Swarm Architecture II

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Space is a computation. Architects design constructs as to structure the movements of information. This is true for the simplest house. Urban planners design strategies as to structure the flow of information in the city. This is true for all cities, big or small. Instead of focusing on the material appearance of spaces which are built after imagining the movements of people, we must pay more attention to the membranes of those spaces in the design process and to the openings in the membranes allowing for the flow of information in whatever form. A door essentially is an on-off switch in the membrane, the movement of stuff is structured as to flow through that door. Doors are open or closed [or half open and half-closed], the spaces are switched on or off, or sort of switched on or off. The membranes are semi-permeable envelopes around a certain quantized volume of space. The semi-permeable membranes let through people, light, heat, cold, small animals, air, radiation, information, food, water, gas, waste, molecules, wind, sun, moist, materials, cars, shopping bags, television programmes, waves, books, paper. A wide range of different materials is coming in through the membranes, another wide range of materials is leaving the space somewhat later. Some things come in through explicit holes, others come in by diffusion, by radiation, by transmission, or are carried by other messengers. Much of it is carried by people, coming in and going out. People are information carriers, they run in, about and out the house. The information they carry out of the house is of different content then the information - in whatever disguise - they take out of their house. The information content and some material properties of incoming information is changed inside the space. This space can be considered as a content transformer, it digests the incoming material / information. Taken to the extreme all material is a form of information, and taken even further all information is a form of computation. Thus space computes information. The question to be raised here is: does the space compute or do the people in the space compute? In the context of Swarm Architecture I understand human action in such a way that it must be the space which does the trick. The space is full of more or less active components, many of them communication with each other, many of them interacting with certain intervals, and many of them interacting in real time. I see people as drivers of the space when looking at it from a certain distance. To understand this better you may imagine a highway with cars running on it. When one finds oneself inside this traffic system, one always refers to the other players as cars. You always would state: that car came from the right, there goes a Ferrari. The cars are the players in the traffic system, and these cars are eventually driven by someone, but they are only their operators, they basically function as programmes running the car. So the car is the flocking bird in the traffic swarm, and the person is a member of the running car, and not a member of the highway traffic system. How can we look at space with this in mind? Then it is the space itself that behaves and acts, as driven by their programmes and executed by a variety of actors, among them people, but also light bulbs, refrigerators, vacuum cleaners, sofa's, shopping, bookshelves, tables and chairs. They all move or are moved inside a certain space. In the mind of the Swarm Architect, all actors / players behave in relation to each other following a set of simple rules. And it is the space which defines the workspace of the players. Seen from further away this space interacts with other spaces. Then you loose track of the swarm of interacting players within the space with their semi-permeable membranes, and you are monitoring a swarm of interacting spaces. And the human people flow through this from space to space, from car to space, from small space to vast space. Seen from the point of view of space, people operate on the space as if they operate a computer. Just like the computer does the computation, the space performs the computation and transforms the information content of the information / materials absorbed into it. People also compute in their own domain: they feed on vegetables and meat, they eat and drink, they absorb sounds and light, they smell and sense. People compute that information and spit out information in a different format. People are transformers, just like spaces are transformers on a meta-level as seen in relation to people.

Now that we have left behind the anthropocentric world view, which states that people are in the centre of knowledge, and now that we have accepted space and people as equal players in the field, we can start thinking of another approach towards architecture. Now we can build up a language of Swarm Architecture [SA from now on]. In SA people interact with people, books interact with tables, paper interacts with people, all are active players in a complex adaptive system called a car, a space, a home, a street, a city.

The building becomes the installation. The ultimate task of SA is to inform its new born structures in real time. The design task of the information architect is how to keep the process alive and apply meaning to the behaviour in real time. How can the designers tunnel a continuous stream of data to and from the built structure and give meaning to the shape and content of the structures changing in real time? To facilitate this fundamental new world view we must look at buildings as if they are instruments, which can be played in real time. These dynamic buildings I regard as running processes, which are continuously informed and which continuously inform other running processes. They are active nodes in a complex adaptive operational network.

So humans are running processes themselves too. Applying new available techniques they cooperate in the making of instrumental buildings which are essentially running processes as well. The building becomes an active installation where numerous actuators are constantly communicating with other actuators, their users and their environments. We know from practice that in each building there is already a large portion of the budget dedicated to the electro-technical and mechanical installations up to 30% of the total budget. In the bright future of instrumental buildings the whole structure will be interpreted as an installation. Project the actual trends into the near future it makes sense to regard all constituting components of the built structure as active members of the installation. The building becomes an instrument, it becomes the installation.

