Research on Digital Design Strategies

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Abstract

To fully benefit from the potential of computer technology in the design process it is necessary to rethink design methodology. New design strategies have to be developed from scratch, strategies which are specially designed to engage the potential of computer technology as well as to address the general problem of complexity within the interplay of urban systems.
This research is focused on the development of practical solutions, which can be applied by other designers. The research design is therefor built around a "laboratory" setting, where new techniques are developed, and a "test ground" setting where these techniques are tested and developed further. The "laboratory" is provided through the authors' participation in the architecture and design group OCEAN, the "test ground" is given through several series of workshops conducted either by OCEAN, or locally, at the Institute of Industrial design at the Oslo School of Architecture. This particular research design is discussed on a general level and demonstrated through a presentation of the specific research on the development of digital design strategies.

Integrated design research.

Seamless integration between practical activities (research by doing) and writing, is possible in design research.[1] The design researcher with a practical background and a professional or educational activity has access to additional sources of experience and knowledge, which is beneficial to research if integration is achieved.
Especially in research on techniques and methods the combination of accumulating knowledge through practical work and theoretical analyses seems to be productive[2]. Theoretically based investigations with additional input through *learning by doing* or development of theory through practical investigations (Grounded Theory[3]) is a way of research which also should be familiar to designers, since they are used to develop ideas, solutions and concepts through sketching and practical work. This type of research is also comparable with engineering research and development, where theoretical knowledge, technical know-how and physical prototyping are integrated.
The designers know-how and tacit knowledge should somehow be taken advantage of in design research. Also the research must be of a generic value, which makes it possible to feed it back to the designers' practice. A suggestion for a research design, which fulfils these criteria, is designed around five distinct units, which are to be understood as elements in a repetitive circular (heuristic) process. (Fig.1):
-A laboratory for the development of new techniques.
-A prototype which clearly isolates and describes selected techniques .
-A test-ground where the prototype is used to test it for generic validity.
-A feedback system to collect data from the test-ground which feed back into the laboratory.
- Documentation and analyses and development of theory.

In the case presented here, the laboratory is given through the collaboration within OCEAN[4] and its long-term research project Synthetic Landscape. Ocean is an international group with "nodes" in London, Helsinki, Cologne, Oslo, Ljubliana and Boston. The work presented here is largely based on the contribution from the “Northern Triangle”: Cologne, Helsinki and Oslo. OCEAN describes it self in the following way:

Since formed in 1995, OCEAN and its affiliated structure, OCEAN net, have emerged as a new architectural initiative. The organisational structure is best described as inclusive, collaborative, synergetic, multi-disciplinary, decentralised and geographically dispersed.

The OCEAN net's operative coherence emanates from connectedness and participation, a transgressive process of interaction and communication between nodes, always unfolding, always in transition. The modus operandi is orchestrated by an unbound heuristic and experimental logic.

Collaboration within the OCEAN net takes place in various ways, including project work, research, workshops, public conferences and symposia, exhibitions, and publications.
The theoretical commitment is the search for new and differential modes in spatial thinking and the making of space, towards fluid and topographical spatial organisations and material effects. On an urban scale the research focuses on adaptive and differential directives that enable a dynamic and largely self-organised urbanism of emergent properties and mobile influxes to occur.[5]

Another smaller laboratory setting is the VORB[6] workshop series at the Oslo School of Architecture. VORB stands *for “Virtuelle Objekter, Rom og Bevegelser”* (Virtual Objects, Spaces and Movements) VORB is a series of workshops at Oslo School of Architecture which started three years ago. The first workshop was an unfocused and general investigation, where the students were told to design a freely defined object or space in a 3D software.[7] The only restriction was that this object or space should be non-figurative, and that the use of traditional drawing tools was prohibited. The intention was to do an initial scan of the virtual space and it’s possibilities and potential. No concepts or distinct techniques were developed at that stage. The succeeding VORB workshops developed from the generic initial approach towards more distinct and defined concepts, and at the same time from the abstract to the concrete, from space via architecture to product. The project description from VORB3 illustrates this development towards more specific modelling techniques:

