

emotive
styling

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Why is the body of the iWEB [\[note 1\]](#) not a simple box? Why not a symmetrical ellipsoid, why not optimized to lead forces down along the shortest route? In other words, why does the iWEB have style?

The answer: there was a motive, a motivation to allow external forces to intimidate the body. The soft, mouldable building body of the iWEB was placed in a force field where several forces were operational at the same time, all of them motivating the shape of the body.

As a designer, I needed a vector. I wanted the body to be a vectorial body, a body with a direction, with intention. I wanted it to feel as if the mouldable body had entered a force field of strange attractors, both inside and outside the volume of the body, driving the body towards a new formation: nose down, tail up, slim hips.

The language I use for describing the forces are inspired by car design, from car styling. Cars are bodies designed with speed in mind; cars at speed are bodies in motion. Our building bodies are not bodies at speed, but certainly they are motive bodies, they certainly are bodies with an intention, which has a vector.

As I explained in the ‘Vectorial Bodies’ essay [\[note 2\]](#), the fundamental characteristic of a vectorial body is that the driver (aka, the user) enters it from the sides. The user steps sideways into a body that has the intention to go places. Stepping into a car may take you places literally. Stepping into a building body like the iWEB, you are absorbed into a spatial experience that takes you places mentally, through the spatial environments projected on the interior skin.

Once the designer of building bodies—the stylist formerly known as the architect—has learned to give style to the body as a whole, the word ‘stylist’ no longer has the negative connotation of being just a decorator. The stylist becomes the designer who imposes intention and emotion to the otherwise apathetic body shape. The stylist knows how to work with the concept of Powerlines, as developed by ONL in the last decade, to empowering architecture and art projects [\[note 3\]](#).

In the interview [\[note 4\]](#) with car designer Chris Bangle [\[note 5\]](#), he states that architecture is decades ahead of car design when it comes to imposing emotion on the bodywork. I have

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The opposite impression, doesn't Bangle realize how advanced his styling work is, and how far architects in general are from getting there? Just look at Bangle's BMW Gina [\[note 6\]](#) prototype, and then at the BMW World by Coop Himmelb(l)au [\[note 7\]](#), both conceived in the early post-2000 years, during the same period that the iWEB was designed and built.

The BMW World building, to me, is a complicated roof design, a talkative cover on top of an otherwise not-so-eloquent building. Being experienced with the design and the fabrication of non-standard structures like the iWEB, I know that the structure, as elaborated by structural engineers Bollinger and Grohman, was extremely labour-intensive and thus, a traditional engineering task. Because of the irrational nature of the design, the structure could not be scripted. The design intent of Coop Himmelb(l)au is metaphoric, that of a cloud originating from a tornado. The emotion imposed is purely superficial, inside there is no cloud, and there is nothing that feels like a tornado. The narrative power of the metaphor has passed away in the engineering and the fabrication. The emotion has not moulded the fabric of the building. BMW World is not an emotive building body.

But Gina is an emotive body indeed, decades ahead in styling intention and emotive expression as compared with BMW World. Gina has motive parts of its body, its body shapes configurations of hood, doors, butt, eyes, and seats resonate with the mood and the preferences of the driver. Mind you, this is emotive behaviour, completely different from a door that swings open, or a hood that opens on command. The shape of the body itself reshapes, it adjust itself to changing circumstances, and expresses a different emotion.

For me it is reassuring to see that Gina was developed at the same time as the iWEB was

designed. Strangely enough, Bangle and BMW kept their prototype as a secret for many years, only revealed years after the production models like the BMW Z4 and BMW 1, 3, 5 and 7 series had been launched. Afterwards is clear to see that the styling of the new BMW's has been derived from the expressive power of the emotive prototype Gina. The curves acting upon the mouldable body in a special way that can only be reached by the way that the curves are pushed from within a body that is thought of as being composed of stretchable materials, as is literally the case with Gina's body.

The design approach for iWEB was there right on time, but indeed years or even decades ahead of the mainstream directions in architecture. While architecture, as taught at the Faculty of Architecture in Delft (as in many other faculties in the world) was predominantly late modern at the turn of the century, and has shifted back to critical regionalism and sideways to conservative greenish strategies, reflecting the narrow-minded, xenophobic nationalist wave which has infected so many creative minds, Hyperbody still rocks, proudly stands up and pursues interactive emotive design.

Hyperbody is not alone. It has strong ties with innovative firms like Festo, the world's leading fabricator of actuators. Festo has commissioned Hyperbody to design the behaviour of an interactive HyperWall [\[note 8\]](#), based on their FinRay principle. Festo applied its FinRay invention earlier, in its swimming and flying Air_ray, Aqua_ray and Airacuda objects. The HyperWall uses FinRay technology combined with Hyperbody-embedded behavioural techniques.

HyperWall and Gina. The embedded computing technology is there and the design attitude has matured so that it may embark on a true emotive architecture, which implies a professional approach towards motive styling. >>

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My inaugural speech at the TU Delft from 2001 had as its title: E-motive Architecture, emphasizing that emotive is not only about emotion but also the ICT and the kinetic aspects of design. My inaugural speech was provocative and challenging, based on my experience with, among others, the interactive interior environment of the Saltwater pavilion in 1997 and the Trans-Ports installation at the Venice Biennale in 2000.

It is reassuring to see that —against all conservative forces at the Faculty of Architecture, that have sought to bring non-standard complexity and emotive architecture to a halt favour of backward-looking critical regionalism— emotive architecture is rooted in a ever-growing international movement that promotes customization in all its aspects. Motive styling is an underappreciated study that needs to be critically examined in the professional setting of a Hyperbody education. <<

Kas Oosterhuis
Professor Hyperbody Chair TU Delft

Notes

1. iWEB, 2005, server pavilion in the Mekelpark TU Delft, architect ONL [Oosterhuis_Lénárd], second life of Web of North-Holland, 2002
2. Kas Oosterhuis, 'Vectorial Bodies', in: *Archis* (1999) 26-39
3. Ilona Lénárd, 'Powerlines', in: bookzine *IA#2*, (Rotterdam: episode publishers, 2009) 22-29
4. Pages 96-113 of this bookzine
5. Chris Bangle, Chief of design BMW, 1992-2009
6. BMW Gina, prototype for interactive emotive car design, 2008
7. BMW World, Coop Himmelb(l)au, completed 2007
8. InteractiveWall, Festo and Hyperbody, Hannover Messe 2009

[Figure 1. Detail Citroen Hypnos 2008, designer Mark Lloyd.]



Acoustic Barrier/ Cockpit

Acoustic Barrier/Cockpit

F2F [File to Factory] 'from parametric 3D
model to mass-customized production'

Kas Oosterhuis
Cas Ralbers

This article is based on the Acoustic-Barrier project at Utrecht Leidsche Rijn in the Netherlands. The development of the parametric detail and the direct link to production makes it possible to design and build large structures without restrictions within budget and timeline. The project involves a newly built Acoustic Barrier along a highway in the centre of the Netherlands. The Acoustic Barrier project is built to reduce the sound level at least 10 dB(A) for a housing district called Leidsche Rijn that is located near the highway.

The rules of the design

The brief idea is to combine the 1.5 km long acoustic barrier with an industrial building of 5.000 m². The concept of the acoustic barrier, including the Cockpit building, is to design in light of the speed of passing traffic since the building is seen from the perspective of the driver. Cars, powerboats and planes are streamlined to diminish the drag. The swarm of cars streams with a speed of 120 km/h along the acoustic barrier. The sound barrier describes a 'one mile building,' seen from the perspective of the highway. One of the rules is that the length of the built volume of the Cockpit emerging from the acoustic barrier is ten times more than the height. The sound barrier can be described as a snake-like body crawling along the highway. Its light grey but translucent skin, patched with triangulated scales, reflects its environment. The transversal sections of the spread-out body smoothly transform from concave towards convex faceted surfaces with occasionally emerging sharp longitudinal folds.

Parametric concept

The concept for the acoustic barrier is based on a relatively simple set of related curves, describing a parametric relation between the height, width and length of the acoustic barrier. These informed curves create a '3D envelope' for the [22](#)

[Figure 1. Situation Leidsche Rijn Utrecht]

[Figure 2. Cockpit outside]

[Figure 3. Cockpit inside]

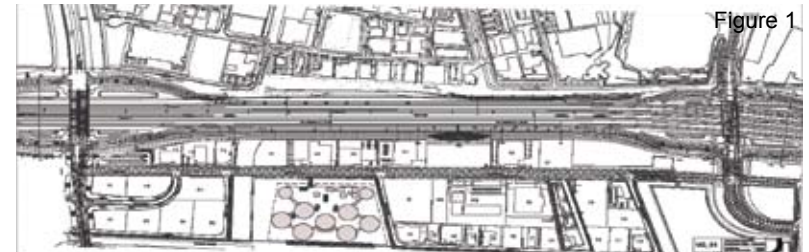


Figure 1



Figure 2



Figure 3

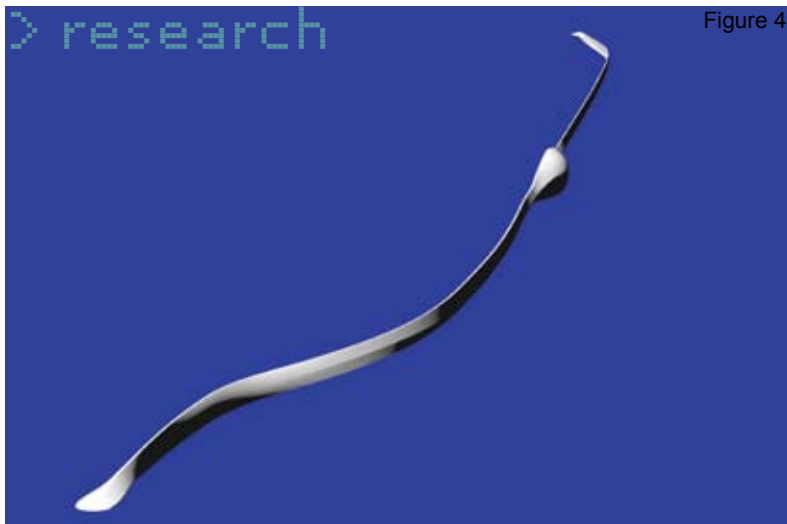


Figure 4

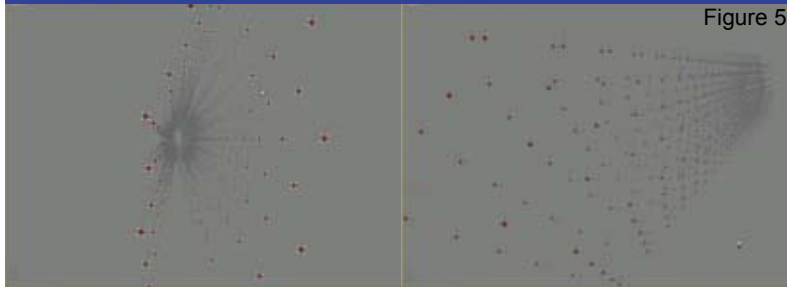


Figure 5

[Figure 4. Nurbs surface model of acoustic barrier with cockpit building]
[Figure 5. Pointcloud]

geometric volume. The evolving geometry is intersected with a 'parametric spatial constructive grid' to create intersecting points between the 3D envelope and the constructive grid. The emerging so-called 'point cloud' describes the carefully designed geometry in a model only built out of points. Each point in the point cloud administrates a constructive node with its specific coordinate, parameters and values. The sound barrier contains approximately 7.000 point-objects. The relations between the points describe the spatial constructive grid and the displacements of the steel-profiles to support the scaling of the glass plates. All points and their relations are administrated in a database.

Generative and [Re]generative design by scripting

The 'point cloud' is the ultimate model for generating or [re]generating all point-data, parameters and the relations between the points. To develop the constructive spatial structure and to manufacture the glazing and cladding material for the sound barrier, a new application had to be programmed. This application, programmed in diverse scripting languages [MAX-script, AutoLisp],

is connected to a database system that has been developed for handling all point-data and their relations. In the script, all points are looking at and analyzing their neighbours. The fact that there is no element exactly the same does not bother the program. The exception has become the rule.

The programmed script-routines applied to the point cloud run, in an iterative way, all the calculations required to update the steel-wire frames (with their databases), the steel-lattice-structure (including all the execution drawings), the glass plates, and the program's administration of all dimensions and execution drawings. Due to the fact that all parameters, relations and values are administrated in either the scripts or the database, a new aspect of analyzing this data exists.

A few practiced examples are: search for missing elements, calculation of extremes and tolerances, comparing values, and recalculation by mathematical or algebraic formulas. These correction-routines are very helpful to handle large amounts of data without losing control or increasing errors. In fact, programmed routines are more reliable than manual routines.

22

[Figure 6. Script definition glass plates]

[Figure 7. Script definition glass profiles]

Figure 6

```
nrc=(ceil((k*2+1+(h-1)*24)/2)+1)
nrc=nrc-1
c=nrc as string
if c.count==1 then c="0"+c

s2.name="axis3Dglass"+c
updateShape s2
is.addnode s2
s2.wirecolor=18.wirecolor
}

--5.5 builds closed splines into layer "p glassplates"

da2=(da*2+db*2-dc*2)/(2*da)
dh=sqrt(abs(da*2-da2*2))
np1=[0,0,0,0,0]
np2=[da,0,0,0,0]
np3=[da,dh,0,0,0]
gp1=splineShape()
addnewSpline gp1
addknot gp1 1 #corner #line np1
addknot gp1 1 #corner #line np2
addknot gp1 1 #corner #line np3
addknot gp1 1 #corner #line np1
close gp1 1
updateShape gp1
gp1.wirecolor=0 255 0
gp1.pos.x=b[2][1].pos.x+(h-1)*3500
gp1.pos.z=b[1][1].pos.z
move gp1 [0,(2000+1500*(g-1)),0]

la2=(la*2+lb*2-lc*2)/(2*la)
lh=sqrt(abs(la*2-la2*2))
np2=[0,0,0,0,0]
np1=[la,0,0,0,0]
np3=[la2,-lh,0,0]
gp2=splineShape()
addnewSpline gp2
addknot gp2 1 #corner #line np1
addknot gp2 1 #corner #line np2
addknot gp2 1 #corner #line np3
addknot gp2 1 #corner #line np1
close gp2 1
updateShape gp2
gp2.wirecolor=0 255 0
gp2.pos.x=b[2][1].pos.x+(h-1)*3500
gp2.pos.z=b[1][1].pos.z
move gp2 [0,(2500+1500*(g-1)),0]

if h==1 then
(
da=distance b[g][h] h[g][h-1]
dc=distance b[g][h] h[g-1][h]
db=distance b[g-1][h] h[g][h-1]
la=distance b[g][h] h[g][h-1]
```

Figure 7

```
local sg2=splineShape()
addnewSpline sg2
local p1=getknotpoint sg2 1 1
local p2=getknotpoint sg2 1 2
local p3=getknotpoint sg2 1 3
addknot sg2 1 #corner #line p1
addknot sg2 1 #corner #line p2
addknot sg2 1 #corner #line p3
close sg2 1
convertToMesh sg2
update sg2
local nf=getNumFaces sg2
if nf==0 then meshop.createPolygon sg2 #(3,1,2) matID:1
update sg2
local normal=getFaceNormal sg2 1
if normal.y<0 then meshop.flipNormals sg2 (1)
update sg2
meshop.extrudeFaces sg2 (1) $thick 0
update sg2
meshop.deleteFaces sg2 (1)
update sg2
local rh=rhell()
rh.outerAmount=0.0
rh.innerAmount=theHeight
rh.straightenCorners=true
rh.autoSmoothAngle=90
addModifier sg2 (rh)
update sg2
local ng3=convertToMesh sg2
update ng3

extrudeFace ng2 #(1,2) 100 100
update ng2
local d=getFaceNormal sg2 28
meshop.deleteFaces ng2 #(25,26,27,28,29,30,31,32,1,2)
update ng2
addModifier ng2 (cap_holes())
local ng3=convertToMesh ng2
update ng3
local ev=theHeight/sin 30
extrudeFace ng3 #(3,4) ev 100 dir:-d
update ng3

meshop.chamferEdges ng3 #(1,4,7,10,34,40,83,86,74,77) ch
update ng3

local b=false
for i=1 to layerManager.count-1 do
(
local if=layerManager.getLayer i
if if.name=="p 3D frame" then b=true
)
if not b then
(
int++1
```


Research

Optimization-routines are programmed to make rectifications and small adjustments in the calculated data. For example, decreasing the amount of members or the span-width of the profiles.

File to factory process

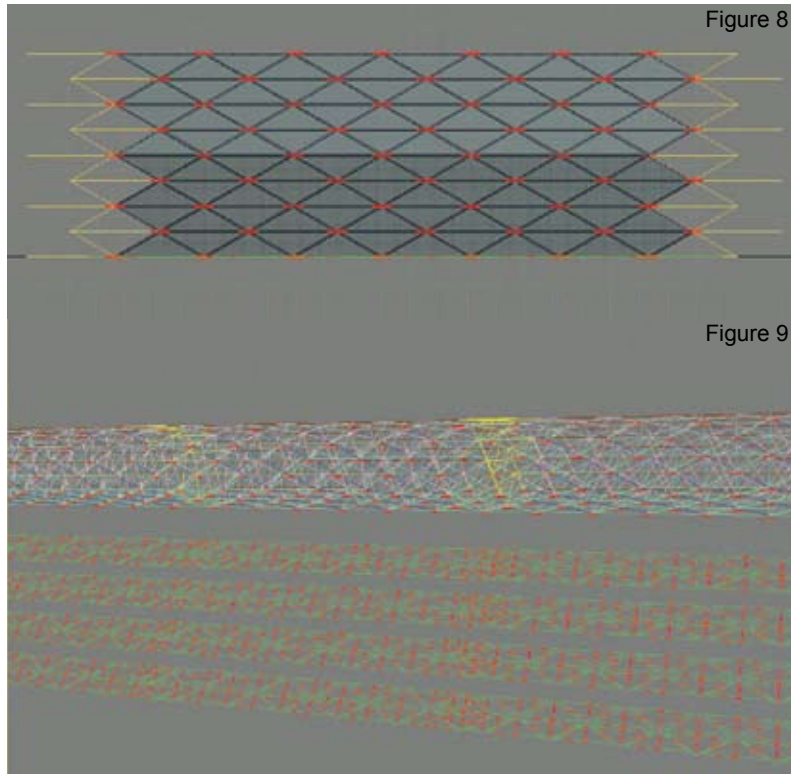
Each manufacturer has his own specific data to interact with the file to factory process for the sound barrier. File to factory processes create new abilities for all participants in the design and execution phase. A few possibilities that arose from the acoustic barrier project can be briefly summarized:

To develop and execute the sound barrier, three main 'file to factory' processes can be described:

1. conversion from point cloud to steel-wire frame model and administration of all its parameters in a database;
2. conversion from steel-wire-frame model to steel-lattice-structure and generating execution drawings;
3. conversion from pointcloud to glassplate manufacturing and administration of all dimensions, codes and specific values plus generating execution drawings.

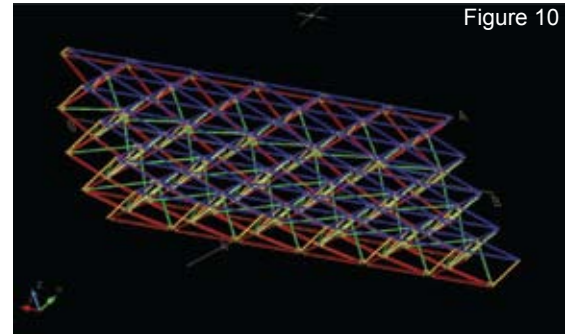
[Figure 8. Front view barrier segment]

[Figure 9. Administration glass plates]



Structure

The applied constructive spatial structure is derived from the typical 'electricity-pylons' that carry electrical wires and power lines, which can be seen all around the world. On each side of the lattice-structure a different material is mounted using its specific [parametric] detail. Two parametric details are developed to mount either glass-plates or expanded steel-plates towards the steel-structure. Each mounted glass plate or steel-plate is unique in dimension and orientation towards the steel-structure, meaning that all these elements need a uniform but parametric detail.



[Figure 10. Construction-[calculation]model]

[Figure 11. Node detail of the 3D model of the steel-glass structure]

Collaborative design

Collaborative design relies completely on the uncompromisable parametric basis for the design. If not built parametrically you can not play with the parameters, and you are not able to interfere with it. You would not be able to communicate smoothly with the 3D model and the project database, neither in the design process nor in the life-cycle of the environment. Working with parametric models creates the communication space for the stakeholders in the building process to discuss the qualities of the proposed environments. It opens up the design process for collaborative engineering in the phase of the execution of the project. It opens up the design process for a possible and meaningful interaction with the clients and the users.



Figure 12



Figure 13



[Figure 12. Impression: scaled glass plates]

[Figure 13. Segment with glass plates]

Figure 14



[Figure 14. Acoustic barrier construction site]

Factsheet

Total m2	10.800 m2 [glass / expanded metal]
Footprint	2.500 m2
Total length	1.537 m [including cockpit building]
Total height	13-18 m
Number of constructive nodes	7.000 pc
Number of steel profiles	40.000 pc
Number of glass plates	7.500 pc
Glass surface	10.800 m2
Budget	5.0 million euro

References

Eiffel Tower, Paris, 1887-1889	[Eiffel Gustave]
Swiss Re Building, London, 2000-2003	[Fosters and Partners, Ove Arup and Partners]
Web of North Holland, Floriade 2002	[ONL]
Variomatic, 2000	[ONL]

Credits

Design: ONL [Oosterhuis and Lénárd]

Design team: Kas Oosterhuis, Ilona Lénárd, Cas Aalbers, Sander Boer, Tom Hals, Dimitar Karanikolov, Tom Smith, Richard Lewis, Barbara Janssen, Gijs Joosen, Andrei Badescu, Maciek Swiatkowski, Rafael Seemann

Engineering: ONL, Meijers Staalbouw BV, Pilkington Benelux BV

Client: Projectbureau Leidsche Rijn Utrecht

Production: Meijers Staalbouw BV

Site: Leidsche Rijn Utrecht, the Netherlands

Completion: 2005



Multi-Agent Design

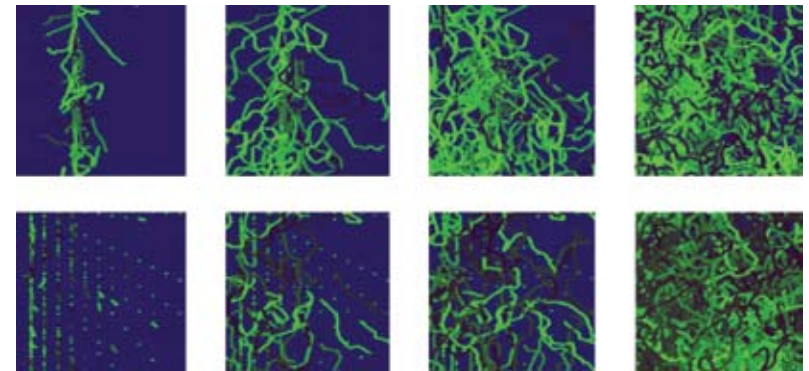
Henriette Bier
Kyle Steinfeld
Sander Korebrits

Multi-Agent Systems [MAS] are in Computer Science distributed Artificial Intelligence systems consisting of several agents capable of reaching collectively goals [Travers, 1996]. In recent years, these systems have become the focus of interest within the discipline of architectural design – largely due to the phenomenon of emergence, or the arising of an intricate and complex whole from simpler constituent parts.

However, multi-agency as a principle has often been misunderstood within the design community, and the mechanics of working with these systems remain out of reach for many designers: Within a workshop and a design studio on Multi-Agent Design [MAD], DSD and Hyperbody students, respectively, have been introduced to the mechanics of a number of MAD-processes with the aim of critically revealing what this technique may offer architectural design, and what challenges remain in its application.

2D studies

Through a series of studies students became familiar with the principles of a multi-agent approach to design: The workshop introduced, initially, an analog, hands-on approach, later moving into programmatic exercises implemented in the programming environment processing.