A fine parallel can be drawn here with interactive art installations. Most art installations have a temporary nature. They are there for the period of the exhibition. Imagine to extend the art installation into the life cycle of a building, and we have a quite accurate picture of the installation building. We find ourselves living inside the installation space of the performance. In our art, architecture and programming driven practice ONL Ilona Lénárd and myself did a similar leap when we were developing buildings as big scale sculpture buildings / building sculptures back in 1994. We developed

the concept of buildings like big scale sculptures in the Sculpture City project (1). Buildings could be explicit sculptures, and sculptures could function like buildings without compromising on the meaning of the sculpture. Now I propose to make the next jump: consider the building / sculpture as an active installation, and consider the city as a swarm of interacting installations. Forget about the city as a collection of static objects, it is only a small part of the quantized city game. In the near future we are planning to come up with a project called Installation City.

Architecture finally becomes truly time-based, it is no longer a simulation, not only in the isolated sectors of the design process but in the experience of the space itself. Space in Swarm Architecture communicates actively with the users of the space in real time: they know each other, they flock together, space and people are becoming linked through a complex series of networks. The knowledge of people is only meaningful because of the connections with other brains. There does not exist something like an independent brain. Knowledge, consciousness, wisdom, innovations, emotions, they all are only possible by their connection to other people. The same is true for cars. One car without the existence of many many other cars has little or no meaning. Neither has the car meaning without a road network where it can drive around. In much the same way our personal computers do not exist disconnected from other computers. You simple need a population of peers to exist as a species. The evolution of the PC is only possible between the peers. And naturally the population must relate to a multitude of other species as well. Kevin Kelly was right again when we stated that the We are the Web²). The Internet is regarded as a giant brain, where the millions of connected PC's are the neurons, firing information into the network. And we people assist in keeping that network operational, we carry information to our PC's, which in their turn submit the info into the global system by one of their running programmes. The world is the installation space, and that ubiquitously computed space becomes the instrument to create new sociotechnical experiences.

Quantum Theory. Quantum Theory states that certain properties occur only in discrete amounts called quanta. Quantum Theory is based on the behaviour of elementary particles like quarks. Quantum Theory has constructed a Standard Model with many types of particles, each of these behaving in a specific way on their own scale: electromagnetic, strong, weak and gravity forces. The bandwidth considered in the Standard Model is 10⁸ mm. These forces represent all possible interactions between the sub-atomic particles within this bandwidth. The observed bandwidth resonates with the bandwidth between building components and the urban scale. If we observe and construct architecture between 1mm and 10⁸ mm [100km] then we cover the scale of our designers profession accurately. Swarm Architecture is based on my postulation that every member of an architectural construct is in essence based on a computed behaviour of discrete quanta. These quanta can represent anything from the smallest building component to the largest building blocks of a metropolis, anything from one single person to multinational institutions. As long as they behave in real time, and as long as their behaviour can be computed in real time.

Would it be possible to feed back our hands-on experience of Swarm Architecture into Quantum Theory? If we could then it proves that we do not feed on other disciplines, that we designers do not use quantum theory only as a harmless analogy. Then we could really establish a bi-directional dialogue. The question I would like to ask the quantum physicists is: could the sub-atomic worlds possibly be as complex as our swarming species as observed and constructed in the bandwidth between 1mm and 10⁸ mm? Is life out there in the sub-atomic world as complex as it is here and now? But obviously observed and constructed by a swarm of species invisible and unobserved by us?

Real time behaviour. Real time effectively means many times, in such a way that it feels smooth and continuous. Computation is a sequence of discrete operations, millions of operations per second, each generation of computers considerably faster again. Stephen Wolfram takes one step further in his brilliant but controversial book Towards an New Kind of Science ³). He states that nature [the universe] as we know it is a pure form of computation, and specifically an operational system of computing cellular automata. The computing of cellular automata is an on-going process of billions of interwoven discrete computational steps, in my understanding similar to the computing of the relations between quanta in Quantum Theory. Everything keeps falling into place.

In the world of Swarm Architecture real time is a much more modest form of complexity in computation, real time here means many frames per second. More then 25 frames per second humans perceive the graphics of computer games and other processes as fluid, streaming and smooth, as existing in real time. Since most of our endeavours in architecture are meant to be experienced by humans, 25-30 times per second is regarded here as the lower limit of real time in relation to a new theory of Swarm Architecture. Real time is implicit in running processes. Installations are running in real time, humans are running in real time, and in the theory of Swarm Architecture the buildings which are designed and experienced as active installations, are also running processes unfolding in real time.

