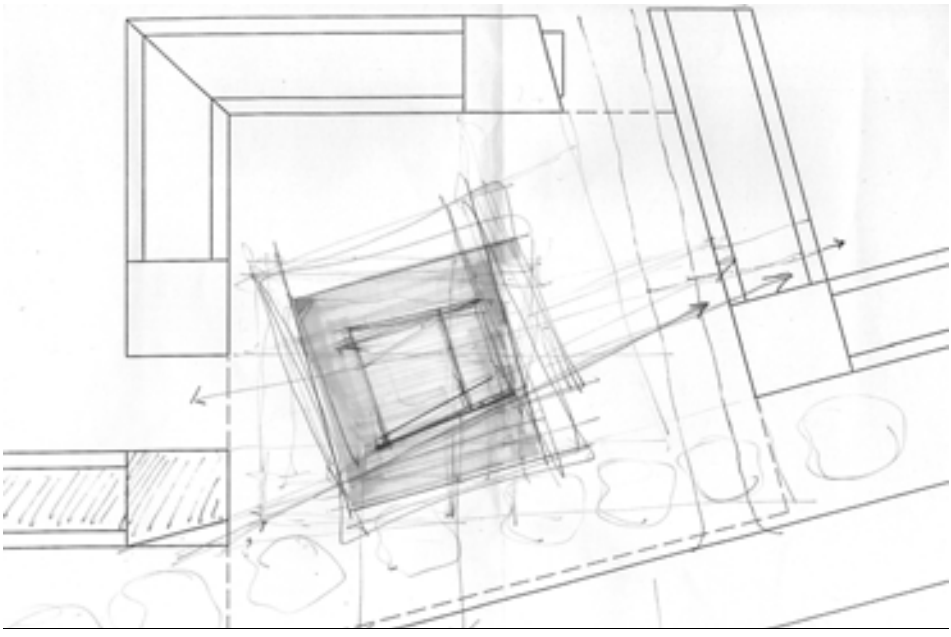
Figure 93. First computer sketch by Architect 3.
Test of the proximity of the square building to the housing block.



Refined ideas and choices - A3 was the only participating architect who tried to actively use the available sketch tools. She drew a box volume on the square in order to find out how she could 'break' the big space. She walked around the sketch and checked the proximity of an edge near the existing building. Sizes were checked by placing several human figures on the street. The human scale gave feedback on the actual sizes.
Ideas from the sketch explorations were directly used in the final design proposal.
The sketch (consisting of just a transparent box with a flat roof box on top) was made very quickly. Investigation into how the sketched object would look from different viewpoints took more time. The 'dynamic perspective' was investigated by walking around.
At a certain moment she felt the urge to sketch on paper, in order to find out exactly which lines she wanted to pick up [@5300].

The design that was handed in - The proposal handed in had distinct similarities with the original computer sketches. Original ideas and insights were not rejected, but were developed further into an elegant pavilion building.
Reviewing own design - Seeing her own design in its urban context was a joyful experience for A3. Most of the design and its details were as expected. Whilst virtually walking in and around the building, she mentioned the

Figure 94. One of the design drawings by Architect 3.



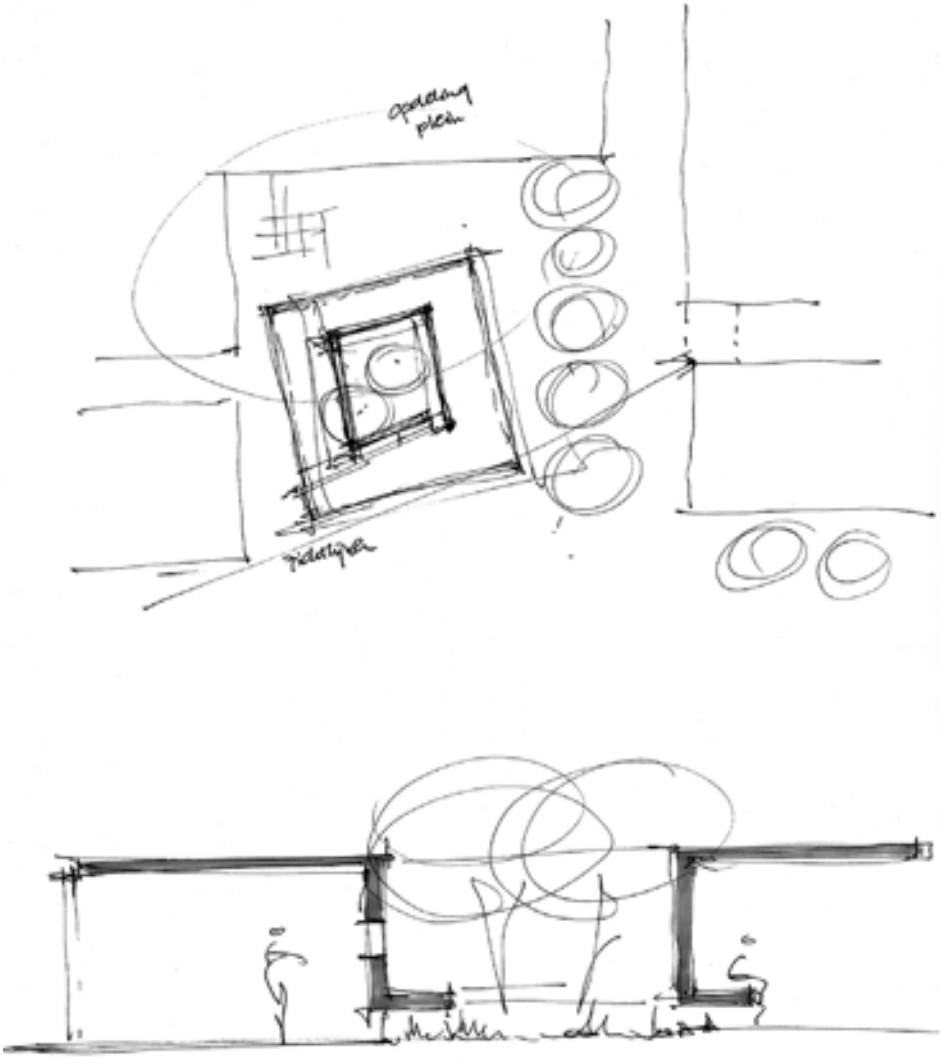
features and judged them positively. Some details in the design needed a bit more refinement. The reasoning behind certain decisions was explained further [@5400– 6000].

Newspaper image - A3: 'I would like to show several images. One from here ... and one from the small underpass … and a bird's-eye view is important' [@5900].

Memory image - The memory drawing was a very accurate reconstruction of the original concept. The section shows details in the same way as in the original design. Written remarks: 'division of square', 'lines of sight', 'Essence: inversion of the building; the garden is located in the heart and is protected/sheltered and modest in expression, the building is turned outwards, showing what's happening. Paving stones give the square a human scale and they continue throughout the pavilion'. This essence of the design was almost identical to what A3 talked about during the previous virtual walk interview [@5904]. Specific angles from the site were not recalled, but this does not reduce the qualities of the design, nor its placement on the square.

Figure 95. Preferred image for publication in a newspaper.

Figure 96. Memory drawing by Architect 3.



Indicative passages concerning the hypotheses

Hypothesis 1 – Situatedness – Most passages of the interview with A3 took place during virtual walks around the modelled site. For both the Architect and myself (the interviewer / researcher), the walks resembled much of a real walk. We sometimes stood still for some time, to discuss a certain line of sight. At other moments, we deliberately went to a specific point in order to check something. For instance, while taking screen capture images, for A3 to take home, I might say: 'do you have that one?' and she might reply: 'Yes, I have that one with the masses. I like to turn over to the square in a moment.' [@4918]. Such talks were reminiscent of a real site visit whereby one might speak about which pictures each had taken.
At the start of the second interview, she walked towards her own building in the given urban context: 'Ah, I'm coming from this side [gets situated]. A ha, those are my trees [gets acquainted]. Wow, you can look right through the building, that is good [starts reflection]. Nice! My first realised building' [plays with the suggestion of reality], [@7417].

Hypothesis 2 – Dynamic Views – Different forms of situatedness were experienced when the façade texture images were switched on or off. When the images were switched on, A3 felt more atmosphere and a sense of realism. Then, when the images were switched off, it was useful to have forms with more abstraction in order to focus on the main aspects of form, direction, distance and size.
A main critique about the model on the computer screen was that A3 found it a bit flat. When the 'fog' was put on, this improved [@4349].

Hypothesis 3 – Design Stimulation – When talking about the way the roofline ought to be laid-back, A3 literally explained how she sometimes picks up sketch ideas that come by mistake: 'When we made the computer sketches we have put a placard on top, a flat box on a box, it was laying a bit back, by accident so to speak but I picked that up in the design' [@5653]. 'It is like sketching, when you draw lines and one line by chance can give you an idea' [@5700].
Seeing the design standing in the environment model 'generates new ideas' [@5953].

Hypothesis 4 – Models OF to Models FOR – Thought processes were triggered, focussed and situated by being confronted with the changing views from the model. The whole sketch exercise and the processes of walking, talking, reflecting, looking around the environment, strongly supports the idea

that such an adaptable urban context model can be very fruitful when used as a model for design.

Hypothesis 5 – Effectiveness – Evaluation of A3's own design and those of other participating architects went well. Instead of serial vision presentations (e.g. slideshow or animations), the evaluator can take her or his own decisions on how to view the characteristics of the design in its urban context.
'Actually, you can stand where you want, it is in fact like a scale model, because the disadvantages of renderings is that someone else decides where you stand, while a model can be turned around. However, you cannot enter a physical model [unless you use an enthescope], while this computer model allows to be entered' [@6036].

Hypothesis 6 – Taking Distance – Researcher: 'if you were really there, you might see bicycles standing and children passing by…' [@4000-]. A3: 'No, now it is first about the study of form, surfaces, transparency, lines of sight. Maybe, that is essentially the good thing in such a model, that you can forget the bicycles and the children for some time' [-@4006]. However, 'you cannot do without a real site visit' [@4417].
When she has learnt more about the buildings and the neighbourhood, A3 prefers less realism in the context model. [@4507]: 'now I can conceive much more', 'the danger of a computer (model) is that you want to make it too realistic, than it does not work anymore' [@4557].
However, when later on the textures are switched on again she says: 'Yes, this helps to bring back the reality' [@5121].

Hypothesis 7 – Combining Methods – A3 gave clear instructions about what she wanted to see in the model. When, at a certain moment I turned on the view with boundary lines, she immediately said that she had not asked for that [@3948]. Later, when she did want it, she indicated to actually like the boundary lines [@4835].
For the rest, everything in the interview went smoothly. Many aspects were discussed in the natural flow of a virtual walk.

4.2.4 Architect 4

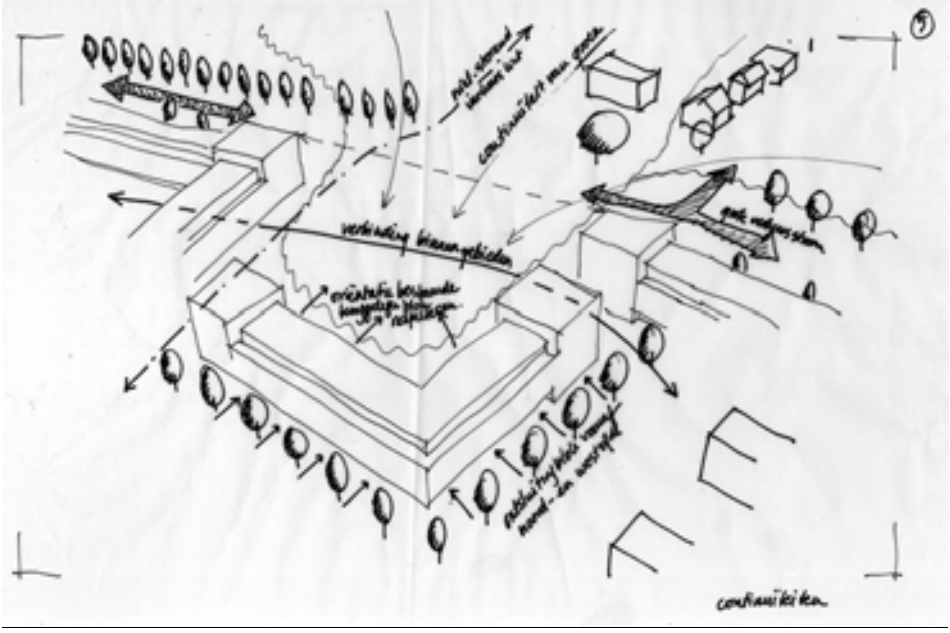
The design of Architect 4 expressed many facets of her comments about shape and atmosphere of the urban surroundings. The design contains promising ideas for further development of the area. Her comments were particularly interesting because of the many metaphorical and connotative subtleties, showing that a real site visit involves much more than may be represented in a model. Detailed demographic and social aspects cannot be understood properly if the site has not been carefully studied.

Tracing design ideas

About context - Initially A4 expressed disappointment about the model, indicating that many aspects cannot be seen in the model. 'I want to taste the ambience. How it smells. I want to know if the neighbours are a supermarket or a sewing workroom…' [@6832]. Later she seems to reconcile and focuses particularly on the morphological aspects.

A4 also tells about her structured way of analysing: 'I link a set of images to a map. That takes some time, but you start to understand the structure of the area. When I take pictures myself, I stand in the middle and take pictures from all directions and of all roads, in a very structured way. However, this model already provides a good structural overview so that you need to spend less

Figure 97. First analytical sketch by Architect 4: 'continuities'.



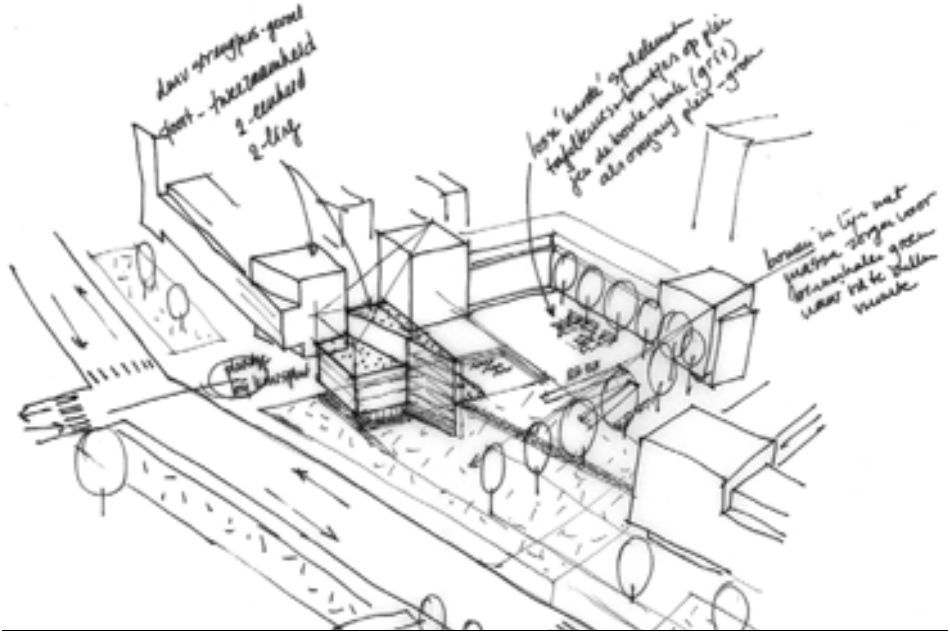
time in analysing 'by bike'. The model provides something ‘extra’ compared to say a cadastral map.’ [@7020-7030].

First idea - ‘here nothing is happening, but that’s a possible motive for something to happen on the empty square’ [@7205].
She is preoccupied by the shapes of the corner buildings [@7212].

Refined ideas and choices - Further ideas were developed as sketches by using tracing paper on top of printed screen captures. Considerations were noted down in a series of analytical sketches with themes like: functions, continuities, perspectives, sun and trees, characteristics of the blocks. All these studies were aerial views, except one eye-level perspective of the street that was made to study the continuity of trees.

The design that was handed in - The design consists of a composite building volume that emphasises the directions of the site. A pocket park with trees adds to the further arrangement of the square. Parts of the façade mimic (mirror) the opposite façades. Other parts are left intentionally under designed, because further reviewing and reflecting needs to take place.

Figure 98. One of the design drawings by Architect 4.
All sketches were made as overlay on a printout of screen captures.



Reviewing own design - A4 takes the chance to look again at the context, to check the rhythmic aspects of the higher corner blocks [@7931-7957]. She likes to see her building represented in the context model. She explains about a 'cut off' idea that she wanted to react to [@8020]. Some design aspects are explained by musical metaphors [@8110-8120] or in reference to the shape of a brick [@8123].
She sees her design as an open idea, a 'vision for the given area'. It can be developed further and it could still change in detail. 'Let it be model, let it indeed be or houses, or catering, or a theatre, or a museum' [@8335]. 'Something that is not finished stays open for better ideas' [@8408].