The students were obliged to find a graphical material which would serve as a starting point for the project. The graphics were analysed and the students, divided into four groups, used the graphics to inform 3D spatial models. Parallel model processes were conducted in both digital and physical form. [8]

The laboratory is a setting where first of all new ideas are developed. This development of ideas and concepts happens through practical activities as well as through theoretical investigations. The prototype is developed through selected concepts and theories that are given a form that makes them suitable for further testing.
The test ground is a setting where these ideas are tested in a broader context. The borders between the laboratory and test-ground are fluid. The VORB series developed from laboratory(VORB1) into test-ground (VORB3). New concepts can appear within the test ground setting. When this happens, these concepts together with other feedback and results are brought back to the laboratory for further investigation, development and analyses.

New technology - new methodology

Most designers and architects have introduced the use of computers to their everyday work. One should expect that the assimilation of such a powerful tool would have a major effect on the way designers work. This has been true only to a certain degree. Mostly the computers serve as an aid to speed up and rationalise the workflow, reduce errors or to monitor logistics, while the way designers work in principal stays unchanged. Still we like to think of the computer as a qualitative aid to the design process. The myths of computer technology animate us to assume that there has to be some unreleased potential, not only when it comes to normal drafting, documentation and production phases, but also in the initial creative stages of the design process. This has so far only happened in a rudimental way. The main efforts of software producers and researchers in design methodology has been to make the software ever more easy to use.[9] The software should be intuitive and as undisturbing to the creative process as using a pencil. Though new 3D software is much easier to use, it still is far from intuitive. On the other hand, the myth of the pencil as a total intuitive tool must be questioned. Though we do not need to focus mentally on how to use a pen, as opposed to while working with a computer, it is not an easy tool to apply. Years of years of training are required, and still the level of accuracy is limited. Sooner or later one is forced to alter the free initial sketching style towards technical drawings, where CAD already has proved its superior advantages.

Design methodology seems to rest in a defensive state towards the new technology. Though a lot of researchers are engaged in computer technology, almost all research is focused on adapting the technology to the way designers work. There is little done to adapt design methods to the new technology[10]. The exceptions, like Greg Lynn, do not define their work first of all as research in design methodology. Their ideological base is more in architectural theory informed by philosophy than in methodology.

Despite considerable efforts and achievements in research on creativity the mental aspects of creative processes still appear to be fuzzy and hard to understand. They seem to have qualities which are difficult to systematise, and which vary from person to person and over time. In addition they vary according to cultural variations. This unstable nature of creative processes makes research on design methodologies difficult, but it also has its advantages.

If we assume that at least some aspects of the mental parameters that are involved in visual creative work are unstable and potentially changeable, this leads to the possibility to alter them, simply by what we do and how we do it. This means to move focus from the investigation of the creative mind and the mental processes, towards research and development of creative techniques based on visualisation and treatment of visual representations aided by computer technology. The problems are externalised and focus moved to the core of the design profession. The empirical base for such research would be the development and testing of techniques and registration of results. Externalisation would be tested through the observance of any designer applying such techniques. The generic validity of these techniques would not be tested by producing identical results, but through the fact that they would (or would not) produce similar effects on different design processes conducted by different designers.

The consequence of this is that we have to adapt to technology, despite our efforts to adapt technology to us. Every new technological achievement changes the way we live and the way we conceive ourselves. Our design methods and way of creative work are no exception.

Building complex situations.

As our environments develop they become increasingly more complicated, interwoven and complex. This draws our attention to the problem of complexity in design[11]. Computer technology can help us to understand, visualise and design complex systems. Visualisation has always been an important aspect of dealing with complexity. Construction drawings are needed to get control over all the bits and pieces in complicated engineering design. Geographical maps are needed to navigate. Graphs and diagrams are needed to understand proportions and patterns between different parameters in trade and politics. Visual analyses are used to understand phenomena through scientific visualisation.