Swarms of building components. Behaviour is essential to processes which unfold in real time. The essential components of every building construct is a swarm of reference points, which are in the process of building relations with each other. I emphasize the present time mode here since I do consider the development of any building construct - from furniture to city – as an informed swarm of relatively stupid reference points behaving in real time. Simple and stupid behaviour means following a simple set of rules. For a better understanding of the term behaviour in this context it is useful to analyse other types of swarms. Like the swarm of birds where the birds indeed act as active nodes in a flock of peers and communicating with them in real time following some basic rules: 1) The Separation rule: steer to avoid crowding local flock mates, 2) The Alignment rule: steer towards the average heading of local flock mates, 3) The Cohesion rule: steer to move toward the average position of local flock mates. Check Chris Reynolds Boids website for further understanding of the phenomenon of flocking and swarm behaviour ⁴). Flocking effectively means that each particle keeps track of their immediate neighbours. Each bird-particle as a member of the swarm computes these rules many times per second. In essence each particle is just looking to its immediate neighbours, they do not have a conscious awareness of the group as a whole.

Flocking behaviour applies to particles systems at any scale, it applies to home appliances, furniture, buildings and cities. Although explicitly seen by him as a metaphor, the book Quantum City written by by Ayssar Arida in 2004 ⁵) gives us some valuable clues for the importance of further research on the quantum-like behaviour of complex systems like cities. Arida discusses world views of great civilisations, quantum theory, uncertainty, interference patterns, eventually proposes the new term diventity, which is a conglomerate of diversity and identity, and states that we must adopt now to the world view of General Relativity and Quantum Theory. However Arida does not develop a tool-box, he leaves that to others. The here proposed theory of Swarm Architecture Quantum Theory is explicitly not used as a metaphor but as an working model of how elementary particles may interact on different levels. First in our practice ONL from 1999 and later from 2000 with my staff and students of the Hyperbody Research Group at the TU Delft, we have built a vast series of interactive design tools using game technology and particle systems. In Swarm Architecture we propose that all arrangements of building components and/or city components are behaving like active but relatively stupid particles in a larger parametric system, which in turn interacts with other parametric systems in real time. From very simple relations running in real time very complex systems arise, but only if we are able to actually build the relations and initiate the running processes.

If we only would look from the outside at the graphics of Quantum Theory and model buildings or cities which would look superficially like that we would probably make a mistake. On the contrary, one must dive deep into the heart of the process which produces the particle-wave behaviour, one must try to understand how it works, find the underlying set of rules and parameters, and construct a new working system of interacting particles from that deep understanding. The parameters inform the rules in real time. Each interactive system absorbs fresh data / parameters in real time, digests them and spits out new data to inform other active running systems. This instrumental process constitutes the behaviour of each complex adaptive system. In the theory of Swarm Architecture the design instrument constitutes the behaviour of swarming built constructs.

A personal history from Synthetic Architecture to Swarm Architecture. For the exact positioning of the new theory the term Swarm Architecture is specific to certain formations the swarm of particles may develop, while the more generic term Interactive Architecture includes a broader scope of possible interactions, also between a small number of components. I have chosen Interactive Architecture [IA] as the title of the new knowledge centre I have founded at the TU Delft recently. IA covers a broader field then SA, and that is exactly what is needed for the knowledge centre since that forms the umbrella for a number of related activities. I use SA for the more basic theoretical background of IA, while SA remains a well defined research area within the IA knowledge centre. I will maintain the name of the Hyperbody Research Group [HRG] in the education and research at the Faculty of Architecture at the TU in Delft. In the HRG we perform further research on intelligent e-motive environments and on constructs based on parametric design techniques and on multi-player game software development platform.