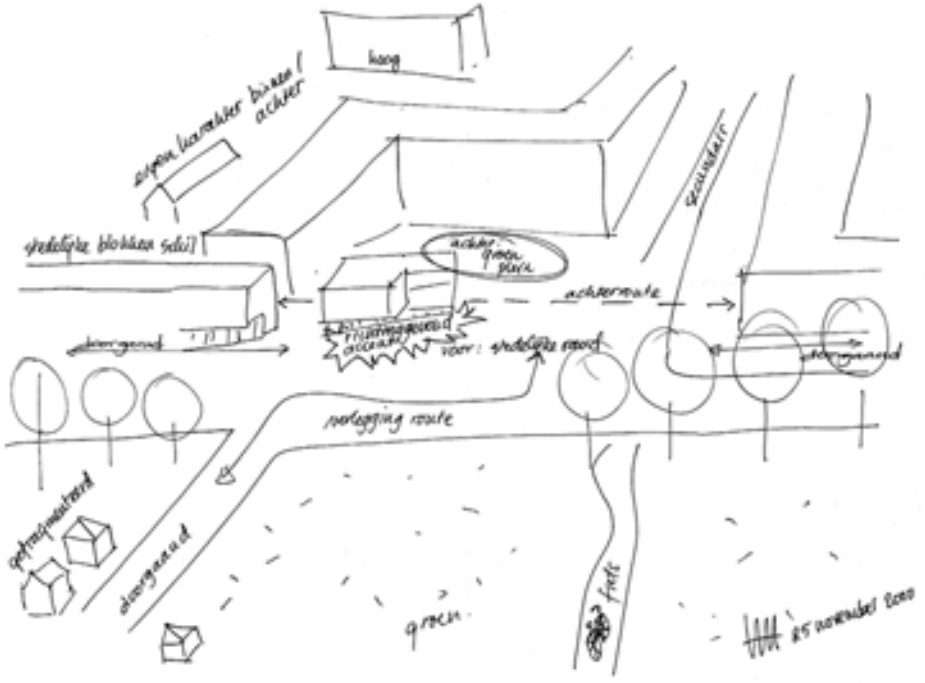
Newspaper image - A4: 'The sort of images to be used in the presentation depend on the audience and the goal' [@8420-8430].

Figure 99. Preferred image for publication in a newspaper.

Memory image - The memory image shows quite an accurate spatial representation that resembles the newspaper image and high viewpoints used in most analyses and sketches of A4. In addition, like in the analyses and sketches, she used written labels to indicate several aspects, such as: high / secondary / own character, inside, behind / urban block peel / continual / green / fragmented. The designed building gets the label: 'direction giving accent, for: urban border/edge'.

The changing direction in the buildings is remembered correctly, but the way it was actually accentuated was not drawn in detail.
Issues that were not made clear in the model, like the actual functions of buildings, were not indicated. This is consistent with the previous judgements of A4, which holds that subtle and necessary facts can only be collected by making a real site visit. By comparison, the labels in the memory drawing of A2 have much more to do with functions and social effects. A4 indicated the importance of such aspects, but she could not reflect on them, as they were ambiguous, at best hinted at, in the model.

Figure 100. Memory drawing by Architect 4.



Indicative passages concerning the hypotheses

Hypothesis 1 – Situatedness – A4 did not talk in such a way that it can be concluded that she felt very situated in the given virtual environment. She was inclined to treat it as a design medium that could provide part of the needed information.
She wanted 'to taste the atmosphere of the surroundings' [@6832], to know what kind of people live there and what they do. The same city structure, the same space and the same sizes of buildings can have a totally different impact when you see the function, the condition and the social use. This she calls the 'danger of the (styrene)-foam model' [@6958].
Situatedness is more of a mental process for A4, rather than an immersed experience within a virtual model. [@7012]: 'if someone else takes pictures for me, it takes some time to find out what each picture is taken from, but while matching the pictures with the plan you familiarise yourself with the urban structure'. [@7344]: 'to have just one single image, means a lot to easily bring back my thoughts in a later stadium. People might say, 'then you will be confined to what is on that particular picture'. I think if you train to use keywords and if you note some things down, one image can help to remember much more. Especially if you need to do more things at a time, it is useful to remember the things that were interrupted for instance by a meeting'. This shows the potential role of media as reminders.

Hypothesis 2 – Dynamic Views – The animated helicopter view (circling around the centre of the site) was appreciated. A4: 'For me you could have started with this image [@7419]. This is nice as a 'screensaver'. At first I would look at this and then while working and thinking further, I would like to have this image turning on and on' [@7430].When looking at eye-level height, she sees the underpass: 'hey, that's funny, I did not see that before' [@7520].
A4's way of working shows a more relaxed use of the image production power of the computer VRML model. It can just be used as a constantly available source of referential images, while you work with pencil and paper on design alternatives. A4 also mentions a practical aspect of using both traditional and digital media in an alternating way: working constantly with a computer mouse can cause RSI. The method to use dynamic views is thus extended to the approach to also dynamically change work methods, media and tools.

Hypothesis 3 – Design Stimulation – A4: 'For the different kinds of awareness, I need different images' [@7324]. This shows the need for different viewpoints and representations.

Hypothesis 4 – Models OF to Models FOR – Architect 4 introduces another concept of situatedness. Kinds of situatedness that can be gained from thoughts that can be remembered by seeing one single reminding image. This relates to her preference to see the continual circling helicopter-view animation that can serve as a trigger while she makes sketches. A4 uses the model as a model FOR design, but the actual visual meaning of the model has more to do with remembering than with exploring. The exploration has to be at the real site.

Hypothesis 5 – Effectiveness – When reviewing her own design and those of others, A4 uses the model quite differently than in the phase of site exploration. She walks, situated, around the building and explains or comments about many aspects. Her accurate understanding of the designs of the other participating architects, makes it clear that it is possible to make a comparative review using a basic context model, with switchable design inserts and freely adaptable visual representations and viewpoints.

Hypothesis 6 – Taking Distance – According to A4, the kinds of digital media presented in this experiment can certainly have value in the architect's office, but they should not replace design sketching and other representational methods. Consistent with this point of view, she preferred to work on the printed views by tracing the main features onto semi-transparent paper, adding design sketches and side remarks.

Hypothesis 7 – Combining Methods – During the interview with A4, it became clear that she did not talk as if she felt immersed in the virtual world. She indicated things by pointing here and there, but she did not speak much about e.g. ‘walking a bit further’. At one point I deliberately spoke in a situated way [@7528]: ‘this is the first time that you stand on this square, now you walk to the zebra crossing’, but this did not have much influence on her way of talking in a less situated, detached way. This indicates that the way of asking did not influence the actual ideas of A4. At the same time, instructions and further questions did reveal aspects that would not have been addressed in the same way in a straightforward design-task experiment.

4.2.5 Architect 5

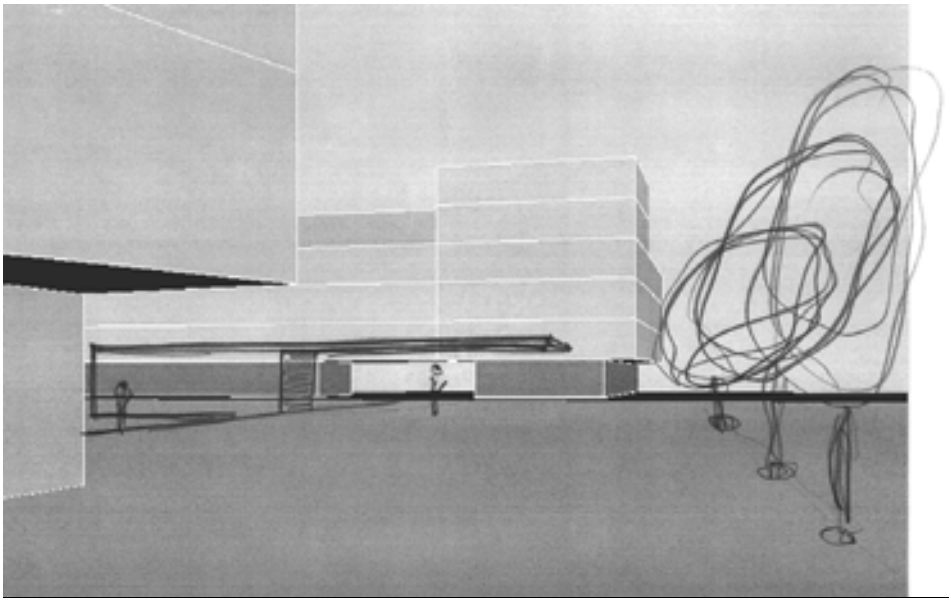
Architect 5 was inclined to respect the open space which could be used for diverse temporary functions in the already densely built-up area. His design consists of a slightly lifted zone of new pavement, a row of trees and a small semi-transparent flower-shop with an expressive roof. This minimal approach facilitates flexible use of the space.

A5 was quite enthusiastic about the possibilities of the VRML model and the prototypes. He saw these developments as potentially useful tools in architects' offices. At the same time, he mentioned a different approach for the presentation phase. The urban context can be presented much more poetically and less literally, in order to 'tell a story' for the clients. Precise representation of the surrounding buildings would only distract people from the presented design and its 'story'.

Tracing the design ideas

About context - At the start he wanted to put in a scale puppet, in order to understand the scale of the buildings [@9110]. The blocks reminded him of Laakhaven in The Hague [@9131].

Figure 101. Design sketch on top of a printed screen image.



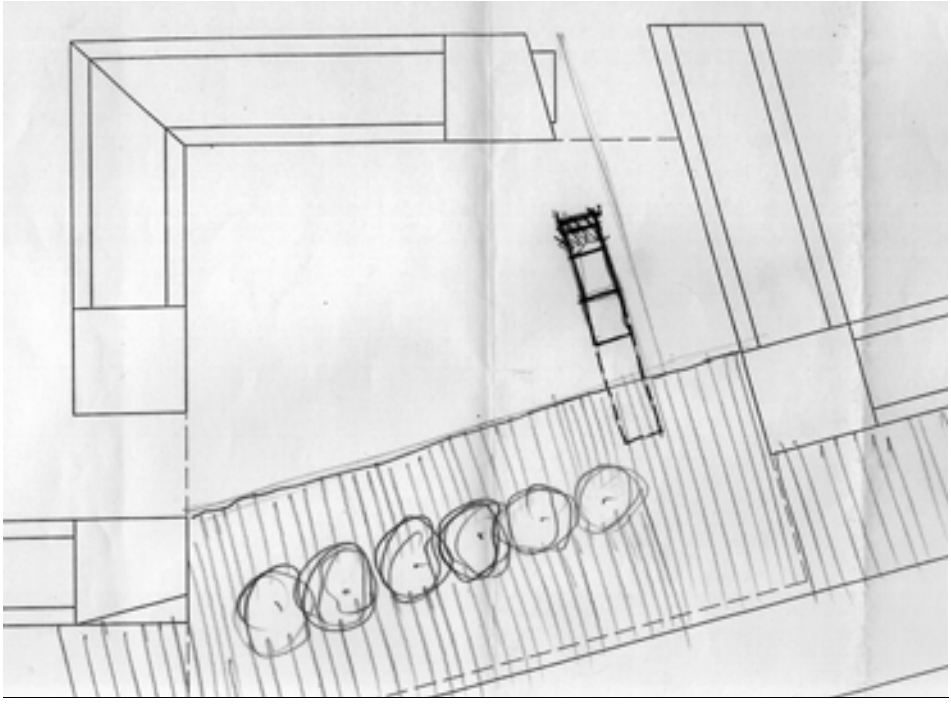
First idea - 'I would make 'a different world' on the square, something that makes you not see the façades' [@9230]. If you put too much there: 'square gone!' [@9839].

Refined ideas and choices - A5 did not happily use the sketch tools, as they often proved to be very time-consuming. 'Yes, I sometimes do that, but often it takes much time later on to get rid of the idea' [@9856].

The design that was handed in - Pencil sketches were made on top of perspective prints and on the map. The main directions of the urban context are used to make border zones to emphasise the form of the open space.

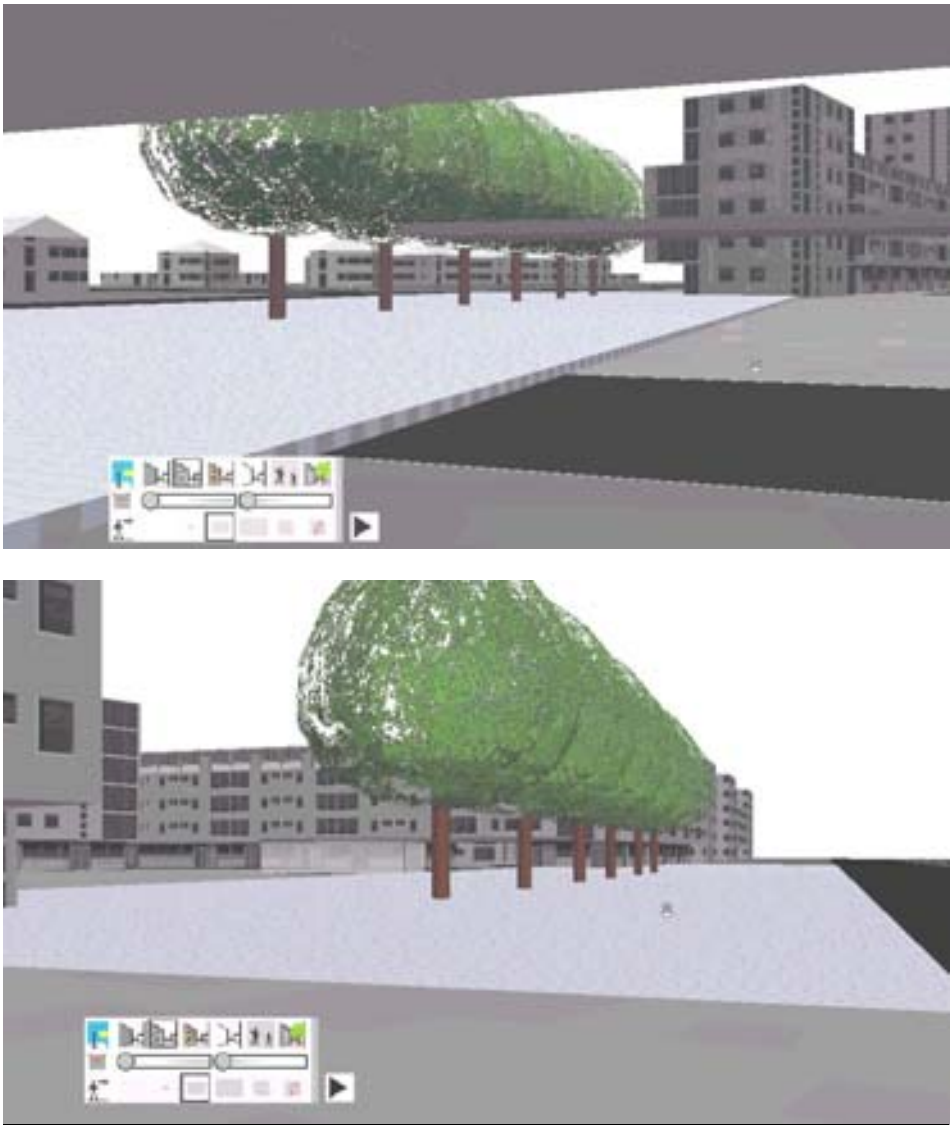
Reviewing own design - Careful placement of the flower-shop and the row of trees is reviewed from different angles. As the objects were kept movable in the digital model, we could try out subtly different positions for the shop and the trees, but it turned out that the initial placement was accurate and well considered. By moving the trees slightly towards the street, or a bit more towards the square, the spatial implications could be explained quite precisely [@10430-10461].

Figure 102. The design by Architect 5 as a 3D model in context.



Newspaper image - A5: I would not choose a view from above. I think you should use more than one image to tell the story about such a space. The design should be a bit more emphasised in comparison to the surroundings [@10657].