As the computer is designed to process huge amounts of numerical data it is well suited to monitor complex systems in a mathematical sense. Though as designers, it is not the digital core of the computer we are interested in but its graphical representation system, its analogue shell. In this sense the computer is not a digital tool but an analogue one, as we desire its graphics and representational power. In fact it is questionable if the “digital revolution”, is not an analogue one as the common breakthrough of the technology is based on the analogue user interface and the accompanying visually based applications, which makes the computer usable for a broad range of purposes. So in order to be usable for designers, mostly with a poor understanding of mathematics, the information has to be represented in a graphical form.

Scientific visualisation is used to present, clarify, communicate and deliver evidence. Visualisation in a design process has a similar but also different role. In a design process we are in a larger degree free to interpret and code the data in any desired way. The designers' means for control include interpretation, selection and monitoring of parameters, but also aesthetic concerns when rendering the data is of importance. In addition the choice of the "seed" conditions or input material is of crucial importance to the ensuing results and is a means to instrumentalise generic design intentions.

The development of new visual design strategies could answer to the increasing complexity of the tasks we face as designers. Good design solutions must relate to the embedded complexity that any design job implies. Complexity in design should be treated in various ways. One item is to understand the mechanisms as well as possible. Simplifying and distilling the present information helps us to perceive the most important tendencies and patterns. Distilling means to render the different aspects of the complex information in alternative ways. These altered ways of rendering will split information into different layers, which are easier to understand separated than superimposed. Simplifying means to interpret the information through diagrams. Diagrams help to understand complex situations. Different entities and the relations between those entities are mapped and described in a clarifying and simplified manner. Such diagrams mostly describe relations between entities and eventually the importance of these relations in a quantitative way. But if we really want to go further in our understanding of complex systems we need to describe relations in a qualitative way as well. This leads to a new type of diagrams where relations between entities are rendered in various ways. We should be able to describe border conditions between entities in a graphical manner. (Fig. 2 and 3) The graphical computer with its mathematical core connected to the graphical system appears to be the perfect tool for such visual complex system analyses.

The concept of "Generic Seeds"

The traditional early stages of most design processes are often based in the appliance of a tool: the pencil. Early sketching techniques are used to "think" visually and in an intuitive way. The sketch can be seen as an initial graphical template for the design. This graphical template is dependent on an interpretation. The designer has often a clear perception of his or hers sketch even though it normally is tentative, unprecise and unclear. Often a team work design process can increase production speed in such early sketching stages because the sketches are reinterpreted in various different ways, others than intended and "seen" initially by the drawer. A sketchy drawing "inspires" to new solutions. The inaccuracy and openness is the potential of a handmade graphical sketch. Still, a pen drawing is limited when it comes to complexity. Most often it has no colour depth, meaning it is only in grey shades at its best. By adding colour the sketch would be able to carry multiple levels of information. Seen from a structural point of view the hand sketch tends to be structural homogenous, since its main structural component is the line.

We can understand the traditional hand sketch as the first "seed" for a design. Many designers start with other information before they start to sketch. In these cases, the first initial information could be a text like a brief of the marked, production facilities, existing products and future intentions, rather than a graphical sketch. For this essay we will limit the discussion to concentrate on the role of the first graphical input, whether there is other preceding information present or not. The term "seed" is also used in the theory of genetic algorithms. The way we use the term here is similar but still different. In genetic algorithms the seed is an algorithm which will initiate an artificial life span. This artificial life form will develop unaltered and autonomous through automated feedback loops and processes that simulate mutation. The seed in our context is first of all not an algorithm but a piece of graphics. The second difference is that we as designers have the freedom and authority to interfere, alter and manipulate the process at any time. We, ourselves make the rules. We can find some similarities with genetic algorithms in the fact that both techniques leave certain moments to the computer to produce unimagined and unexpected results.