[Figure 1. Developed models show moving particles - agents - leaving traces behind]

The developed models are simulations of moving particles - agents - leaving traces behind. The employed system is a particle-spring system, which can be seen as a collection of pointmasses in 3D space potentially connected to each other by springs. The system obeys laws of physics, and forces acted on particles include gravitation and friction, whereas springs exert forces on particles according to spring-damping principles. This system has been successfully employed in architecture for models such as a dynamic, interactive hanging-chain model developed by a team of architects, computer scientists and engineers at MIT. This hanging-chain model employs a particle-spring system for representing a structure by applying a gravitational field to it in order to generate its most efficient form [Kilian and Ochsendorf, 2005]. According to the developers, MIT's virtual method is as straightforward as Gaudi's physical method for exploring and testing new forms. In opposition to the hanging-chain model, the models developed within this workshop employed the particle-spring engine embedded in processing not for developing physical simulations but for developing 2D design studies. The analog model, which

the course started with, implied that a group of students worked together: One of the students, the programmer, defined the rules according to which each agent/student had to draft. The rules were: 1) Put your pen to the centre of the paper and draw a triangle; 2) When you finished drawing the triangle, choose a corner of that triangle, which is the starting point of a new triangle. Draw a new triangle; 3) Repeat this step and vary in size and direction.



[Figure 2. Analog simulation of Multi-Agent Design]

After simulating analog-wise MAD-principles, students started working in processing on digital models: Similarly to the analog models, these implied definition of agents and rules, according to which agents behave. Alternatively, by changing parameters for agents and behaviour-rules new systems were generated. However, even restarting a simulation with the same parameters for agents and behaviour-rules, would produce different results due to emergence: The emergent order would arise, therefore, not from the coexistence of the parts but from their interaction.

3D studies

While the 2D studies described in the previous section were implemented in processing, 3D studies were implemented within a design studio in Virtools, which is a development environment to create 3D real-time applications. Focusing on the development of an interactive design tool, which allows

simulation of complex design processes, the project named BuildingRelations [BR] proposed an alternative design method based on swarm behaviour: BR consists of agents interacting locally with one another and with their environment similarly to the way fish interact in a swarm and birds in a flock, respectively. In the absence of top-down control dictating, how individual agents should behave, local interactions between agents lead to the bottom-up emergence of global behaviour. The rules according to which agents are interacting are simple: Reynolds' flocking simulation, for instance, is based on three rules according to which digital birds, named boids, are flocking: 1) Maintain a minimum distance to vicinity 2) match velocity with neighbors, and 3) move towards the centre of the swarm. While these rules are local establishing the behaviour of one agent in relationship to its next vicinity, the flock behaves as a whole, coherently [Reynolds, 1987].

Similarly, all functional units pertaining to a building can be seen as flocking agents striving to achieve an optimal spatial layout. In this context, spatial relations between functional units can be described as rules, according to which all units organize-themselves into targeted configurations. This approach is particularly suitable for the functional layouting of complex structures.

While the architect might find it difficult to have an overview on all functions and their attributed volume and preferential location, functional units can easily swarm towards local optimal configurations. Functional layouting in architectural design deals with the placement of functions in 3D space, whereas building components such as rooms have no fixed, pre-defined dimensions, and are resizable. Attempts to automate the process of layout incorporate approaches to spatial allocation by defining the occupiable space as an orthogonal 2D grid and use an algorithm to allocate each rectangle of the grid to a particular function. Other strategies break down the problem into parts such as topology and geometry: While topology refers to logical relationships between layout components, geometry refers to position and size of each component of the layout. A topological decision, for instance, that a functional unit is adjacent to another specific functional unit restricts the geometric coordinates of a functional unit relative to another [Michalek et al., 2002].

Based on a similar strategy BR generates solutions for complex layouting problems in an interactive design process. Furthermore, it operates in the 3D-space and therefore, it represents an innovative approach to semi-automated design processes. The developed software prototype consists of several sub-tools such as 1) SizeDefiner, 2) FunctionsDistributor, and 3) BoundingBox.

1) SizeDefiner is a sub-tool, which establishes interactively dimensional relationships and constraints for building components based on data originating from Dutch Building Regulations. These define rules and restrictions regarding minimum required floor areas and occupancy numbers in relation to the allocated

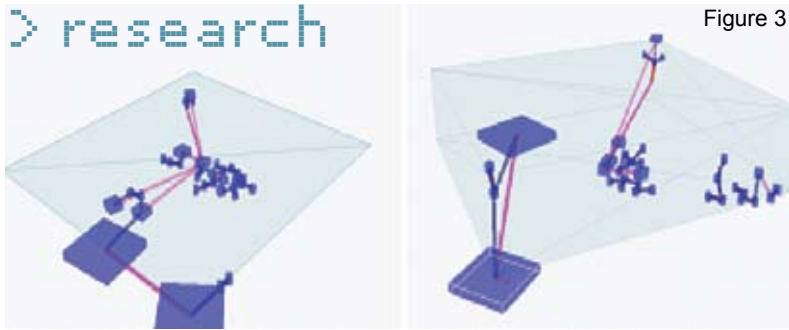


Figure 3

[Figure 3. Functional layout development using Multi-Agent Design]

function. SizeDefiner receives the input from the Building Regulations database and the user/designer, who defines number of people occupying the space; SizeDefiner generates then accordingly the space and scales it to fit the minimal size needed according to those regulations [Bier et al, 2007]. Spatial units adjust themselves to their surroundings. They are linked, therefore, to other units creating spatial relations defined and simulated with another sub-tool: FunctionsDistributor.

2) FunctionsDistributor takes, basically, a program of requirements - number of specific spaces, their occupancy numbers, and building regulation classes - and translates it into an ordered spatial layout. Objects of same and different type are clustering or dispersing, accordingly. Placement of all functions in 3D space is controlled by FunctionsDistributor: SizeDefiner generates functions depending on their Building Regulation values as well as their external placement defined by FunctionsDistributor or by the user/designer [Bier et al, 2007]. This system enables adjustment of spaces to their surrounding spaces, whereas distances to other objects are defined by: Bounding-box, in which all functional objects are supposed to fit in, establishing 3D boundaries for the building to be designed; Preferred-distance to the nearest functional object, and Collision-detection that enforces that object keep a distance to each other.

These self-organization mechanisms are complemented by interactivity: The layouting process does not take place outside of the influence of the user/designer. The user can select objects and move them to other places and the model re-adjusts to the new configuration. By clicking on an object, the user can free the object from a specific position enabling it to participate in the simulation all over again. In this way, the system and the user/designer search for a preferred layout of functions [Bier et al, 2007].

A third sub-tool is 3) Bounding-Box, which establishes boundaries within which functional objects position themselves. It contains real-time editing features, which enable form-finding processes pertaining to surface definitions such as NURBS and polygon-meshes. This sub-tool converts the data defining min-max areas, min-max floor heights, into a

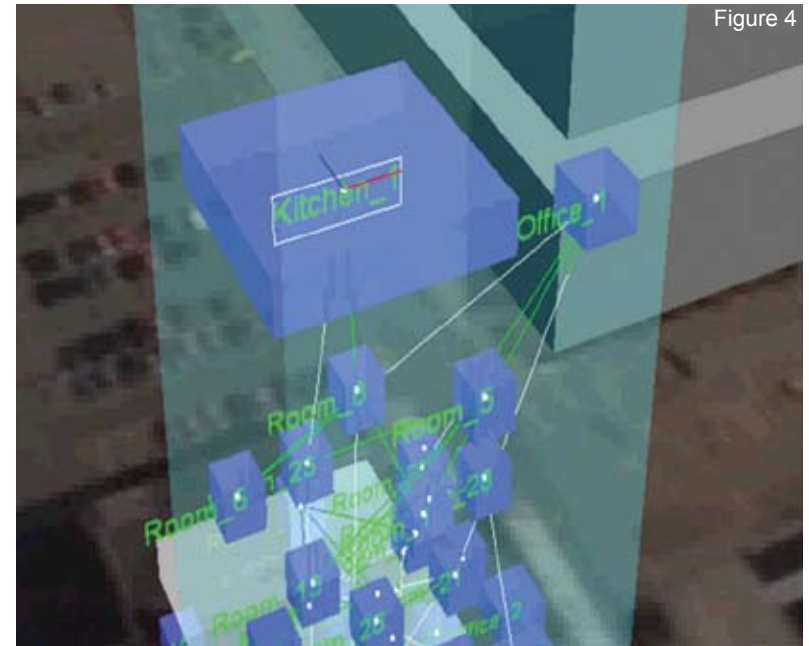
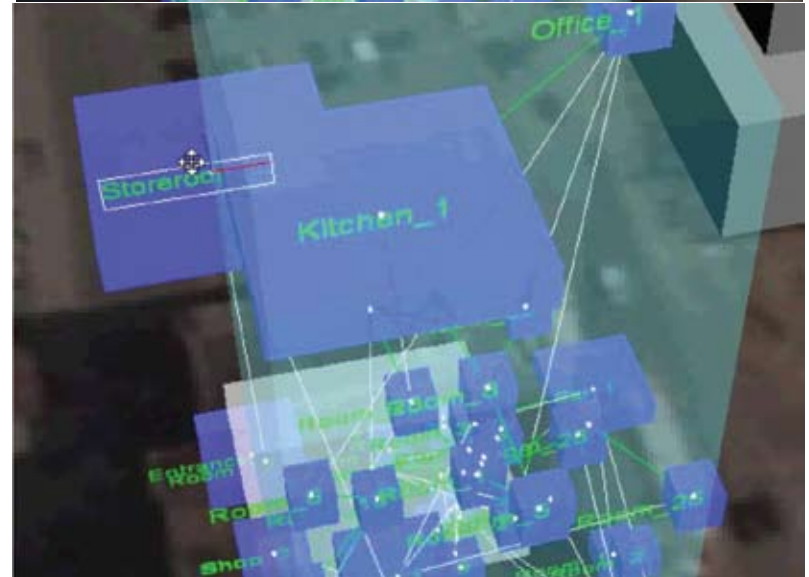
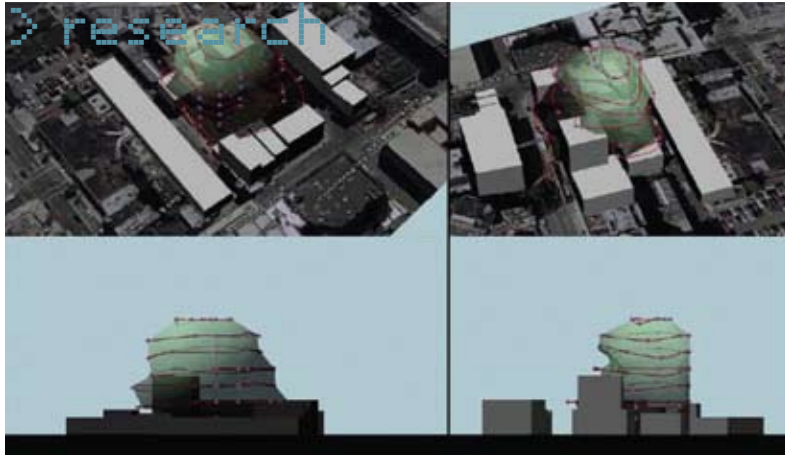


Figure 4



[Figure 4. Functional units pertaining to a building operate as flocking agents striving to achieve an optimal spatial layout]

geometric model by creating a shape according to predefined square-metre requirements. By dragging control points the model is recalculated to stay within the pre-determined boundaries, while changing shape. BR receives and sends continuously data from and to the database, which >>



[Figure 5. The Bounding-Box establishes boundaries within which functional objects position themselves]

contains all information regarding which group the objects belongs to, which other groups they may relate to, etc. Functional units are, therefore, described by their building regulation type, their name, scale and position, their occupancy, their number of floors, their condition such as active - free to move - or inactive - fixed. These values or combinations of values can be used by other subtools running at the same time. Furthermore, they can be exported to other programs: Positions, dimensions and scale of objects can be exported to other 3D modelling programs such as Rhino, Maya, etc.

The database, therefore, establishes connectivities between different software and functions as a parameter-pool containing geometric and functional data. A 3D model developed with the BoundingBox sub-tool could be saved to an online database, for instance, from which FunctionsDistributor would take data to generate a functional model within the parameters defined by the 3D model. BR, therefore, is being used interactively and in combination with other software, to achieve non-deterministically designs. It is a design support system, since it supports the user/designer in the functional layouting process rather than prescribes a solution. Its current implementation, even though diagrammatic, demonstrates an obvious capability to support functional layouting of large and complex buildings based on swarm principles, on condition that global optimization mechanisms are incorporated into it - which is the next step in the development of this software. The inability to achieve a consistent functional layout with this software prototype goes back, in part, to the definition of local optima: The software generates endlessly many local optima. It does not, though, generate a global optimum. The further development of this tool aims, therefore, to incorporate global optimization mechanisms. It also aims to address issues related not only to functional organization of space but also issues of spatial coherency. <<

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In Virtools D. Hoffers, M. Frederiks, and S. Korebrits respectively scripted 1) SizeDefiner, 2) FunctionsDistributor, and 3) BoundingBox.

References

- Bier, H. et al, 'Building Relations' in: H. Bekkering, D. Hauptmann, *The Architectural Annual 2005-2006*, Delft University of Technology (Rotterdam: 010 Publishers, 2007)
- Kilian, A. and Ochsendorf, J.A. 'Particle-spring systems for structural form-finding', in: *Journal of the International Association for Shell and Spatial Structures, IASS* (2005)
- Travers, M., *Metaphors in Programming with Agents - New metaphors for thinking about computation* (thesis MIT, May 3, 1996)



F-Zuid; social housing with an artists impression

Marthijn Pool

What characterizes the F-Zuid project most is the way it looks from the outside. The façades as well as the roof are carved with a gigantic calligraphic pen. The building blocks are marked by the touch of visual artist Ilona Lénárd.

Kas Oosterhuis and Ilona Lénárd bundle forces in the field of art and architecture in their practice ONL [Oosterhuis_Lénárd] BV. Marthijn Pool has been working on the façade engineering of the project to achieve the artistic goals of Ilona Lénárd by means of modelling techniques with incorporation of production constraints, laws and regulations, and material properties in a parametric design model. Marthijn Pool will introduce the F-Zuid project's background and realization and will focus on the façade engineering.

Unity in identity and individuality

The Bijlmer redevelopment project F-Zuid is a low-rise housing project where individual apartments are clustered in closed volumes, or building blocks. In contrast to the unity of the high-rise flat buildings, remarkable to the Bijlmer expansion of the 1970s, during Amsterdam's increasing population, the F-Zuid building creates an improved sense of community. The concept of the F-Zuid housing is to make this part of the neighbourhood feel connected to a community. Connected to their neighbours, but also connected to their own premises—each house has its own garden and front yard. The closed volume and the way the façade is designed create a great sense of uniformity. This uniformity does not mean it is aesthetically and morphologically equal, on the contrary, the imprint on the façade and the roof make each section of the apartment block a unique segment of the whole. Within the community, there is strong reference to individual identity. Each of the inhabitants owns a particular part of the façade. Within the individual expression of each house, the housing block as a whole refers to the larger community.

Artistic intuition

The façade consists of a continuous aluminium clad surface. Based on the specific intuitive sketch imposed by Ilona Lénárd, the façade is deformed according to the impressions of the stroke of a gigantic brush onto the external boundaries of the building, the façade and the roof. The intuitive sketch is created on a foldout of the roof plan and the connecting façades have been printed on a 2D sheet [\[Figure 1\]](#).

The sketch derives from pure emotion and intuition. The expressive, dynamic lines are typical for the artworks of Lénárd; the so-called powerlines are the medium to express energy in an elegant form of dynamics. Particular parts on the 2D foldout are populated with curves and loops in different densities, depending on the artist's intuitive local expression. The sketch is created in an instant in order to minimize the inevitable rationalization when feeding oneself with information while looking, listening and thinking. The unexpected, spontaneous, and unconscious is thus expressed in built volume. The calligraphic sketch is the recognizable character for the entire building block, but at the same time it creates a high sense of individuality, because each house is different from its neighbours; the owner possesses a constituent, unique part of the total artwork. The façade is appreciated from close up as well as from the viewpoint of the [22](#)

surrounding high-rise buildings. From here the dynamics of the powerlines on the overall level of the building block is best perceived [Figure 2].

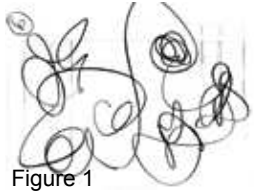


Figure 1



Figure 2

[Figure 1. Intuitive sketch on building block exterior on 2-d fold out sheet]

[Figure 2. intuitive sketch on roof and façade of building near completion]

Art + architecture

The sketch lines are digitized and inserted in CAD software. The specific sketch is placed onto the corresponding façade and roof part. Now the 2D created powerlines define the enclosure of the 3D built volume in the process of making art and architecture into one entity. The mapping of the sketch line onto the 3D perimeters define the areas of attention. Locally, the building blocks have been intuitively marked by variations in densities of curves and loops. In close collaboration with Ilona Lénárd, the powerline is locally adapted for maintaining the dynamics. In this interactive collaboration, the artwork forms integral part of the architectural design process.

Calligraphies in 3D

To make the powerlines a realistic representation of brush strokes with varying width and speeds, the behaviour of the action needs to be analyzed and animated. The behaviour of a brush stroke is determined by the pressure it is given, the angle it makes with the canvas, the sharpness of the curvature and the speed [Figure 3]. These four parameters strongly relate to each other and require closer investigation.

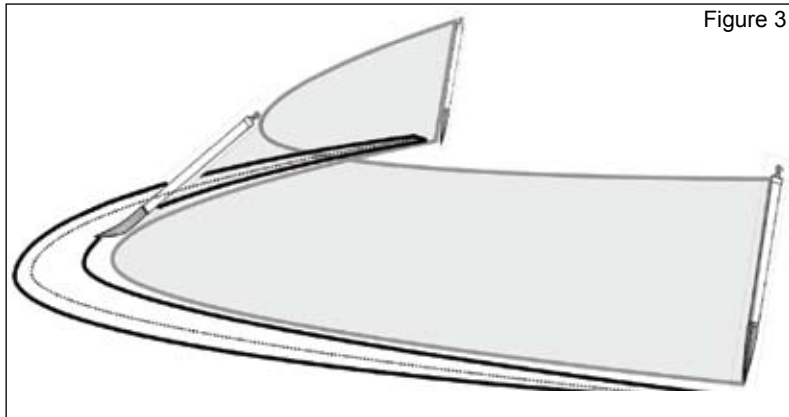


Figure 3

[Figure 3. Dynamics of brush stroke behaviour]

Where calligraphic styling is used in painting and writing to embed the elegance of rotation and speed represented by the varying width of the applied paint or ink [Figure 5]. Artistically a similar expression is set as a goal for the F-Zuid façade. ONL worked out the sketch without the application of an additive material, which is familiar in painting. Instead, the strategy of modifying the material properties in itself is applied. For the aluminium façade, the stroke represents the actual pressure and angle as a deformation of the material [Figures 4, 5, 6, 7]. The material properties of aluminium allow it to be deformed, while the reflective character of the material is used to express the touch of the artist in different grades of shading and reflection.

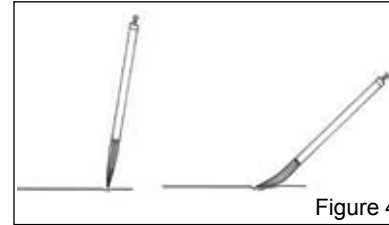


Figure 4

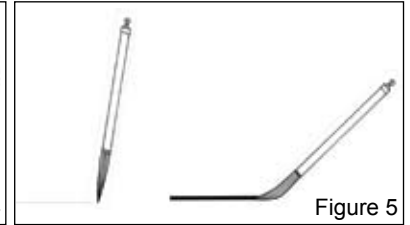


Figure 5

[Figure 4. Brush stroke on aluminium canvas as deformative]

[Figure 5. Brush strokes with different angle and pressure as an additive]

The behavioural calligraphic deformation of the aluminium canvas is built up in the parametric software Pro Engineer. Parametric modelling for this project allows modifications and adaptation upon a set of rules that are predetermined by the artistic expression and the architect.

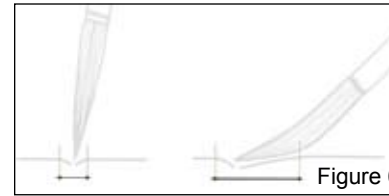


Figure 6

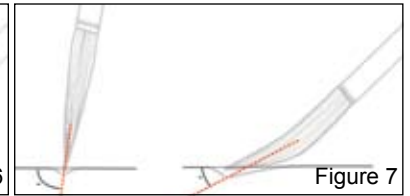


Figure 7

[Figure 6. Dynamic width deformation]

[Figure 7. Dynamic angular deformation]

Behavioural modelling

The physical dynamics of brush strokes being imposed on the aluminium cladding are modeled as a behaviour that feeds itself with the information of the actual sketch. The aluminium is the canvas, which is being cut and deformed. The original sketch is first translated into digital powerlines. The powerline describes the central axis of the brush stroke; the curvature's tangency describes inherently the speed and rotation of the virtual brush stroke. Stating that the powerline trajectory ranges from 0 to 1 (start to end), along that trajectory, the powerline tangency is highest where the brush changes direction fastest and thus creates a wide and deep stroke. A sine curve approximates this relation >>

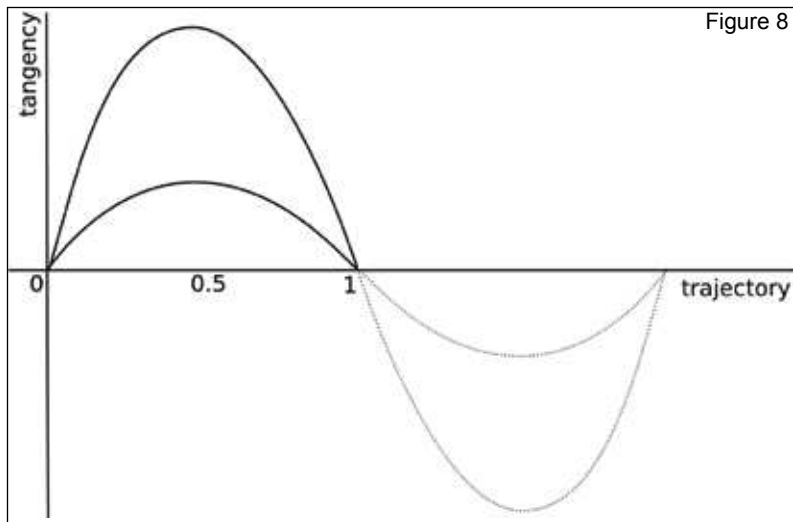


Figure 8

[Figure 8. Sinus properties in relation to tangency and trajectory]

between tangency and position [Figure 8]. The sinus properties are used to describe the typical behaviour along the trajectory. The actual behaviour is evoked by linking dimensions to each other and creating interconnectivity between the parameters. This parametric set up is the rule-based behaviour of the powerline. Consolidating the behaviour is the trace of the brush, where the cut and gradual deformation are the resulting geometry. The effect of the brush is described in a variable cross section; this cross section is smoothly and gradually changing along the trajectory [Figure 9]. The cross section feeds itself with the variation in pressure, angle tangency and speed along the trajectory. This process is parametrically modeled and automated to produce the necessary 3D geometry, which is used for production.