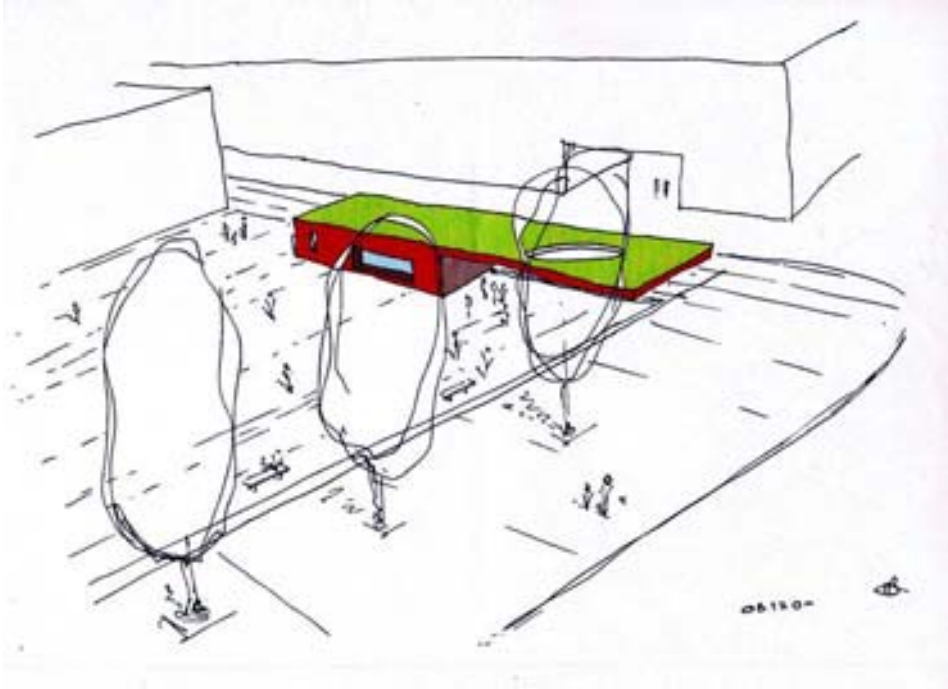
Figure 103. Preferred images for publication in a newspaper.



Memory image - The memory image of A5 has an enduring, suggestive quality. The trees, for example, do not give reason for dispute as is often the case with trees that are visually represented in computer models. His trees are simple lines, but they have still a typical 'tree-ity' and they are not '80% transparent', they are transparent where they need to be transparent. The first tree is almost solid in its foliage, while the second and third tree are equally simple, but they become transparent in order to show the design.
The building itself appears to be much larger in the memory drawing than in the computer model. The atmosphere of the whole comes across as friendly, while the context of buildings does not idealise the situation.

The way A5 presents his design proposal through his design images and memory drawing is consistent with his expressions about how he likes to work with contextual models and drawings. The surroundings should not be too exact, but they should reflect the atmosphere of the neighbourhood [@9310-9350].

Figure 104. Memory drawing by Architect 5.



Indicative passages concerning the hypotheses

Hypothesis 1 – Situatedness – A5 actively 'situates' himself by checking the scale, by putting a scale puppet near the façade [@9110] and by changing quickly from eye-level views to birds eye views and back again [@9100-9260]. He was instructed to look around, as an architect and to tell everything he sees, his interpretations and thoughts [@9103]. He picks that up and indicates he wants to look along the streets, turn, look over the square and then suddenly the sense of situatedness is spoken out: 'With our back towards the big block there' [@9109]. This indicates that the feeling of situatedness begins to include 'what is behind' and involves both the architect and the researcher with whom he talks.

Hypothesis 2 – Dynamic Views – When the façade textures are switched on, the impressions change and the thoughts are directed towards the façades and atmosphere [@9222]. A5 directly indicates the influence of single images: [@9151] 'with this image, with the lines, from under the canopy, you immediately have a sense of scale', while [@9231] 'this image (with the façade textures), would motivate to make something to hide the façade and create another world on the square'. 'That influence would not be there if I would just see the abstract blocks' [@9240].

Hypothesis 3 – Design Stimulation – The reflective conversation, (changing viewpoints to see, to conclude and to go on to next points of view, that require yet other viewpoints to be investigated), starts immediately in the first phase. A5 wants to see and check nearby features from an eye-level perspective [@9100-9530], then he wants to see from above, zoomed out as he wants to check if there are similar large squares in the neighbourhood [@9535]. The higher viewpoints bring up different questions: about how much traffic is on the streets [@9606] and where the north is [@9619].

Hypothesis 4 – Models OF to Models FOR – Usefulness of the model is confirmed, but the extensiveness and quality of the larger model as a whole is not. A5 indicates a preference for working with sketch paper, or sketching on top of printed perspectives from screen captures. His present position in the architectural office no longer requires him to design in detail using CAD programs. That takes too much effort and time [@10110-10120]. Therefore, the model acts as a model for design, but not directly. The model generates images and impressions which are subsequently used and other people in the office do the actual modelling and drafting.

Hypothesis 5 – Effectiveness – A5's answers do not support the hypothesis that the experimental system can simply be used for presentation without personal instructions. Architect 5 really wants to present his 'vision' by his own type of representation. Presenting just with a given context model would not emphasise the design intervention enough, or it might be an 'overkill' [@9340]. The context should be kept simple in order to let the eye and imagination fill in the rest. The right atmosphere can be evoked by montage techniques and simple cues from typical façade images [@9310-9320].
A5 would create his own serial vision, based on the walks through the computer model. Then he would print some selected images and 'sneakily' trace them over with a pen [@9708].
When viewing the designs of the other participating architects, A5 could easily understand, evaluate and criticise them. Views of the other designs were used to support his design. He empathised with the other views and elaborates his own vision [@10926].

Hypothesis 6 – Taking Distance – In his design practice there had never been a site that A5 did not visit. Visiting each site can become a dilemma if you have many projects and if many people work on the same projects together [@9738]. He also sees the advantages of having the 3D model available in the office. In that way, a lot of information can be shared [@9624]. The 'virtual walk' through the 3D model is referred to as 'we have walked extensively through the site so that it is stored very well in your head' [@ 10528]. 'In fact, this substitutes a extensive series of site visits' [@10537].

Hypothesis 7 – Combining Methods – Understanding an architectural design and reacting to a given urban context takes time. Answers in research are not always straightforward. The interview with A5 made it clear that some motivations can only be revealed after a more extensive talk. For example, A5 argued about the qualities of his open and spacious square after seeing the designs of the other participating architects. [@10925]: I reason based on the larger urban plan. I saw there is rather little open space.
Direct questions were partially confirmed [e.g. @10612] and partially contradicted by A5 [e.g. @10657]. There does not seem to be any evidence that A5 was influenced by the way questions were asked, nor that the participant was in any way trying to satisfy the researcher.

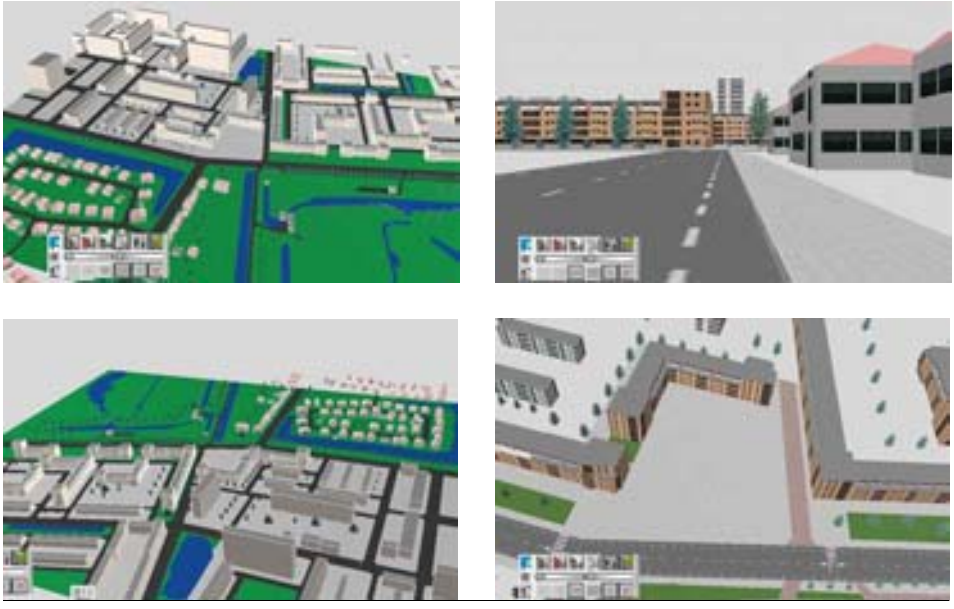
4.2.6 Architect 6

At first sight, the interview with Architect 6 went much different from the other interviews. There were almost no indications of situatedness because the digital model was constantly seen as a medium and as a source for information to be evaluated [@11960]. The model was not treated as an *environment* (a building site) for a design assignment. A6 started to ask questions about the digital model instead of concentrating on what he could do with it. Furthermore, design ideas were hardly expressed during the interview; most ideas came during the private design session in-between the first and the second interview.
At second sight, the interview with Architect 6 did prove useful and interesting as it brought unexpected answers that questioned the research framework. The interview gives useful insight into the conditions for a reflective conversation and it indicates that other approaches need to be considered.

Tracing the design ideas

About context - Much of the first interview with A6 was about recognition in relation to different viewpoints and representation types. The recognised aspects ranged from functions (houses / flats) [@11558-11600] to dated styles (seventies and later) [@11705]. A6 said you need to know what makes a site *specific*. According to him, that is not the 'micro' but the 'macro' information,

Figure 105. Images collected by Architect 6 to make his first plan.

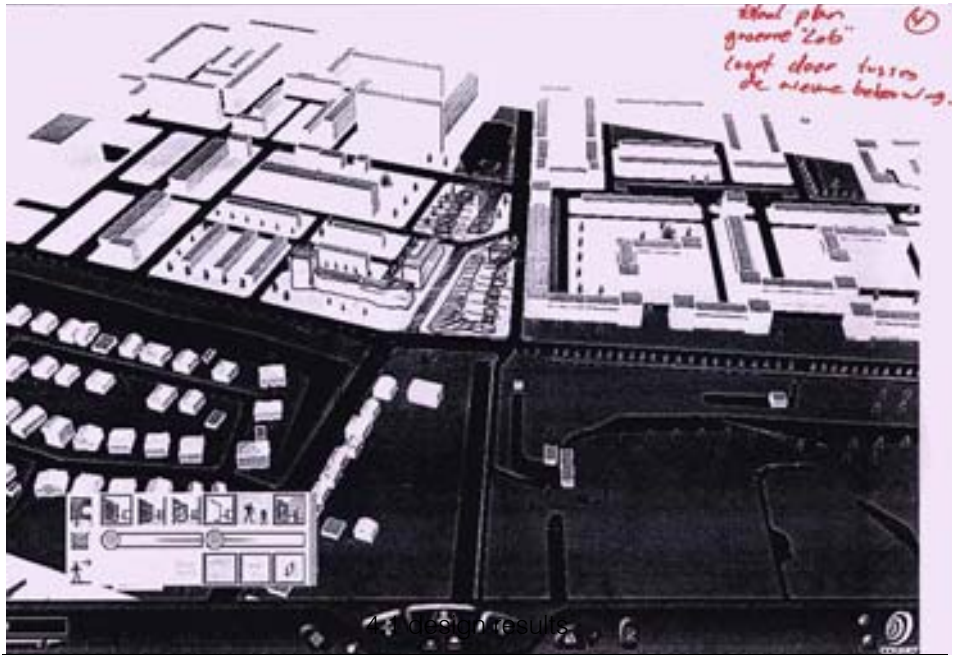


such as ‘located near the sea, next to a highway and whether it is possible to combine working and living’ [@11715]. He prefers to see maps and overviews to get objective information.

First idea - When asked about first ideas during the first interview, A6 came up with ‘some possibilities’ [@12000]: ‘Detached, or at the edges. I also have to think about what is needed at that place, you keep many things free to be decided and how big can it be. A tower of fifty storeys?’

The design that was handed in - In most of his answers and in his design, A6 looked to the larger scale aspects in this design assignment. He drew his design interventions in five steps on top of a photocopy of an aerial view. His comments about the site were based on the structural connection between the left and the right neighbourhood. Existing buildings 'were blocking the wedge-form' where the two building directions met. His design goes beyond the area given in the design task and includes the demolition of a building block and introduces a much more open spatial ‘connection’ to the rigid structures of the two neighbourhoods. His approach gave an unexpected dimension to the broad range of possible improvements for such an area.

Figure 106. Architect 6 made a collage of collected images to draw the design. Some unwanted buildings were deleted.



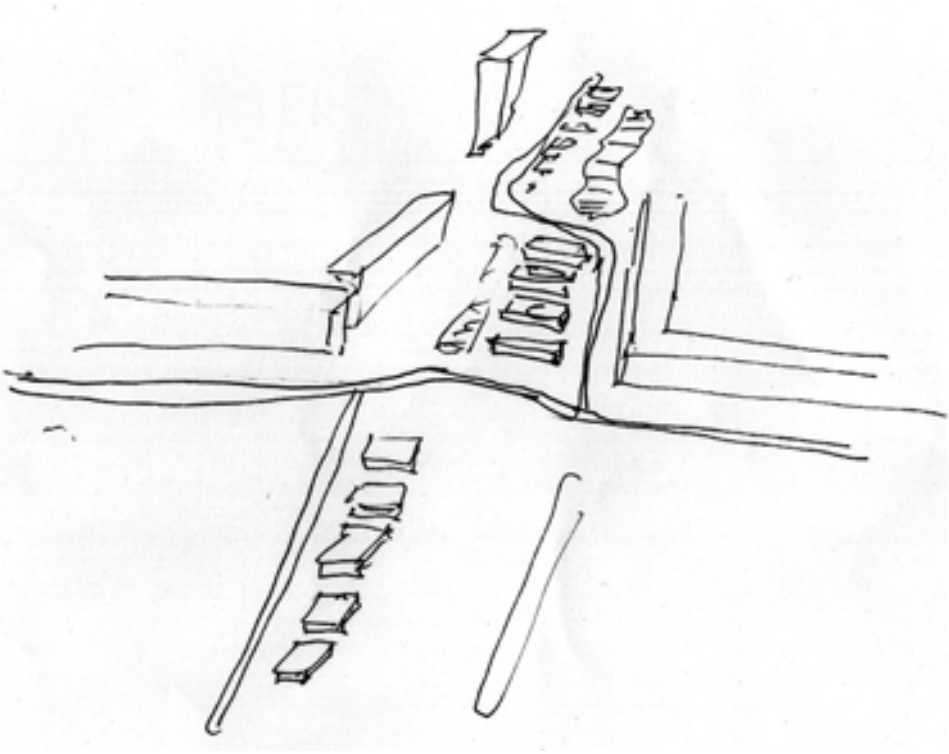
Reviewing own design - He recalls his own main arguments: 'there is a suggestion of a wedge between the two neighbourhoods and there is openness to the landscape and behind there was some more green space, but suddenly it was separated by that building block. So I took that block away and think it is much better now' [@12215].
'These houses should be made more accessible and this façade should be improved' [@12200].

Newspaper image - A6: 'If I am allowed to choose just one image, it would be a bird's-eye view because than you can understand the story of the new connection. This is good, but than: the nicer, the better' [@12245].

Memory image - Because A6 was the last Architect to be interviewed, the task to draw the design from memory was given just before the second interview. There were two months between the design and this drawing task. Drawing [figure 108] showed conceptual aspects of the design and main aspects of the situation that played a role in the design. When A6 was confronted with the modelled design, several aspects were remembered and mistakes in the drawing were corrected [@12124].

Figure 107. Preferred image for publication in a newspaper.

Figure 108. Memory drawing by Architect 6. The road was mirrored.



Indicative passages concerning the hypotheses

Hypothesis 1 – Situatedness – It was difficult to identify a 'feeling of situatedness' in the rather focussed and rational conversations with A6. He always spoke about retrieving *information* from images and maps: 'Views from the air, aerial pictures combined with a drawing of the situation are most important to get much information. Views from the street are to confirm certain suppositions' [@12238]. It never appeared that he felt as if he was walking or standing at a certain place. Once, based on proportions, he referred to a specific real building [@11601], but this only indicates recognition through comparison; it does not indicate a 'feeling of being there'. Another statement that indicates a lack of situated feeling was: 'Putting scale puppets immediately gives more sense of scale, but for me it does not make much difference, but for presentations it is a useful presentation effect' [@11753].
For a short moment Architect 6 was lost and immediately found his bearings again based on a big building (landmark) [@12051]. This is one (very small) indication of situatedness, in which a position is found in reference to a contextual cue.

Hypothesis 2 – Dynamic Views – For Architect 6, dynamic views and adaptable representations do not lead to different forms of situatedness, but do lead to discovering different facts, impressions and associations: 'With some extra information (of façades), I can immediately imagine how the plans of the houses are; so I know where the living rooms or the bedrooms are located' [@11625]. By choosing the "chopper flight animation" over the surroundings, he remembered details about the building composition: 'I forgot that I left over a part of that building, standing loose. Yes that immediately gives an impression' [@12124].

Hypothesis 3 – Design Stimulation – Most design activities of A6 were performed after the first interview session. During the interview, he was busy indicating what sorts of information are important to him. He refused to quickly provide some design ideas, so a 'vivid reflective conversation' (as worded in the third hypothesis) could not be indicated.