I introduced the term Hyperbodies and the word E-motive in my inaugural speech at the Faculty of Architecture in 2001 titled Towards an E-motive Architecture⁶) and in my book in the cute IT-Revolution series titled Hyperbodies, Towards and E-motive Architecture 7). I found these terms important to play a role in the architectural discourse, since they deal very accurate with the worldwide paradigm shift in architecture from the analogue to the digital and the animated. I was working in those early digital days in sync with a dozen other transarchitects. Numerous new words were invented and many of them are still very adequate today, they have become natural members of my personal glossary of architectural terms. I have invented the term Programmable Architecture for one of our books, and I have referred to our new architecture as A New Kind of Building in many lectures around the world. My PA theory has been developed from the experience of building our practice, which has been since the last 10 years based on scripting techniques in the design process and on CNC production techniques of mass-customization in the process of executing the design. The experience of designing and building a dozen structures has been leading us to become a competitive Non Standard Architecture practice. I stated that Architecture Goes Wild⁸) - the title of the book with most of my / our essays written the past 15 years - as a logical consequence of the choices we have created for ourselves with the hardheaded assistance of our computing devices to be considered as equally valid alternatives for any architectural shape and behaviour. We had to learn to swim in a deep ocean of possibilities and choose directions. We chose to go from Synthetic Architecture [1990] ⁹) and Sculpture City [1994] via Programmable Architecture [2000] ¹⁰) and E-motive Architecture [2001] to Non Standard Architecture [2004] ¹¹) and Swarm Architecture [2006].

I have my roots in the paradigm of repetitive serial prefabrication of the sixties. In our design practice ONL [Oosterhuis_Lénárd] we bridge the gap between the sixties of the 20st century and the zeroes of the 21st. While the group of Non Standard Architects labels their architecture as: Liquid Architecture, Hypersurface Architecture, Hybrid Architecture, Animated Architecture, Transarchitecture, Performative Architecture, Machining Architecture, Evolutionary Architecture, Generative Architecture, we realize in our design practise a very pure form of the File to Factory design and build process, all based on the principles of Swarm Architecture. Moreover we have invented and realized assisted by members of my Hyperbody Research Group a dozen interactive installations like Trans-ports and Handdrawspace ¹²), we have built half a dozen working prototypes for a meaningful Interactive Architecture. This all happened within the time frame of the past 15 years, coinciding with the use of personal computers in our new digital design practices.

Surprisingly my roots are to be found in the Dutch De Stijl movement of the early twenties of the last Century. They made a convincing shortcut to fresh universal mathematical theories which were dealing with a complete new understanding of the Universe. Artist Theo van Doesburg and furniture maker Rietveld were considering space as a certain variable density of the Universe. They were understanding space as a space-time continuum where the built construct, chair or building was something like a locally increased density of that space-time continuum. Even today I could not agree more. But now we have new theory, new tools, new production techniques for furniture design and building constructs, and that is the main reason why our projects look so different from their design. We share a

fascination for natural physics, mathematics and computation. One of my first realized works was a 1988 exhibition design, displaying the works of Theo van Doesburg in Museum Boymans van Beuningen in Rotterdam. Our approach to design can be understood as a cross-over of radical art and radical architecture. Radical concepts from the past inspiring us typically come from both the arts and architecture: from the thirties constructivist architect Ivan Leonidov for his Magnitogorsk plan and his Library, from the fifties artist Constant with his New Babylon project, from the sixties cybernetic artist Nicolas Schöffer for his book La Ville Cybernétique ¹³) and his Tours Cybernétique, from the seventies artist Frank Stella for bringing painting into 3d space and for his book Working Space ¹⁴), and the Italian architects of Superstudio for their radical Nine Cities.

My fascination with theory, technique, art and architecture really goes back to the twenties of the previous Century. That period was in my eyes crucial for modern civilisation. Many new theories were constructed using language and mathematical formulas, many technological inventions and applications were made and found their way into art and soon after that into the avant-garde of architecture. The common basis is that we have our minds virtually connected to the understanding of the universe. This may sound vague at first sight and avoiding concrete viewpoints, but I experience this as a very tangible and relevant. These days I am reading the book The Fabric of Reality ¹⁵) written by the natural physicist David Deutsch claiming that Quantum Theory implies that there must be billions of parallel Universes. My favourite magazine is Scientific American, I am always looking forward for the next issue. Scientific theories teach me more on the essence of architecture and its genes then any book on architecture has ever given me. And after reading scientific hypotheses I do relate the often speculative concepts back to the history of architecture as we know it from experiencing the real work. History is not an objective reality, it is rewritten every moment in our brains. We are in a constant process of evaluating and rethinking the memorable moments of history. I am convinced that the right way to go for the information architect of our era is to inform ourselves on the actual techniques and use the tools which are available to us, and to construct with this knowledge and with these tools an appropriate architecture of the zeros of the 21st Century, just like sensitive architects did in their time. Later people will look back at this period and find their inspiration exactly because it has given consistently and honestly shape to the actual developments in society.