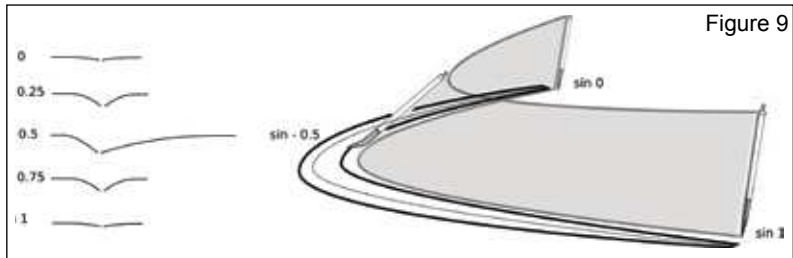


Figure 9

[Figure 9. Pressure, angle, tangency and speed relationship along the trajectory of a powerline]

Parametric relations

Along the path of the curvature the behaviour is set up in Pro-Engineer according to the following rule set, with incorporation of multiple constraints, which will be addressed in the next chapter. The effect of this script-based behaviour on the

deformation of aluminium is shown in three typical positions [Figures 10, 11, 12]. The deformation is an elegant transition from minimal to maximum deformation along the power line trajectory.

depth = $40 * (\sin(180 * \text{trajpar}))$
angle = $90 - (30 * (\sin(180 * \text{trajpar})))$
width-a = $250 - (100 * (\sin(180 * \text{trajpar})))$
width-b = $250 + (100 * (\sin(180 * \text{trajpar})))$
width-tangency-a' = $100 + (50 * (\sin(180 * \text{trajpar})))$
width-tangency-b' = $100 - (50 * (\sin(180 * \text{trajpar})))$

depth = variable ranging from 0 mm to 40mm, thus will never be deeper than 40 mm.

angle = variable ranging from 90 to 60 degree, thus will not be more sharp than 60 degrees.

width = variable ranging from 350 mm to 150 mm

width-tangency = variable ranging from 150 mm to 50 mm

trajpar = trajectory parameter. This parameter gives a float output (between 0 and 1) as the relative position on the trajectory.

The modelling is built up in three steps, starting with the implementation of

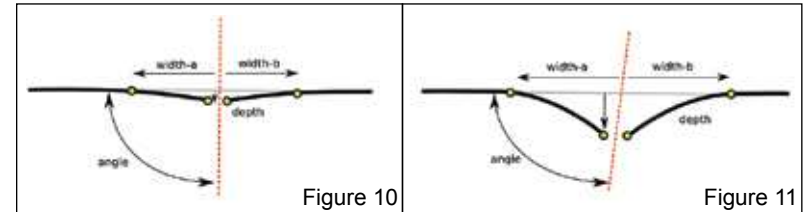


Figure 10

Figure 11

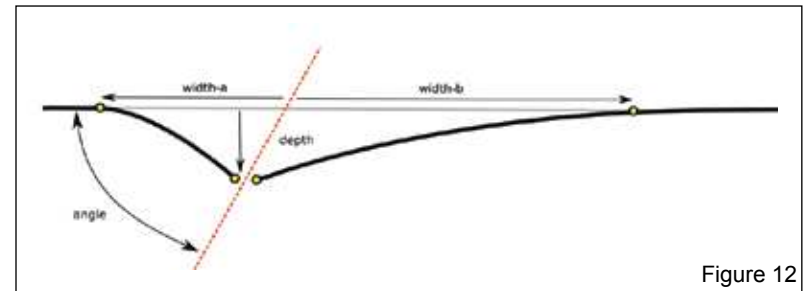
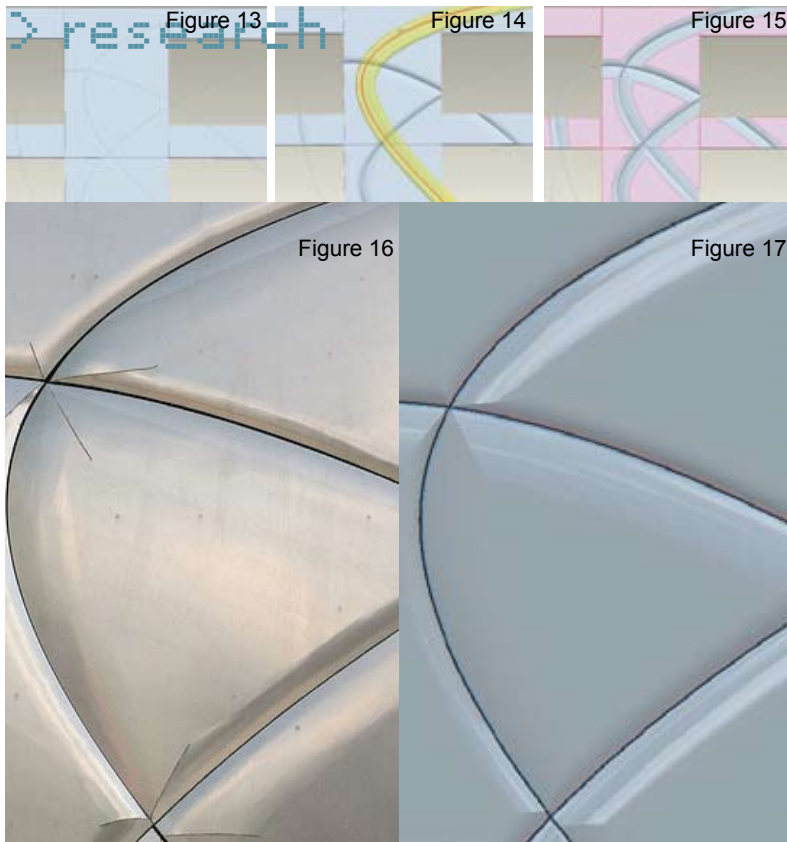


Figure 12

[Figure 10 -12. parameter condition for minimum to maximum brush pressure, angle, tangency and speed]

the digitized powerline on the appropriate façade, next the variable section is swept along the trajectory resulting in the local deformation of the cladding and the final 3D geometry [Figures 13, 14, 15]. The 3D geometry in the virtual environment [Figure 17] is linked to the production facility and therefore directly fit for fabrication. This strategy of linking architects' data to production is >>



[Figures 13, 14, 15. Powerlines in the surface; digital projection, behaviour and resulting carvings]

[Figure 16. Photograph of façade]

[Figure 17. Digital model of the carved façade]

ONL's guarantee for accuracy and control over the actual 'as built' geometry [Figure.16]. For this ONL, continuously develops its file-to-factory processes with new materials, design techniques and fabrication partners.

Makeability

Rule-based platform

Beside the architectural engineering of modelling the brush behaviour, necessary for the intuitive sketch to embed itself in the façade surface, it's the architects task to take into account regulations, material properties and manufacturing limitations. The forms that compose a building are defined by a set of attributes. Hierarchies and priorities are set and are manifested as constraints that inform the physical attributes of forms. Rules and constraints help create an overall unity and organization for a design solution. To build up this organizational, rule-based platform, we need to describe the rules and

constraints as parameters. Parameters are valued according to the design logics hierarchies and priorities.

Constraints

Constraints are omnipresent in the building industry. We can differentiate the level of constraints. Budgets, urban planning, municipalities and supervisors define constraints on a macro level, while additionally there are the design constraints, which can derive from the concept's origin and the architect's pragmatic approach. Constraints are the set of rules the proposed solution needs to fit within, thus resulting in consolidated parameters. Parameters and the rule-based platform are the playing field (flexible parameters) in which the architect operates and embeds the design solution. In order to minimize time-consuming design iterations because of a certain change of one of the parameters, it's important to understand the interrelational behaviour of the parameters. By building up a 3D model parametrically, most geometry can be built up with relationships. These relationships are the backbone of the project's logics. The grid system of a design determines on a macro scale the division between units. The grid system in this specific project is subject to the housing convention dimension of 5.40 m. This is the constraint of the concrete tunnelling system. Since the grid defines the apartment's separating walls, the openings in the climatic façade relate to these walls and will be centred. The window frames are placed in the openings and the façade cladding is creating the visual unity [Figure 18].

Shipbuilding technique

For this project ONL has selected a partner that fulfills the accuracy requirements and is capable of linking 3D data to production. ONL has set up cooperation with CentraalStaal to realize this non-standard façade. CentraalStaal has expert knowledge in CNC (computer numerical control) cutting techniques as well >>

[Figure 18. Interdependency of building block elements]



as 3D deformation technologies. Aluminium was chosen to be the appropriate material for the façade, because it is maintenance-free, robust, relatively light and it has appealing aesthetics. The aluminium AlMg3 is a robust alloy that is used for shipbuilding. This high quality aluminium does not need any cost-consuming protective treatment, neither will it fade white after corrosion. The 6 mm thick sheets are robust enough to cope with vandalism forces, the deformation of the surfaces actually makes the surface partition more stiff, because of the convex shaping around the edges.

File to factory

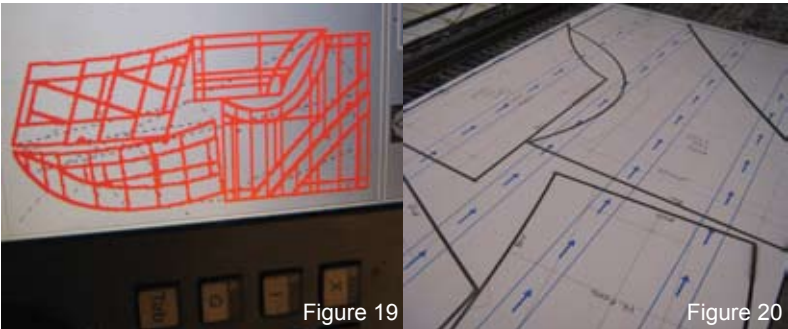
ONL's 3D façade geometry is flattened using Nupas Cadmatic software. This program also nests the individual sheets to minimize the amount of rest material [Figures 19, 20], though the rest material is directly used for recycling without devaluation. In close collaboration with the engineering staff of CentraalStaal, ONL needs to get a grip on the determining parameters that set the limitation for production. The constraints for 3D forming the 6mm aluminium plates are set by the deformation parameters. Since the trajectory of the deformation is not linear, tensions will accumulate in the sheet. Only the perimeter of the sheet will be deformed while the untouched surface needs to remain flat. Experience and testing tells us that a curve cannot be bent deeper than 40 mm. The powerline segment with the highest tangency at its apex is the determining factor for setting this constraint. Inherent for determining the maximum depth is the length, which is needed to reach the specific depth, this is the parameter width-a. To reach the maximum depth of 40 mm, no less than 150 mm of length is required to spread the tension in the material. These determining parameters are investigated in an early phase and are fed into the parametric behavioural model to update itself according to these limitations. The resulting 3D geometry of the façade is sent to the manufacturer's software, which is directly linked to production.

Standards in non-standard

The size of the initial aluminum sheets are limited to 6000 by 2100 mm. The actual aluminium façade partition needs to fit within this production size. The

imposed sketch is an elegant way to subdivide the façade in the necessary façade patches that built up the cladding of the entire surface. A standard façade would be subdivided in an optimal rectangular patch pattern, whereas this non-standard façade incorporates the same production limitations but frees itself from repetition and standardization. This is where ONL and Ilona Lénárd have succeeded in creating added value for this housing block without increasing cost. The same amount of material is used to clad the façade. To maintain the material's characteristics, the cold forming technique is a fairly minimal effort with a maximum effect.

[Figure 19. Façade element contours in nesting software]
[Figure 20. Nested flat aluminium sheets after CNC cutting]





Morphogenomic urban and architectural systems (an investigation into informatics oriented evolution of form: The case of the A2 Highway)

Nimish Bitoria

Morphogenomics, a relatively new research area, deals with the intricacies of morphological informatics. It is closely linked with the term morphogenesis (from the Greek *morphê*—shape, and *genesis*—creation), which deals with the study of the development of form during its early cellular stages in developmental biology. Morphogenomics, however, focuses upon the informatics constituent behind the emergence of diverse morphologies. This informatics constituent specifically involves studying the structure, behaviour, and interactions of natural and artificial systems that store, process and exchange information. This information intensive communicative process thus serves as a dynamic medium for mapping the morphological genome onto architectural space and structure. Such an informatics-based network of information serves as a determining factor for deciphering architectural nomenclature, while allowing digital manipulation of form in the design process, and enabling mass-customization in digital manufacturing.

This paper, in line with the aforementioned research strand of morphogenomics, exemplifies upon an ongoing design-research case: the development of a Distributed Network city along the A2 Highway. Within Hyperbody, 22 students from ten different countries, along with Hyperbody researchers, were organized into five groups (five design firms), each working collaboratively with the other in order to produce generative urban and architectural morphologies along the A2 Highway. The visions of the governmental organizations in charge of the A2 development were abstracted as a set of global rules/constraints within which the five, Hyperbody-based design firms creatively operate. In order to aid this intensive collaborative design-research effort, Hyperbody developed a series of computational tools for simulating real-time interactive behaviour such as: a dynamic updating database with a corresponding data visualization and real time data manipulation web based interface, a swarm CAD tool for global and local spatial as well as programmatic layout (operating on the logics of swarm behaviour), an L-systems based urban and architectural pattern generation tool, and computational tools for generating performative structural solutions for complex geometry. Information pertaining to each of the five design groups, collaborative decisions pertaining to breeding programmatic variants along the A2 Highway, and the morphogenomic process behind the translation of abstract thought/mechanisms into computationally enriched urban and architectural morphologies, with the help of the aforementioned tools, will thus form the crux of this research paper.

Background research

Contemporary research investigations into evolutionary and developmental biology have revealed intricate data in regard to issues of adaptation, efficiency and robustness as well as the phenomena of redundancy and differentiation in which natural living systems acquire competitive performance. Specific fields of interest such as biomimetics, which delves into understanding such natural mechanisms and the application of the extrapolated knowledge into constructing performative structures, have since been at the heart of contemporary architectural and engineering research. Tools and methodologies in the computational domain pertaining to the understanding and simulation of such diverse natural growth, development and hybridization processes have been extremely efficient in forming the backbone of our understanding of such dynamic phenomena. Genetic Algorithms (GA) are probably the best known examples of such computational processes [Van de Zee and de Vries, 2002] that have been explained.

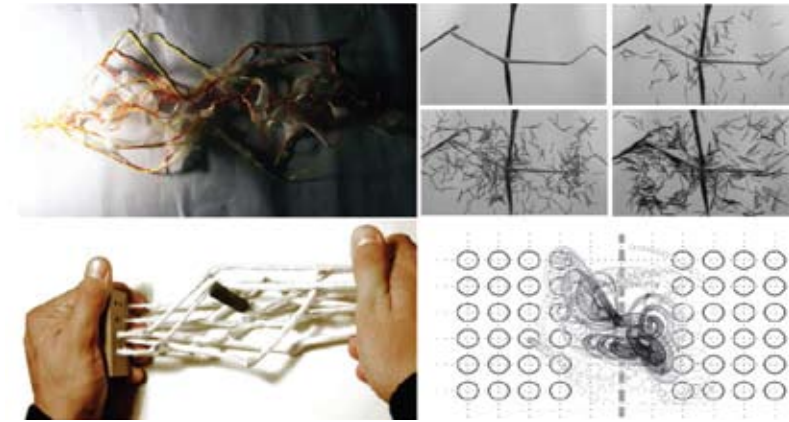
Hyperbody, through its own initiative of understanding the informatics-oriented behaviour of natural systems, has been experimenting with computational techniques such as real-time multi-agent interaction, complex systems and swarm simulations over the past six years. L-systems, another computational technique, were first used to model the growth processes of plants [Lindenmayer, 1968], but were then applied to describe the morphology of a variety of patterns [22](#)

including urban and building designs [Hart, 1992]. These have also been extensively experimented with in the course of our morphogenomic research and design initiative.

The morphogenomic process

Abstract machines

Parallel to this computational view of understanding natural dynamics, issues pertaining to philosophy and theory, specifically an understanding of Deleuzian notions of population, intensive and topological thinking were incorporated during the first phase of analysis and interpretation of the site (A2 Highway) and the designer's intent. The notion of an abstract machine [Figure 1] defined by Deleuze as abstract, singular, creative, real, non-concrete, actual, non-effectuated consolidated aggregate of 'mattersfunctions' served as an effective mode of communicating each of the five design team's psychological intents and aspirations. The creation of topological genetic-body plans (essentially non-metric), which could give rise to a variety of morphologies, embodying different metric structures, thus became a logical underpinning for deciphering computational logistics per design team.



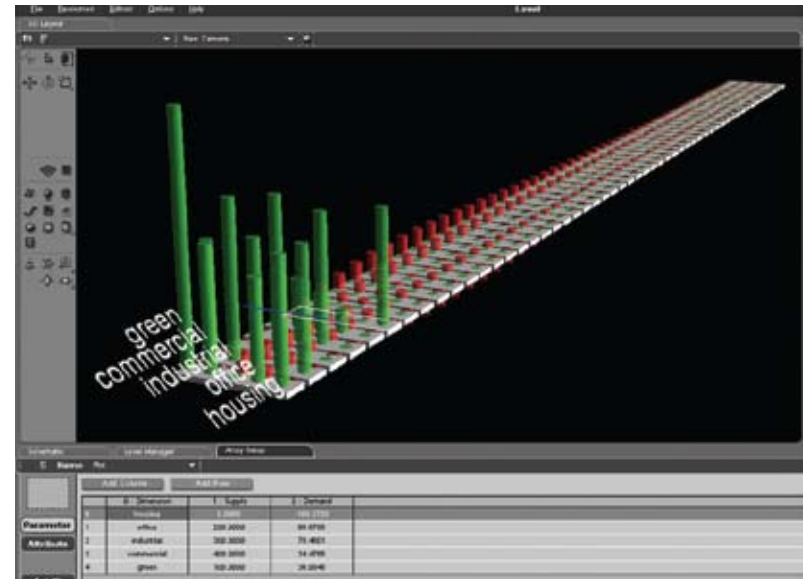
[Figure 1. Abstract machines developed per design team]

Real-time Interactive program distribution database

The second phase, in order to add a realistic dimension with regard to thinking in terms of development affordances and design constraints per sector, led to the development of an interactive computational tool termed the 'A2 Highway database and plot table' [Figure 2]. This tool is specifically built as a real-time updating database pertaining to the program distribution over the entire site, or, in other words, for deciphering environmental (catering to functional demands and supply ratios) constraints per sector. Each design team was provided with its own web-based interface (of this database) pertaining to its sectors, into which they introduced values corresponding to their functional and envisioned demands. However, one crucial feature of this tool was the interdependent (and

thus relational) linkage between the data-sets entered per design team. The notion of collective/collaborative functional program development was thus embedded within the interactive simplicity of the tools operation.

Global rule sets, which correlate the ratios between demanded functionalities/activities of the site (housing, commercial, industrial, office and green), are inbuilt to this A2 database tool, and, owing to the tool's real-time updating nature, any data entered by any group has a direct impact on datasets being handled by other groups as well. The exercise in this phase for all the groups was thus visualized as collaboratively attaining a stable functional distribution (matching the supply and demand ratios, indicated by green signals), and thus collaboratively setting up specific breeding environments per sector.



[Figure 2. The A2 Highway database and plot table showing the sector based distribution and the programmatic input per design team along the length of the A2 Highway]

Breeding Urban morphologies using Multi-agent Swarm based computational applications

In the third phase, the above-mentioned design intent oriented, mutually negotiated contextual environmental setup (per sector) is further processed locally (per group) by the application of evolutionary computational techniques. At this stage, the interlinked environmental set-ups are populated with respect to their environmental demands (program of demands or rather demanded requirements which the respective sectors should be catering to). A computational tool, namely: the A2 Highway Swarm CAD [Figure 3] was introduced to the design groups at this stage.

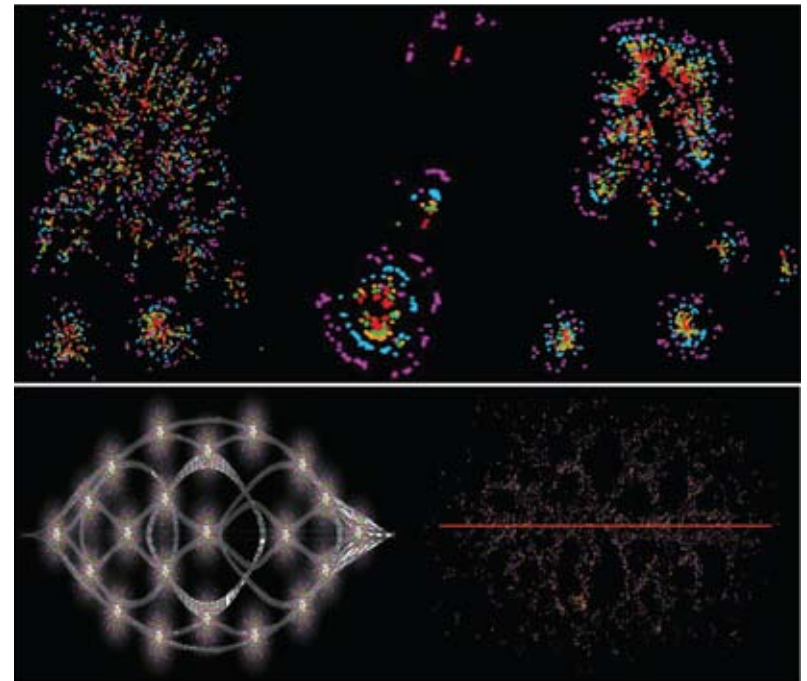


[Figure 3. A2 highway Swarm CAD screenshot and its application]

This tool and its principle: the behaviour of a group of agents that may be able to perform tasks without detailed representations of the environment and other agents, was successively used for generating a variety of clustering and self-organizing patterns. Each functional unit (housing, commercial, industrial, office and green), in this phase attains the dimension of an agent with programmed behavioural rules such as its affinity/closeness with other functions, relational ratio-based multiplication per agent, volumetric data, etc. Dependent upon such programmed behavioural modules, interaction routines are automated for attaining meaningful and logically structured urban morphologies. Urban patterns can thus be seen as self organizing systems with constituent components akin to members of an organic swarm, working constantly to generate activity, usability, occupational and territorial patterns. An example of the resultant output [Figure 4] of this principle exemplifies how this process enabled a design team to develop emergent urban patterns while providing them with computational logistics to defend these ecologies of mutually interlinked species (functional variants).

Generating urban morphologies using L-systems and Turtle graphics

Apart from the above mentioned Swarm and Multi-agent systems based applications, L-systems combined with Turtle graphics interpretations were also effectively experimented with during the third phase of the morphogenomic process. A combinatorial approach for experimenting with the co-evolutionary generation of two L-systems was generated respectively: one for the design of the highway itself and one for the residential city, characterized by residential



[Figure 4. Iterative swarming gene pools leading to the generation of urban systems]

and commercial units. Inter-dependency between the two L-systems was set up for facilitating an iterative growth of the residential city in relation with the generated boundary conditions of the highway based L-system.

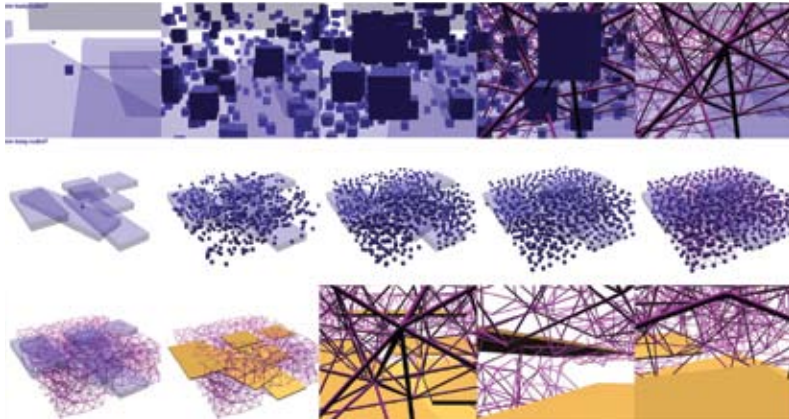
The highway based L-system performs two operations: firstly, creating a clear bifurcation of the highway into the surrounding landscape, thus strongly establishing a set of transversal connections between the highway and its surroundings and secondly, fragmentation of the highway for solving noise-related issues along the highway stretch. The principal branch thus confirms the linearity of the highway and allows for fast travelling, while the secondary branches reconnect the landscape and aid in the reduction of speed-noise generated by the cars. The fragmentation process, which switches the main route of the highway into multiple paths, thus provides a system of transversal connections between either sides of the highway, enabling it to become an integral part of the urban tissue.

Operating upon this branched, fragmented L-system, the residential L-system, in the first operation, establishes qualitative and quantitative relationships between these branching patterns and breeds surfaces from the intersections of these differential branching line networks. The meaning associated with the network of lines in the highway-based iterations eventually transcends

its initial association linked with representational infrastructural systems, to virtual, relational linkages between the different programs. At a second stage, parametric relations are established amongst the derived elements (surfaces) for the generation of urban patterns of different functional species. A highly interdependent mutually interactive L-system structure, giving rise to urban morphologies, is thus visualized.