The existing information is interpreted directly through visual perception. But we can also alter the sketch graphically to animate diverse re-interpretations. Well known is the trick to observe a sketch through a mirror or upside down. The computer equipped with graphical manipulation software can add a lot to this. Just a simple trick like the negative of an image is very efficient in adding to new readings of a graphical material. Blurring is very well suited to identify the overall structural features, which often are confused by layers of detail. By increasing contrasts we can easier read the most important “force fields”. (Fig. 4, 5)

Through what is said so far we focus on the structural qualities and the potential complexity of information channels in the initial graphics, while semantics and content are less important. Let us take the full step and state that the initial seed information should be purely structural and only render organisational principles. This implies that first we initiate a structural organisation principle that we believe is adequate for the situation. Then we start to analyse and clarify these structures and instrumentalise them through codification. Codification means to apply operators to the structural entities. At last we move towards spatial and programmatic organisation and concrete solutions. That means, we start with a structural array, and end up with design.

The idea of using such a technique is amongst other sources inspired by Jeffrey Kipnis who initiated the term *colour graft*. The colour graft was meant to initiate a spatial structure a priori. Initially the designer and even more the architect faces an empty space which more or less automatically is conceived through a Cartesian organisation. To initially introduce an alternative, more complex and continuously articulated organisation of the void Kipnis suggested the use of complex colour maps[12]. The void was to be filled with some articulated information to escape the Cartesian paradigm, which is not capable to serve as spatial organisational principle for the rendering of complex scenarios in an articulated and enriched way. Colour maps should be structurally complex and interwoven, with articulated border conditions that help to render the relations between the different elements at play.

Computer graphics help to add colour depth to the graphical seed. This means that if we split the graphics into its colour components through colour filtering, one and the same visual data set can contain several channels of information. Since these channels come from the same graphics they are related to each other. Therefore they can be seamlessly re-integrated to each other. Colour fields also easily can be codified into spatial structures, through displacement mapping.

Dynamic generative diagrams

If we understand the initial hand sketch as a graphical seed to a design process, where shape, structures and relations between elements are more important than semantics, it is a short step to replace the traditional hand sketch with any other graphics. The “seed” could still be hand drawn but in a completely different way, as in the colour graft for synthetic landscape. (Fig. 6) In this case the sketch was cautiously designed to initiate certain structural qualities inspired from different other sources. The seed could also be any "found" and / or manipulated graphics that has certain structural and formal qualities as shown in the projects of the VORB3 Workshop[13]. (Fig. 7, 8 and 9) These graphical sources for information of both form and program we call generative diagrams[14]. In contrast to descriptive diagrams, which help us to understand structural principles of existing systems and situation, generative diagrams help us to generate possible structural, organisational and formal principles on a generic level. A few architects and writers have been occupied with the notion of the diagram in this sense[14].

All our designs, whether it is on an urban scale, building scale or product scale are likely to be used in unexpected ways or contexts and will have unpredictable futures. In this respect, time becomes an ever more necessary element in the comprehension of the urban fabric. We wish to know the future, since urban dynamics generates uncertainty through its potent production of future possibilities. Through scenario techniques we can tell well grounded stories about our possible futures, prepare both mentally

and practically, and implant adaptability to our designs. Though scenarios can not be taken as true predictions, we can say that they are potentially true on a structural level.
Scenarios introduce the dimension of time into the design process. Generative diagrams with a time dimension (animation or other time based processes) can be seen in relation to scenarios as indicators and structural generators of possible futures.[15] These types of diagrams we call dynamic generative diagrams.
Several architects (Greg Lynn, Ben van Berkel, Marcus Novac, Stephen Perella) are breaking barriers in terms of the creative potential of the computer media combined with diagrammatic thinking. Especially Greg Lynn has contributed with crucial new ideas and techniques, especially on blobs and animation.[16]
Dynamic generative diagrams help us to investigate how different structural organisations might evolve and interact over time, and establish qualitative principles for such events. They also help us to develop concepts around timing of events and sequences.