Hypothesis 4 – Models OF to Models FOR – As with hypotheses 1 to 3, there was not much evidence for situatedness. For A6, the model did not work as a virtual environment that could be visited and might actively trigger a reflective conversation. The model was just a tool to provide information. The viewpoint was often set to a high bird's eye view, in order to get as much information in one view as possible. This relates to the architect's position that the 'macro' information and exact information of floor plans etc. is most important.
The lack of 'felt situatedness' does not mean that the model was not useful to A6. The different impressions offered him different sorts of information. He used this information to get ideas and to make design decisions.

Hypothesis 5 – Effectiveness – A6 wanted to see all of the other designs from a bird's eye point of view. Details and qualities like viewing in motion, that were important to most other architects, were not that important to A6. He indicated that the choice of the right function [@12332] and the main division of space [@12458] are most important. However, he underlines the importance of a context model with the right representation related to the design: 'This design shows up much better if the façades of the surrounding buildings are shown. You can see the contrast between the two sorts of architecture' [@12319].
It is important to A6 that an architect keeps control over exactly how the design is presented: 'In an architectural contest, each architect should choose and prepare his own sort of presentation. It is not fair when the presentation is made by the contest organisation, because they also have their own ideas about

the design commission. Therefore, it will become different' [@12520]. This partially refutes the idea of the fifth hypothesis, whereby a dynamic view is expected to be more suitable than the fixed (serial) vision of architects. However, this hypothesis might be confirmed by a design evaluator, who would not want to be limited and directed by the architect's presentation.

Hypothesis 6 – Taking Distance – A6 quite 'brutally' knocked down several building blocks; it is doubtful whether he would propose this if he had visited the site for real and if he did not think of it as just a computer model. This might support the hypothesis if it were to be interpreted as giving a stimulus towards a 'freer' approach to the design case.

Hypothesis 7 – Combining Methods – It has already been indicated that the interviews with A6 gave some surprisingly insights. It seemed that A6 assumed the role of tutor, trying to critically understand the digital model handed in by a student. He asked direct questions about the representations in the model: 'is there a meaning behind the use of colour?' [@11522] 'Does it represent a certain type of material?' [@11546] and he immediately tried to find out if the situation was real or fictitious [@11506].
After the question about colour, I returned the question in order to keep the direction: 'What do *you* think about these colours?'. That helped.
Later, when he saw the aerial picture on the ground plane of the model, he said 'Ha! So it turns out to be a certain real place, because you used an aerial picture,' after which I explained that the aerial picture was 'recomposed' like in a song created from musical samples.
Such passages may reveal something about the inner reasoning behind the design process. Not all discussions are relevant to the understanding of the design development, but many thoughts can be easily followed and the direction of the overall process can be guided along the research questions.
The fact that this sixth architect did not feel situated and that he approached the model more as a source of information, does not support the first four hypotheses. That, however, does not refute the seventh hypothesis, because negative insights are also appropriate results in research.

4.3 Assessments

This paragraph consecutively documents the findings for each prototype, for each hypothesis and delivers a general view on the ways in which design ideas are developed and represented. This is another representation, another view on the results. This paragraph tries to give an overview, while the previous paragraphs were intended to provide more detailed insights on specific aspects of the study. Partially, this paragraph is a pastiche of quantitative design evaluations. Tables of scores and an example of a Protocol Analyses table, briefly attempt to show that much essence is lost in this kind of analysis. Further and detailed insights can be better gained by reading the interviews in Dutch. As the interviews reveal many more subtleties, the functioning of prototypes, hypotheses and idea development processes become more evident. For this experiment the detailed qualitative assessments in the previous paragraphs stand out against the quantitative assessments.

4.3.1 Assessment concerning the prototypes

If all prototypes are to be judged, a table can be made, indicating per architect, if the prototype performed well (+), was disapproved (-), or if the judgement remained undecided (0). The table was made based on paragraph 4.1. Only those selected quotes were used to determine a score. The original transcripts bear many more indications of the use and appreciation of the prototypes.

The first prototype was made to find out if different façade representations and ground textures could be helpful to gain insightful impressions and help the subject get focussed during the site exploration and subsequent design phases. Plain-coloured faces, different textures and geometry lines could be chosen. In addition, some more details in street furniture and trees could be switched on or off, as preferred.

The general impression concerning this prototype is that different representations are appreciated. Especially, it seemed to be preferred that the two modes of a rather abstract image and a more detailed façade image could be alternated. It showed raster textures were not appreciated. The reason is that a raster, indicating metres, is not a natural cue for providing a sense of scale. The façade images and scale puppets are much better means for suggestion of scale.

The second prototype turned out to be dependent on the design approach of the participating architect. Some architects liked to focus on the macro aspects of the site. They even preferred to know more about the city structure, the social aspects of the neighbourhood and the availability of information concerning

specific qualities of the location. Others liked to know more about the particular aspects of the buildings immediately surrounding the site. They often focussed on the morphology and rhythm of the building blocks and close-by features of the square and site, such as a little pond and an underpass.
The third prototype, surprisingly, taught something about 'represented realism' in a model. The fog was appreciated because it gave a natural cue to the atmospheric depth in the mono-perspective screen images. Fog was also used to make the environment a bit less blatantly available, in comparison to the design proposal. Transparency was not valued highly because it introduces an unrealistic aspect to building volumes. This is in contrast to transparency and line representations, which are frequently used to increase spatial understanding when working with CAD modelling software.
Different viewpoints in prototype 4 and in further questions about movement and orientation, turn out to be very valuable in the whole understanding and exploration of a digital context model.

Judgement of prototypes	A1	A2	A3	A4	A5	A6
Prototype 1: different visual representations						
about plain faces without texture	+ -	0	+	-	-	0
about outlines of the geometry and floor-lines	+	0	+	0	+	0
about raster textures	-	-	-	-	-	-
about colour façade images	+	+	-	+	+	+
about black and white façade images	+	0	0	0	+	0
about more details	0	0	+	0	0	0
about trees	0	0	+	+	+ -	0
Prototype 2: model extensiveness						
about extensiveness	+	0	0	+ -	0	0
Prototype 3: fog and transparency						
about fog	0	0	+	+ -	+ -	+
about transparency	+	0	-	0	0	0
Prototype 4: eye-level and bird's-eye views						
about eye-level views	+	0	0	0	+	0
about bird's-eye views	+	0	0	0	+	0
Some remarks about movement and orientation						
about wandering	+	+	+	+	+	+
about animation	+	+	+	+	+	+
about using an interactive map	+	0	0	0	+ -	0

4.3.2 Some remarks about Protocol Analyses

The Protocol Analyses were often used in order to identify and characterise the development of design ideas during the experiments. They functioned well as indices for quickly looking up specific patterns and aspects. At the same time, it appeared that many interesting subtleties tended to get lost in the abstractness of the codes. Protocol Analyses can be seen as only one way of representing the findings. It is a relatively reduced and abstract analyses and representation method, but it is clear for specific purposes. At first sight, such lists just do not communicate to 'us humans'. Maybe machines that guide us with their artificial intelligence in order to show us the right view at the right time can use the codes.

The analysis process made it necessary to read the interview transcripts in a specific analytic way. The need to translate the whole text into codes involved focusing and framing on specific aspects instead of on the original content and meaning.

At first the PA-lists were used for counting and finding patterns based on the codes in the lists. In some of the previous sections (§4.1.1, §4.1.3 and §4.1.4) of this chapter cumulative lists have been used to indicate the outspoken preferences of the participants. These scores give a first clue to conclusions that: the representation type of 'rasters' did not function for the participants, the other representation types were equally preferred 'each for its own value, at specific times', the most extensive 'large' model was preferred, both the bird's-eye views and the pedestrian's eye level views were equally preferred 'each for its own value, at specific times' and that many viewpoints were deliberately chosen.

Protocol lists can also be used to quickly find specific 'visual language' aspects, such as the use of metaphors and references to other buildings. These indicators of atmosphere, metaphors and references show the width of thinking that takes place in respect to visual information from the model. The several examples indicate that a virtual environment can play a role as intermediate between the real world and the world of thoughts in the mind.

Furthermore, Protocol Analysis lists can be used to check if there are signs indicating how the design is virtually rooted in the mind. The lists make it possible to check the first design idea and find it back in designs and in memory images. Thus, Protocol Analyses were used here mainly as a tool to support further analyses using a broader discourse.

Protocol Analysis Codes :

Ways to look around :

| bird's-eye view, 90° angle
/ bird's-eye view, ±70° high angle
\ bird's-eye view, ±45° low angle
- ground level view, 1.70 m.
* looking from a specific indicated point, not triggered by what is visible
> looking around in explorative way, wandering triggered by what is visible
< going back to a previous viewpoint
looking by means of a map
~ looking by means of a preset path (~- a walk, ~-- by car or ~\ circling like a helicopter)

Model Representations :

extends of the model: 1 small 145 x 160m. 2 : medium 435 x 480m. 3 : large 745 x 800m.
P Plain, coloured faces without any texture.
R Rasters indicating meters on facades and ground.
B Black and white facades and aerial picture
B-- Black and white facades, without aerial picture
F Facades and aerial picture in colour
F-- Facades in colour, without aerial picture
L Lines, indicating edges of buildings and the floors.
D Details (street marks, sidewalk tiles, street tiles, crosswalks, lampposts)
T Trees
..f percentage of fog
..t percentage of transparency

Participant :

view preferences e.g.: p\ prefers to see it from above
checks e.g. : cF- a check with colour Facades from ground level
recognition of r= views, lines, spaces
r& shape
r[facade
r^ sphere
r: metaphor
r@ reference to other building
r! function, use , what it is
r] dimensions
r) material

ideas i1 first design idea
i2 about context
(in combination with =&[^:@!]))
i3 further ideas about the design
i4 ideas based on sketches

opinion o1 about context
o2 about design
o3 about medium

actions a1 draws a scale puppet
a2 draws a mass
a3 draws lines
a4 draws on paper
a5 takes measurements

wishes w1 to see real situation
w2 to take pictures
w3 to draw
w4 to use other media
w5 to see casted shadows
w6 to see with a wide angle

opinions about dM Methodological decision
dD Design decision

Example of a coded interview:

virtual walk 1

line	-		1		2		3		4	
00	/			i1		r!		pP		i3
05		r&	\		3|				a2
10	|			a1		a5			F	r)[
15	1	r&		pP		a6				pPL
20	-*		-			a1			PL	p50t
25	\2	r=	R		1|	w4			50t	r&i4
30		pP		r!		dD				r=
35	-*	r=		r]	3\	r&				dD
40	\	r!	F	r^		r]			~--	
45	-*	pa1		r@		i2]				r^
50		pP	\3	r!		dD		w3		p*
55	\	r=		r^		r&		w4	-*	
60		i1		r:r=		dD			~>	
65		a1		r&r!		p-p\				

4.3.3 Assessment concerning the Hypotheses

In this paragraph, each hypothesis is analysed and discussed and each hypothesis is then evaluated in reference to the collected information per architect.
Hypotheses are decomposed into conditions and effects. This distinction made it possible to identify different categories in the narrative of the interviews.
Hypotheses 1 to 4 are clustered as they are subsequently dependent.

hypotheses 1 - 4 : about the role of 3D-models

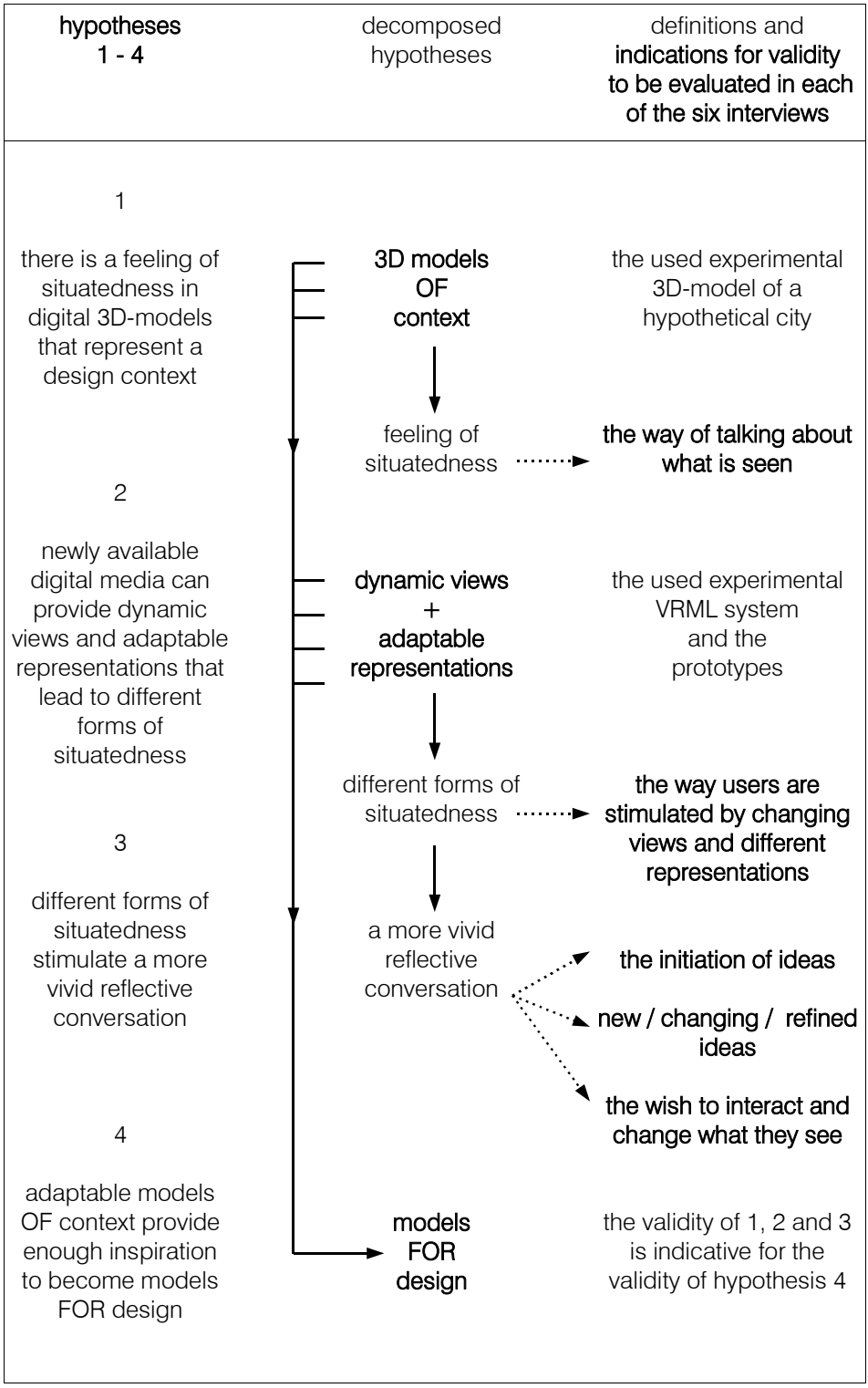
The first four hypotheses try to pinpoint the imaginative potential of 3D city-models. It was expected that, if an architect uses such interactive contextual representations, 3D city-models would play a role in the generation of new ideas.

Firstly (hyp.1), a *feeling of situatedness* is an indicator that the model delivers environmental information in such a way that the architects talk *as if they were there*.

Secondly (hyp.2), the possibility to make a *'virtual walk with adaptable representations'* offers the designer *new impressions* in an interactive way.

Thirdly (hyp.3), changing viewpoints could lead to impressions which can generate *new design ideas* and lead to *conceptual changes*.

Finally (hyp.4)*, if* there is evidence for the above effects, *then* specific qualities may be expected from the use of such models. In such a case, 3D adaptable models do not just have an illustrative role, but facilitate the active generation of ideas. Thereby the fourth hypothesis might also be valid. This means that adaptable models OF context provide enough inspiration to become models FOR design.
As discussed in 2.2.6 (p 98) 'models OF' refer to models that have a purely descriptive role: they provide information. In contrast, 'models FOR' are open to exploration and invention. They can be used as design media and thus enable a reflective conversation between one's inner thoughts, the expressed ideas and the represented context.


hypotheses
1 - 4
decomposed
hypotheses
definitions and
indications for validity
to be evaluated in each
of the six interviews
1
there is a feeling of
situatedness in
digital 3D-models
that represent a
design context
3D models
OF
context
the used experimental
3D-model of a
hypothetical city
feeling of
situatedness
the way of talking about
what is seen
2
newly available
digital media can
provide dynamic
views and adaptable
representations that
lead to different
forms of
situatedness
dynamic views
+
adaptable
representations
the used experimental
VRML system
and the
prototypes
different forms of
situatedness
the way users are
stimulated by changing
views and different
representations
3
different forms of
situatedness
stimulate a more
vivid reflective
conversation
a more vivid
reflective
conversation
the initiation of ideas
new / changing / refined
ideas
the wish to interact and
change what they see
4
adaptable models
OF context provide
enough inspiration
to become models
FOR design
models
FOR
design
the validity of 1, 2 and 3
is indicative for the
validity of hypothesis 4

If all hypotheses are scored in reference to the interviews, a table can be made, indicating per architect if the hypotheses are confirmed (+), refuted (-), or if the outcome is undecided (0).