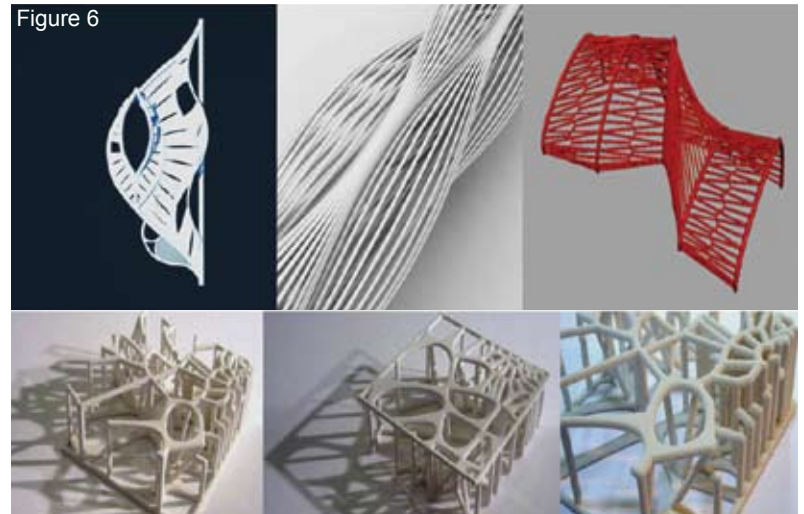
Architectural interventions within the urban morphologies

After arriving at urban morphological patterns, the design groups focused on architectural and structural issues pertaining to a chosen portion per sector. These local level interventions thus lead to morphological fine tuning leaving one with a set of abstract voluminous architectural entities while developing a connective infrastructural and functional logic in the whole site. Once a mutually agreeable solution (amongst the design groups) was arrived at, each designer started to articulate/model a series of these abstract architectural bodies crucial for elaborating upon their design language. The students were provided with a set of computational tools for translating these volumes to a 3D point, cloud, and swarm-based morphology [Figure 5]. This morphology is also meant to provide the students with clues pertaining to the structural morphology of the designed/evolved spaces.



[Figure 5. 3D point cloud generation and structural morphology estimation tool]

Computer aided manufacturing processes for physical modelling and analyses of the urban morphologies were subsequently carried out. The morphogenomic urban output in terms of patterns per sector were either CNC milled or were stereolithographed per group and were assembled together to understand how the entire urban fabric operates [Figure 6]. The students were thus not only able to compare the morphological variations per sector but were also able to understand the vitality of the informatics component in this file-to-factory-based



[Figure 6. Resultant CAM models]

approach. Experiments with colored as well as monochrome rapid prototyping also formed an essential part of the exercise [Figure 6]. The limitations and affordances of different manufacturing processes also allowed the design groups to reappropriate their design outputs (form finding processes) for efficient selection of the appropriate production technique.

Conclusion

This morphogenomics research and design project proved to be a critical exercise in collaboratively understanding the implications (generation, representation, >>

[Figure 7. The resultant computer manufactured architectural interventions]

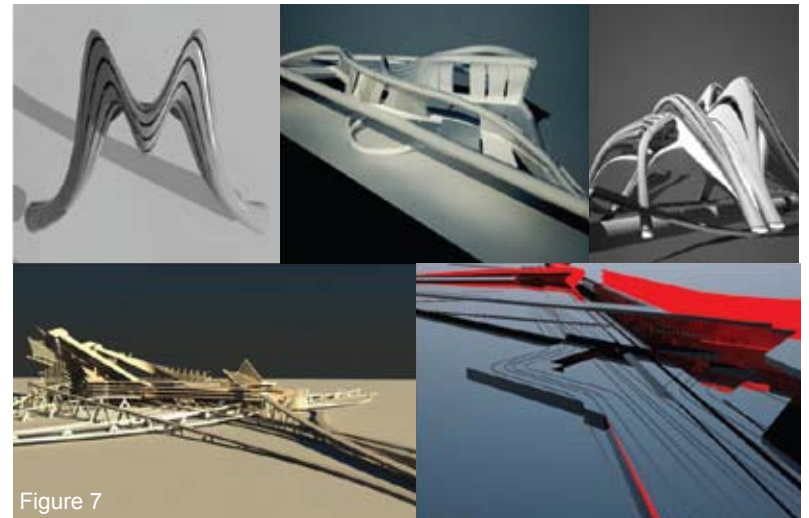


Figure 7

communication and processing) of compounding the term informatics with the discipline of design. The emergent generation of data driven urban and architectural morphologies [Figure 7], inherently interlinked with their contextual settings formulated the crux of this design-informatics oriented initiative.

The computational tools developed during this process provided one with the opportunity to efficiently connect and alter the project database as well as to precisely communicate three dimensional data to appropriate manufacturing tools. A critical level of understanding with regard to the inter-linkage of philosophical, socio-cultural and computational thinking (as a driving forces behind the generation of meaningful morphologies) was thus brought forth through this exercise.



Acknowledgements

I would like to thank Hyperbody's MSc3 batch of 2007 for their valuable contribution with regards to their research findings. I would also like to thank Christian Friedrich, Tomasz Jaskiewicz and Jan Jacobs of Hyperbody for the computational applications and the Hyperbody staff in general to make this morphogenomics research and design initiative a learning experience.

References

- Broughton, T., P. Coates and H. Jackson,. 'Exploring 3D design worlds using lindenmayer systems and genetic programming', in: Bentley, P.J. (ed.) *Evolutionary Design by Computers*, (San Francisco: Morgan Kaufmann, 1999) chapter 14
- Burry, M., 'Parametric Design, Associative Geometry', in: *Blurring the Lines: Computer-Aided Design and Manufacturing in Contemporary Architecture* (London: John Wiley & Sons, 2003)
- Coello Coello, C.A., D.A. Van Veldhuizen and G.B. Lamont, *Evolutionary algorithms for solving multi-objective problems* (New York: Kluwer Academic, 2002)
- Coenders, J.L. and D. Bosia, 'Computational Tools for Design and Engineering of Complex Geometrical Structural', in: Kas Oosterhuis and Lukas Feireiss (eds), *GamesSetAndMatch II On Computergames, Advanced Geometries and Digital Technologies* (Rotterdam: episode publishers, 2006)
- Frazer, Frazer, Xiyu, Mingxi, Janssen, 'Generative and Evolutionary Techniques for Building Envelope Design', in: *Proceedings of the 5th International Conference on Generative Art 2002* (2002)
- Gurer, E. and G. Cagdas, 'A Multi-Level Fusion of Evolutionary Design Processes', in: V. Bourdakos, D. Charitos (eds), *Proceedings of the eCAADe 2006 Conference: Communicating Space(s)* (Volos, Greece: University of Thessaly, 2006) 904-907, September 6-9, 2006
- Hensel, M. and A. Menges, 'Differentiation and Performance: Multi-Performance Architectures and Modulated Environments', in: *Architectural Design AD*, 76 (3), 60-69 (London: John Wiley & Sons, 2006) 60-69
- Janssen, P., Frazer, J. and M.X. Tang, 'Generative evolutionary design: A framework for generating and evolving three-dimensional building models', in: S. Sariyildiz and B. Tunçer (eds), *Innovation in Architecture, Engineering and Construction Volume 1*, (Delft: Delft University of Technology Chair Technical Design & Informatics, 2005) 35-44
- Johnson, S., *Emergence, the Connected Lives of Ants, Brains, Cities and Software* (London: Penguin Press, 2001)
- Lindenmayer, A., Mathematical models for cellular interactions in development I & II, in: *Journal of Theoretical Biology* (Elsevier, 1968)
- Oosterhuis, K. 'Swarm Architecture II', in: Kas Oosterhuis and Lukas Feireiss (eds), *GamesSetAndMatch II On Computergames, Advanced Geometries and Digital Technologies* (Rotterdam: episode publishers, 2006) 14-28
- O'Reilly, U.-M. and M. Hemberg, 'Integrating generative growth and evolutionary computation for form exploration', in: *Genetic Programming and Evolvable Machines Volume 8, Issue 2* (June) (Berlin: Springer, 2007) 163-186
- Rosenman, M.A., 'Case-based Evolutionary Design', in: *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, 14, (Cambridge: Cambridge University Press, 2000) 17-29
- Sass, L. and M. Botha, 'The Instant House: A Model of Design Production with Digital Fabrication', in: *International Journal of Architectural Computing*, Issue 4, volume 4, (2006) 109-123

> education city translator for sector

City Translator

Ke Zou
Howard Chung

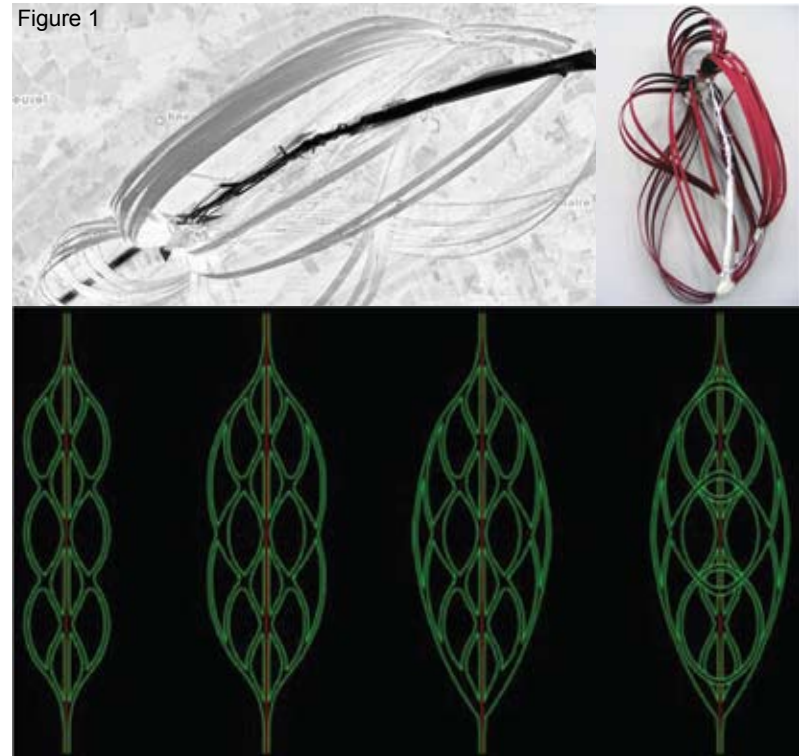
Our aim for this project is to design a city that, through its connection with the highway, establishes a close communication between the city itself, the neighbouring sector cities, and the terminal cities at both ends of the highway. Integrated into the highway circulation system, this city is called 'City Translator', translating the information from the highway into its own city language. City Translator can thus read, record and process the information it receives from the highway. It then gives a real-time interaction to the highway, transmitting it to the other neighbours and the terminal cities. The critical point is hence to explore the possible forms of communication between the cities through the highway.

Signals from the terminal cities are carried by the highway and through the 'secondary translation', the information is translated into another level of band wave into the cities. In the model, the white backbone is linked with the red parenchyma with some thin ropes [Figure 1]. Each time a rope is cut, one after another, the overall form changes a little. This abstract machine describes the self-organizing relationship between the highway and the sector city.

The highway translates the information from terminal cities into a linear system of signals. These signals are seen as a compression of the signals from the terminal cities as well as from the fore-sector cities. Each sector of the highway is seen as a beam of signals which, depending on the different sector cities, is translated into different forms of wave band.

The information can then be read as land scales, traffic conditions, requirement for living spaces or other functions, which subsequently influences the surrounding environments. >>

Figure 1



[Figure 1. Abstract machine: self-organizing relationship between the highway and the sector city]

[Figure 2. Hierarchical transition system: strict specifications on the vehicular speeds, numbers of highway exits and the turning angles for the cars]

Structure education

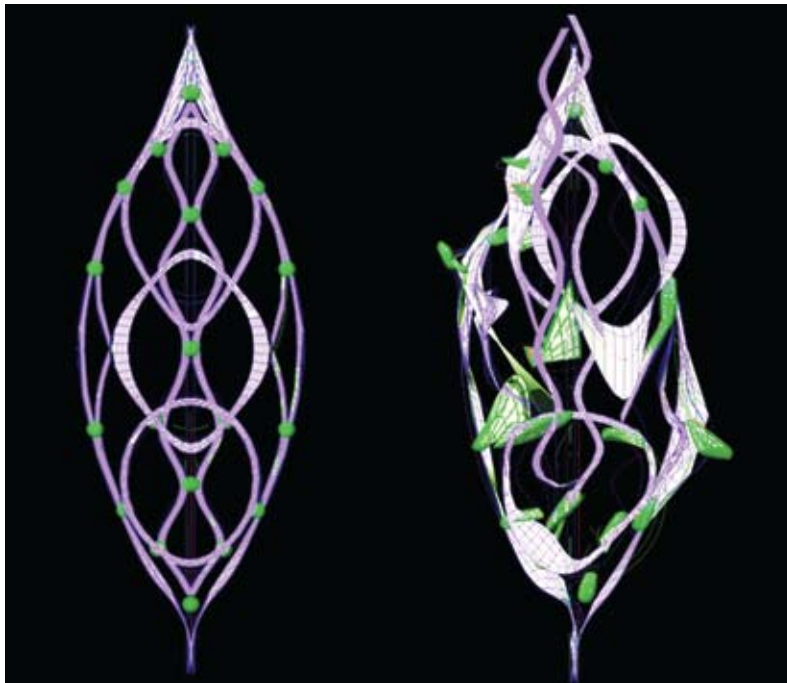
According to the rules on the highway, there are strict specifications on the vehicular speeds, numbers of highway exits, and hence the turning angles for the cars. By integrating the entrances of the sector cities and variations in speeds, [Figure 2] shows that a hierarchical transition system has been established to describe the relationship between the central highway and the influenced area, i.e., the sector cities. This abstract model, represented in a pattern with multiple variations, provides us with a framework to the exploration of the highway and the sector city (HSC).

Attractors

Attractors at the intersections

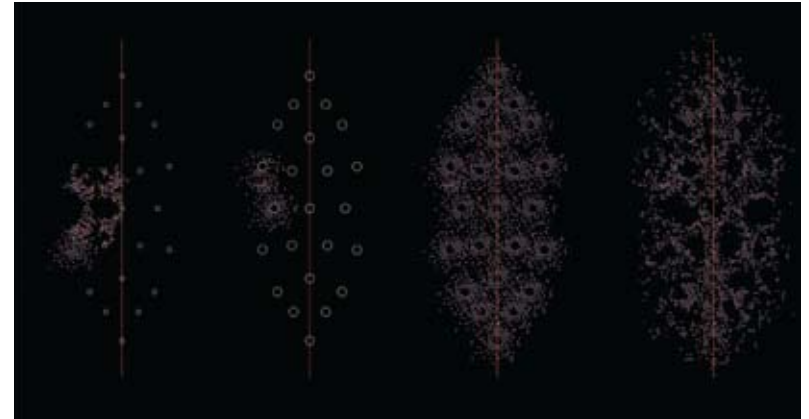
To regulate the translation of information between systems, we introduce the concept of 'attractors' that are located on the intersection points of the model pattern [Figure 3]. After the first translation at the exits of the highway, the information signals, which are constituted by drivers and cars, are further transformed at these attractors into a physical structure. The attractors are where different functions under consideration, living, office, industry, commercial, landscape, etc. have the most possibility for growth. These basic structural nodes in the city do not define the geometry of the city pattern, but their specific positions have become the control system of the HSC.

[Figure 3. Attractors at the intersections: where different functions have the best possibility for growth]



Between the Attractors

Each attractor contains five types of genes, or functions, as a precondition. These genes interact within themselves according to a set of microscopic rules. By changing such parametric rules or the initial positions of the attractors, the concentration and patterns of the genes, the ones that represent the distribution



[Figure 4. Distribution of the functions in the city: Numbers of particles and distances between them are parametrically controlled]

of the functions in the city, would be totally different [Figure 4].

With the software of Virtools, the microscopic rules are applied onto the particles and their subsequent swarm patterns are simulated. We started with the exploration in L-system-line generation and ended up with rules that control the relative distances between different functions. By exploding numerous particles from the attractors, point clouds appear in a three-dimensional space, and each particle looks for its own position in space abiding the rules set. The numbers of particles and distances between are parametrically controlled, with a certain degree of randomness. The self-organizing process is simulated and interacts in real-time with any changes in the parameters. Consequently every unit of the different functions finds its own position in the city, which is dependent on the attractors' locations and the distances set between the different functions. In this way, an interactive communication is established between the highway (the average speed of vehicles flowing on it) and the general function distribution in the sector city.

Refreshment and Regeneration

Every city undergoes a cycle of regeneration, just as the average speed on the highway fluctuates significantly every period of time. Since the positions of the attractors change with the city structure according to the speed of movement on the highway, the concept of refreshment comes in to describe the potential developments of the HSC. In every regular interval of time, as the genes, or functions, are exploded again from the attractors, the distribution of



Figure 6

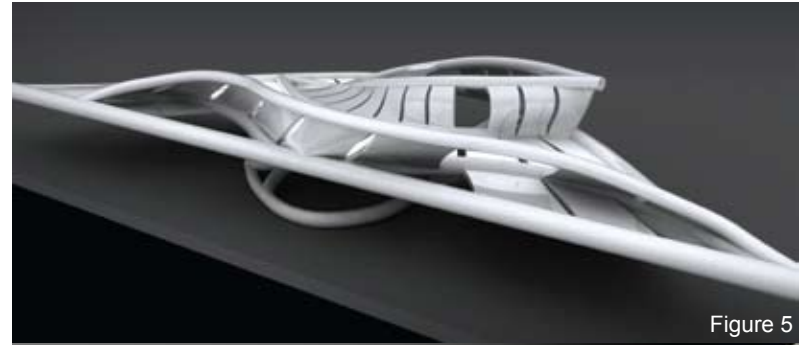


Figure 5

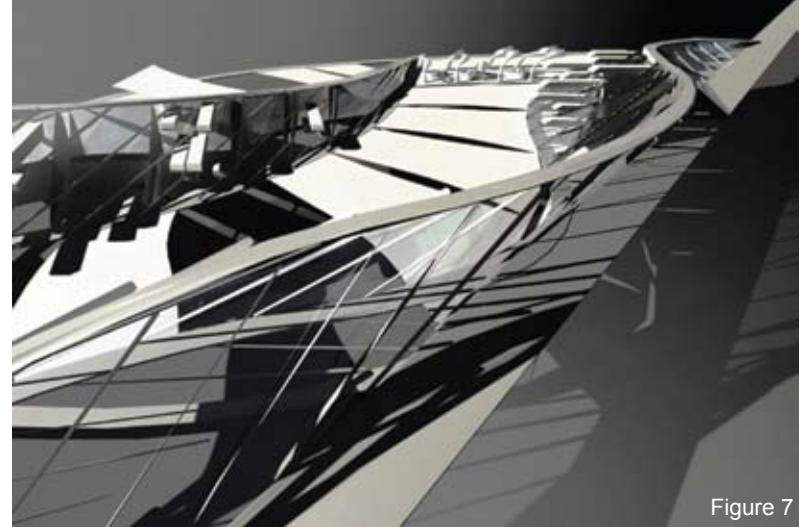


Figure 7

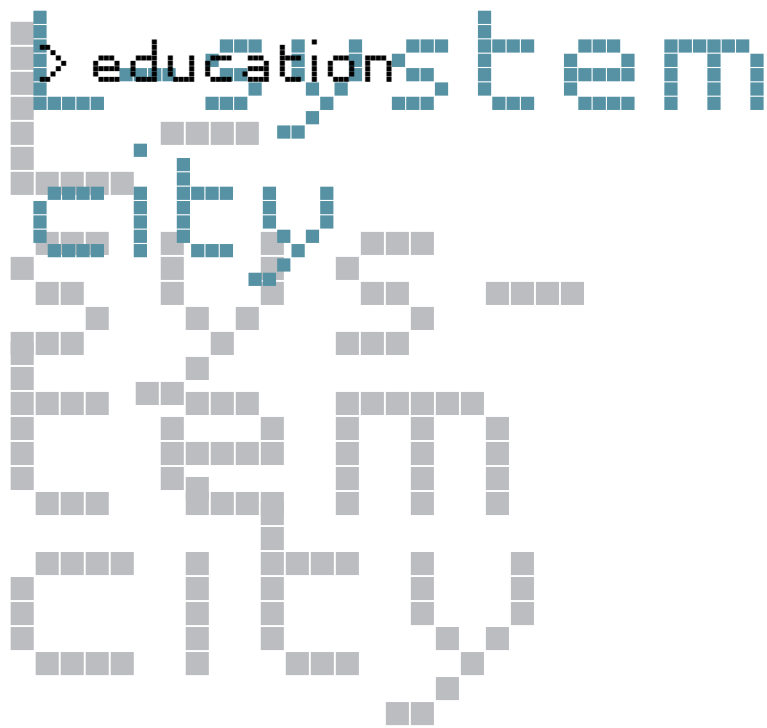
[Figure 5. Flexible construction adaptable to refreshed distribution of functions]

[Figure 6. Integration of architecture and infrastructural system of the city]

[Figure 7. The highway, the structures of the city, and the architecture]

the functions in the city is actually refreshed according to the new locations of the virtual attractors.

Macroscopically, every refreshment accompanies an emission of impulse from the sector city. Such impulse contains information on average speeds, quantities of vehicles, rhythms, etc., flowing along the highway. Impulses are continually emitted by the cities along the highway and by the terminal cities at both ends. Every time the 'City Translator' senses the impulse, it reacts by its own expansion or contraction. This counter-reaction is done according to the 'Redeem principle'. Each city is giving feedback to the impulse on the highway; they are strengthening or weakening the impulses emitted from the former city along the highway. Every expansion or contraction of the virtual infrastructural grid in the city is complementing the overall flow of information in the HSC system.



L-system city

Ilaria Giardiello

The Distributed_city project, along the A2 Highway, deals with the investigation of the relationship of Lyndenmayer systems to architecture to generate urban patterns.

Design process

L-systems are generative models usually applied to describe and simulate the morphogenesis of plants and complex structures in nature. Their generative logic is based on the recursive replacement of elementary units according to specific rules of substitution, defined in the early stages of the design process. Each unit has a formal component, represented with a single or a multiple string, and a geometrical component, visualized with the Turtle Graphic system of notation. During each cycle of iteration, the string that encodes the geometric properties of the systems evolves exponentially and conditions the evolution of the morphology of the system itself. Additionally, parametrical variables are embedded into the system to investigate different configurations. The project consists in the elaboration of a general computational model in Vrttools, able to generate two L-systems, respectively for the re-design of the highway itself, and the design of the residential city. The idea behind the project is that the designer is able to control the final state of the system by means of controlling its first iteration. The values and the meanings informed in the primitive stage of the system will be then applied to the entire generative model, assuring that the final stage contains the same set of values and meanings. During the proliferation, the entities and their relationships interact with each other producing more complex configurations by juxtaposition and superimposition in the three-dimensional space.

L-system_01_highway

The first part of the project deals with the re-design of the highway considered, in the present configuration, as a reductive and incomplete model. Interpreted as something more than a forced constant in the landscape, the highway itself could become a dynamic component of the organization of the territory and increase, with its new morphology, the potentials of the site itself. The linear elements, generated with the L-system and visualized with the Turtle Graphic, represent the main focus of this part of the project; they correspond to infrastructural entities with different functions. The principal branch confirms the linearity of the highway and allows for fast travelling, while the secondary branches accomplish the two main focuses of the project: the reconnection of the landscape and the reduction of speed-noise generated by the cars. The noise pollution created by the car traffic along the highway, in fact, limits the possibility to build residential environments in its immediate proximity. With an operation of fragmentation, consisting in switching the main route of the highway into multiple paths, the project limits the cruise speed of the cars and reduces the noise in the surrounding area. At the same time it provides a system of transversal connections between the two sides, which enables the highway to become part of the urban tissue [\[Figure 1\]](#).