Reconfiguring schemata

Another effect of the graphical techniques applied to abstracted data sets is the production of unexpected solutions.
In many creative techniques the idea of breaking established conventions and rules, in order to reach new insight, is a well-known strategy. There are numerous ways of achieving what we could call the breaking and reconfiguring of schemata.[17] All of these techniques are designed to loosen up "mind control" when dealing with design problems. In the research exercises in OCEAN we applied a simple technique. By applying a "mechanical" procedure in the process one ensures that no prejudices bias the production through “unconscious” selection. Without any regard to preferences or foreseen solutions all possible structural solutions are reviewed. Only when all possible structural solutions have been investigated they are evaluated according to user needs, technical problems, aesthetic concerns etc. The technique is devised in order to force the designer to engage with alternative solutions to those preferred by his or her established design schemata. Other techniques like brainstorming are employed to loosen up or delegate mental control. This technique has proven to efficiently produce new and unforeseen solutions.

Graphic computers can be used in a similar way. In fact as generators of unexpected effects in visual material, and/or in the production and visualisation of complex information, the use of graphical computers is superior to any traditional method. Though similar effects can be produced analogously with physical models, the computer offers a high degree of flexibility, which allows for quick altering of the input material, the set-up and the parameters.

The output from the computer can be understood and interpreted in many different ways. On a generic and principal level it could be used to derive visual phenomena or structural systems which again could be used to inspire and inform specific designs. It could also be used as a form generator or form template for specific design problems, or it could be used as underlay for organisational systems layout. Also as a rendering of programmatic distribution, principles and systems scenarios the technique seems to have a vast potential. In all those cases the technique emphasises the important and crucial role of the human as interpretator and selector.

Synthetic Landscape as a laboratory. (A case)

Synthetic Landscape is a conceptual research project, partly financed through the Norwegian Research Council.[18] The project is still under development into its fourth stage. Intermediate stages have been presented at exhibitions at the Hennie Onstad Center for Modern Art, Norway (Phase Two) and at the AA School of Architecture in London (Phase One and Three)[19].
Through the long-term work with SL several concepts have been developed. In this essay only one of the concepts and a narrow segment of that concept will be presented.

The prototype

The prototype in this case is produced as a dynamic generative diagram for the generation of spatial structures in Synthetic Landscape Stage 2. A initial "graphical information seed" (Colour Graft) was treated through several stages in a completely abstract manner, to translate, release and investigate the spatial potential of the initial graphical information. The different colour channels were isolated and used to map colour intensity to 3D surfaces through displacement of the 3D surfaces according to colour intensity[20]. The separated surfaces were brought back together (superimposed) and intersection lines were generated to extrude the minimum common data. Time cursors were applied to the intersection lines and animated along these lines to add the dimension of time. Finally a selection of the cursors were equipped with forces and particle generators, to render possible interaction fields between the cursors over time. This process is a cyclic exercise in letting the data set grow and expand towards unexpected results and through extraction of representative minimum data, reduce the data fields to comprehensible scale. Repeated reductions of the data sets are important in the process of re-utilising them or codify them on a later stage. (Fig. 10)

The final result of this process was several animation sequences, some investigating and graphically rendering specific phenomena[21], others producing complex dynamic particle fields for use as dynamic generative diagrams.[22] (Fig. 11 and 3)

The Test Ground

To test the prototype according to the mentioned research design one needs a wider context than the laboratory itself. Student classes and workshops are well suited for this purpose.
The ideas and concepts generated in Synthetic Landscape have been tested in several occasions, like the later VORB workshops and the "Dynamic Relations in Design" workshop series conducted in co-operation with AA (London)[23]. Another occasion was a parallel workshop at the University of Art and Design in Helsinki and at the Vaasa Institute of Technology in 1998, called "Building Dynamic Relations". Aspects from this workshop will be discussed further here, not because it is outstanding in its results but because it has the most clear research design and because it is so far best documented.

At the workshop the students were presented to a selection of frames from the particle field animation sequences (Fig. 3) in top, right and front view from each selected frame. (Frames as frames in animation or singular images in a movie.) The frames were selected with an even distribution of every 20th frame. This selection was necessary because of the huge amount of information a complete printout of every frame would represent. This material was delivered both in digital form and as prints. In addition the video was available. This implies that the 3D time-space is only accessible through 2D "time-sections" and 2D video animation.