Confirmation of hypotheses	A1	A2	A3	A4	A5	A6
hypothesis 1	+	+	+	0	+	-
hypothesis 2	+	+	+	+	+	0
hypothesis 3	+	+	+	+	+	-
hypothesis 4	+	+	++	+	+	-

For five of the six participating architects, the digital model provided a feeling of situatedness and as they indicated different impressions gave alternative ideas. Thus the prototype model proved successful and it stimulated vivid reflective conversations between designer and design media. The prototype which had been created can be seen as a rich and adaptable model, which has not just a pictorial or descriptive function. The context model adequately represents the urban site and its wider surroundings. The benefit comes from the quick changes in viewpoint that can be chosen. Use of aerial pictures for overviews and eye-level views for insights were alternated according to the needs during the design process.

Situatedness was described as ‘where you are, when you do, what you do matters’ [Gero, 1997-1998]. In Gero’s words, situatedness comes across as a natural phenomenon, an essential given that emerges at a certain moment and is triggered by the surroundings. If you strive towards situatedness in a digital environment, a certain level of dynamism in views and some information richness is a requirement. Furthermore, the feeling of situatedness is dependent on the empathy of the architect. When sketches are made they immediately have a situated quality, as they come directly from the situated ideas of the person that makes the sketch. For others, it can take a while before they understand the sketch and feel situated.

Situatedness is difficult to pinpoint as a phenomenon. Indirect clues indicate how the research participant interprets the images on the computer screen. Interviews with the six participating architects indicated different personal forms of situatedness. The way they talked and reacted sometimes showed a more distant approach. At other times the images were seen as a source for information (this was to a certain extent the case with A4 and even more so with A6). At other occasions, the way of talking supported the idea that the digitally represented environment can actually be explored in a ‘virtual walk’.

hypothesis 5 : about design evaluation

The experimental system made it possible to view the architect's designs as 3D-models positioned within the 3D-context model. By means of a screen-button, the participant could instantly switch to another design. This allowed for comparison of designs from the same viewpoint after which viewing position and representation type could be changed freely.

The architects were asked to evaluate their own design as well as the other designs. They were asked to indicate what they liked and disliked and what they thought about using this method of evaluation. Questions were asked to find out how this method compared with traditional and individual presentations, e.g. in design competitions.

Serial vision was not mentioned specifically, but it was kept in mind when the architects talked about their preferences of showing specific views. The tendency to direct the customer's eye would indicate a preference towards serial visions comparable to the serial presentation images of Gordon Cullen.

The vivid argumentation and rapid understanding brought about by the other design presentations, would appear to indicate the plausibility of hypothesis 5.

hypothesis 5	decomposed hypothesis	definitions and indications for validity to be evaluated in each of the six interviews
dynamic views and adaptable representations can be used to evaluate a design in its context and stand out from fixed serial visions	dynamic views + adaptable representations ↓ better evaluation possibilities then serial visions	the used experimental VRML system and the prototypes ⇢ more aspects or better circumstances for design evaluation

If the hypotheses is scored in reference to the interviews, a table can be made, indicating per architect if the hypothesis is confirmed (+), refuted (-), or if the outcome is undecided (0).

Confirmation of hypotheses	A1	A2	A3	A4	A5	A6
hypothesis 5	+	+ -	+	+	-	-

Hypothesis 5 brought to light two opposite ways of reasoning. Therefore, an attempt is made to reformulate this hypothesis into two valid conclusions.
The first aspect of reasoning comes from the architect presenting his or her own work. In that respect, it was evident that they wanted to present their *vision*. Their answers became contradictory when they had to judge the design of another architect. Then they preferred not to follow the (serialised) vision of the other architect; they wanted to *build up their own view*, by personally chosen viewpoints. However, the architects are also inclined to think about what the client wants. Sometimes they look down a bit on the 'visual literacy' of the client. Others want to give their vision first and then allow the client to take an own view.

The technical conditions for viewing and switching between different designs within the same contextual model was judged positively.

hypothesis 6 : about separation from the real site

This research does not advocate that architects should not need to visit the building site even if they have a good 3D-site-model available. Of course, the rich experience of several site visits is essential before and during the development of a design. However, the separation from all, possibly overwhelming impressions of a site could potentially offer alternate, unexpected impressions and design ideas.
This idea was not tested in a direct comparison between use of a real site and a virtual one. Talking about more and less realistic design proposals was an alternative way of addressing this issue. An extra insert design had been prepared beforehand and included into the set of designs which were to be compared. This was deliberately a rather disputable proposal. The design entailed a glass volume with brightly coloured boxes inside, the volume was brutally positioned as a bridge over the road. This design was included to test if the 'virtuality' of the site model would impact the judgements of the 'unrealistic' proposal.
The effect that withdrawal / separation from the real site would allow an architect more freedom to think, could also be indicated if the architects

themselves would bring more daring proposals. Of course, this was not comparable with other situations.

hypothesis 6	decomposed hypothesis	definitions and indications for validity to be evaluated in each of the six interviews
the design process (in the office) can benefit from the withdrawal / separation from the real site and all constrains in the built environment as it allows more freedom to think about the (im)possible and (un)desirable alternatives	design in isolation from reality by using design media in the design office ↓ freedom to develop alternatives	no direct feedback from the constrains in reality by using design media i.e. by using an adaptable model and tools as tested in the experiment ⇢ alternatives that do partially break with laws and constrains of reality

The score was also made for hypothesis 6, indicating per architect if the hypotheses are confirmed (+), refuted (-), or undecided (0).

Confirmation of hypotheses	A1	A2	A3	A4	A5	A6
hypothesis 6	+	0 +	+	+	+	+

All participating architects agreed that a site visit is necessary, if possible. However, in some special cases, if for instance it is for a contest, with a far away site, or if other colleagues have visited the site, an exception can be made. Having a good digital or physical site model available at the design office is considered a great asset. Such a model can be used to quickly check a certain detail and to test workings of the design within its context.
A higher level of abstraction in a model, leaving out the details, can be useful when focussing on overall aspects of form and space. In general, the used prototype model may have a bias in the direction of form and composition-related design. In reference to the provided prototype model in this research, the visit of the real site would have added more impressions of atmosphere, traffic and functions of buildings.

hypothesis 7 : about the applied methodology

The risk in this experiment was that the objectivity and validity of answers to questions and tasks might be influenced by the researcher. The seventh hypothesis challenges the common view that research can only bring about valid answers if the researcher uses rigid methods that supposedly lead to objective truth. In the first chapter, page 25, it was stated that: '*A careful description can be very effective in order to reveal the precise considerations of an observed designer.*' To reduce subjectivity, the results should include the 'second order effects' from the researcher and his role as involved interviewer and observer should be evaluated.

The choice for discourse analyses as part of the research approach has to do with the notion that design is highly embedded in personal experience and should not be deduced to one or more quantifiable aspects, from e.g. cognitive science. Furthermore and this touches the seventh hypothesis, it is believed that the 'involved roles' of the researcher ('me') can contribute to shed a light on what is being searched for. The answer is often hidden in the question. The active involvement of the researcher in the experiment is valid as long as the effects are noticed and noted.

The hypothesis is hereby 'decomposed' into two conditions: the 'think aloud method' and the 'controlled influence from the researcher'. The effect of this approach should lead to 'more appropriate results'. This means: answers and

hypothesis 7	decomposed hypothesis	definitions and indications for validity to be evaluated in each of the six interviews
combining the 'think aloud method' with intermediate instructions, conversations and direct questions gives more appropriate results	'think aloud method' + 'controlled influence from the researcher' ↓ 'more appropriate results' ⋯►	the think aloud method [M.W. van Someren] consideration of 'second order effects' answers to specific research questions related to asked questions and given conditions

insights should help to test the hypotheses and the prototypes. It also means answers and insights should have coherence during the progress of the interview and are corresponding to the given experimental situation. Actually, hypothesis 7 is a test to see if answers are given independently and to see if it is possible to encourage accurate, unbiased answers.

The score was made for hypothesis 6, to indicate per architect if the hypotheses are confirmed (+), refuted (-), or remain undecided (0).

Confirmation of hypotheses	A1	A2	A3	A4	A5	A6
hypothesis 7	+ -	+	+	+	+	+

The 'think aloud method' was implicitly introduced by instructing the participants to constantly speak out what they saw, what they thought and what they wanted to do. In addition, during the interviews several neutral hints were given to let participants express what they were thinking about and what their opinions and intentions were.
Next to the rather neutral instructions to let the participants think aloud, there were questions that are more prescriptive and hints, to direct the flow of the session.
In my role of interviewing researcher, on some occasions I felt I might have said something that was too prescriptive. However, I was able to 'neutralise the situation' by giving alternative options, or by checking the same aspect later on.

A1 was rushed by the overall approach, but after he indicated that and then more time was taken. Most of the participating architects were a bit headstrong preferring to stick with their familiar ways of working. They did do their best to give serious answers, but these answers were never meant to please and their design approaches were related to the tools and prototypes which were provided.
During the process it occurred that A4 was not talking in a very situated way. I provoked a change in perception by deliberately talking to her in a situated way. This did not influence her approach.
With A5 it occurred that taking time and returning to previously discussed aspects can bring new insights.
Finally, the process with A6 showed that because he took the lead, a return question could change the situation. After that, I could continue asking questions and found out what I wanted to know.

4.3.4 About the developing design ideas

Ideas of each participating architect were traced back and reconstructed by analysing the interview transcripts with the following focuses: *about context, first idea development, refinement of ideas and choices, the design that was handed in, newspaper image, memory image.* These carefully chosen indicators showed how design ideas came up, how they developed into a design proposal, how the design was presented and how the concept had been memorised after a time span of several weeks to several months.

Thereby, the ideas were not only verbally expressed, they were also evident in the images, sketches and designs made or chosen by the architects.

It was remarkable how fixed some of the ideas became. Some of the passages show how fruitful considerations about the site can successively be remarked, favoured, expressed, repeated and improved until they become somewhat leading themes for a design. Moreover, these ideas re-emerge as main themes in the memory drawings.

Getting back the different designers' memory images was always fascinating. Each memory image encapsulates the most important features of each participant's design. On the one hand, the images show how well the visual memory works, on the other hand it shows how selective it is.

In some mysterious way, the 15-degree angle in the directions of the site was gone in almost each of the images. However, the general directions and the most important lines of sight were kept intact. A1 had the longest time span between the experiments and the question to draw an image from memory. A1 invented a new passageway in the top-left corner of the buildings. His drawing shows the 'reconstructive memory'. Major considerations (such as: the important line of sight from the houses towards the polder ditch, the differences in height and the walk around the pavilion) stay intact. The rest is reconstructed into a new image. Such images could be useful to reassess the essential qualities of a design as the specific, once the distracting aspects of reality are filtered out.

Memory images might be lacking in precision, however they did prosper in expressiveness and they clearly represent the 'core' of ideas making up the essence of the design as a whole. Memory images might even be compared to naivety in dreams. While computer images stubbornly remind us of facts, images drawn from mind show what it really is about: the generation of ideas.

4.4 Towards a Concluding Chapter

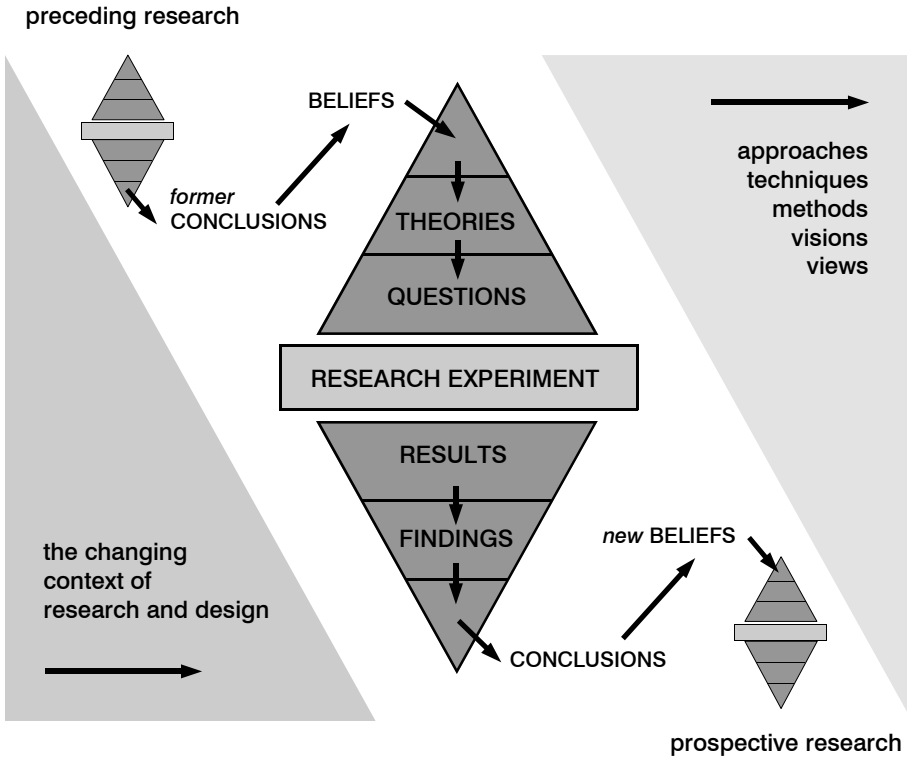
Results, findings and conclusions are outcomes with a different status.

Results consist of the collected, original material such as the interview recordings, the transcripts, 3D models and design sketches made by the participating architects. The *findings*, as presented in the previous paragraphs, are seen as the *noteworthy answers and insights in relation to the originally stated research questions and hypotheses*. *Conclusions* can be drawn from these findings. Conclusions rely on the interpretation of results and findings in the light of the original beliefs, expectations, questions and hypotheses.

In this chapter, I have tried to match my beliefs, expectations, questions and hypotheses, with the concrete results as well as possible.
Others might select different passages from the same results. However, through direct references to the original transcripts, combined with a selection of most typical hand-sketches and computer images, I have tried to make the findings as transparent, accessible and well-supported as possible. For the readers who want to check these findings, full interviews are available in Dutch in a supplement.

While design is related to a continuously developing *societal and material* context, research is related to a continuously developing *societal and scientific* context (see scheme on the next page). At the start of each research project, one can draw from previous results. The actual research is supposed to provide knowledge, novel approaches, techniques, methods, visions, views, etc. From such a project prospective research can carry on. Thus, research tends to be framed in a specified context, with the intention to contribute to the temporal societal needs and the continual scientific developments.
In the next chapter an attempt will be made to describe the temporal, societal and continual scientific relevance of this research. Findings, stemming from the research experiment will be used to support the conclusions. A broader view related to the changing context of research and design will be taken. I consider 'radical constructivism' and 'second order cybernetics' to be essential contemporary theories for performing design research. Both the experimental findings and the theoretical framework, support the notion that design ideas (virtual views) can be created through a dialogical process between representation and imagination.

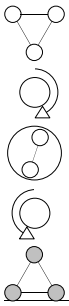
Figure 109. Continuity of research.



Kublai asked Marco:
"You, who go about exploring and who see signs, can tell me toward which of these futures the favouring winds are driving us."

"For these ports I could not draw a route on the map or set a date for the landing. At times all I need is a brief glimpse, an opening in the midst of an incongruous landscape, a glint of lights in the fog, the dialogue of two passersby meeting in the crowd and I think that, setting out from there, I will put together, piece by piece, the perfect city, made of fragments mixed with the rest, of instants separated by intervals, of signals one sends out, not knowing who receives them. If I tell you that the city towards which my journey tends is discontinuous in space and time, now scattered, now more condensed, you must not believe the search for it can stop."

Italo Calvino — Invisible Cities



Chapter 5

Conclusions and Recommendations

Drawing conclusions is like rendering an overview from a rich palette of insights. The extensive lists of enumerated results in chapter 4, the case studies and the references to existing theories are the foundation on which conclusions and recommendations in this chapter are based.
The conclusions are presented in four themes: *situatedness* (§5.1), *conversations* (§5.2), *observations* (§5.3) and *constructed realities (§5.4)*. Each theme is discussed in relation to the field of *architectural design* and the field of *design research*. Distinct parallels can be seen in the conclusions for both fields.
The chapter concludes with a discussion about trends, tendencies and recommendations for future initiatives.