L-system_02_Residential city

A second L-system generates the pattern for the city itself, characterized by residential and commercial units. It is conceived in a more dynamic way, since [22](#)

> education

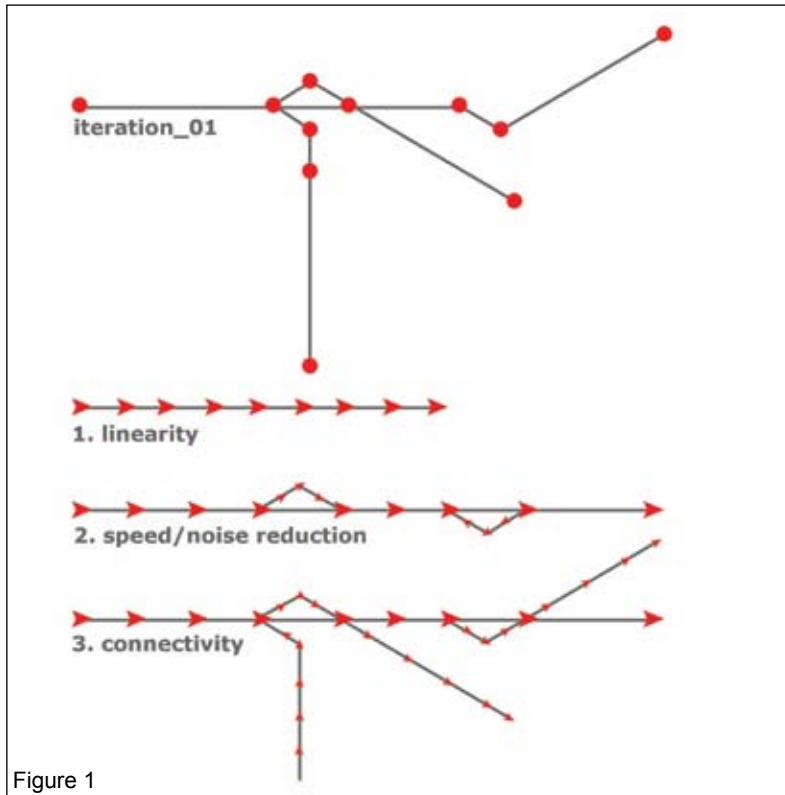


Figure 1

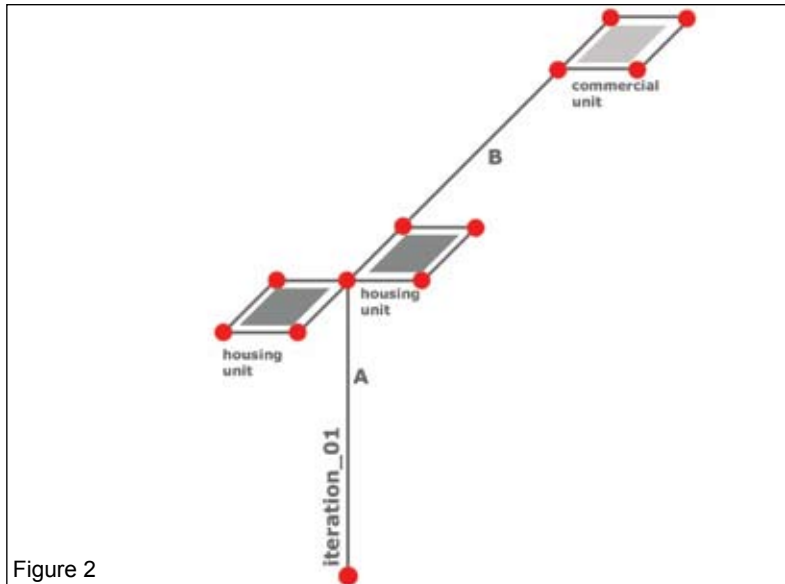


Figure 2

some of the variables, designed in the system and translated in the script, have a parametric nature. Adjusting the controllers, different configurations emerge, allowing the designer freedom to adjust for multiple solutions. In this case, the design does not focus on the linear elements themselves, but on their interaction. Their combination, in fact, creates closed shapes interpreted in the computational model as surfaces representing respectively commercial and housing facilities [Figure 2].

The definition of the sequential order of displacement of the elements in the string sets the quantitative and qualitative relationships between the units of the pattern; it defines the number of units for species and the nature of their numerical and physical relationship -e.g. the applied ratio between housing and commercial facilities is 2:1. The further iteration of the system generates new local configurations and increases the level of interactivity between them. New typologies are explored and new hybrid configurations determined, so that the potentials of the design itself increase [Figure 3].

Some of the variables of the string are defined parametrically. Adjusting their value, it is possible to control different aspects of the design and define different possible configurations for the final state of the system. For example, the [22](#)

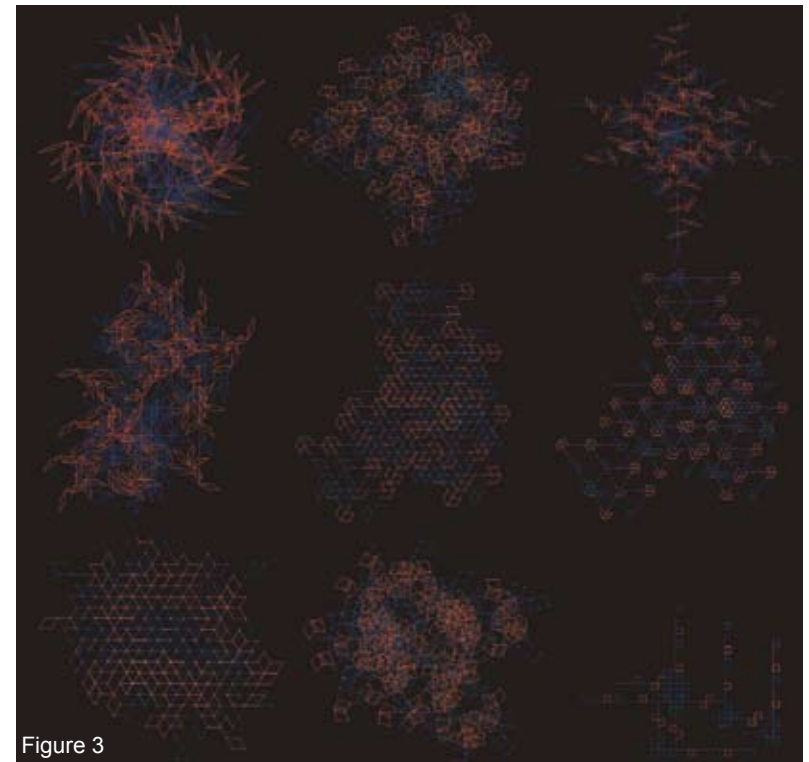


Figure 3

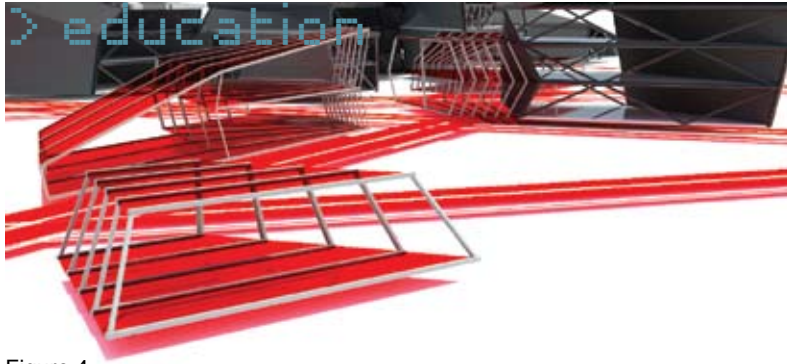


Figure 4

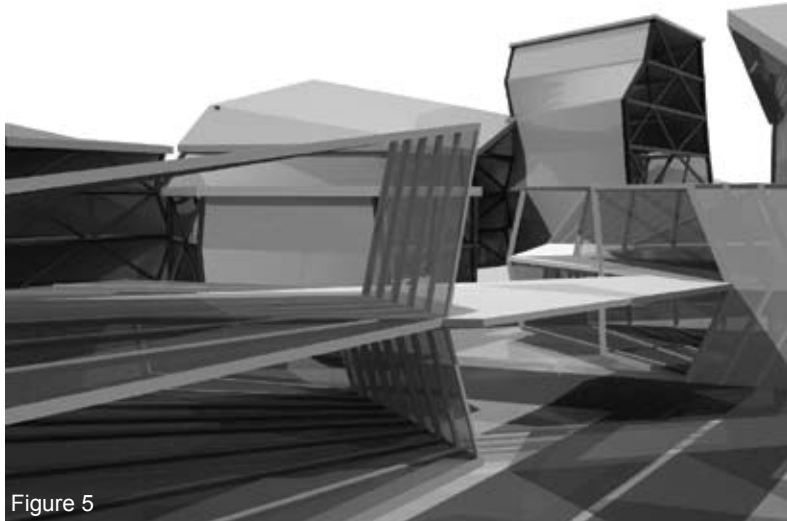


Figure 5

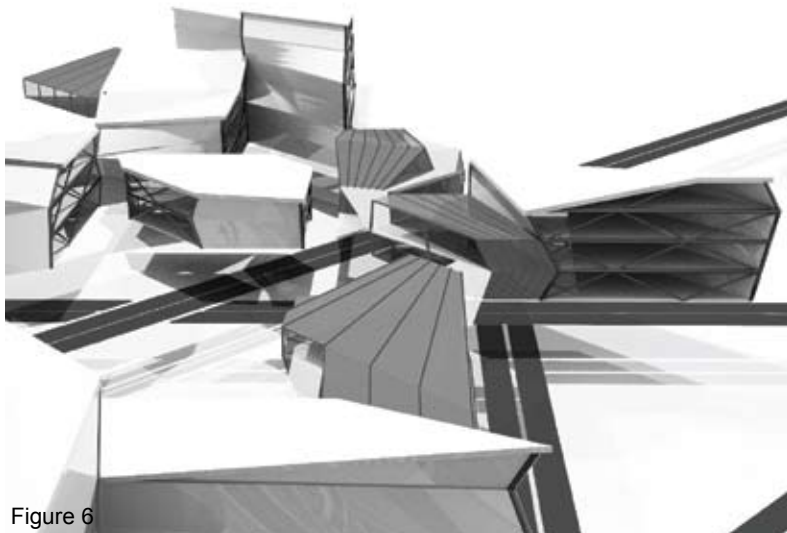


Figure 6

variable 'A' never iterates but it acts as controller to determine different degrees of density of the pattern.

The values 'F' and 'C' act as size-controllers. Adjusting their values it's possible to determine different configurations of the footprint size of the commercial and residential units. Finally, the value of the angle ' α ', expressed in the string with the substring '+' and '-', for the positive or negative value, determines different configurations of the pattern itself. With the variation of this angle, it is possible to obtain more or less regular organization and finally choose for the most appropriate and more interesting solution [Figures 4, 5, 6].



Notes

Note to Figure 1, L-system_01_highway

Constants: A, +, -

Iterating variable: F

Axiom: F

Rules of substitution: $F = F [+A--AF] [--A--AF] +F [-A++F] +$

Final level of iteration: 2

Note to Figure 2, L-system_02_Residential city

Constants: A, H, K, +, -

Iterating variable: F, C

Axiom: F

Rule of substitution a: $F = AFK+ [+FH+FK][+FH-F][++FH+FK][FH-F]AC[CK-C]-[CK+C]$

Rule of substitution b: $C = C[C-C]-[C+C]$

Level of iteration of the final system: 3

> education dynamic diagram in design

dynamic diagram in design

Dynamic diagram in design

Owen Slootweg

The decadent lifestyle of the Western world has put design on a pedestal. Beauty and aesthetics are highly valued aspects of contemporary design. But there is more to design than just that. A good design has a philosophy behind it, making the design not simply 'beautiful' but giving it an added value.

Those values might be related to, for instance, function, performance, technical quality, innovation or image/status. The quality and success of a design is often found in these added values. The same goes for architectural design as well. The well-known saying in architectural design: 'Form follows function' underlines this. Since computers are used in architectural design, the potential of designers to have form follow the other aspects of designing has increased immensely. Think about the exotic forms of Calatrava that follow structural forces rather than function. Due to the processing power of computers things that could hardly be calculated, verified, checked or tested have become data, which is easily extracted from computer models. One powerful example of such a computer model is the dynamic diagram.

Using a dynamic diagram in design is principally the same as using a more traditional 2D or 3D diagram. It can be used to structure and organize relevant information, making the information easily accessible and readable, ready to use in the design process. As opposed to the 2D and 3D diagrams, a dynamic diagram can do even more. It can run calculations actively, making the data come to life. Providing the proper interface turns the diagram into a design tool, which can actively and interactively relate different data to each other to compare, optimize, calculate, test or even sketch different design solutions. The possibilities are endless. This paper gives a detailed description of a design process making use of a dynamic diagram as a design tool, to give insight into how dynamic diagrams can be of benefit to a design process.

The design task that will be the case study of this paper was to create a sports and congress centre over the highway connection hub Kleinpolderplein in Rotterdam. Although the three dimensionality of the highway crossovers enforced severe design and building constraints, it also provided a dynamic and lively context, which is suitable for giving input for a dynamic diagram.

Location Kleinpolderplein

First we must take a look at the location's specifics. In order for a building to get its roots in the location, it is important to analyze the location and see which are the defining aspects that give the location its character. In the case of the Kleinpolderplein location, it is the dense network of highways crossing over each other that have a dominating influence on the location's character. The highways have different heights to be able to pass over and underneath each other. They create an impressive three-dimensional spectacle and connect to each other on several points on the outskirts of the network. On ground level there is a roundabout allowing access from and to local directions. Highways from seven different directions come together and process more than 80,000 vehicles every day, making noise and air pollution key problems for building there. Yet it also is an area, which is commercially very attractive due to the thousands of passers by per day and its excellent accessibility. Taking the flow of traffic as a starting point for the dynamic diagram was the inevitable first step.



[Figure 1. Panoramic view of traffic square Kleinpolderplein with its impressive flyovers]

[Figure 2. Schematic top view of Kleinpolderplein]

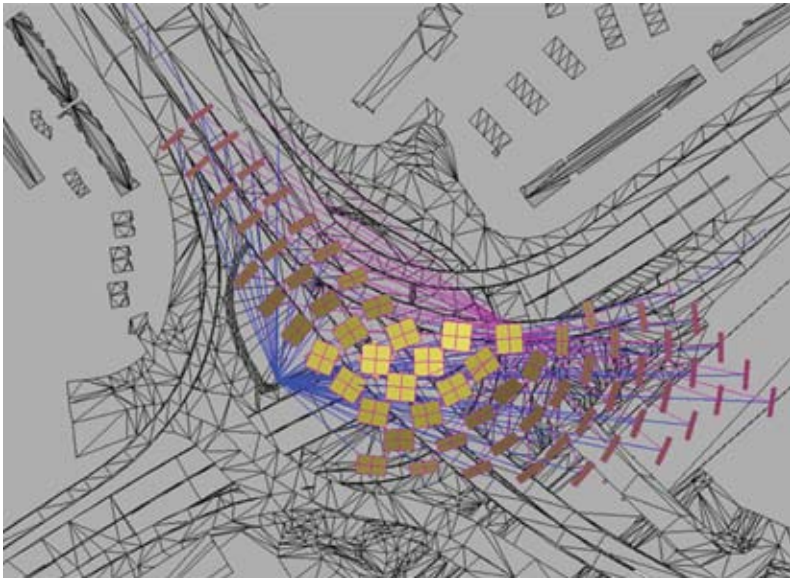
Conceptual development

With traffic flow as the most dominant force in the location, it had to play a large role in the design concept. Since the users (and use) of a building are also of major influence on the design process these two aspects are combined in the design concept. The connection between these two seemingly different aspects (external influence as opposed to internal influence) is the façade, since the façade can be experienced from the inside as well as the outside of the building. The concept involves a dynamic diagram that manipulates a series of panels (that are to become the façade) in such a way that it evokes an interaction between users and passers-by. The panels are mirrors that reflect the mirror images of users and passers-by to each other, establishing a visual connection between them. The movement of the passers-by gives the building a dynamic and intense interior, while for the passers-by, the reflections stand still,

giving a sense of calmness. In this scenario, the outside world is taken inside the building where the different functions, like sports, events and congresses benefit from an active environment, while the inside can be experienced calmly from the surrounding highways without being too much distracted from driving.

The set up of the diagram is to create a building form that is able to perform exactly as it is described above. To accomplish this without use of a computer model would be virtually impossible, due to the extremely large amount of points on the surface that have to fulfill these specific requirements of reflection. The dynamic diagram is basically a form finding tool.

To get a deep understanding of how a dynamic diagram can be of use in the design process, a detailed description of the setup and the implementation in the design process of the diagram is given.



[Figure 3. Schematic top view of Kleinpolderplein. Diagram setup]

The global idea for the diagram was to create a three dimensional grid of flat panels (the façade panels-to-be) over the location. Out of this grid, a selection would have to be made that suited the above-specified requirements of reflection. This selection would then be the basis of the building's façade. The diagram was created in Virtools Dev, a software development kit that is mostly used for games. Virtools Dev was used to setup all the interactivity and functionality of the diagram. Virtools Dev is also a platform to do mathematical calculations, which were required for the rotating the panels and the selection procedure explained in more detail below. Modelling the necessary 3D information and making animations was done in Maya.

These are the different steps that were made to get from diagram to building:

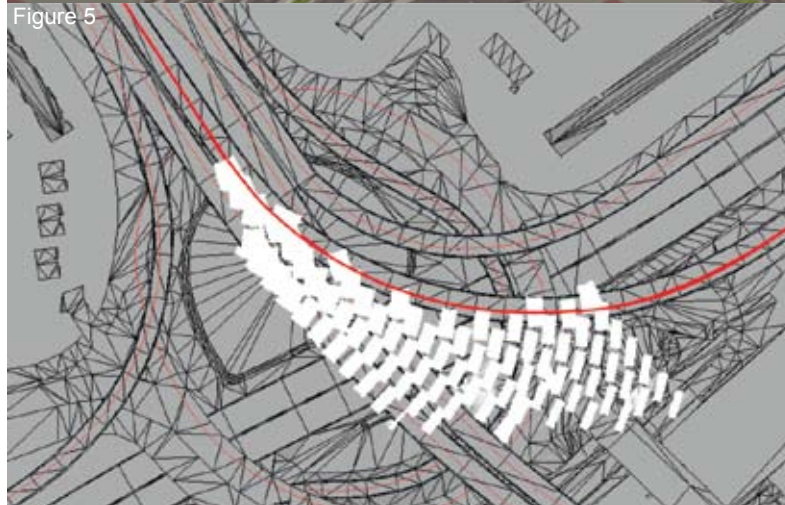
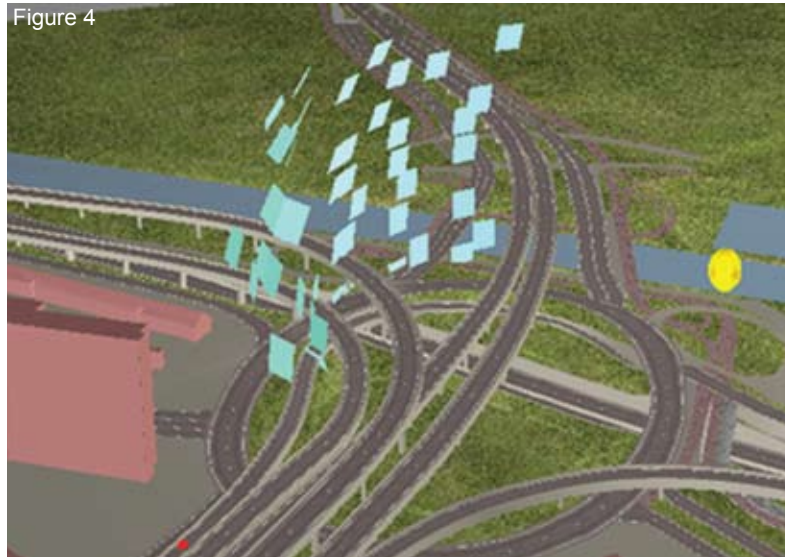
- 1) Grid of panels 2) Animation/simulation 3) Orientation of the panels
- 4) Selection of suitable panels 5) Using the diagram 6) Diagram to design

1 Grid of panels

The first step in setting up the diagram is defining the starting grid of panels. To establish a suitable grid, a perfectly dimensioned 3D model of the location is an absolute necessity. The most important aspects for defining the grid

[Figure 4. Snapshot of the 3D view of the diagram. The yellow dot represents the point of interest, the red dot represent the motorist]

[Figure 5. Animation paths for 7 flyovers]



were the size of the grid and the resolution. The size of the grid was important because eventually it would have a major impact on the building's size. The extent of the grid was determined based on the buildable areas on the ground floor level of the traffic square to ensure the building's structure would have enough space to come down to the ground (in between and on the outside of the crossing flyovers of the traffic square), yet keeping as close to the location's centre as possible. Also the borders of the grid are different from the inside (the panels on the borders have less neighbours). This is to avoid miscalculations or other anomalies in range of the preferred building size. The grid, therefore, is slightly over-dimensioned, transferring these problems to outside the building's bounding box. This resulted in a 325 by 290 by 80 metre grid. Next the amount of panels in the grid needed to be defined. By trial and error an optimum was established of 540 panels (12*9*5) based on the processing speed of the diagram and computer. A higher resolution may seem desirable, but the lower resolution grid was later interpolated into a set of smooth surfaces anyway, making the higher resolution grid an insensibly slow one.

2 Animation/Simulation

In order for the reflection requirements to be tested interactively, simulations had to be made of the passing traffic on each highway/flyover. In the traffic square, there are seven highways crossing each other on different heights and from different directions. These are all accurately modelled and are the basis of the animation paths. On each of the seven animation paths, an object is placed representing a motorist. The object changes its orientation according to the curvature of the animation path, just like a motorist would do driving on the flyover in real life.

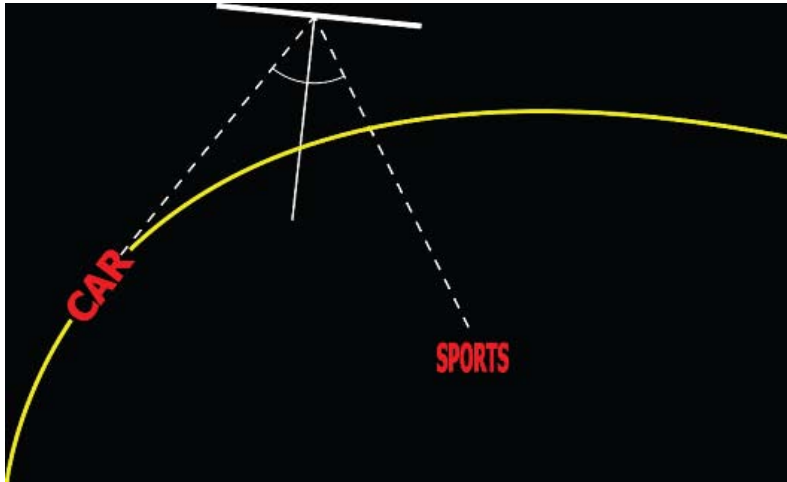
The position and orientation of the object is saved for each moment in the time it takes to cross the flyover. The animations are made in Maya and implemented in the Virtools Dev to allow the user to read out the data (e.g. position and orientation of the motorist) when needed.

3 Orientation of the panels

In the diagram, the animations can be called on by pushing the button of the corresponding flyover. When the animation runs, the panels in the grid respond to the motorist's position on the flyover, but only when the panels are in the line of sight of the motorist. The line of sight is a representation of the motorist's view of the environment when driving on the flyover. It is conceived as a straight line in the direction/orientation of the motorist, 150 metres long. (This 150 metre constraint is to avoid senseless results of panels rotating that are actually being blocked from the motorist's view by other panels.) When this virtual line intersects one of the panels in the grid, the panel is rotated in such a way that it mirrors a certain reflection point in the building towards the motorist. This means that in that specific moment in time the motorist is able to see that certain point mirrored in the façade of the building if he/she was to look straight ahead.