Implications for the daily practice of architecture. Once a script for the production of a building is executed this results in an explicit shape, both in the case of a mass-customized Non Standard Architecture as for an installation of real time Swarm Architecture. The only thing that counts after the production and the assemblage is: how do we experience the shapes when moving in or along that structure? Our design for the Acoustic Barrier was made from the point of view of the car driver driving with a speed of 120 km/h along the barrier. The experience of the driver has a duration of 40 seconds. In these 40 seconds ONL wishes to offer the drivers an experience of slow transformation, intended to make them feel comfortable. Not disturbing the eye of the observers, but rather giving them a sort of light visual massage. Experience Lite. The experience is dynamic but not wild or exotic, but rather a smooth 1,5 km long stretched soft feeling. There has been much misunderstanding that NSA architecture is wild and restless. If not controlled well it sure can be like this, but ONL prefers to create sensations of quiet excitement. We are not crazy expressionists, we are not shouting loud, we try to offer the public a sensation of slow beauty, finding its way into the hearts of people, and making them feel better, like it makes feel ourselves better. In the end we want to share our knowledge jump with others. In order to achieve this goal we need to work on the digital platform and we need to develop project-specific routines and scripts to organise the tens of thousands unique components. Architecture Goes Wild as is the title of one of my books, but Non Standard Architecture does not necessarily looks wild. It is our explicit goal to produce natural beauties. The next upcoming paradigm shits towards Programmable and Interactive Architecture has in our vision a similar goal. We do not design buildings like the Muscle and Trans-Ports to disturb people, but rather to offer a natural feeling of slowly changing conditions. The building transforms slowly like the weather does. Eventually it may explode like a thunderstorm, which is likely to happen in our Ground Zero Proposal for a sensitive 200x200x200m3 hypercube, but that is only functional as to appreciate the silence after the storm even more.

But there is another strong practical argument for developing Programmable Architecture. Building components like columns, trusses, floors, ceilings and walls will become actuators cooperating with each other to perform the changes of the physical structure and the graphic content in real time. Actuators are addressed by a programme which can effectively be described as a multi-player game. The actuators are being orchestrated like the birds in a swarm. The orchestration is not necessarily a nervous up-tempo beat. The orchestration can be smooth, slow and may act as a tranquillizer to slow down the excitement rather then as a stimulus for fast movement. At the extreme other end of excitement the swarm techniques can be applied to stabilize buildings as to not move at all, which will be extremely useful in high-risk earthquake regions. The technology of using actuators in buildings may be used to make buildings and bridges even stronger and more efficient with their components then traditional constructs that are calculated as to resist tot the strongest possible force. Adaptive constructs react in real time to forces acting upon the structure and tighten their muscles as to resist only locally to the forces. When the train passes the bridge, only those members are informed to contract which are in the immediate neighbourhood of the weight of the train. The other trusses remain unstressed and relaxed. The rest of the structure does not have to work that hard, and does not need to be post stressed. Post stressing in real time promises to be a real economical advantage for bridges, skyscrapers, floating airports and such large scale structures. As a conclusion we can say that by having developed a pure Non Standard Architecture and in their prototypes of Interactive constructs ONL not only widens the bandwidth of possible experiences and emotive feelings of built structures by its clients and its users, but also opens up a territory of potential profitable economical exploitation.

None of our executed works we consider experimental. Like most designers we do not know where the design process will bring us in the end. Designing is an open-ended process. What makes the works of ONL special here is that we take bigger risks. For example when we were invited to exhibit at the Biennale in Venice in 2000 we proposed an interactive installation using game software. We never worked with this before, we never had built such a behavioural installation before. Ilona and I had 3 bright collaborators at that time which we invited to join the team [Richard Porcher from France,

Andre Houdart from Belgium and Nathan Lavertue from the USA] and gave them each the task to built one of the three environments of the Trans-ports installation. We asked sensor and interface expert Bert Bongers to join our team. Bert Bongers has worked with us before for the real time behaviour of the Saltwaterpavilion. None of us and none of them had any experience in interactive game design before and yet we succeeded. It worked because we had an explicitly clear and radical concept. It worked almost perfectly, theory was tested successfully and since we developed the concept of Trans-Ports further. The same can be said about the mass-customization production process of the Cockpit building and the Acoustic Barrier. We never had done it before on this large scale. We did develop the Web of North-Holland some years before, but now the whole process was set up from the beginning as a parametric model, and instead of making drawings we scripted the behaviour of all nodes of the constructs, and communicated the relevant data through tables with the production machines. This represents a radical break with the traditional practice of architecture. The project was not designed in the traditional way, it was developed as a product and offered for a fixed price. We have been working very closely together with the manufacturer, the steel manufacturer Henk Meijers of Meijers Staalbouw. We have linked, very much like autistic savants have direct access to their central database deep down in their brains, our scripts to their Autolisp routines to build the successful machine to machine communication. We take the risks of the responsible entrepreneur, so in that sense we do not regard it as experimental but more as as a new form of entrepreneurship. We do not create problems for others to solve [as so many old-school architects do], we design and build complete working products, in which procedure ONL has taken responsibility for the exactness of the data describing the geometry.