The students were encouraged to analyse the animation in diverse ways. First step was an analysis on a generic level to derive spatial and organisational principles. Brain storming techniques were used to generate concepts to comprehend significant time / space events (Virtual Phenomena). Several of these phenomena were chosen by the different groups for further analysis. The criterion for this selection was the proposed potential off the phenomena to be developed into generative diagrams. Some phenomena were analysed as principal force- direction- and density diagrams. (Fig. 12) Others were used as colour under-lays (colour grafts). Our design intentions were to interweave the diverse entities at play and carefully design the relations and interactions between entities and forces. Also we intended to design systems that were able to adapt to unforeseen future contact with other complex systems. This adaptable complex design with an implied multiple system mechanics is achieved by imposing minimum one system on another, generic diagram on program, colour graft on topology. (Fig. 14) The adaptable systems answer to complexity in the way the structure and topology is investigated for co-relations and quasi-congruencies, interactions and continuities. Colour grafting can be applied in many stages and on different areas of the design process. In the workshops such different situations were experimentally investigated. Colour grafts were imposed to diagrammatic program, social space, topology, form and structure. (Fig. 13) The entire colour grafts were derived from the source material (video) through various steps of transformation. Transformation processes were driven both by manual drawing and by digital manipulation. Manual drawing was in most cases closely integrated with analytical interpretation, while digital transformation turned out to appear as a non-analytical graphical approach to transformation. Individual interpretation, redefinition and redesign through selection are important elements in the transformation process.

From the analyses and transformation of the source material the students built abstract structures as physical models. Consciously avoiding the term “model” (as this is associated with a semantically representation) we wanted to emphasise the fact that this was an intermediate step towards architecture. (Fig. 15, 16) The idea was to avoid a direct translation into architecture, which could result in banal schematic solutions. Instead this process was meant to ensure the extraction of the essence and the principal features of the implied material. The abstract structures served in some cases both as structural and generative diagrams.

In the next stage the students had to invent a user profile for a pavilion placed on specific sites. The user profiles were meant to deliver a detailed system of user activities and needs. At this stage we introduced in other words two new systems, topology and user profile. The user profiles were analysed and generated diagrammatically through colour grafting and the use of generative diagrams with the source material as deliverer. (Fig. 13)

The user profiles together with topology, abstract structure and generative diagrams used in different ways produced the spatial and structural programs for the pavilions. Diverse techniques were used as planning templates. Different independent views from the structural models could be used to inform plan and sections. Sampling of geometry was another technique used by some groups.

Feedback

The feedback from the diverse test-grounds to the “Synthetic Landscape” research project has been considerable and increased the understanding of the techniques. The workshops gave important hands-on experience and reinforced the belief in the value of this research. Especially important was the input on how to codify different channels of activities and forces, like user activities, needs and spatial concerns. Also important input on how to relate these activities and to integrate them in an articulated way was produced.

The concepts from the workshops are presently developed further in “Synthetic Landscape 4”. A new prototype is to be applied on the urban scale.

Summary and conclusions

It is hard to break new ground through the development of new software according to old design methods. (The dream of the intuitive software) A better strategy would be to develop methods adapted to the existing computer technology and from that reach a radically new design methodology. The graphical computer and graphical image software seem to be specially important tools when it comes to the visual representation of complex data fields. In practical terms this means to use existing software in redefined ways. The option to specially program software is tedious because first one needs programming skills and secondly one needs to have a fairly clear picture where to head for. Any software which produces a graphical output can potentially be used, from custom made design tools to scientific visualisation tools or medical software. By redefining the use of these software’s, by looking for structural qualities that could inspire systems structure and relations and generic principles, we release the tools from its determined context.

Since the traditional way of initial sketching seems to have its limitations, this opens up for other methods, methods that might be easier to implement to computer technology or which even would benefit through the use of this technology. Graphical information, with no coded meaning is one example of the use of seed material with which to initiate digital processing in the design process. The computer is an essential aid when such graphic information is to be developed and analysed into systemic principles and inter-relations between subsets of information. Later in the design process, the information can be coded and instrumentalised to deal with material and other systemic variables.