After the animation has ended each panel that has been intersected by the line of sight has been rotated to mirror the same point to the motorist all the way over the flyover. This mirror point is different for each flyover and represents an interesting feature or function of the building. Since there are also users inside the building, they can be seen by the motorists during the time it takes for them to cross the flyover. In turn, the users get a panoramic view of the flyover, allowing them to follow the motorist from the start to the end of the flyover.

For the correct orientation of the panels, a vector calculation is performed in Vrttools Dev. For this purpose a VSL-script is written embedding some basic vector mathematics. The incoming vector is defined by the motorist's line of sight, which is the line between the position of the motorist and the centre of the panel. The outgoing vector is the line between the centre of the panel and the point of interest inside the building. The panel is rotated tangent to the two

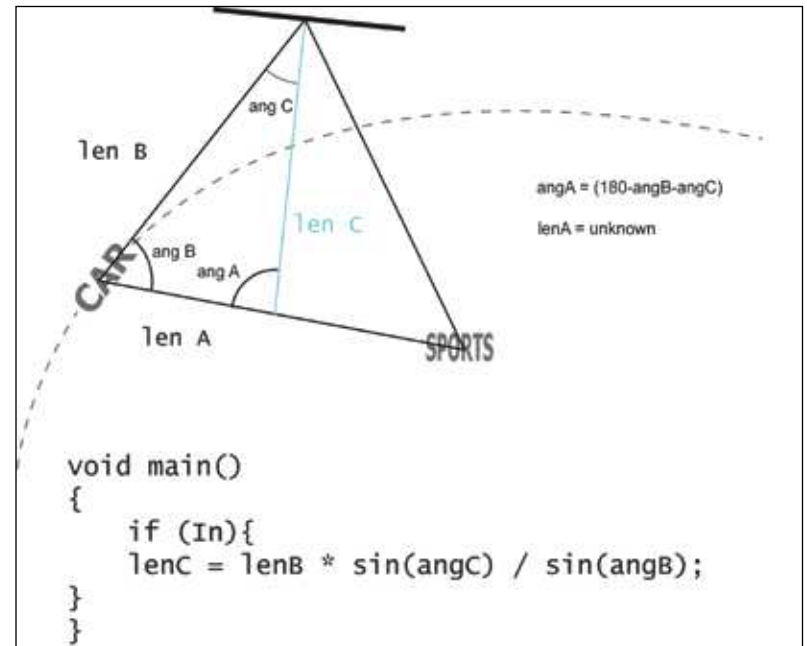


[Figure 6. Concept of mirroring panels]

vectors, making the panel mirror from the motorist to the point of interest and vice versa. The auxiliary scripts make sure that every panel is rotated only when it is in the line of sight of the motorist. Freezing the panel at exactly that moment ensures that the point of interest is only visible when the motorist is looking straight in front of him. After running an animation of a flyover, all panels would be rotated into the proper orientation. This allows for an accounting of the motorist's changing position over time as well as the line of sight changing direction according to the curvature of the flyover and intersecting different panels subsequently.

4 Selection of suitable panels

After running the animation for one of the flyovers one would have a 3D grid of panels that are now rotated into the proper orientation. To create a façade out



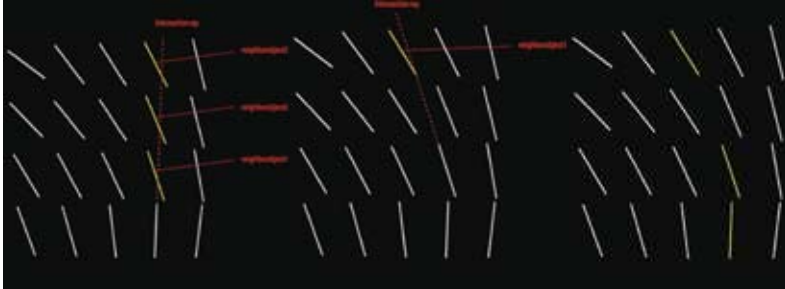
[Figure 7. Vector mathematics implemented into scripting]

of these panels a selection must be made based on a stringent set of rules. The most important rule in selecting the panels is that the panels in a selection are oriented in such a way that it is possible to connect them in a fluid manner, not allowing for a curvature that is meandering, because a meandering curvature would mean the reflected point of interest would not constantly be visible in the façade for the motorist. The curvature of the façade must be a smooth interpolation of the selected panels. Another rule is that all panels in a selection are on the same height, so no panels are selected above or below the other panels in that selection. The result of this decision is that the façade would become a set of ribbon-like surfaces with a distinct direction which is more suitable with the character of the surrounding flyovers as opposed to a more three dimensional surface.

The script of the functionality of selecting the panels is an elaborate calculative and organizational process. It is best described by this short-list of actions:

- Each panel sends out an intersection ray on its right-hand side.
- Only when the intersection ray intersects a neighbouring panel on its left side it is registered in an object dependent array (of the original panel) as a neighbour. This means the neighbouring panel is able to make a fluid curvature with its original panel when interpolated.
- A maximum of three intersected neighbouring panels are registered for each panel.

- An empty array is created to store chains of panels.
- For each panel, all chains it forms with its neighbours and their neighbours consecutively is stored in the array.
- After all the panels in the 3D grid have been iterated and the array is full all chains are descendently organized in order of length.
- In the dynamic diagram the first proposed solution of façade panels is the longest chain. Up and down arrows allow the user of the diagram to toggle through all the solutions (chains) and hand-pick their favourite.

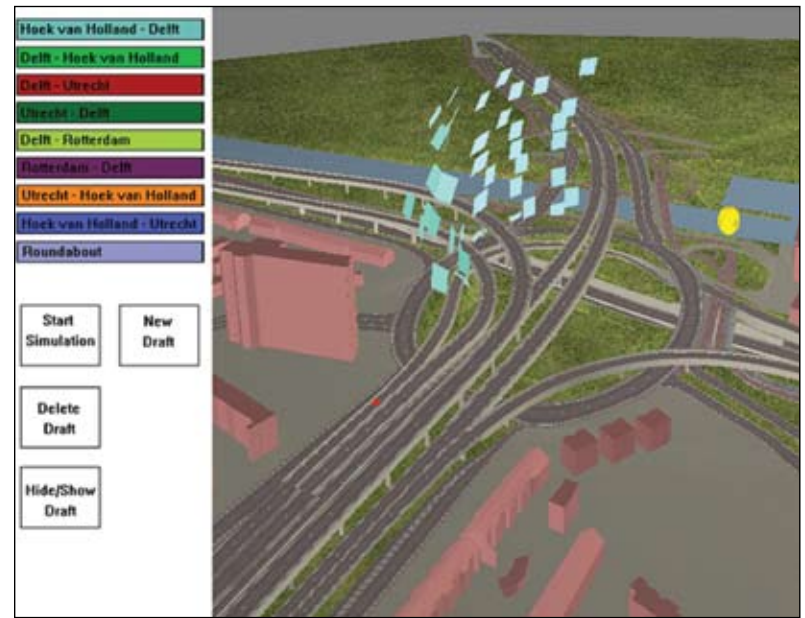


[Figure 8. Principle behind the forming of chains of selected panels]

5 Using the diagram

The functionality of the diagram, the simulations and calculations necessary for the generation of design solutions for the façade are made accessible through an interface linked to a virtual 3D environment. The interface consists of a 2D window containing buttons to control the functionality and a 3D view of the location model including its flyovers, animations and the 3D grid of panels. There are buttons to choose the flyover for which you want to generate a façade, a button to start the animations and generate a solution for the façade and the arrow-keys are assigned to toggle through the different versions. There's also a button to delete a version and to start again. The 3D environment can be navigated through using standard game controls w/s/a/d (respectively: move forward/move backward/rotate left/rotate right) to get a closer view on the generated solutions.

To ensure the solutions for each flyover do not interfere with each other while checking them out there's also a button to hide and show the generated solutions per flyover. The diagram's functionality is scripted using Virtools Dev, a software development kit that is generally used for creating games, which has an integrated 3D engine and a giant library of script-bits as well as a supporting scripting language to manually write your own scripts called VSL (Virtools Scripting Language). For the modelling of the 3D environment an external 3D modeller was used (Maya) to handle the accuracy and dimensioning constraints of a 3D model with such specific purposes. In essence three major elements; a 3D model, a 2D interface and the scripted functionality are brought together in one interactive dynamic diagram.



[Figure 9. Snapshot of the diagram showing the 2D interface and 3D view]

6 Diagram to design

Using the interactive diagram, one can generate a series of façade panels for each flyover in the location, seven in total. These panels form the framework for the building shape since they decide where the exterior skin of the building will be. To get this done, these series of panels need to be interpolated to create a smooth continuous ribbon-like surface. This is a process best done with NURBS surfaces. Since Virtools Dev is not a modelling program the panels are extracted with 3D ripper software from Virtools and imported back into Maya. The ripper software takes a sort of 3D photograph of the Virtools scene using camera aperture settings and focal length. The 3D data is imported in Maya where MEL (Maya Embedded Language) scripts are written to attach all the panels in one series while preserving their tangencies. Using scripts in this stage is to maintain accuracy as well as to avoid a lot of manual labour and time. Mistakes in the interpolation would destroy the mirroring behaviour of the façade so accuracy is an absolute necessity and scripted geometry is flawless provided that you set the right rules to create it.

To check the performance of the created façades the same animations are used that were previously exported from Maya to Virtools. A line is drawn every 50 frames in the animation between the motorist and the façade straight in front of him (the line of sight). The lines are then visually checked to see if they intersect with any of the façade surfaces. In case the façade surface of a specific flyover obstructs the lines of sight too many times, it can be deleted and a new one has to be generated with the dynamic diagram. Attaching cameras to the animation



Figure 10

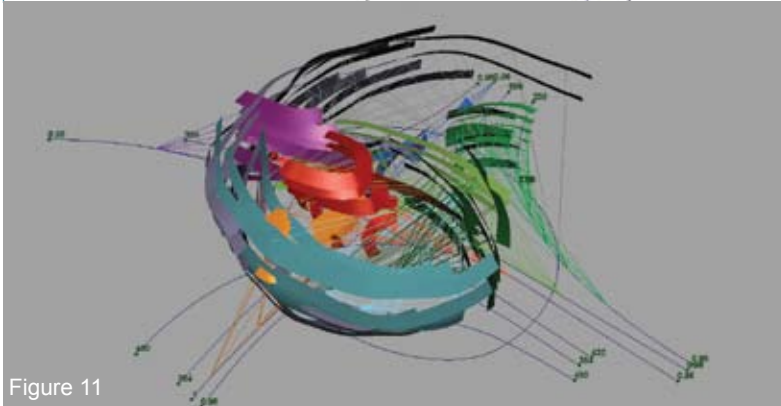


Figure 11



Figure 12

paths makes it possible to check if the mirroring behaviour is working properly. Finally the façade surfaces are extruded outwards to create tunnel-like volumes that will house the buildings functions.

Validation

The process of creating an interactive design tool like this is an elaborate and labour intensive task, which is the most obvious back draft of this approach. However the benefits far outdo the amount of work you have to put in initially. First, there is the specific performance that the façade should fulfil. The dynamic diagram provides accurate calculations that guarantee an errorless performance. Second, the interactivity of the diagram allows the user to make several different design solutions with the click of a button, winning back a lot of time spent on setting up the diagram. In this case it would have even been near to impossible to 'design by hand' due to the sheer complexity of selecting the right series of panels, making the diagram a basic necessity rather than a choice of approach.



[Figure 10. Result of interpolation of several chains of panels into ribbons. Each set of chains belonging to the same gets the same color]

[Figure 11. Lines of sight of the motorist for each flyover are constructed for several positions on that flyover to check if the motorist's view on the façade is not being obstructed. The blue lines with numbers on the ends are the animation paths representing the flyovers]

[Figure 12. Render of the final design]

> project An Inter- active Wall

An InteractiveWall as a prototype for an emotive architectural component

MarkDavid Hosale
Chris Kievid
Kas Oosterhuis
Remko Siemerink
Dieter Vandoren

The InteractiveWall is an architectural-scale installation work commissioned by Festo, a leading world-wide supplier of pneumatic and electrical automation technology, for their presentation at the Hannover Messe 2009, the world's leading showcase for industrial technology [Figure 1]. The InteractiveWall was a collaboration between Festo, Burkhardt Leitner constructiv, and Hyperbody, as part of the Festo Bionic Learning Network [see Appendix A for a listing of the participants and contributors]. The InteractiveWall is composed of 7 wall components based on the Fin Ray Effect [Kniese 2003a, 2003b], a proprietary technology used in Festo's factory automation [Figure 2].

Participation in the InteractiveWall project provided Hyperbody with an opportunity to develop a prototype for an emotive architectural component. An emotive architectural component is a component that responds to the participant, a wall that has a character, a wall that can move because it wants to, and displays real time behaviour. Applying behaviour to the InteractiveWall prototype is an important step towards the development of emotive architecture; it transforms the wall from a static backdrop to a key component in a dynamic customizable environment.

Another approach to defining the concept of emotive architecture is through the exploration of semantic constraints. The term emotive can be expanded with the permutation e-motive, allowing the e to become electronic, emotional, engaging, emergent, informing the emotion. These terms in turn are driven by the motive, the intent, the motion. In this way e-motive describes the emotional and kinetic aspects of an architecture that is data driven, transforming architecture from a vessel of information to a means to express information.

Kas Oosterhuis defines interactive architecture as the art of building relationships between built components in the first place, and building relations between people and built components in the second place. Oosterhuis stresses the need for interactive architecture to be proactive, actively establishing connections in real time, and communicating with its internal and external context [Oosterhuis 2007]. At the heart of the emotive InteractiveWall prototype lies interactivity; it builds upon the alliance between two active parties (both transmitters and receivers). Intuitive and immediate, interactive architecture must be able to behave in unique and unpredictable ways. It no longer has a static end-configuration, the role of the actor shifts from that of the viewer to one of an interactive participant. In this sense, interactive architecture is an instrument to be played by its context and its participants.

The motivation for the development of interactive architecture is a response to the demand of programmable, multi-mediated, dynamic, flexible, and customizable environmental conditions of the digital age. Interactivity has entered the every fabric of public and private domain. In this context the emerging of interactivity in architecture manifests itself as the inevitable evolution of architecture. As the paradigm shifts in the international architectural discourse, emotive and interactive architecture are transforming and revolutionizing our social life and the domestic built environment. Inventing entirely new ways of using and designing space incites us to explore new ways of embodying user participation and locality.

Designing Interaction

As described above, the development of the interaction design for the InteractiveWall provided a unique opportunity to explore the theoretical concepts of interaction using a real world architectural-scale building component. It



Figure 1

was from this context that a multimodal spontaneously synchronous system (described below) was designed. To this end Hyperbody followed a methodical approach to interactive design that attempted to provide meaningful interaction with a participant by moving beyond a superficial one-to-one cause and effect interaction and designing a one-to-many interactive system that exhibited emergent behaviour and performed liked a living system. A living system embedded in an architectural component, transforming an otherwise static component into living architecture.

In order for an interactive system to be meaningful it must be believable. A reference to being submerged in water, the term immersion is a widely used metaphor to describe the experience of being saturated in a subject or situation. In other words, the term immersion could be used to describe the believability of an interactive system. Saturation occurs in contexts whereby artificial realities can be constructed. In an interactive system this is achieved through loudspeakers, lights, projections and, in the case of the InteractiveWall, movement. In order for a constructed reality to be truly immersive it must be believable as well as controlled. Therefore, an immersive artwork can be judged by how well it helps the participant create belief [Murray 1997].

In a believable constructed reality a participant often assumes certain roles based on past experiences and familiar cues that are taken from their understanding of the contexts being presented. Through role-play the actions of the participant increase believability by attributing meaning to the constructed reality. Whether consciously or unconsciously, the participant chooses to assume the implied role through their behaviour. In contexts that encourage a more active range of participation the participant is given greater latitude over choice and action within the constructed reality, further facilitating their ability to create belief. The conditions described here of participant role-play empowered by choice are examples of the concept of agency.

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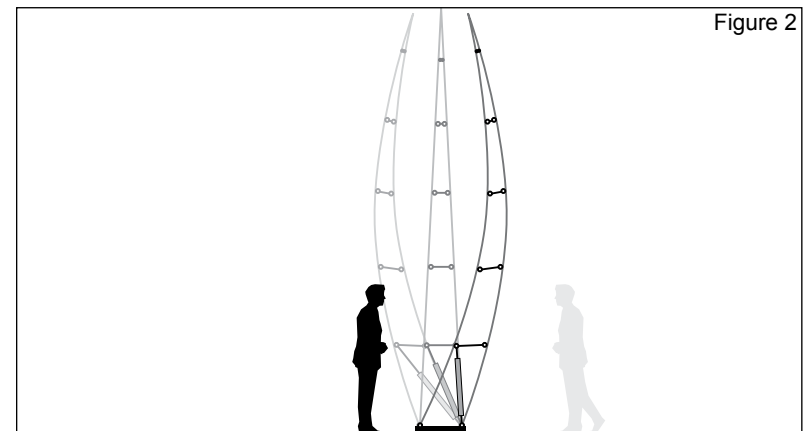


Figure 2

[Figure 1. The InteractiveWall. A wave pattern is expressed by the wall. photo source: Festo AG & Co. KG, by Walter Fogel]

[Figure 2. The Fin Ray bending characteristic of the InteractiveWall]

Project

The issue of agency underscores the need for interactivity in the construction of immersive contexts: the more active the participant, the greater the sense of agency, and the greater the sense of agency, the greater facility for the participant to create belief. Therefore as the sense of empowerment increases through interaction, so does the sense of agency. This relationship between the participant and the system is a reciprocal relationship, which according to Mark Meadows, takes place over 4 steps: 1) Observation: The reader (or participant) makes an assessment, 2) Exploration: The reader does something, 3) Modification: The reader changes the system, and 4) Reciprocal Change: The system tries to change the reader. According to Meadows, 'interactivity is a bidirectional conduit. It's a response. Interaction is a relationship. It's mutually executed change.' [Meadows 2003]

The characteristics of immersion, agency, and interaction compose one of the building blocks needed for the construction of nonlinear narratives as described in MarkDavid Hosale's PhD. dissertation, *Nonlinear Media As Interactive Narrative*. The foundation of this approach lies in the development of nonlinear narrative structures and layers of dynamic processes that act as a living system. The totality of this living system is what Hosale describes as the Universe of the work, a narrative construct built of 'a world of worlds', with each world forming a complex layer in the system:

A world not only encompasses the space of the constructed immersive reality of a work, it encompasses the imagined constructed immersive reality that exists in the observer's imagination as well. In this sense the world is more than the work itself; it is a set of operations, structures and semiotics that form the processes, which are beyond the format of the presentation of the work. [Hosale 2008]

Thus a living system is a system that will change and evolve whether or not a participant is present, it doesn't wait to react; it always exists. The living system is a complex system of layered and connected behaviours operating on many scales and many modalities simultaneously. The living system behaves independently, following its own patterns of ebb and flow. A living system is also connected to its environment, responding to users, and other input, expressing outside influences through its various modalities.

When considering these concepts in the development of the interaction design of the InteractiveWall it was not enough to design a system that simply caused a wall component to move when a participant was present. Rather a participant introduces an interruption to the processes unfolding in the living system of the InteractiveWall. This interruption changes the path of the behavioural processes of the InteractiveWall, causing it to reconcile the interruption with its normal ebb and flow by dissipating the energy of the interruption throughout the various scales and modalities of the InteractiveWall's interactive system.

Behaviour

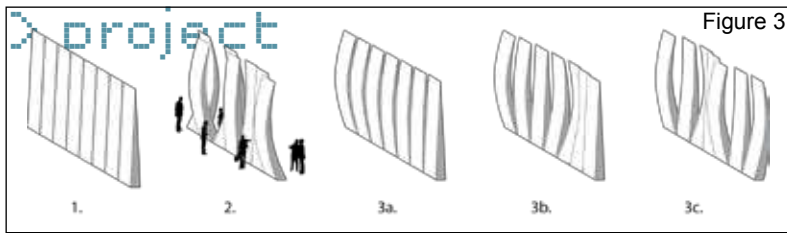
The overall behavioural pattern of the InteractiveWall is inspired by the phenomenon of emergent synchrony as described in the book, *Sync: the emerging science of spontaneous order* by Steven Strogatz [Strogatz 2003]. Spontaneous order is a characteristic found throughout nature in systems ranging from physical phenomenon to complex social behaviours, which can be observed as spontaneous sync. In his book, Strogatz asserts that this synchronous behaviour is guided by a simple set of rules:

- Individual elements are only aware of their nearest neighbors.
- The elements have a tendency to line-up in relation to each other.
- While the elements follow each other, they are attracted at a distance.
- Response to stimulus.

One way Strogatz illustrates the phenomenon spontaneous synchronicity is through the behaviour of the firefly. Fireflies have a tendency to synchronize their flashing tails whenever they are near each other. Through the cumulative effect of their flashing tails complex patterns emerge out of a simple localized behaviour of emergent sync. Although they are fairly simple animals, the fireflies are incredibly able to maintain this sync behaviour even when they are swarming by the thousands.

The characteristic of the spontaneous synchronous behaviour as expressed in the motion of the InteractiveWall is illustrated in [Figure 3]. As shown in step 1, the InteractiveWall components are aligned in a row on the show room floor in seven components. In step 2 participants approach the InteractiveWall and the components of the wall react to the participants by bending away from them in response to their presence. The bending is a local response, with each component bending independently based on the distance of the participant from the node. While the primary synchronous behaviour of the firefly is flashing light, the primary synchronous behaviour of the InteractiveWall is movement. The components of the InteractiveWall bend independently of neighboring components in response to the presence of a participant. Although responsively independent, the Interactive components also synchronize by constantly readjusting their positions in order to align with the position of their nearest neighbors. If the wall is left alone it ultimately comes to a resting state as shown in step 1 of [Figure 3]. The synchronous behaviour between the components of the InteractiveWall conflicts directly with the asynchronous behaviour produced by the response to a participant. The result is a series of complex wave patterns that propagate through the InteractiveWall as a whole; this is illustrated in the three phases of step 3.

As both sides of the InteractiveWall are responsive to participants, the InteractiveWall must negotiate how to respond to participant input when detecting the prescience of participants on both sides of a component. Because of this the behaviour of the InteractiveWall has a game like quality as well [Figure 4]. The >>



[Figure 3.1. The seven components of the Interactive Wall. 2. Participants approach the wall, stimulating movement in the wall components. 3. Cumulative wave patterns emerge in the body of the wall, resulting from inter-component synchronous behaviour conflicting with the asynchronous input]

game behaviour is designed so that an InteractiveWall component will favor the participant who is closest to the wall by responding only to that participant. As a result the participant furthest away from a component becomes even more repelled as the component pushes them farther away from the structure, while the winning participant is rewarded and sheltered by the arc of the component's curved form.

A summary of the behaviour of the InteractiveWall is best stated in the context of the description of designing interactivity provided above. The InteractiveWall is motivated by an independent system built on synchronous behaviour. This system is then interrupted by the game-like response of multi-participant interaction. The result is then propagated throughout the body of the InteractiveWall. The result of this action provides the participant with a greater understanding of the system motivating the InteractiveWall, encouraging them to explore further, and engage with the InteractiveWall system. The engagement thus follows the intended cycle of observation, exploration, modification, and reciprocal change desired in the interaction design concept.

Multimodal Feedback

Although the focus of the discussion of behaviour above was focused on movement, the InteractiveWall is a multimodal interactive system composed of movement, light, and sound. Each modality of the InteractiveWall is a layer of interactive communication connected through the synchronous behaviour described above, while remaining independent in terms of its mode of



[Figure 4. The responsive behaviour of the InteractiveWall leads to active participant engagement. photo source: Festo AG & Co. KG, by Walter Fogel]

expression of the current synchronous state. The skin of each component of the InteractiveWall is covered by a unique, irregular distribution of dynamically controlled LED's that form a highly reactive interface. The LED's are controlled individually and are used to create patterns of light that glide across the body of the InteractiveWall component. The LED skin doesn't respond directly to the presence of a participant, but indirectly by changing in response to the motion of the body of the InteractiveWall component. As the InteractiveWall component bends outward, the patterns of light become more agitated, moving rapidly over the skin of the component. When resting, the light patterns on the wall become tranquil, moving in a calm and pleasant manner.