Swarm Architecture from research to practice. I insist to use the term SA not as a metaphor but as to indicate the running process of a complex adaptive system. SA is the computation of the group design process itself. SA is the operational field of architecture in the process of constructing and executing itself. This includes the design process, the fabrication process and the process of interacting with the constructed environment. In all cases SA is an input-processing-output [IPO] vehicle, communicating in real time with other IPO systems. We must have a closer look at the computational nature of the interacting particles in the design process first, the computational nature of the scripts to inform the fabrication process and the computational nature of the games playing the life of the constructed environments.

When we look at an urban environment from the point of view of SA we no longer see isolated objects. Instead we see objects which have a relation with each other. One of my student exercises is: take a close-up picture of a street scene and describe all relations. Describe how the rubber of the tire touches the asphalt of the street, describe how the fender is related to the neighbouring members of the car body. In urban planning the building volume has a relation with the plot. The plot has a relation with the access road. The floor area of the building on the plot has a relation with the number of m2 of parking places. The parking area has a relation with the road. All relations are described in simple rules. The rules are played by the parameters as if it were an instrument. The objects behave in relation to each other. When we build such a system of relations in a 3d modelling programme it is parametric design. When we build the system in the game development programme it displays real time behaviour, the parameters may change continuously over time. We label this dynamic behavioural design method Swarm Architecture [SA]. In the traditional design process these kind of relations are usually built inside the creator's mind, but in SA they must be named, quantized and scripted.

We never try to imitate nature, we never try to look natural or to mimic natural evolutionary processes. We try to understand the behaviour of elementary particles and construct a logically possible world from there, balancing between the bottom-up behaviour of the particles and the top-down rules applied on the players in the design game. As for the design process we think of it as living diagrams, we want to be an active player inside a running process, inside the multi player design game. The design process includes all relevant experts who are authorized to change the rules of the game while playing it.

Although we have adopted a fluid architectural style and although we declare ourselves working within behavioural science. I resist to the impression that ONL designs biomorph buildings. I agree that they sometimes display a resemblance to shapes as we know from natural history, but we never start with that idea. We never try to copy superficially the appearance of a biological species. Rather we try to invent new species which by its complexity and due to their complex behaviour may eventually familiarize with living objects as we already know. We always try to get as close as possible to the genes of our designs. We have organized in 1995 an international workshop simultaneously in Vienna, Budapest and Rotterdam titled the Genes of Architecture. We exchanged memory-genes, form-genes and meaning genes on a daily basis. But biotechnology as such has not directly influenced our work. We never try to mimic an image from the realm of biology. We adopt to new technologies and try to work with them in unexpected ways. New technologies allowed for the invention of industrial muscles, produced by Festo company who is big in providing for actuators in the processing industry. To use these muscles in interactive installations was an act of the artist in ourselves. The Festo muscles were not intended to be used in this way. The use of muscles as pro-active actuators is an evolutionary step in the proliferation of industrial muscles. We are happy that we could contribute to that evolutionary process. Loaded with that knowledge we are tempted to construct a new species of behavioural architecture from our knowledge and experience with art installations. I dare to predict that within 5 years we will have realized a building where part of the building behaves in real time using actuators. And it would not surprise me if that building would be built in the Middle East region.