At an early stage of this kind of systemic design, any pre-existing conception would violate the need to operate on a generic level. Therefore the systems first have to be developed on a generic and diagrammatic level. Only at a later stage the generic systems are coded.
Another problem is presented in how to develop a technique, which will produce complex systems, render the various relations between the entities in such systems and to maintain their complex qualities throughout the design process.
These problems are possible to address successfully through and with the aid of computer graphics and the concept of generative diagrams.

References

[1] The integration between practically based knowledge generation and design research is earlier discussed in the essay "Research Design in Design Research" Birger Sevaldson, Cumulus Working Papers Rome, UIAH 1999

[2] Anselm Strauss, Juliet Corbin: *Basics of Qualitative research, Grounded theory Procedures and techniques,* P. 42, Sage 1990

[3] Anselm Strauss and Juliet Corbin describe grounded theory as *"…..one that is inductively derived from the study of the phenomenon it represents. That is, it discovered, developed, and provisionally verified through systematic data collection and analyses of data pertaining to that phenomenon. Therefore, data collection analysis, and theory stand in reciprocal relationship with each other. One does not begin with theory, then prove it. Rather one begins with an area of study and what is relevant to that area is allowed to emerge"* (op. Cit. P.23)

[4] The author is a member of OCEAN Oslo.
Much of the work and ideas presented in this essay are developed and inspired in the OCEAN context, with contribution from a long list of people. Especially to be mentioned Michael Hensel, OCEAN.Cologne, and his contribution on theoretical aspects, workshop pedagogic and diagrams. Kivi Sotamaa, OCEAN.Helsinki, on contributions on many levels from practical to theoretical, Johan Bettum, OCEAN.Oslo, with heavy theoretical input and criticism and with valuable contributions on the development of digital model concepts and graphical treatment. All the OCEAN work credited to individuals is to be seen as highly influenced and inspired by the OCEAN network.
OCEAN website: http://www.ocean-net.org.

[5] http://www.ocean-net.org/info-ocean.htm

[6] VORB was initiated by Birger Sevaldson. The series are influenced and inspired by OCEAN through the contribution of Johan Bettum.
VORB website: http://www.ifid.aho.no/bs/3d/vorb/

[7] Jorgensen describes the use of unfocused methods in situations where one enters new research areas. The method is meant to avoid prejudices to influence the first investigations.
Danny L. Jorgensen: *Participant Observation,* Sage 1989 P.82

[8] http://www.ifid.aho.no/bs/3D/vorb/vorb3/

[9] Malcolm Mac Cullough discusses the problems connected to the development of intuitive software seen in relation to traditional crafts. He states that there still is a long way to go and that the key is visual thinking.
Malcolm Mac Cullough: *Abstracting Craft*, MIT 1996 P.41

[10] This situation is described by Malcolm Mac Cullough as "cultural lag*": "New thinking and new tools may og together, but only rarely are an altogether new tool and an altogether new task invented simultaneously…. ….Usually a new tool is used to do things pretty much as they always had been done; usually a new task is done quite some time by means of adapting existing technology."* (op. Cit. P. 75)
See also page 104 for a discussion on the limits of symbolic processing as a means for creative processing.

[11] A short introduction on how complexity is understood here is to be found in Greg Lynns article *Blobs*

Journal of Philosophy and Visual Arts, Volume 6 1995

[12] on continuos heterogeneity see Jeffrey Kipnis: *Towards a new Architecture*, Architectural Design Profile no 103 London 1993 p.40-49

[13] http://www.ifid.aho.no/bs/3d/vorb/

[14] Generative diagrams are discussed in Greg Lynns article on Ben van Berkel.
Forms of Expression: The Proto-functional Potential of Diagrams in Architectural Design, El Croquis no.72/73

[15] Here to be mentioned Ben van Berkel, Stan Allen, Manuel De Landa, Peter Eisenmann and Sanford Quinter. A collection of essays with the mentioned authors and additional ones is to be found in ANY magazine 23 1998. Central in this line of thinking is Gilles Deleuze and Felix Guattari's notion of the "abstract machine":
"An abstract machine in itself is not physical or corporeal, any more than it is semiotic; it is diagrammatic… …The diagrammatic or abstract machine does not function to represent, even something real, but rather constructs a real that is yet to come, a new type of reality."
Gilles Deleuze and Felix Guattari: *A thousand Plateaus : Capitalism and Schizophrenia*, Univ. of Minnesota Press
The work presented in this essay has to be seen against this context.