As with the light patterns, the modality of sound is localized, representing only the state of the local sync of a particular InteractiveWall component. Moments of synchronicity are represented by calmer, lower pitched sounds, while asynchronous behaviour results in more intense sound. The propagation of the sound from high to low intensity is varied throughout the InteractiveWall, transforming each node into a member of a choir that sings a complex pattern of oscillating chords. The inter-component synchronous and asynchronous behaviours (and resulting wave patterns) described in the modality of movement above are present in the light and sound modalities as much as they are present in the behaviour found in the movement.

Although connected, the physical movements of InteractiveWall components, the light patterns, and the sound behaviour change independently, reacting at varying rates, expressing the state of the InteractiveWall component in a unique manner. These components contribute to the living system as scaled and modulated expressions of the synchronous and game-like systems described above. The perceived sum of the behaviour of the three modalities results in a layering of complex synchronous, asynchronous, convergent, and divergent patterns that propagate through the InteractiveWall structure as a whole.

Conclusion

Festo's commission to develop the interactive design for the InteractiveWall presented at the Hannover Messe industrial trade fair provided Hyperbody with an architectural-scale prototype for the exploration of emotive architecture. The motivation for the development of interactive architecture is a response to the demand of programmable, multi-mediated, dynamic, flexible, and customizable environmental conditions of the digital age.

At the heart of emotive architecture is interactivity. Therefore, the development of emotive architecture requires an interactive design that is a multimodal spontaneously synchronous system that exhibits the characteristics of immersion, agency, and bidirectional feedback. From this perspective the interactive system is a living system that expresses interactive input from participants as an interruption to a continuously evolving system propagating





through its various scales and modalities. Intuitive and immediate, interactive architecture must be able to behave in unique and unpredictable ways. It no longer has a static end-configuration, the role of the actor shifts from that of the viewer to one of an interactive participant. In this sense, interactive architecture is an instrument to be played by its context and its participants.

Although the work completed in the InteractiveWall project is a small step towards the larger exploration of question of architecture, it has provided Hyperbody with a greater insight into the development of emotive architectural components. Starting from a clear interactive design concept, we developed a one-to-many interactive system that exhibited emergent behaviour and performed liked a living system. The result is an independent system built on synchronous behaviour that is interrupted by the game-like response of multi-participant interaction. This layered system encourages the intended cycle of observation, exploration, modification, and reciprocal change in the participant, reinforcing believability in the system, and providing a sense of agency to the user.

As interactivity has entered the fabric of public and private domains, the emerging of interactivity in architecture manifests itself as an inevitable evolution of architecture. As the paradigm shifts in the international architectural discourse, emotive and interactive architecture are transforming and revolutionizing our social life and the domestic built environment. By inventing entirely new ways of using and designing space that embody user participation and locality, we will transform architecture from a static environment to one that is customizable and dynamic, emergent and alive.



[Figure 5. Front view of the InteractiveWall (long shutter speed)]

[Figure 6. The Interactive Wall at night, showing the irregular distribution of lights on the skin of the Interactive Wall. photo source: Festo AG & Co. KG, by Walter Fogel]

References

- Hosale, MarkDavid, *Nonlinear Media As Interactive Narrative* (Santa Barbara: University of California, 2008)
- Kniese, Leif, *Bauteil zur Aufnahme von Kräften mit einer flexiblen Außenhaut* (Germany: European Patent EP 1 316 651 A2, 2003a)
- Kniese, Leif, *Vorrichtung zur Aufnahme von Kräften mit einer flexiblen Außenhaut* (Germany: European Patent EP 1 203 640 A3, 2003b)
- Meadows, Mark Stephen, *Pause & effect: the art of interactive narrative*. (Indianapolis, Ind.: New Riders, 2003)
- Murray, Janet Horowitz, *Hamlet on the holodeck: the future of narrative in cyberspace* (New York: Free Press, 1997)
- Oosterhuis, Kas, 'Introduction / Editorial', in: *iA#1*, Kas Oosterhuis, Xin Xia (eds). (Rotterdam: episode Publishers, 2007)
- Strogatz, Steven H., *Sync: the emerging science of spontaneous order*. 1st ed. (New York: Hyperion, 2003)

Project partners

Project initiator: Dr. Wilfried Stoll, Chairman of the Supervisory Board, Festo AG

Project managers: Professor Kas Oosterhuis, Chris Kievid, Bernard Sommer, Hyperbody, Faculty of Architecture, Delft University of Technology, the Netherlands; Michael Daubner, Andreas Dober, Burkhardt Leitner constructiv, Stuttgart, Germany; Markus Fischer, Festo AG & Co. KG, Ostfildern, Germany.

Project team:

Mark-David Hosale, Remko Siemerink, Vera Laszlo, Dieter Vandoren, Hyperbody, Faculty of Architecture, Delft University of Technology, the Netherlands; Robert Glanz, Domenico Farina, Burkhardt Leitner constructiv, Stuttgart, Germany; Gerhard Bettinger, Roland Grau, Uwe Neuhooff, Festo AG & Co. KG, Ostfildern, Germany

Drawings: Remko Siemerink, Hyperbody, Faculty of Architecture, Delft University of Technology, the Netherlands

Photographs: Walter Fogel, Angelbachtal, Germany

[Figure 7. The Interactive Wall responding to a participant. photo source: Festo AG & Co. KG, by Walter Fogel]



> project

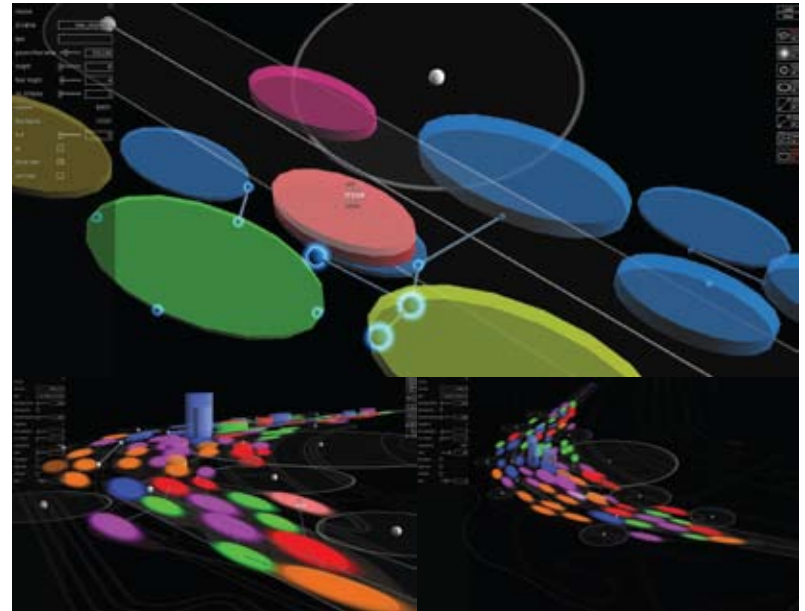
Behavioural
modelling
being applied
to both
the Automotive
Complex project

Behavioural modelling applied to the Automotive Complex masterplan project

Tomasz Jaskiewicz

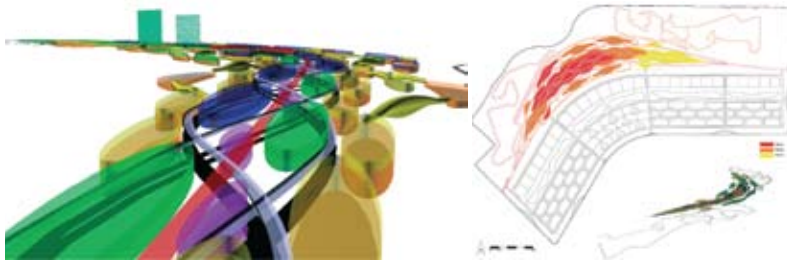
There's no better way to validate theories than by applying them to practice. Hyperbody design application prototypes, allowing for non-linear design of complex architectural and urban behavioural models, were validated by being applied to a master planning project of Speed and Friction Automotive Complex [Note 1] of ONL [Oosterhuis_Lénárd][Note 2].

The Automotive Complex project assignment was not trivial. The assignment was to create the master plan for the site located on the outskirts of Abu Dhabi, covering more than 6 km². This huge site came with a huge program of demands. 800,000 m² of covered showrooms, car shops, car-themed leisure experiences, restaurants, a hotel, a conference centre and even two gas stations. All these were accompanied by over 500,000 m² of covered parking spaces and many more outdoor facilities such as Formula 1 and 4x4 race tracks. All of this had to be organized into one project, while retaining a certain amount of flexibility as to the exact location and floor spaces of planned functions. What's more, this project not only had to work as a well-organized, complex system; it also had to become the landmark of a global destination hub for all car enthusiasts.



[Figure 1. Behavioural modelling in action (Swarm Toolkit Modeler©T.Jaskiewicz/Hyperbody)]

The scale of the master plan is comparable to that of a small town. However, the complexity of the planned Automotive Complex in many ways surpasses the complexity of a town system. To be able to handle this, a new kind of a parametric design strategy was chosen. The program of demands was broken down into program cells, ranging from 1,000 to 13,000 m², ordered in a Fibonacci sequence. These cells were subsequently given additional parameters; function type, floor space area, number of floors, average floor height, additional shape defining parameters and connections to other program elements. All this information was put into a spreadsheet and exported to the custom-made application, based on Hyperbody's Swarm Toolkit developments and Protospace design tools [Note 3].



[Figure 2. 3D and 2D arrangement of the program of demands, including phasing (project material, © ONL [Oosterhuis_Lénárd])]

Subsequent steps that were taken in the design process can be described as behavioural modelling [Note 4]. In a behavioural modelling process, each of the unique parts of the project, in this case program cells, becomes an autonomously acting entity.

Behaviour given to individual cells of the Automotive Complex master plan was simple in its principles. Each cell had to avoid overlapping with other cells. If that were to happen, the cell would be forced to move away from the collision point. Connections between particular cells were formed in a top-down manner. If two cells were connected, they would try to stay closer to each other than the specified maximum and further away than the specified minimum distance. 'Bulkiness' of cell capsule shapes could be controlled by handles attached to each of them. Additionally, spatial attraction points, lines and curves were introduced to the system in order to repel or attract all or just a selection of cells to specific areas in the master plan.

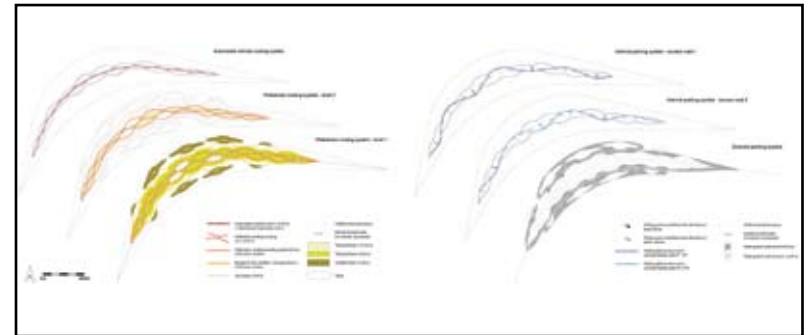
From individual, simple local actions and interactions of such entities, a complex, holistic system comes to being. Even though all those rules and behaviours are very straight-forward, the system as a whole exhibits a very high degree of adaptability and allows emergence of unpredictable qualities. To use a relevant analogy; the behavioural model can operate similarly to how a city evolves over decades or centuries, but with the main difference that the same and many more new and unprecedented qualities can now emerge within minutes instead of years or centuries of systems operation, while at the same time allowing for explicit top-down control of their development throughout the process.

While the distribution of the functional program coming from its decentralized behaviour was entirely emergent and unpredictable, attractors and explicit relations between selected cells were used to 'tame' the whole system, add deterministic qualities and impose constraints on it in order to allow its operation within a chosen development scenario and an overall design vision. Introduction of global parameters such as the global floor space or volume of all cells together allows changing these values locally while maintaining strict control of the overall project feasibility.

The ability to achieve holistic design quality and exceptionally efficient yet flexible spatial organization of the project was a high-priority aspect of the master plan. The project is meant to become a global landmark location, visible from most airplanes approaching to land at the Abu Dhabi international airport. In order to give it the desired unique appearance, both design and spatial organization systems took inspiration from the ripples that appear on the desert surrounding the project site as an effect of wind interacting with individual sand particles and forces keeping these particles together.

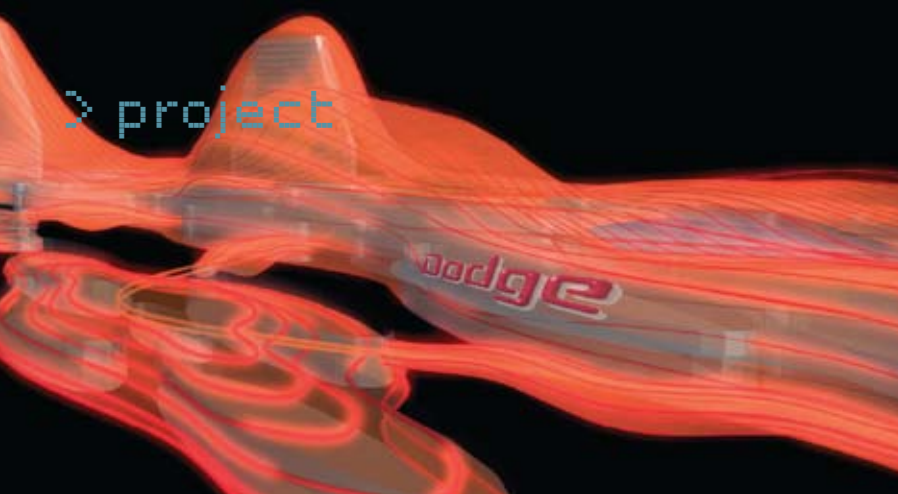
In order to achieve a similar self-organizing behaviour, several kinds of geometric curve objects with unique behaviour called powerlines [Note 5] were introduced to the system. These powerlines enforced an analogous behaviour of project components to this that in nature causes the appearance of wind ripples on sand. Different powerlines would follow the spatial arrangement of program cells and form a pattern of communication flow as well as create the shape of the building skin wrapping the entire project.

Inside the complex, the flow of cars, people, energy and information follows these powerlines. All aspects of movement are smooth and continuous for both cars and people. The result of this is the three-dimensional weaving pattern of circulation for cars and people crystallized in the functional plans of the project. The circulation begins on the south-west entrance of the complex and continues throughout the entire 1.5 kilometre-long building. The user never has to stop; he or she naturally follows the communication routes while being informed both physically and virtually about directions to take in order to reach particular destinations.



[Figure 3. Routing plans on different levels based on Powerlines (project material, © ONL [Oosterhuis_Lénárd])]

On the outside, building skin uses a different type of powerline to achieve unique articulation of the skin covering the entire building. Subtle ripples form a new landscape emerging from the desert, with most articulate parts covering the hotel and conference centre and voids from which thrives the greenery of newly created oases.



Just like the scale model of the project was created using a file-to-factory process, the digital data of the project can be directly send to contractors and their machines to accurately and efficiently build the entire complex in full-scale, full-detail.

The qualities coming from the swarm logic embedded in the design process of the Automotive Complex masterplan are in many ways absolutely revolutionary. As Kas Oosterhuis envisioned; 'Building and Architecture has from now on two aspects to it: at the one hand one creates a physical environment, at the other hand one designs the behaviour, the rules of the game, the states of mind of the buildings and the environments, directly connected to the physical places.'

[Note 6] The Automotive Complex project proves that this idea is valid not only for buildings, but also for an entire urban-scale development. The designed masterplan has a unique and consistent design and organization, yet it can be dynamically changed and adjusted throughout the design process, and potentially also after completion of subsequent phases of its construction. All this without compromising any of its functional, engineering and design qualities. <<

Automotive Complex Masterplan Project credits

Date: 2005

Client: Aldar Properties, Abu Dhabi

Site: Abu Dhabi

Project architect: Kas Oosterhuis

Design team: Kas Oosterhuis, Ilona Lénárd, Gijs Joosen, Cas Aalbers, Sander Boer, Tomasz Jaskiewicz, Chris Kievid, Dieter Vandoren, Barbara Janssen, Henrike Michler, Eirini Logara, Han Feng, Brenda Vonk Noordegraaf

Notes

1. Kas Oosterhuis and Ilona Lénárd, 'Automotive Complex', in *ONL Logics, Speed and Vision* (The Images Publishing Group Pty Ltd, 2008), 84-87
2. 'ONL [Oosterhuis_Lénárd]', www.oosterhuis.nl
3. Kas Oosterhuis et al., 'Protospace Software', in *Second International Conference World of Construction Project Management* (presented at the Second International Conference World of Construction Project Management, Delft, the Netherlands: TU Delft, 2007), www.wcpm2007.nl/
4. Craig Reynolds, 'Flocks, Herds, and Schools: A Distributed Behavioral Model', in *Computer Graphics 21(4), SIGGRAPH '87 Conference Proceedings*, 1987
5. Ilona Lénárd, 'Powerlines', in *iA#2* (Rotterdam: episode Publishers, 2009)
6. Oosterhuis Kas, 'Swarm Architecture', in *Hyperbodies: Towards an E-Motive Architecture* (Basel: Birkhäuser, 2003)

[Figure 4. Powerlines used for form articulation, inspirations for their use and scale model of the project (project material, © ONL [Oosterhuis_Lénárd])]



Material is expensive, but form is cheap

Han Feng

Matias Del Campo is the co-founder of the architecture firm SPAN. The main focus of the company lies in the exploration of innovations in the architectural field triggered by the continuous evolution of technological means.

These explorations encompass projects in various scales, from urban (Gradient Scale) to industrial design (Bombay Sapphire Martini Glass), embracing the latest technologies supporting the design corresponding to the fabrication processes. Since 2004 he has been a doctoral candidate under the auspices of Greg Lynn at University of Applied Arts Vienna, with the research topic of 'complex curved geometries, high genus architecture modelling and botanical issues in organic design for architecture'.

This lecture is the last one of the four lectures series introduced to Hyperbody MSc1 and three students in the autumn semester of 2008. The first three lectures of this series are primarily based on theories: Arida's lecture introduced quantum thinking, Kilian's lecture explained the underlying logic of complex geometries and their modelling, and Leach's lecture provided a mega-structure to understand the development in digital design from a global perspective. Matias Del Campo's lecture, however, presented a perspective from a practicing firm in the top-end digital design field. Instead of drilling deep into the theoretical logics of digital design, Matias Del Campo demonstrated how he generates, develops, translates and materializes his ideas using latest digital technologies.

Three projects of Matias Del Campo's firm SPAN were introduced in the lecture so as to illustrate different design interests and approaches of the firm.

Project 01 : Shop in Japan — cross-disciplinary approach

The 'black blossom' was a competition entry for a Japanese fashion chain, which wanted standardized pieces to compose an entire shopping environment. A system with different layers was conceived where the design performed different functions (furniture, display shelves, the shop itself) operating within the same geometry.

This project demonstrated very well of SPAN's cross-disciplinary approach to architecture. From mere interest in the form, colour and formation of flowers, to detailed studies in the botanical logic of the formation and structure of flowers, and then to digitally simulate the process of the formation of flowers through 3D animations, Matias Del Campo ran through a cross-disciplinary process to generate his idea for the shop in Japan.

In short, these cross-disciplinary approaches contributed to the design in three ways:

1. Flowers, first of all, contributed to the formal, colorative and aesthetic decisions for the design;
2. The botanical studies contributed to the structural and organizational logic behind the final product, which the veins in flowers turned into steel structures to hold the form and the nodes and pedals in flowers turned into a network of nodes, which organized and connected the spaces of the design;
3. The use of digital animation

Figure 2

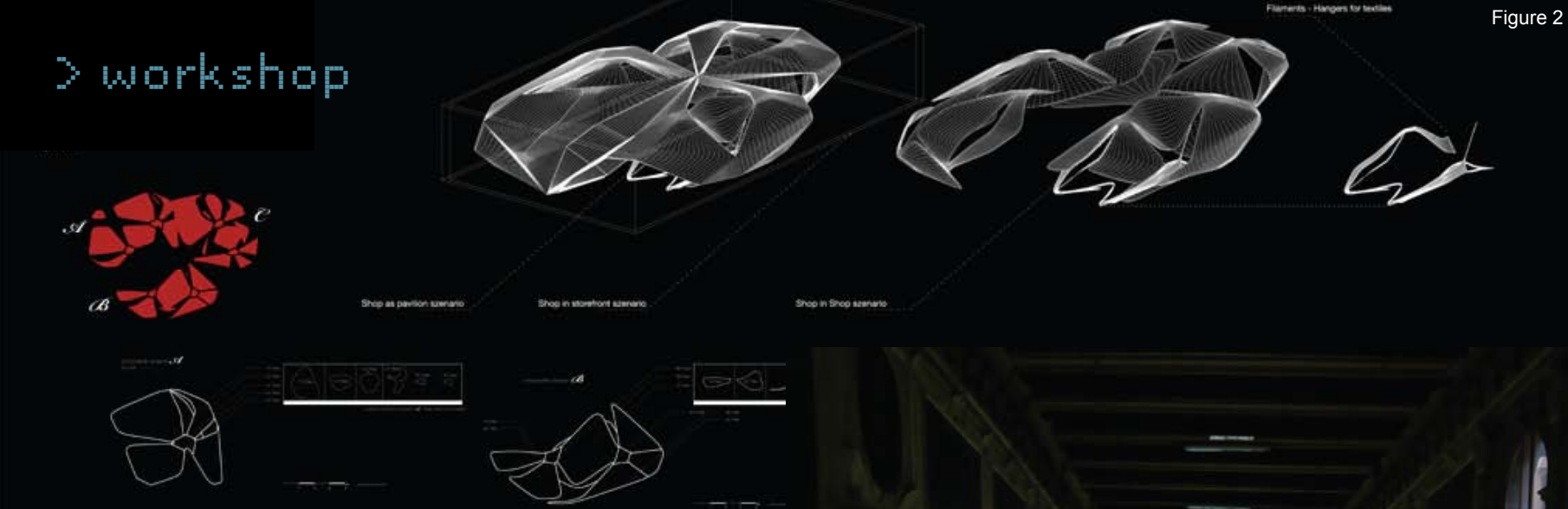


Figure 1

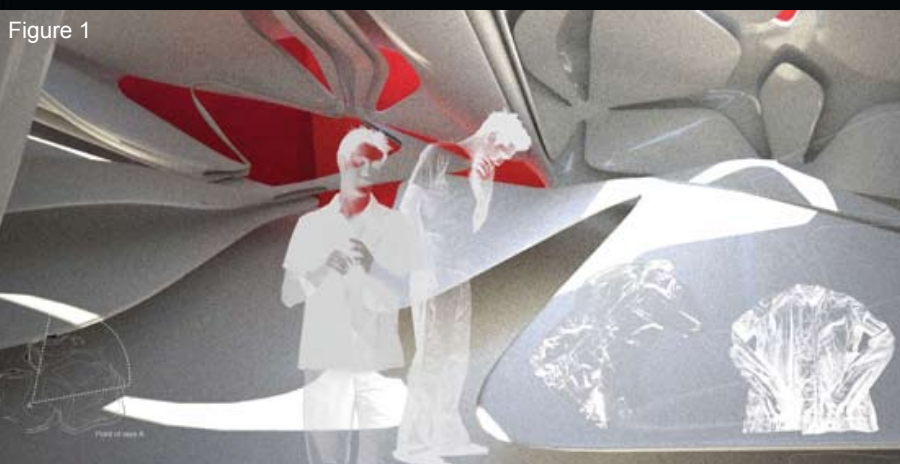


Figure 4

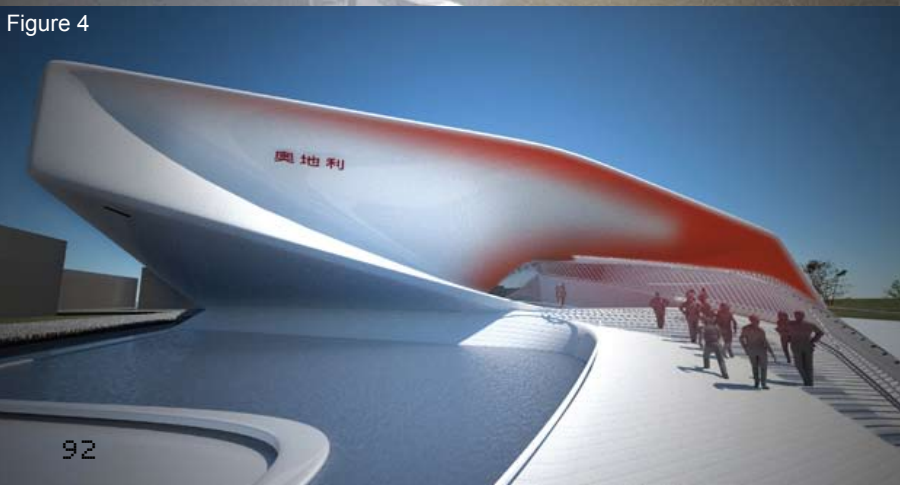


Figure 3



made the creation of hundreds of variations of 3D spaces possible. The visualization of the animations is then served as the medium for the architect to study and select the spatial options generated from the botanical studies.