Uncertainty and unpredictability. In the design process we start by defining elementary particles representing the players in the game. Players can be people, cars, nodes of a construct, houses, office space, parking places, streets. They all are basically particles behaving according to a simple set of rules. For example: if we introduce 100 homes in the playing field, they swarm together is a specific way, they keep a certain distance to each other following a specific algorithm, they distribute themselves according to simple rules. They only look at their immediate neighbours to decide where to position themselves. The behaviour is an open system which means that if the behaviour of other players

change, that they will respond to the new parameters coming in into their system. In this way all players follow simple rules and interact with all other players, again according to an open rule-based system. Imagine thousands of different swarms of various species interacting, at the same time imagine thousands individuals interacting with other individuals. That feels like the complexity of our cities. Starting from very simple rules applied to a limited number of particle-players a very complex behaviour emerges. SA [and swarm-based urban planning] is an intriguing and very dynamic design game indeed. The challenge for the designer is to find those rules that are effective and which are indeed generating complexity. Some design rules produce death, others proliferate life. Some design rules create boring situations, other rules may generate excitement. You can only find the intriguing rules by testing them, by running the process.

The uncertainty principle is at work here. The outcome of the process is not predictable in the classical sense. Although the system works by playing by the rules, the outcome of the game can not be predicted. There are billions of possible outcomes, all of them adequate as a response to the challenges posed to the system. Some of the outcome are more favourable for some experts, some are more favourable for other experts which limits the solution space, but still in theory an infinite but discrete number of possibilities are answers within solution space. But just like playing a tennis game, not all games are thrilling and beautiful. You need strong and intelligent players to play an exciting game, you need expert designers with a strong will to perform at their top level. This understanding implies that a tennis game unfolds according to quantum mechanical principles of uncertainty, probability and chance. Always something unexpected may happen. The game has to be played in real time to matter for the unfolding of the fabric of reality. The player may give up, the player may be much better then expected. If the design game is not played it is a mere simulation. I am not interested in simulating reality, I am interested in constructing reality by the actual playing of the serious design game.

Top-down styling interventions and bottom-up swarm behaviour. In my earlier writings I took the black monolith coming from outer space and having landed on the surface of the earth from the film Space Odyssey 2001 as the ultimate example of the environmental role of our designs. Our designs are designed in weightless space, where there is no gravity so we can easily tweak the volumes, twist them and rotate them freely around. In the meantime we gather information about the future landing site of our weightless bodies. You could imagine this as a bi-directional communication between the site and the spaceship. The spaceship design sends signals back to earth and earth prepares as to accept the alien body. Earth and spaceship inform each other on every relevant aspect of the future successful reception. First when the floating design lands gravity starts to execute its actual forces on the design. Before gravity has been simulated through calculations, informed by a crew on earth. Urbanists seem to be trained to think that buildings grow like plants from the ground up, using local food to grow. Nothing is less true, they come from elsewhere, all concepts and materials are transported from remote places as to be assembled on that very spot. I have noticed that many urban planners have developed a sort of xenophobic fear for alien bodies. But I have a completely different feeling about this. Look at what happened after the black monolith landed. The apes started to wonder what it was and especially how it could be that the edges were so straight and sharp. They had never experienced something like it before. They had to take an intelligence jump to cope with it, a sort of quantum jump into another state of consciousness. I think this is exactly what our designs could bring about in historic settings. Proof of this theory is the implementation of iconic buildings in old city fabrics like Gehry's Guggenheim Museum in Bilbao. Although very decon and more traditional then our design concepts you can clearly see this process at work. Like all xenophobic theoreticians they would like the aliens to resemble us, they have difficulties in accepting that society is a very complex organisation, which is continuously transforming because it feeds on materials and information coming from a space exterior to the boundaries of their own protected environment. But obviously the implementation of the newly arrived body only can be successful if both parties inform themselves and each other properly. Our buildings do not place their backs to their environments, they rather make a soft landing in a carefully prepared nest. Their bi-directional information threads will be carefully interlaced and their physical presence will be equally carefully interwoven.

Modernist architecture and especially Mies van der Rohe has chosen the aesthetics of the Stijl movement to build the modernist movement empire. Mies was not so much interested in the variable densities of the space-time continuum like Theo van Doesburg was but he was aware of the fact that that this language was well suited to build cheaper, that is: without ornaments. And this stripped Spartan architectural language was on speaking terms with the principles of massproduction of steel and concrete components. Now we have entered the era of mass-customization, and this demands for a radical new design approach. Digital technology, Non Standard Architecture [NSA] and File to Factory [F2F] Computer Numerical Controlled [CNC] mass-customization principles are naturally bound to each other. The NSA architectural language of doubly curved surfaces, of soap bubble constructive principles, calculated through algorithms rather then drawn as 3d models comes from within the complexity of the new NSA world view, it sprouts from its own internal logic. Although theoretically possible it will be quite irrational to use NSA design techniques and masscustomization production techniques to build a simple square box. Traditional techniques will be more likely to be applied. It is would be like using swarm behaviour algorithms to describe the fixed position of two points in space. The Swarm Architecture aesthetics come from the bottom-up processing within the system, but the styling of the complex surfaces come into play as top-down interventions from the exterior of the skin of the building. I am very much keen upon establishing a balance between the bottom-up and top-down aspects of design. That is why I am, besides practising the new paradigm of NSA, also very interested in automotive styling. Beauty comes from within and is at the same time imposed on the object from the outside. This matches perfectly our theory that buildings are complex adaptive systems communicating with their exterior and their interior environment. Buildings are the interface between the exterior urban and climatic conditions and their interior users.