Recommendations on the level of design are primarily practical and have societal relevance. The insights that come from testing prototypes, rather than the prototypes as such, may be relevant for new working methods in architectural education and design practice. Education should be directed to include more diverse representation techniques to train the 'visual literacy' of architects. The software industry can learn about the broad variety of wishes among architects and their growing need for software that reacts / acts / reflects as a medium for thoughts, ideas and facts.
Recommendations relating to doing design research are linked to contemporary conceptions of science and have relevance for prospective research. The role of the researcher must be taken into account. The way of questioning and the set-up of an experiment, influences the answers that can be expected to be found. The problem of finding scientific truth and proof can be reframed into the notion that understanding about what is going on, is to a certain extent a personal construct from a large number of unique observations. Each step of asking and answering renders a new semi-transparent layer of understanding. Thus, some *virtual future views (§5.5)* will be drawn on the canvas of thought.

5.1 Situatedness in Design and Research

The concept of situatedness, described in more detail in paragraph 2.2.1, can be understood as knowledge that is structured, based on real places or real applications. The research experiment demonstrated that situatedness could also be brought about with *media that represent* aspects of real places. Findings from interviews with architects, who were instructed to think aloud while performing design tasks, showed that:

- It is possible to create situatedness in digital 3D-models that represent a design context. This feeling is indicated and testable by the way architects come to their ideas and in how they describe what they see.
- Newly available digital media can provide dynamic views and adaptable representations in a variety of ways, leading to different experiences of situatedness.

It turned out that dynamic views and adaptable representations allow the architect to quickly change points of view related to impressions from quickly changing viewpoints. Short-term memory, generally considered to be limited to seven, plus or minus two, 'chunks of information' [Miller, 1956], can be aided by visual reminders. A visually rich 3D-model with contextual urban and design information, with the possibility to explore and adapt the information, can serve as an 'external memory' in complex thought processes. The spatial composition of the model makes it possible to explore 'chunks of information' in an incredibly powerful way. Likewise, by means of changing images, the focus in thoughts can be influenced dramatically.

In this context, situatedness is not only a matter of 'where you are, when you do, what you do matters' [Gero, 1997-98] in reality. It can apparently also emerge by working with representations. The prototype system that was built for the design tests turned out to be an efficient platform for quickly changing views in diverse ways. However it is worth noting that the participating architects often preferred personal ways of stimulating situatedness, structuring information and focussing on issues of design; they often wanted to note things down or to sketch. One of them indicated that a single photo would be enough to get situated after being distracted. Impressions from 3D-models and collections of photos can serve as useful reminders of real building sites for designers. Boldly stated: *what you see is what you think*.

The theme of situatedness can also be applied to research. A good research environment can help one to be focussed and different contextual impressions

can provide new ideas. The space 'where you are, when you do, what you do matters' can be available in a physical or virtual way. Contemporary researchers are inclined to situate themselves in a global research context. Conferences, networks, communicating between online research groups, private conversations with peers and 'gurus', all help to enrich and position research initiatives in the current environment of the so called *knowledge society*.

On another level, the different ways of representing, provide different sorts of situatedness, can stimulate the exchange of insights. Interviews, recordings, transcripts, sets of collected images, Protocol Analysis lists and finally, precise descriptions of idea developments per architect, in this project, each means gave a particular dimension to the subject.

It was important for this research that during the interview sessions with participating architects, the researcher was situated together with them. Both the architect and the researcher saw the same urban context representation and design images on the computer screen. We were able to share a 'virtual walk'. Questions were not imposed from outside the experiments setting, instead there was opportunity for situated questions, for which the order and flow was not strictly set beforehand. Of course, the interaction was targetted towards the research ambitions. However, for the study of how situatedness developed, it was important to improvise and let ideas and impressions direct the flow of walk and talk.

The level of situatedness, is related to both the physical or virtual context and to the person. Two terms can be used to evaluate the issue of situatedness: *evocation and serendipity*. Evocation can be described as 'expressiveness' and the potential to inspire; the condition to bring up ideas. An environment or its representation can be more or less evocative. On the other hand, there is the person who needs to pick up ideas. Serendipity is the potential to grasp ideas while you are not intentionally looking for them. In the case of design, which frequently comes with a number of *ill-defined problems* and an initially wide *solution space*, the importance of an evocative context and a 'serendipitous' architect may be evident. If the site provides stimuli for the architect to react, a well-situated building may be the result. With that notion, the circle is complete: *a well-situated architect designs a well-situated building*. It became clear that media, e.g. models of a site, need to represent the reality in such a way that they bring situatedness to remote and global architectural offices.

5.2 Conversations in Design and Research

Situatedness appears to become apparent if it involves interaction. If someone feels the urge to act or react to specific situational stimuli, this may result in an (intellectual) reaction, for instance a conversation. In this research, several types of conversation can be distinguished.

Firstly, there is the primary topic of this research: bringing about a conversation between the architect and the urban context. Context can be perceived during a real site visit, or in this case by means of representations and design media. Situatedness - feeling aware of the surrounding site - provides reasons to act and react. As soon as a position is taken, for instance if one moves or acts, feedback is provided directly from the perceived context. The site, or its representations (whether it is a piece of paper or a virtual reality set) '*talks back*', '*thereby informing further designing'* [Schön and Wiggins, 1992]. A reflective activity comparable to conversation exists if '*the designer sees, moves and sees again'*.
Findings from the interviews indicated that:

- Different forms of generated situatedness tend to stimulate a more vivid reflective conversation, involving focus, concentration, reframing of thoughts and potentially shorter design cycles.
- A reflective conversation is indicated and becomes aspect of testing by the way architects react to changes in what they see and by the way they determine what they want to see next.

It is a prerequisite for digital design models that they allow a reflective conversation between designer and design object to take place. Only then, the model gets the value of a medium to be used within a design project. In such a case we may speak of a 'model FOR', open to exploration and invention [Glanville, 1996]. This in contrast to a mere 'model OF' something, which holds only a rigid descriptive role.

A second type of conversation is the inner reflection upon observations and design ideas. In this research, it was necessary to find out what the architects were considering and how they perceived the digital context model. Think aloud methods helped to reveal the inner thoughts and motivations of the architects.

Thirdly, to have control over the research experiment, conversation was required between the researcher and the participating architects.

A fourth type of conversation came from the contextual situation of the research set-up. Not only the prototype system, but the whole setting, the room and the level of acquaintance between the subjects and the researcher may be expected to have played a conversational role in the way information could be gathered for the research.

Finally, the process of deriving conclusions from findings can be seen as a conversational process in which texts are conceived, read and refined.
Conversation analysis [Psathas, 1995] is a qualitative data analysis method, frequently used in social sciences. Techniques of analysis are based on *ethnomethodology* (focussing on processes referring to breakdowns and givens in daily life), *semiotics* (finding denotations and connotations), *dramaturgy* (looking for performance, acts, actors, means and motives) and *deconstruction* (unraveling relevant explanations for multiple meanings implicit in a text) [Feldman, 1995]. The conversational analyses in this research involved a mixture of these techniques. Ethnomethodology can refer to the typical idiom of an architect. An important consideration, in this respect is the possibly typical modes of discourse of Dutch-/Delft- architects. Each participating architect originally came from the same 'school' and shared comparable frames of reference. Therefore, it should be noted that insights about the approach of context, the use of computers and ways of sketching are likely to be, at least partially, culturally biased.
Semiotics is concerned with how minds produce, communicate and codify meaning. It applies in particular to signs or symbols, not just words (as in semantics); - a word, a gesture, a sound - is a sign [http://en.wikipedia.org/wiki/Semiotics]. In the research interviews, architects reacted in two typical ways to the represented urban context and to the design representations within the context. In a denotative way, they tried to describe what they saw in explicit meanings, such as shapes of blocks and directions in streets. In addition, they used connotations of implied meanings, such as about atmospheres, metaphors and references to known buildings.
Dramaturgic analysis of conversations can be found throughout descriptions of how the participating architects reasoned about their design in context and how they developed their ideas and opinions.
Deconstructive analysis largely took place by making Protocol Analyses and by searching for evidence supporting or refuting hypotheses. Search for explicit aspects in the whole transcript of conversations frequently revealed implicit answers and insights. The same findings, but differently deconstructed, might be used to (dis)proof wholly different assumptions and hypotheses.

5.3 Observations in Design and Research

If the five types of conversations from the previous paragraph are considered as modes of communication that lead to conclusions, it must be clear that even qualitative research may holds subjective results and insights. Although it is not always admitted, subjectivity is not foreign to science. Each understanding we have comes from a collection of observations. Each observation is subjective as it includes the characteristics of the observer. Objectivity may be a peculiar delusion within our Western scientific tradition [H. von Foerster, 1979].

Observation, is a subjective undertaking. Each new observation is totally dependent to the concepts and perceptive curiosities that the researcher already has in mind. A finding might be overlooked if it is not new and outstanding information. If it is new, however, it needs some form of recognition, some context to which it is to be related. Observing allows one to construct the further notion of what is and what is going on.

It was remarkable to observe how the participating architects approached the experimental urban context model. Each architect was eager to match the model to their own frames of reference. Therefore, they came up with parallels, metaphors and references to well known buildings. The model was intentionally made recognisable as a typical orderly Dutch neighbourhood. Like the choice of test participants, the provided context was culturally biased.

As an observing researcher, one should not exclude observing ones own process of observation. The seventh hypothesis in this research evaluates *my* influence on the process, being involved as a questioner and as the developer of prototypes for the design experiments with the participating architects. Subjectivity should not be seen as a failure to grasp truth. It was a way of getting involved in the experiment to explore new views and to find new ways of dealing with context, design and design media.

Carrying out conversation analyses and handling qualitative research data, may involve pitfalls and biases. Doing technical research, by developing and testing prototypes along with theories and hypotheses, one should always take the considerations and choices of the experimenter into account. In that way *'observing ones own role critically'* becomes a central theme for getting representative insights and inventions in a responsible way.

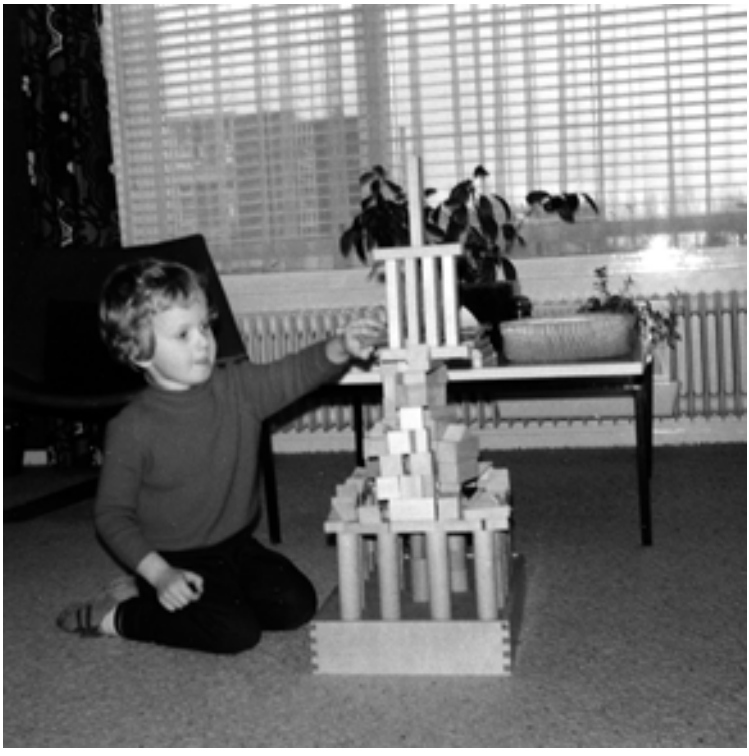
5.4 Constructed Realities in Design and Research

Architecture is a language in time. A city is a constructed reality, based on contextual givens and interventions springing from the imaginations of architects and their clients. Cities are not owned by architects. Buildings in a changing city are used, changed and demolished. The language of architecture sometimes seems to have become a global Babylonian speech. Buildings too often do not often listen to each other. Context is not always a serious design consideration in current architecture. Many buildings are intended to be unique. They cry for attention, but in their uniqueness, they are also equally 'unheard'…

Reading the city is like constructing a new reality in mind. This reality can be seen as a context for reference, to reflect upon, to construct new insights, ideas and designs. New designs alter an existing context. Moreover, they are introduced to fulfil new needs. It seems justified to expect that new buildings should try to be 'on speaking terms' with their older neighbours…

On the basis of observations, architects and researchers alike, construct realities in their mind. Heinz von Foerster, (1973) wrote about 'understanding understanding' and supported the idea of construction in mind by means of neuro-physiologic examples.
The experiment to let research participants draw an image from memory, revealed that not the image, but its underlying properties and concepts were memorised. This makes the drawing a reconstruction of the original observations and principal design ideas.
Findings from this research indicate that, to a certain extent, *design can be defined as a reconstructive act*. Building design starts with getting situated, getting in conversation with the context and the givens, then observations can be done on the basis successive actions. Prototypical design variants can be tested (see block construction examples on next pages), cyclic design iterations hold temporal realities. Some mental constructions can be immediately deconstructed and valuable parts can be re-used. Scale models, sketches and digital models can be seen the 'externalisation' of design concepts. These objects can hence be seen as temporal constructed realities that serve to investigate and communicate design ideas.

To increase design knowledge, one needs to act and react. Breaking down allows one to start over again, to find other ways and to choose from a project specific family of solutions.



5.5 Virtual Future Views

In previous paragraphs an attempt was made to put the findings of this research and the methods used in perspective. In the light of concepts of *situatedness (§5.1), conversations (§5.2), observations (§5.3)* and *constructed realities (§5.4),* it is worthwhile to think about contemporary trends and tendencies and what recommendations might be made for the near future.

One important line of thought that has surfaced in this research has been that representations of reality are essential elements of the working methods in the education and practice of architectural design. Scale models and digital models, photos and sketches, thoughts, notations and talks, all serve as means and media to reflect the future reality of an urban building site. Represented references are beneficial to the team of architects and of other actors involved. Design support using digital models with related multimedia links and physical models and sketches, requires consistent, up-to-date data, that can be relied on as facts. Only then can an architect extract that information into a concise set of relevant information. The architect should (re)view such in different ways, adding new ideas as the project progresses. The status of each component of information should be known. The model and the architect should be able to be 'on speaking terms', so that a reflective conversation is facilitated. A simplistic description of such a useful representational model would limit the diverse possibilities, so it seems opportune to write about some trends and tendencies which may influence developments in the near future.

First, there is the trend of the 'digital divide' between information owners and people who cannot access or acquire certain information. The 'first digital divide' is not a big issue anymore, for example even the poorest countries have places (Internet cafés) where a connection is available. However, there is - and will remain - a 'second digital divide' concerning high quality datasets for e.g. Geographic Information Systems. It would be good for architecture in context if architects were freely able to access contextual information about building sites. Within trends of globalisation, remote architects would need to be able to have access to local information sources.

Secondly, architects need to communicate their intentions, so clients are able to understand what is (and will be) going on. Therefore, not only architects, but others involved, including people from local neighbourhoods should be able to become literate in the (visual) language of architects. This would empower them to debate [Stellingwerff, Kuhk, 2004].

Thirdly, design software should become 'multimedial' and allow for collaborative design sessions and different representations and views. A large amount of implicit knowledge in architecture should also be documented and exchanged [Stellingwerff, Verbeke, 2001]. In too many cases, architects still grasp pencil and paper, because they cannot 'touch'and interact or even retrieve the data via computer interfaces. Only explicit data can be used to build a building, so the implicit should be able to be expressed and translated. As long as the state of explicit construction descriptions is not reached in the design process, the implicit information could be made available by means of links to less exact media (e.g. audio, scans, pictures, etc).

Fourth, the trends of ubiquitous computers and augmented reality (see p. 78) should be better understood and further explored [e.g. Mitchell, 2003]. Both trends could facilitate more direct connections between urban context, design offices, advisers, manufacturers, contractors and the actual building parts of the new construction. Smart tags, already normal in many types of retail shops, will in the near future completely replace barcodes and texts on many objects. Near Field Communication microchips and other cheap devices will be the guidelines for further robotisation of the entire Architecture Engineering and Construction industry. Accurate data models of the site and the new construction will be essential to further the Automation in Construction.

Fifth, the terms *situatedness, conversations, observations and constructed realities* will prove relevant to understand further developments in design and in man-machine processes. In the near future, it will be necessary to teach students to use different representation modes in their designing work and in communication with other people, peers and laymen. On the other hand, the new digital design media will need to acquire more qualities for *situatedness, conversations, observations* and *constructed realities* as well. Software should make visible what the architect wants to see in terms of dynamic interactive representations. Future software should become more like an environment that reacts to its users. The concept of software agents is only one result of this trend. Care should be taken to avoid software irritation. Some 'thinking' help agents can be irritatingly prescriptive.