[16] See also Chapter Malcolm Mac Cullough on generative systems: *"…there are dynamic representations where not having control over lower-level operations yields a higher sense of control over a complete process. One can work at the level of derivatives, for example, controlling velocity rather than position. By altering the settings of a dynamic system…. ….one can improvise within the context of a simulation."* (op. Cit. P. 231)

[17] See Greg Lynn: Folds: *Bodies & Blobs collected essays*. Books-By-Architects 1998
and Greg Lynn: Animate Form, Princeton Architectural Press 1998

[18] The notion of schemata is used by Piaget as an explanatory model of the process of understanding the environment. This model was related to design thinking by Mark Gelernter :
"In both acquiring new knowledge or developing new skills, the mind works from a repetoir of mental schemata- programs of conception or action - which in the past have enabled individuals to negotiate problems successfully. Whenever the individual faces a new situation, a new piece of information or a physical problem, he or she first tries to solve it with one of the schemata in this existing repetoir. Should one prove to be successful, the problem is said by Piaget to be assimilated by the schema. On the other hand, if no existing schema will make sense of the new information or enable the individual to negotiate the physical problem, then the individual begins to search through the repetoir for a schema closest to the action or understanding he or she desires. By testing an existing schema against the problem, adjusting the schema in light of its success or failure and then testing again, he or she eventually might develop a new schema which will cope successfully with the new problem. A schema which has been evolved to cope with a new problem is said by Piaget to be accommodated to the problem. Once developed, a new schema is put back into the repertoire for possible future use, and in this way an individuals understanding and skill grows ever more extensive"
Mark Gelernter: *Reconciling Lectures and Studios*, Journal of Architectural Education P.41/2 1988

[19] Synthetic Landscape was founded and administrated by Johan Bettum, member of OCEAN Oslo and a doctoral student at the Oslo School of Architecture

[20] http://www.ocean-net.org/exhib/urbs-pr.htm

[21] Displacement Mapping is a similar process as Bump Mapping. In this case the mapped textures were translated into 3D geometries.

[22] Virtual Phenomena Video 1, OCEAN.Oslo, Birger Sevaldson, Johan Bettum 1997

[22] Virtual Phenomena Video 2, OCEAN.Oslo, Birger Sevaldson, Johan Bettum 1998

[23] "Dynamic Relations in Design" was a series of three workshops, winter 98/99, initiated by Michael Hensel, member of OCEAN Cologne. Hensel is leading the diploma unit 4 at the AA school of Architecture together

with Ben van Berkel. The workshop series conducted three workshops, one in co-operation with the Oslo School of Architecture and the Norwegian Academy of Architecture and another in co-operation with UIAH Helsinki.

Image references:

Fig. 1 and 2: Birger Sevaldson 1999
Fig. 3, 10 and 11: Synthetic Landscape 3, OCEAN.Oslo, Birger Sevaldson 1998
Fig. 4 and 5 : Synthetic Landscape 4, OCEAN.Oslo, Birger Sevaldson, 1999
Fig. 6: Synthetic Landscape 1, OCEAN.Oslo, Johan Bettum 1996
Fig. 7, 8 and 9: VORB3 Oslo School of Architecture IFID Ina Nicolic, Anette Marthinsen, Rene Safin, Gergely Agoston 1998
Fig. 12 and 13: Building Dynamic Relations OCEAN-Workshop Vaasa, Group1, Riia, Sanna, Pauliina 1998
Fig. 14: Building Dynamic Relations OCEAN-Workshop Vaasa, Group3, Jouni Rekola, Jani Ikkala 1998
Fig. 15 and 16: Building Dynamic Relations OCEAN-Workshop Helsinki, Group3, 1998