In 1999 I wrote an article for Archis magazine titled Vectorial Bodies. At the bi-annual car show in Amsterdam I took pictures of headlights, folding lines, continuity in power lines of the body styling, inlay techniques, body shapes and analysed emotive aspects of the design. I started the article with the observation that one always enters a car through the side door, never through the front door. One steps into a vectorial body, a body with a vector. And that is exactly

what our designs are: they are bodies with a vector. And I was very pleased by the observation that in our designs we come in through an entrance at the side of the building body. In the Saltwaterpavilion the door is detailed as a cutting out of the skin. Just like the door in the body of the car is not expressed as a frontal porch but as a delicate cutting in the class A surface of the body. There are so many striking similarities that we started to use the term Automotive Styling for the top-down styling of our own building bodies. But we do not design cars without wheels, in the same way that we are not designing biomorph species. The simple reality is that we embody speed and friction in our designs, as much as we embody smoothness, flow and behaviour. It is recognized by certain clients that our architecture is well suited for situations along highways where speed and flow from the point of view of speed is a possible design issue. Like it is recognized by other clients that our architecture is well suited to build buildings as a memorizable iconic experience rather then as a static piece of neutral architecture. Our architecture fits particularly well where there is an explicit people flow [multi functional buildings and shopping centres], an explicit flow of cars [along highways or on the banks of a river], and where the clients are looking for iconic landmark buildings, which are experienced dynamically from different viewing angles, experienced from people walking by, cars driving by or from ships passing by. Clients having shown the guts to take the step from the Experience Economy towards the Transformation Economy ¹⁷) would feel attracted to the real time behaviour of our interactive Swarm Architecture.

¹) Sculpture City, Kas Oosterhuis, Ilona Lénárd and Menno Rubbens, 1994, ISBN 90-6450-229-3, www.oosterhuis.nl

²) We are the Web, Kevin Kelly, 2005, Wired magazine, <u>www.wired.com</u>

³) A New Kind of Science, Stephen Wolfram, 2002, www.mathematica.com

- ⁴) Boids, Chris Reynolds, 1986, <u>www.red3d.com/cwr/boids/</u>
- ⁵) Quantum City, Ayssar Arida, 2004, ISBN 0-7506-5012-5, <u>www.quantumcity.com/</u>

⁶) Towards an E-motive Architecture, Kas Oosterhuis, inaugural speech Faculty of Architecture TU Delft, 2001

⁷) Hyperbodies, towards an E-motive Architecture, Kas Oosterhuis, 2003, series IT-revolution in Architecture, Birkhauser ISBN 3-7643-6969-8

⁸) Architecture Goes Wild, Kas Oosterhuis, 2002, 010 Publishers ISBN 90-6450- 409-1
⁹) Synthetic Architecture, Kas Oosterhuis, 1990, Galerie Aedes

- ¹⁰) Programmable Architecture, Kas Oosterhuis, 2000, L'Arcaedizione

¹¹) Non Standard Architectures, Frédéric Migayrou and Zeynep Mennan, 2004, exhibition in Centre Pompidou Paris ¹²) Trans-ports / Handdrawspace, Kas Oosterhuis and Ilona Lénárd, 2000, Architecture Biennale Venice curated by Massimiliano Fuksas

¹³) La Ville Cybernétique, Nicholas Schoeffer, 1972, Denoël, ISBN 2282300912

- ¹⁴) Working Space, Frank Stella, 1986, Harvard University Press, ISBN 0-674- 95961-2
- ¹⁵) The Fabric of Reality, David Deutsch, 1997, Penguin, ISBN 0-14-027541-x
- ¹⁶) Vectorial Bodies, Kas Oosterhuis, 1999, Archis
- ¹⁷) The Experience Economy, Joseph Pine and James Gilmore, 1999, ISBN 0- 87584-819-2