Sixth, the small and the large context, the genius loci, now so often neglected in global architecture, will continuously need to be revaluated. Both local and global cultures are essential for architecture to 'make a place'. Bonds between countries, like the EU, will have to be conscious of making rules and regulations that allow and protect the cultural quality of diversity. This does

not only count, for example, local kinds of cheese or ways of clothing, it is also relevant for norms for land use, building construction, energy regulation, use of materials etc.

Recommendations for design research are directly related to 'near future' trends in design, some of which were touched upon on the two previous pages. In general terms, the trends in design should be supported by research and technological development.
Design research will need to develop methods that are not confined by traditionalist scientific methods. In the whole debate of research in architecture [e.g. Research by Design Conference (TU-Delft 2000) and The Unthinkable Doctorate (Sint-Lucas Brussels 2005)], the notions of Context, Experimentation and Observation are most essential.

Context is not only important in place-related design, it is essential in research. Context of a scientific domain or of experimental conditions, influences and provides chances to interpret research findings in relation to this context. Context should not be an excuse for specific biases in findings; it should help to define and enrich the insights.

Observation of processes and actions, extensively discussed in this research, is essential as an alternative to simple measuring facts. Inclusion of the observer is needed to properly interpret what is observed. The attitude of observation becomes most important if an architect attempts to do research on his or her own work. Then some way has to be found to 'take another view', close up or from a distance in order to look with different eyes to ones own actions and design artefacts.

Experiments in design research should not be focussed on 'guinea pigs' or fixed procedures. The design process and designers should not be expected to be irrefutably confined by experiments. Practice is relevant to understand how architects work. An experiment can however simulate reality by introducing specific constraints and conditions. A prototype is the practical, technical counterpart of a hypothesis. Prototypes and hypotheses can be experimentally tested, so that new techniques can be evolved and theories can be postulated.

5.6 To Conclude...

A research initiative may be considered successful if relevant issues, characteristic phenomena and theoretical considerations are addressed and studied in such a way that a contribution is made to the existing body knowledge and/or state of technology, whereby new theories may be put forward and further study may be stimulated.

From the outset, the focus of this research initiative has been on furthering the opportunities for *computer based* representation *media* for the benefit of *creative design*.
On the basis of an extensive series of explorative preliminary studies – concerning aspects of design and the experience and simulation of design artefacts in their 'real' surroundings, as well as the constantly changing potentials of emerging computer technologies – the subject of this research was targeted:
the issue of Design in Context, or more specifically: Design in a *virtual* Context.

For the sake of this project various aspects of Virtual Reality applications were systematically studied. Proposals for the improvement of existing computer aided representation formats were drawn up and developed into a number of interface *prototypes* and *support tools*, which were successively incorporated into a coherent *system* for the benefit of designing in context using the computer.
At the same time, experiments were carried out concerning the development and production of a feasible virtual context *model*, which should form the basis of a *design driven experimental study*, whereby the workings of the proposed system components would be tested systematically.
Eventually, an integral – purely fictitious – design 'environment' was constructed in the computer and a half dozen design professionals were invited to participate in a closely monitored experimental exercise.

Rather than aiming for a 'broad' survey, in which only general information might be expected to surface, a conscious choice was made for an *in depth* study, on a relatively modest scale.
In the context of this project's research ambition, this approach seems to have worked well. By allowing for a measure of mutual *involvement* between designer and researcher, it proved possible to confront the participants with the finer aspects of the proposed system in a relatively short time and to gather a

wealth of detailed data.
The conclusions of this explorative study therefore do not result in a list of straightforward, indisputable *facts*, to be considered representative for the design community as a whole.
On the contrary, the study shows that, even within a concise group of design practitioners, sharing a more or less comparable background, the working *methods* of the individual participants – when discovering aspects of the site, developing and presenting proposals and reflecting on the qualities of represented designs – varied considerably.

In this light, the proposed representational system was on the whole considered to be promising by the participants, particularly because it proved to go a long way in accommodating the participants' *different view preferences*, with more or less *realistic* image modes being used in *different phases* of their design developments.
In addition, with most of the participants the visual characteristics of the interactive representation system clearly contributed to a sense of feeling *situated* in the virtual context model. Some participants were very open to the system's opportunities, others tended to be more 'set in their ways'.
The merits of the various prototypes and tools were appreciated in different ways by the designers, indicating that it is not opportune to develop straightforward virtual representation systems with only one *type* of designer in mind…
On the contrary, this experimental study indicates that it would be worthwhile to develop interface applications which would be able to function interactively and in different combinations, offering individual designers – *and* others involved in evaluating design proposals – a *variety* of tools with which to approach specific design artefacts in their changing contexts.

This research project focused exclusively on *virtual* context models. This does not mean that the designer's traditional exploration 'in-situ', prior to designing, should be considered obsolete.
On the contrary, much can be learnt by physically 'tasting' the *genius loci*…
However, the results of this experiment indicate that the virtual model can play not only an important role as a 'reminder' for the privileged designer who 'has been there', but also as an 'informer' to other parties playing an active role in the design and implementation processes leading up to a design's realisation.
In addition, the findings show that such an interactive environment model is potentially not only useful as an instrument for exploration and data retrieval concerning the *existing* site, but potentially also particularly valuable to

actually see what the impact of a design proposal would be on its location and to discuss what would need to strengthened, changed, fine-tuned etc..

An added benefit of this type of model could be in the facilitation of design processes whereby actually visiting the site would be very *difficult* or even *impossible*, or in cases where the submission of different design proposals using a shared *format* would be considered preferential for the sake of *comparison* and *evaluation*.
Examples could be (international) design competitions or design projects in an educational context, but also projects where the context does *not* as yet *exist*, the kinds of large scale project developments in which different teams of designers would be working parallel with each other on different specific facets of an intertwined, *collaborative* project, as is increasingly the case in contemporary practice.

After documenting and evaluating the outcomes of this explorative research initiative, it is my considered opinion that it would most certainly be worthwhile to continue with the development of certain aspects of the representation system, which was created specifically for this project.
Probably the best 'laboratory' for further *knowledge construction* in this field would be that of the academic learning environment: where the architectural designers of the future – not yet too set in their ways – might be expected to contribute valuable insights concerning 'situated' approaches to Context, Observation, Design and Experimentation.

References

Alexander C. Jacobson M. et al, 1977, *A Pattern Language; towns, buildings, constructions.* Oxford University Press, New York.

Alkhoven Patricia, 1993, *The changing Image of the City.* Dissertation, Rijksuniversiteit Utrecht.

Arnheim Rudolf, 1957, *Art and Visual Perception*, Faber & Faber, London.

Arnheim R., 1970, *Visual Thinking*, Faber and Faber Limited, London.

Arnheim R., 1996, *Sketching and psychology in design.* Editors: Margolin V. and Buchanan R., in The idea of design, MIT Press Cambridge MA, pp 70-74.

Ashihara Y., 1989, *The hidden order; Tokyo through the twentieth century,* Tokyo, Kodansha. Original title: Ashihara Y., 1986, *Kakureta chitsujo*, Tokyo.

Bekkering H.C., 1998, *Significance and tradition,* in *The Architectural Annual 1996-1997*, Delft University of Technology, 010 Publishers, Rotterdam.

Bekkering H.C., 1999, *Voetlicht op het stedebouwkundig ontwerpen in het fin de siècle - Naar een stedebouw van conventie*, Intreerede, Delft University Press.

Bekkering H.C., 2002, Stedenbouwkunde | Stedenbouwkundig Ontwerpen | Leerstoel Stadsontwerp, *Beschrijving van het vakgebied*, description of the urban design speciality: http://www.bk.tudelft.nl/scripts/inc/hoogleraar.asp?nr_cv=16&tekst=Research

Bergeijk Herman van and Hauptmann Deborah, 1998, *Notations of Herman Hertzberger*, NAi Publishers, Rotterdam.

Bergh van den Wim, 2002, *Contemplation for Copenhagen.* Editors: Jong T.M. de and Voordt D.J.M. van der, 2002, in *Ways to study and research: urban, architectural and technical design*. Delft University Press, DUP Science, Delft, the Netherlands.

Bourdakis Vassilis, 2001, *On Developing Standards for the Creation of VR City Models,* in Architectural Information Management pp.404, 19th eCAADe Conference Proceedings, Helsinki.

Branzell Arne, 1993, *The studio CTH-A and the searching picture,* in *Endoscopy as a tool in Architecture.* in *Proceedings of the 1st European Architectural Endoscopy Association Conference,* Editors: Aura Seppo, Alavalkama Ilkka and Palmqvist Henri, Tampere, Finland.

Branzell Arne, 1995, *Management of Sequential Space Experiences*, in: *The Future of Endoscopy*, Editor: Bob Martens, Proceedings of the 2nd European Architectural Endoscopy Association Conference, ISIS Publications at Ökk-

editors, Vienna, 1996.
Breen Jack, 1994, *DYNAMISCH PERSPECTIEF – beeldvorming en simulatie in het ontwerpproces,* Sector Media, Deelprogramma's A- en B-onderzoek, mei 1994, Vakgroep 6, Geschiedenis, Theorie, Media & Informatica.
Breen Jack and Stellingwerff Martijn, 1997, *Imaging Imagination - exploring the impact of dynamic visualisation techniques in the public realm, results of the Delft EAEA conference workshop*, in *Proceedings of the 3rd EAEA-Conference*. Editors: Does Jan van der, Stellingwerff Martijn and Breen Jack. Delft University Press. See also: http://www.bk.tudelft.nl/media/eaea/imim/
Breen Jack, 2002/1, *Design Driven Research*. Editors: Jong T.M. de and Voordt D.J.M. van der, 2002, in *Ways to study and research: urban, architectural and technical design*, Delft University Press, DUP Science, Delft, the Netherlands.
Breen Jack, 2002/2, *Designerly Enquiry*. Editors: Jong T.M. de and Voordt D.J.M. van der, 2002, in *Ways to study and research: urban, architectural and technical design*, Delft University Press, DUP Science, Delft, the Netherlands.
Bridges A. Charitos D. Rutherford P., 1997, *Wayfinding, spatial elements and spatial support systems in virtual environments*, in *CAAD - Towards New Design Conventions.* Editors: Asanowicz A. and Jakimowicz A. , Technical University of Bialystok Press, pp. 45-60.
Broadbent G., 1990, *Emerging concepts in urban space design*. Van Nostrand Reinhold, London.
Calvino Italo, 1974, *Invisible Cities*. Harcourt Brace Jovanovich, Inc.
Calvino Italo, 1983, *Mr Palomar*. Harcourt Brace Jovanovich, Inc.
Clancey William J., 1997, *Situated Cognition; on human knowledge and computer representations*. Cambridge University Press, Cambridge.
Cross N., 1982, *Designerly ways of knowing*, in Design Studies 4, 1982, pp. 221-227.
Cross N.,1989, *Engineering design methods, Strategies for Product Design*, Chichester.
Cullen G., 1961, *Townscape*. London, Architectural Press.
Dahl D. W., Chattopadhyay Amitava and Gorn Gerald J., 2001, *The importance of visualisation in concept design*, in Design Studies 22, 2001, pp.5-26.
Dibbets Pauline, 2002, *Humans as an animal model? studies on cue interaction, occasion setting, and context dependency.* Dissertation, University of Nijmegen.
Does J. van der, Breen J.L.H., Stellingwerff M.C. (eds.),1997, *Architectural and urban simulation techniques in research and education - developments of analogue and digital eye level visualisation.* Third Conference of the European Architectural Endoscopy Association (Delft, 8/27/97), Delft University Press, Delft, 1998, pp. 152-159.
Does J. van der and Giró H., 1999, *Imagining. A fresh look at design, presentation and communication.* Delft University Press.
Does J. van der, 2001, *Ontwerp en Wijze van Overdracht / Design and Methods of Presentation.* Omschrijving: Afscheidsrede prof. Jan van der Does op CD-ROM, Uitgave: Faculteit Bouwkunde, TU Delft, Delft, 2001.
Dokonal Wolfgang and Martens Bob, 2001, *A Working Session on 3-D City*

Modeling. pp. 417 in: Architectural Information Management, 19th eCAADe Conference Proceedings 1, Helsinki, Finland, 29-31 August 2001.
Dokonal Wolfgang, Martens Bob and Ploesch Wolfgang, 2001, *On the Borderline – Building a 3-D City Model with Students* pp.410 in Architectural Information Management, 19th eCAADe Conference Proceedings, Helsinki.
Durmišević S., 2002, *Perception Aspects in Underground Spaces using Intelligent Knowledge Modeling,* DUP Science, 90-407-2296-X, 2002.
Ennis Gary and Maver Tom, 2001, *Visit VR Glasgow – Welcoming multiple visitors to the Virtual City* pp. 423 in Architectural Information Management, 19th eCAADe Conference Proceedings Helsinki, Finland pp. 29-31 August 2001.
Ennis, Gareth and Lindsay, Malcolm, 2001, *VRGLASGOW.CO.UK implementation of internet multi-user functionality to Glasgow's virtual city* , In: {*ACCOLADE*} *-Architecture, Collaboration, Design,* Delft University Press, Delft. pp. 135-142.
Foerster Heinz von, 1973, *On Constructing a Reality*, in: W.F.E. Praiser (ed.), Environmental Design Research, Volume 2, Dowden, Hutchinson and Rose, 1973, pp. 35-46.
Foerster Heinz von, 1979, *Cybernetics of Cybernetics,* in: Communications and Control, K. Krippendorff (ed.), Gordon and Breach, New York, 1979, pp. 5-8.
Frampton, Kenneth, 1985, *Critical Regionalism, Modern Architecture and Cultural Identity*. In: Modern Architecture: A Critical History. London, pp. 314-326
Gero J.S. and Neill Mc Th., 1998, *An approach to the analysis of design protocols*, Design Studies 19, 1998, pp. 21-61.
Gero John S., 1997-1998, *Situatedness in design*, in: The International Journal of Design Computing, KCDC 1997-1998 volume 1, editors column, see http://www.arch.usyd.edu.au/kcdc/journal/vol1/columns/gero.html
Glanville R., 1995, *Creativity and Media in Architecture*, in: The future of endoscopy, proceedings of the 2nd European Architectural Endoscopy Association, ISIS-ISIS publications, Vienna, 1996, pp.133-143.
Glanville R., 1996, the distinctions between *models of* vs. *models for* were privately explained after a discussion at the CAD Creativeness Conference 25-27 April 1996, Białystok, Poland.
Glanville, Ranulph, 1997 *Behind the Curtain*, 1st Int. CAiiA Research Conference "Consciousness Reframed '97", University of Wales College, Newport, UK. http://www.univie.ac.at/constructivism/papers/glanville/glanville97-curtain.pdf
Glasersfeld, Ernst von, 1997, *Distinguishing the Observer: An Attempt at Interpreting Maturana*, http://www.oikos.org/vonobserv.htm
Goel V. Sketches of Thought, MIT Press, Cambridge, MA, 1995.
Goldschmidt G., 1989, *Problem representation versus domain of solution in architectural design teaching*, J. Archit. Plann. Res. 6 3 204–215.
Goldschmidt G., 1991, *The dialectics of sketching*, Creativity Res. J. 4 123–143.
Goldschmidt G., 1992, *Serial sketching: visual problem solving in designing*, Cybemetics Syst.: Int. J. 23 pp. 191–219.
Goldschmidt G., 1994, *On visual design thinking: the vis kids of architecture*, Design Stud. 15 pp. 158–174.

Goldschmidt G., 1995, *Visual displays for design: imagery, analogy and databases of visual images, Visual Databases in Architecture: Recent Advances in Design and Decision-making*, 1995, pp. 53–76.
Gosling David, Gordon Cullen, 1996*; visions of urban design,* London: Academy Editions.
Hamel, R.,1990, *Over het denken van de architect; een cognitief psychologische beschrijving van het ontwerpproces bij architecten*, Publisher Amsterdam : AHA Books, .
Heeling, J., 1998, *A quest for the principles of urbanism*, in The Architectural Annual 1996-1997, Delft University of Technology, 010 Publishers, Rotterdam.
Heuvel, F.A. van den, 2001, *Reconstruction from a Single Architectural Image from the Meydenbauer Archives*, In: Proceedings of CIPA symposium, Postdam Germany, September 2001, 8 pages
Heuvel, F.A. van den, 2001, *Object Reconstruction from a Single Architectural Image Taken with an Uncalibrated Camera*, In: Photogrammetrie Fernerkundung Geoinformation, Jahrgang 2001, Heft 4, ISSN 1432- 8364, pp 247- 260
Heylighen F. & Joslyn C. ,2001, "*Cybernetics and Second Order Cybernetics",* in: R.A. Meyers (ed.), Encyclopedia of Physical Science & Technology , Vol. 4 (3rd ed.), (Academic Press, New York), pp. 155-170.
Holmgren, Steen; Rüdiger, Bjarne; Tournay, Bruno, 2001, *The 3D-City Model – A New Public Space* pp. 430 in: Architectural Information Management [19th eCAADe Conference Proceedings, Helsinki, Finland 29-31 August 2001.
Jong T.M. de, Voordt D.J.M. van der, Eds., 2002, *Ways to study and research: urban, architectural and technical design*, Delft University Press, DUP Science, Delft, the Netherlands.
Kavakli Manolya, Gero John S.,2001, *Sketching as mental imagery processing*, in: Design Studies 22, p347-364.
Kavakli Manolya, Gero John S., 2002, *The structure of concurrent cognitive actions: a case study on novice and expert designers*, in: Design Studies 23, 2002 pp. 25-40.
Kaye S., *Okham's Razor,*2003, http://www.royalinstitutephilosophy.org/think/print.php?num=18.
Klercker, Jonas af and Henrichsén Jan, 2001, *Can simulations in VE support architects in solving complex design problems?* In: {*ACCOLADE*} - *Architecture, Collaboration, Design,* Delft University Press, Delft.
Koolhaas R., *Bigness*, 1995, in: *Stylos Hotel New York Conferences* - The critical landscape, Stylos Bookfund, De Omslag - Nummer 15, maart 1995.
Kós, José Ripper, 2001, *Modeling the City History* pp. 436 in: Architectural Information Management [19th eCAADe Conference Proceedings, Helsinki, Finland 29-31 August 2001.
Kosslyn, S. M.,1994, *Image and brain*, MIT Press, *Cambridge, MA,*
Kosslyn, S. M.,*1995, Mental imagery,* in S. M. Kosslyn and D. N. Osherson, eds. *An Investigation to Cognitive Science, Visual Cognition*, 2nd edition, MIT Press, Cambridge, MA*, pp267-296.*

Krier R.,1983, *Elements of Architecture*, London: AD.
Kruijff E. and Donath D., 2001, *Supporting Shared Architectural Understanding.* In*: {ACCOLADE} -Architecture, Collaboration, Design,* Delft University Press, Delft.
Kurokawa Kisho, 2000, *Retrospective Kisho Kurokawa*, See the website, last verified on 25/11/2002: http://www.kisho.co.jp/information/retrospective/re01.html
Lagendijk, R. L., 2000, *Ubiquitous Communications Updated Technical Annex 2000,* Delft University of Technology, http://www.ubicom.tudelft.nl/docs/UbiCom-TechnicalReport_2000_1.pdf
Liddament T., 2000, *The myths of imagery*, in Design Studies 21, 2000 p589-606. [Posthumously published]
Lynch K., 1960, *The image of the city*, MIT Press, Cambridge, Mass. 1997, 1960.
Mckim R.H., 1980, *Experiences in Visual Thinking*, Stanford, Wadsworth, 1980.
McLuhan M., 1964, *Understanding Media: The Extensions of Man*, Cambridge: The MIT Press, 1994., original, 1964.
Miller, G. A., 1956, *The magical number seven, plus or minus two: Some limits on our capacity for processing information,* in Psychological Review, 1956, 63, 81-97.
Mitchell, William J., 2003, *Me++ The Cyborg Self and the Networked City*, Cambridge: MIT Press.
Norberg-Schultz Ch., 1979, *Genius Loci*. Towards a thenomenology of architecture. Academic Editions, London, 1979.
Nvidia ,1999, http://www.nvidia.com/view.asp?IO=gpu .
Olsthoorn, Bernard, 1998 '*MORV*', Publicatieburo Bouwkunde TU-Delft.
Pask, G. ,1975, *Conversation Cognition and Learning*, Elsevier, Amsterdam.
Pask, G. ,1975, *Artificial Intelligence - a Preface and a Theory.* Preface to chapter on Machine Intelligence, in *Soft Architecture Machines*, ed., N. Negroponte. MIT Press, 1975.
Perky, C. W., 1910, '*An experimental study of imagination*' Journal of Psychology Vol 21, 1910 pp422-425
Pietsch, Susan; Radford, Antony; Woodbury, Robert, 2001, *Making and Using a City Model: Adelaide, Australia* pp. 442 in: Architectural Information Management [19th eCAADe Conference Proceedings, Helsinki, Finland 29-31 August 2001.
Popper, Karl Raimund, 1963, *Conjectures and Refutations: The Growth of Scientific Knowledge*. London: Routledge, 1963.
Priemus Hugo, 2002, *The Empirical Cycle*, in: Jong T.M. de, Voordt D.J.M. van der, Eds., 2002, *Ways to study and research: urban, architectural and technical design*, Delft University Press, DUP Science, Delft, the Netherlands.
Riegler, A., 2003, *The Key to Radical Constructivism.* http://www.univie.ac.at/constructivism/key.html
Rubin E., 1915, *Synsoplerede Figuren*. Copenhagen: Glyndendalska.
Rubin, E., 1958, *Figure and ground*. In Readings in perception (DC Beardslee and M Wertheimer, Eds). Van Nostrand: Princeton, NJ.
Segal Lynn, 1986, *The Dream of Reality by Heinz von Foerster's Constructivism*

Published by W. W. Norton & Company in 1986.
Schön D.A. , Wiggins G., 1992, *Kinds of seeing and their structures in designing*, Design Studies 13(2) 1992 pp.135–156.
Schön, Donald A. and Rein, Martin, 1994, *Frame Reflection - Toward the Resolution of Intractable Policy Controversies*. Basic Books / Harper Collins Publishers, New York.
Someren van M.W., Barnard Y.F. and Sandberg J.A.C.,1994, *The think aloud method*, *a practical guide to modelling cognitive processes,* London: Academic Press.
Spence J., 1984, *The Memory Palace of Matteo Ricci.* - New York, N.Y.: Viking Penguin, 1984.
Stellingwerff, Martijn*,* 1999/1, '*Evocation and Serendipity in a Cyberreal world*', pp. 181- 188 in: *AVOCAAD Second International Conference* - AVOCAAD Conference Proceedings, Brussels Belgium, 8-10 April 1999.
Stellingwerff, Martijn, 1999/2, '*SketchBoX*', pp. 491- 497 in: Architectural Computing from Turing to 2000 - eCAADe Conference Proceedings, Liverpool, UK 15-17 September 1999.
Stellingwerff M. C., Verbeke J., ed.:, 2001, {*ACCOLADE*} *-Architecture, Collaboration, Design,* Delft University Press, Delft.
Stellingwerff M. C., 2002 *Architects' Visual Literacy*, paper in New impulses in planning processes, digital / analogue environmental simulation, Schmidt, Schlömer, editors, proceedings of the 5th conference of the EAEA, Essen Germany, 2001, p160-176.
Stellingwerff, Martijn and Kuhk, Annette, 2004, *3D/4D Communication Tools for Facilitators in Public Participation*, in: Architecture in the Network Society [22nd eCAADe Conference Proceedings, Copenhagen (Denmark) 15-18 September 2004, pp. 593-600
Thackara J., *Rehearsing the future*, in: The future of design and design research, Research School for Design and Computation, proceedings of the opening conference, p96-103, TU Delft, faculty of Architecture.
Thiel, Ph., 1997, *People, paths, and purposes; notations for a participatory envirotecture*. Seattle: University of Washington Press, 1997.
Tzonis, Alexander; Lefaivre, Liane, 1981, *Die Frage des Regionalismus.* In: Andritsky, M. et al.: Für eine andere Architektur. Frankfurt a. M.
Tzonis, Alexander; Lefaivre, Liane, 1990, *Why Critical Regionalism Today?* In: Architecture and Urbanism. No. 236, May, pp. 22-33
Tzonis, Alexander; Lefaivre, Liane, 2003, *Critical Regionalism. Architecture and Identity in a Globalized World*. Munich et al.
Venturi R., 1966, *Complexity and contradiction in architecture*, Museum of Modern Art, New York.
Verheijen F.,2002, *Het schijnbaar onmogelijke en omgaan met de twijfel*, inaugurele rede TU Delft, DUP Satellite, 22 2 2002.
Vos A., Mare, H. de,1993, *Urban rituals in Italy and the Netherlands; historical contrasts in the use of public space*, Assen : Van Gorcum, 1993.
VROM-raad, 2001, *Tussen feit en fictie…Verkenning van ontwikkelingen in de informatie- en communicatietechnologie en de gevolgen voor het beleid over*

wonen, ruimtelijke ordening, milieu en mobiliteit, Den Haag, maart 2001 [http://www.vromraad.nl > adviezen > achtergrondstudies > nr 008]
Xaveer de Geyter Architecten, 2002, *After-Sprawl Onderzoek naar de hedendaagse stad*, 2002.
Yi-Luen Do, E., 1998, dissertation, *The Right Tool at The Right Time*, Investigation of Freehand Drawing as an Interface to Knowledge Based Design Tools, Georgia Institute of Technology.
Zeisel, J., 1984, *Inquiry by Design: Tools for Environment-Behaviour Research*, Monterey, Cal: Brooks/Cole, Cambridge University Press, 1984.

All Internet references were checked and updated on February 14th 2005.

Samenvatting

Dit onderzoek handelt over Architectonisch Ontwerp in relatie tot een Virtuele Context.

Centraal staan de innovatieve mogelijkheden en instrumentele kansen van digitale visualisatie media. Het is al enige tijd mogelijk om interactieve digitale modellen te genereren en deze vanuit verschillende kijkrichtingen en in verschillende representaties te tonen. De ambitie in dit onderzoek was echter om preciezer uit te vinden hoe deze weergave technieken gebruikt kunnen worden ten behoeve van stedelijk en architectonisch ontwerp. Ten eerste wordt een bijdrage geleverd aan kennis van digitale visualisatie technieken en hun toepassingen. Ten tweede wordt uitgebreid ingegaan op de theoretische voorwaarden en consequenties van de gekozen onderzoeksmethode.

Het onderzoek werd gestart met een reeks verkennende studies waarbij steeds de nadruk lag op het gebruik van digitale representatiemedia voor creatief ontwerp. De ervaringen van deze voorstudies zijn uiteindelijk gebruikt in een groter experiment waaraan zes architecten meewerkten. Het uiteindelijke thema werd: Ontwerpen in een Virtuele Context.

Gedurende de loop van het vooronderzoek is er een ontwikkeling ontstaan van onderzoek met de nadruk op technieken naar onderzoek met een focus op de ontwerpende architect die deze technieken aanwendt om een beter zicht te krijgen op de complexe stedelijke omgeving.
Het begrip ‘gesitueerdheid’ is geïntroduceerd om vast te stellen in welke mate het gebruik van de virtuele context voorwaarden en ideeën genereert.

Voor het hoofdexperiment is een computermodel ontwikkeld dat middels een gebruikersinterface interactief aangepast kon worden aan de momentane behoeften van de proefpersoon. Een reeks van beeldtypen en posities kon vrij gekozen worden gedurende de ontwerpexercities van de architect. Het

onderzoekssysteem bestond uit meerdere prototypen en ondersteunende modules. De prototypes zijn getest door middel van kleine ontwerptaken. Hierbij is gekozen voor een onderzoeksmethode waarbij de proefpersoon een actieve rol krijgt toebedeeld en de onderzoeker richting geeft, zodat aandacht wordt gegeven aan de verschillende onderzoeksvragen. Terwijl ze samen een virtuele wandeling maakten door de omgeving, was de proefpersoon in gesprek met de onderzoeker en werden al de onderzoeksaspecten en ontwerptaken uitgevoerd. Methodologisch is dit interessant omdat het onderzoek een sturende component bevat die meegenomen dient te worden in de evaluatie van bevindingen.

Voor het experiment is een fictieve stedelijke omgeving in model gebracht. Het model vertoonde een aantal duidelijke overeenkomsten met een 'gemiddelde Nederlandse stadsrand' en er was een groot ongebruikt plein waar de architecten een ruimtelijk ontwerpvoorstel voor moesten maken.
Als belangrijke resultaten van deze studie worden de werkmethodes en ideeënontwikkelingen van de architecten beschouwd. Ook hun schetsen en herinneringsbeelden zijn betrokken bij de evaluatie van resultaten.

Virtuele Context zal een steeds belangrijker rol spelen in het ontwerpen, plannen en beheren van de werkelijke stedelijke omgeving. De modellen hebben daarbij zowel een inspirerende alsook feiten representerende functie. In plaats van 'harde kwantitatieve feiten' levert het onderzoek vooral inzichten met betrekking tot keuzen, voorkeuren en werkwijzen van architecten. Met deze inzichten kunnen softwareontwikkelaars, makers van digitale omgevingsmodellen en architecten beter inspelen op beschikbare digitale middelen. Met name het onderzoek aan 'Virtual Collaborative Design Environments' en 'Human Computer Interfaces' kan putten uit de beschreven technieken, methodes en resultaten in het proefschrift.

Curriculum Vitae

Martijn Stellingwerff was born on August 20th 1968 in Amstelveen, the Netherlands. His vocational life is enumerated below.

Research

- Since 1997 Teacher / Researcher at Form & Media Studies, faculty of Architecture, TU Delft, the Netherlands. Manager of the CAMlab.
- 2001-2004 Researcher at the Hogeschool voor Wetenschap & Kunst, Sint-Lucas Architecture, Brussels. Involved as researcher / teacher in several funded projects: AVOCAAD, DYNAMO, {ACCOADE}, PICT.

Conferences and workshops

- 2000/2004/2005: Member of the 18th, 22nd, 23rd eCAADe Conference Review Committee.
- 2003: Organising the fourth AVOCAAD conference at St. Lucas.
- 2000: Organising the ACCOLADE conference / European workshop, about Architectural Collaborative Design at the St. Lucas Hogeschool voor Wetenschap en Kunst in Brussels, Belgium. This was a join event of Delft University of Technology and St. Lucas, sponsored by the European Committee.
- 1997: Organising the third conference of the 'European Architectural Endoscopy Association' held in August 1997 at the faculty of Architecture, TU Delft, The Netherlands.
- List of publications includes more than 25 papers and presentations for several national and international conferences and Scientific Journals.

Teaching

- 2005: Msc 2 AR0450 Living on the Water
- 2005: Msc 2 AR0235 Verbeelding in maquette
- 2004/5: Maquette oefening BKB602E “Het Presentatiemodel”
- 1997-1999, 2001: Assistance D11 presentation module
- 1995 - 1996: Guidance of a MSc student at the faculty of Geodesy,

DUT. Subject: Photogrammetric modeling of buildings. Short Video: 'Virtual Geodesy', ir F. van der Linden.

- 1995: gave a computercourse at Palestinian Bir-Zeit University near Ramallah (WestBank) Framework: EG-project; MED Campus Course and the chair "Technical Design and Computer Science", Prof.Dr.Ir. S.Sariyildiz, faculty of Architecture, DUT, The Netherlands.
- 1993: gave a series of lectures: Hergebruik van gebouwen, drie architecten.

Education

- 1994 - 1996: two years Post Graduate Design Research, OPB, Faculty of Architecture of Delft-UT and Eindhoven-UT, The Netherlands. Theme: Exploring New Digital Design Media.
- 1994: Three months practical training at Instituut Calibre, Eindhoven University of Technology, The Netherlands. (professional projects for CAAD, urban/architectural simulation techniques and VR).
- 1993: MSc degree in Architecture, Faculty of Architecture - Delft University of Technology, The Netherlands.
- 1991-1993: Student Assistant for the Chair "Renovation and Re-use of Buildings" at the Faculty of Architecture, Delft University of Technology, The Netherlands.
- 1990: Practical training at "Architecture Office Kok & Joustra", den Hoorn, The Netherlands.
- 1987: Finished HWC High School, Atheneum B, in Amstelveen, The Netherlands.

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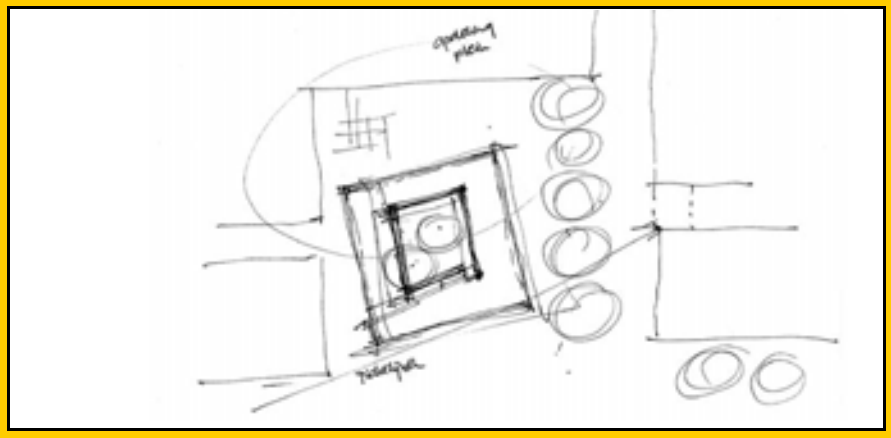
"Have you finished your thesis yet?"

:-) Martijn Stellingwerff,
Delft, 12th February 2005.

virtual context



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