This project introduced how Del Campo started a design with a simple interest in flowers and from there created a connection to architectural spatial formation. Once the connection was established, it was diversified into various disciplines to continuously promote the initial design idea.

Project 02: Exhibition Table for 'Housing in Vienna' — from 2D pattern to 3D form

The project of the table design for the exhibition of *Housing in Vienna* demonstrated Matias Del Campo's interest in typological and geometrical studies. Started from a slightly deformed pure hexagon, Del Campo created a 2D pattern that can be limitlessly aggregated in various ways. With the development of a parallel fabrication strategy,

[Figure 1. Black Blossom interior, Janpanses fashion chain competition entry from SPAN]

[Figure 2. Black Blossom geometry logic, Japanese fashion chain competition entry from SPAN]

[Figure 3. Exhibition table for housing in Vienna exhibition, designed by SPAN]

[Figure 4. Sonic Body. Price winning design of Austrian Pavilion at the EXPO Shanghai 2010, competition entry from SPAN]

Del Campo translated that 2D pattern into 3D components under the concerns and constraints of the fabrication technology and material behaviour.

Project 03: Sonic Body — cooperation of disciplines

Cooperated with Zeytinoglu, Vienna, SPAN won the architectural competition for the design of the Austrian Pavilion at the EXPO Shanghai 2010. This project focuses on the co-evolution of acoustic performance and architecture spatiality. As Del Campo put it: 'The driving force behind the design of the Austrian Pavilion for the EXPO in Shanghai 2010 can be described as acoustic force, or more accurately, music. Music, as a concept, reflects continuity in terms of architectural articulation that seamlessly connects the various spaces within the program.'

Pinpointing classical music as the best representative of the culture of Austria, and acoustic performance as the driving force behind architecture spatiality formation, Matias Del Campo conducted a sound quality study with audio experts and created this piece of competition-winning architecture out of the cross-disciplinary cooperation. Software designed for testing acoustic qualities was used to test the acoustic performance of the spaces in the project and those features that were found to contribute to the acoustic quality were made into the digital ornamentations in the physical space.

Key Messages from Del Campo

Through introducing the three projects, Matias Del Campo revealed four key messages during the lecture:

1. Architects today have to reclaim architecture by discussing and studying architects' specialty of SPACE but not to equivalentize the role of architects to artists, scientists or any other disciplines. The technological aspects from other disciplines, for instance, digital modelling and simulation techniques, should not take over the importance of the discussion of space and aesthetics in the field of architecture.
2. Beauty in architectural design is itself something worth exploring - to avoid discussing aesthetics is itself a doctrine that has no point to stand upon.
3. Fabrication strategies should be developed in parallel with the digital formation process so as to understand the materialistic logic behind the aesthetic forms generated.
4. Inspirations from different disciplines are important sources for the creation of architecture

All in all, Matias Del Campo's design approach proved to be very special and inspiring, especially in comparison with the mainstream of current digital architecture production.

First of all, he asserts that architects today have to have enough scientific knowledge to communicate with experts to carry out cross-disciplinary

collaboration. Secondly, he insists on the importance of unceasingly establishing a discussion on architecture itself rather than on scientific, engineering or budgeting issues. By creatively balancing these two seemingly divergent attitudes, Matias del Campo successfully positioned his own architecture practice between the poles of traditional architecture debate and current advancement of digital technology. He argues that the contemporary architect's role should be a talented designer equipped with enough scientific knowledge to execute his vision. With this lecture, Matias Del Campo provided a window into his thinking on geometry, multi-disciplinary collaboration, digital fabrication and more importantly, modes of practice in contemporary architecture.

Acknowledgements

This lecture was given by Matias Del Campo on the 16th of December, 2008. Participants in this lecture include Hyperbody MSc1 and three students.

This article is based on lecture reports made by Hyperbody students. The report made by Yunwai Wing has been chosen as main basis for this article, for its clarity in structure.

Photo source of all pictures in this paper: SPAN (Matias del Campo & Sandra Manning) 2009



DIALOGUE >



Chris Bangle



Gijs Joosen

> dialogue Interview Chris Bangle Hogve

Interview Chris Bangle

Gijs Joosen

In February 2009, Gijs Joosen visited the BMW Headquarters in München for a one-hour dialogue with parting head designer Chris Bangle (1956). He has a long history in the automotive industry and is regarded as one of the most influential designers of his time.

Chris Bangle's work is characterized by designs like the Coupé Fiat, where the typical sharp lines and edges broke with the traditional rounded curves that dominated car design in the late 1980's. The sharp edges influenced trends like Ford's 'New Edge Styling'. He moved to BMW in 1992. His move changed the entire design strategy for BMW and transformed it to one of the most progressive design brands. The controversial BMW 7 series in 2001 shocked the public and introduced the 'Bangle Butt' as a signature styling element. The reason for the meeting came with the public launch of the BMW GINA Light Concept Car. Not by coincidence, this launch took place via [Youtube](#), one of >>

[Figure 1. Coupé Fiat (1996-2000). photo source: David Hurst]

[Figure 2. BMW 7 series (2002-2008). photo source: BMW Group]



Figure 1



Figure 2

the most popular video websites among the young generation. Gina shows the possibilities of artificial 'behaviour' and dynamic styling in its most literal form. Architecture and car design have always been a mutual source of inspiration. The following interview is an interpretation of the actual interview that followed a (not so strict) pattern of Q&A. Each chapter starts with a question that somehow relates to architecture and building design, Chris Bangle then responds in the context of automotive design.

History of car design

To start the dialogue, we return to the roots of automotive design at the beginning of the previous century and compare the Barcelona Pavilion of Ludwig Mies van der Rohe to the BMW 3/15 DA-1, the first car ever produced by BMW. While the Barcelona Pavilion is still regarded as contemporary architecture, the BMW with its carriage styling looks hopelessly outdated compared to modern day car design. Can it be that car design is decades ahead of architecture?

Chris Bangle clearly disagrees. He says that the statement above can be reversed. Architecture was so far ahead that it took the automotive industry almost seventy years to catch up and be as contemporary as the Pavilion of Mies van der Rohe was to architecture in the 1930s. In the 1950s, BMW developed a car called the 'Baroque Angel', based on an architectural language that dated back to the start of the century. It took until the 1970s for car design to start to be as contemporary as architecture.

Architecture leads all design by a gap of decades.

To understand this statement, Chris Bangle takes us a little bit deeper into the history of cars and car design. There are two main phenomena that drive the physical morphology of cars he explains. 1) What a car means to people, what it represents in a social context. 2) The physical production process of a car. Throughout the relatively short history of car design only two shifts in paradigm occurred that changed the appearance of cars drastically. The first cars are direct pre-decessors of the classical horse-and-carriage and were built using

post and lintel construction methods. Very similar to building a house. To most people this was the beginning of mobility as we currently know it and cars first and foremost needed to be reliable and usable. This led to little freedom in expression and most cars of this era look alike. A shift in paradigm occurred in the 1930s when cars began to be integrated into everyday

Architec-
ture leads
all design
by a gap of
decades



Figure 3



Figure 4



Figure 5



Figure 6



Figure 7

[Figure 3. Mies van der Rohe Barcelona Pavilion (1928-1930). photo source: vicens]

[Figure 4. BMW 3/15 DA-1 (1927-1929). photo source: BMW Group]

[Figure 5. T-Ford (1908-1927)]

[Figure 6. Alfa Romeo B.A.T. 5 concept (1953). photo source: Bertone]

[Figure 7. BMW 2002 (1966-1977). photo source: BMW Group]

life. Car design now had to reflect social signals. The car became fashionable, with tailor-made bodies by world famous coachbuilders. At the same time, production shifted to hand-welded steel sheets, much similar to ship building. Morphology followed the boating industry with sculptural, symmetrically hull-shaped objects. This led to a great diversity in appearance and styling. During the 1970s the meaning of cars changed dramatically. Cars became a product and people wanted reliability, safety and value for money. Mass production and

full automation limited the possibilities for expression and had a major impact on physical appearance. With multinational corporations taking over the design form, the hand crafted coachbuilders cars started to look very similar again.

Design processes

Most designs follow a typical process from sketch to final product. To stay with BMW we look at the Ekris Headlights, a project by ONL that drew inspiration from the BMW 5 series grille and headlights. Seen from the front, the twin buildings refer to the typical kidney shapes in the grille. The showroom façade is inspired by the evolution of the car headlights. Headlights began as lanterns on the fenders of the car, slowly moved to the grille, and ended up becoming an integrated part on the corner of the body.

The Ekris building integrates the glass façade into the body of the building. It is able to round the corner and provide a continuous front to be seen from the public road. The folds in the building play with light and shadows as the folds in car design. These folds create a non-standard, complex geometry that requires 3D modelling skills to take it from a first idea to a shape that can be styled. First conceptual ideas and sketches are transferred into physical models and 3D computer models. From there, they are styled and modelled to perfection in collaboration with the engineers. For this process, ONL relied on 3D surfacing software similar to that used in the automotive industry. Can you describe a typical design process to get from sketch to a car?

This is a process, Chris Bangle explains, consisting of three main stages: Understanding, Believing and Seeing. Each stage takes approximately one year to evolve and deals with different aspects of the design process and its actors.

Understanding is comparable to the defining of the context and brief in building design. It is the first phase in car design that determines the type of car. To understand what the morphology will be, is it a coupe, a saloon, what is the size and the range it will be used in? This phase is used to develop concepts and sort out alternatives. It will define a rough outline of the bandwidth that the design will operate within. There is no time for full multidisciplinary design and engineering. The Understanding phase is essential to the birth of a new model.

Believing is the phase of comprehension. It can take a lot of effort to start with sketches and get from Understanding to Believing. BMW had been experimenting with a large 5 series-based coupé since the early 1990s. It was not until the Z9 concept car that the team understood that it was not the 5 series coupé, but a (larger) 7 series coupé that answered their search. It opened up a new segment and can be seen as a breakthrough in the phase of Understanding. Many styling elements of the Z9 concept found their way into



Figure 8



Figure 9

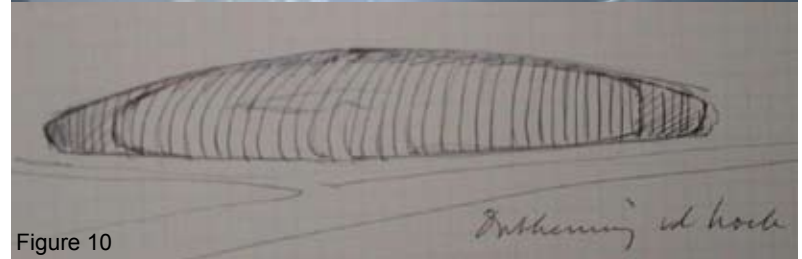


Figure 10

[Figure 8. ONL Ekris Headlights (2004 - 2006). photo source: Rob Hoekstra]

[Figure 9. BMW 5 series headlight (2003 - onwards). photo source: BMW Group]

[Figure 10. ONL Ekris Headlights design sketch (2004)]

the succeeding generation of BMW designs and formed the re-birth of the 6 series. A large coupé positioned between the 5 and 7 series.

Within the bandwidth set during the Understanding phase, the car is now [22](#)

> dialogue

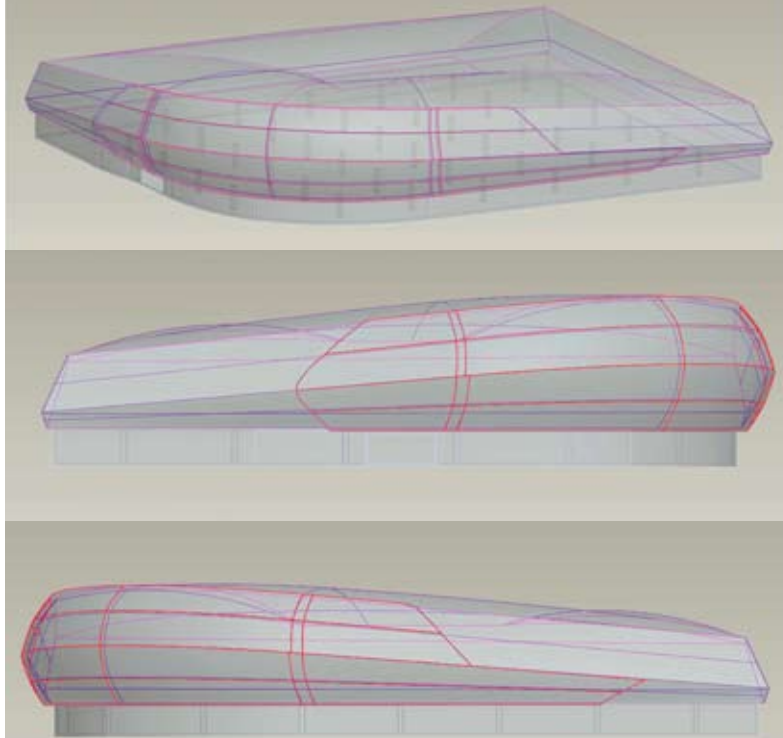


Figure 11

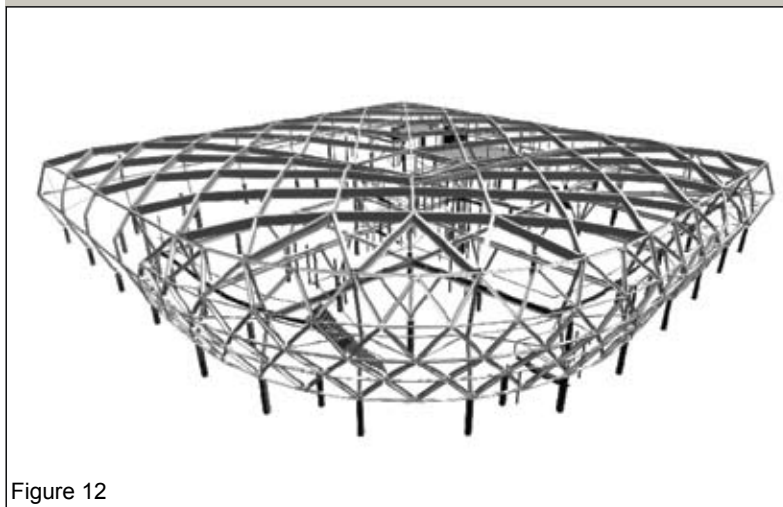


Figure 12

[Figure 11. ONL Ekris Headlights 3D model 'powerlines' design studies. (2004)]

[Figure 12. ONL Ekris Headlights 3D structural model. (2005)]

developed and materialized. The engineers get involved in the design process and collaborate with the designers to reach an optimum between form and function.

Crucial for this stage is the role of physical models. 'Hardware speaks' as it cannot be ignored. You are continuously confronted with the presence of the clay model where images require deliberate action to be displayed. The computer is used as a tool to support the process and tighten the loop between design and final styling.

This is a process consisting of three main stages: Understanding, Believing and Seeing

Seeing is the final phase and takes the design in all its aspects to perfection and prepares it for production. Rough edges and small imperfections are taken out and the car can be presented to the public.

The actors that play a crucial role in this process can be grouped under Brand, Content, and Manufacturing. The content consists of the designers, the design-brief, technical support, and modelers. The designer has the ability to guide the design process. He needs a strong outspoken opinion and requires political skills within the larger corporate structures.

>>

[Figure 13. BMW Z9 concept (1999). photo source: BMW Group]





Figure 14



Figure 15



Figure 16

[Figure 14. BMW 6 series coupe (2003 - onward). photo source: BMW Group]

[Figure 15. Synchronization between form and function.]

[Figure 16. BMW Z4 clay model (2009). photo source: BMW Group]

Modelers play a crucial role in the 3D development of the ideas into a car's shape and styling. They can be seen as the virtuoso that takes the notes of a composition and brings it to the next level. Modellers have the ability to make or break the design. Manufacturing is the final actor and since the shift to mass production in the 1970s has had a major impact on design and appearance. The shift in production from small series of hand crafted coaches to mass produced products led to the rise of the big multinational corporations and the brand identity. Car design had been the domain of coachbuilding houses like Bertone, Pininfarina, Ghia and Touring. The massive manufacturing plants that were needed for mass production reduced the significance of the independent designers.

With the shift in scope during the 1970s, cars became a status symbol and an expression of the lifestyle of their owners. People started to identify with the much less tangible elements as corporate identity and the values the brand represents. Cars not only became a fashion statement, they were part of a bigger corporate identity that also has to represent family values and corporate identity.

Collaborative design

In architecture, the design teams are different for each and every project. Collaboration between people and firms is common and usually the designers and engineers have never worked or even met before. This forces building design into a collaborative thinking and operating mind set. Buildings require a complete re-invention with each and every new context. The structural design for the Hessing Cockpit is a result of intensive collaboration between the architect and structural engineers.

The steel structure follows the curvature of the surface that defines the shape of the building. This is supported by the integration of the sprinkler system that follows the same logic and lines of the building. As a result of this, all components define the appearance of the building and become embedded in the architecture.

With Protospace and the iWeb, Hyperbody has a collaborative design and engineering platform

The possibilities of collaborative design efforts are limited and can only take place after the phase Understanding >>

that supports design processes in real time. It provides insight into the different specialists fields, it allows for bi-directional communication, and enables design influence to all parties involved in a building design. Collaboration leads to better optimization of design and technique where the different elements become part of a bigger whole. Is there a bi-directional collaboration between design and technique in car design?

The possibilities of collaborative design efforts are limited and can only take place after the phase Understanding, Chris Bangle explains. Evaluating many de-signs in all their aspects will simply take too much time. As opposed to architecture, where a group of different specialists creates a one-off, a car design process leads to a mass-produced commodity. New models evolve out of their predecessors and are improved with each consecutive generation.

Complete integration between technique and skin is much less advanced and the engineering requirements set a more top-down playing field for designers to operate in. Changes of the design on the technique and vice versa are only minor. This constraint environment gives a much more focused effort on styling. Advanced modelling and computer-aided design is used to create a set of tools for surface design that is far ahead of the design tools available to architects. With the unveiling of the Gina concept car, BMW has taken surface styling to the next level.

Architecture = information

Processes are becoming more and more digital. By connecting streams of information, one can activate, respond and make interactivity possible. With the *Trans-Ports* project, Kas Oosterhuis explored the possibilities of interaction by connecting the architectural appearance of the building to the information stream flowing through the portal. The building provided a gateway by creating a network of active structures around the world and their virtual parent structures residing on the Internet.



Figure 17



Figure 18



Figure 19



Figure 20

[Figure 17. ONL Ekris Headlight car showroom. photo source: Rob Hoekstra]

[Figure 18. ONL Hessing Cockpit car showroom]

[Figure 19. ONL Hessing Cockpit interior. Structure and MEP are embedded in the architecture. photo source: Rob Hoekstra]

[Figure 20. BMW 3 series evolution (1975 - present). photo source: BMW Group]

Dialogue

The active structure digests fresh data in real time. It is nothing like the traditional static architecture that is calculated to resist the biggest possible forces. On the contrary, the Trans-Ports structure is a lean device that relaxes when external or internal forces are modest, and tightens when the forces are fierce. It acts like a muscle. In the Trans-Ports concept, the data representing external forces comes from the Internet and the physical visitors, who produce the data that act as parameters for changes in the physical shape of the active structures. In 2008, the Gina concept car shocked the automotive industry and caused a huge public response when it was presented through *Youtube*. It got over 4 million hits, which is quite exceptional for something not related to Pop Stars or porn, Bangle says wryly. The interactive car body is made from a flexible fabric skin and can change appearance by changing the position of the underlying structure. This gives Gina a very strong and lively character. This concept clearly appeals to the younger, more digitally oriented generation. Can Gina be seen as an interactive form-finding tool? The first live and real time clay model for styling studies?

Chris Bangle tells the story behind the Gina with much inspiration. Gina did not follow the traditional three-step program as described before. It was a much more conceptual study of the merging of shape and behaviour. In the late 1990s the idea was developed to have a car made of cloth that would be able to show emotions. Within a fixed bandwidth of the underlying curvature and structure, Gina can change her surface appearance and interact with people and the environment. The effect is that the car comes to life. It is no longer just an object, it becomes a person with a changing spirit. As the relevance of cars is changing, Gina tries to fill the gap between the generations. The younger generations care differently about cars, driving, and getting a license than the previous generations. Where Gina may scare the traditional motorist, it attracts the attention of the younger people who grew up in a hybrid mix between real and virtual life. They are much more used to seeing emotional and animated objects on the screen. The car can be a personalized avatar. A car that will take a deep breath before a drive along the coast and will show physical symptoms of exhaustion when driven to the limit. It is not fiction or a virtual object on the screen, it is an actual car that can be seen as the Herbie or the Christine of the next generation. Gina breaks with the traditional role of the car as an object or a product. It is appealing, friendly, even sexy.

Gina and styling

Hot item in current architectural design is the form finding aspect. Computer models and simulation software is used to create shapes and fine-tune designs. Do you use any form finding techniques and who decides what is beautiful in styling and curvature?

The form finding element in Gina is limited, Chris Bangle continues. The underlying curvature is fixed and the surface can only take a limited amount

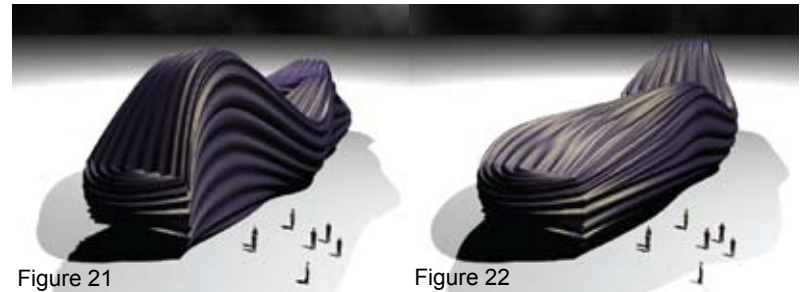


Figure 21

Figure 22



Figure 23

[Figure 21. ONL Transports interactive skin maximum (2001)]

[Figure 22. ONL Transports interactive skin minimum (2001)]

[Figure 23. BMW Gina concept (2008). photo source: BMW Group]

of variations. The styling possibilities in clay, for instance, are much larger as you can manipulate every point of the entire surface, where Gina is limited to indirect manipulation by changing the lines. Clay models are deterministic, if you want a shape you can find it there. Gina is self deterministic, the shape is a result of the indirect changes of the surface. Gina is free of context: how it looks is how it works. The actual styling process is craftsmanship and the key lies in the eye of the designer. The design supervisor has the final decision of what makes a line or surface beautiful. You cannot replace this with computerized form finding tools.

Mass customization

ONL combines freedom of architectural expression with expert knowledge of innovative mass-customization production methods. It allows for the construction of geometrically complex objects where none of the constituting elements are the same. As a result of the double-curved surfaces that form the base of the

Ekris Headlights design. all triangles and structural components are different in size and dimensions. A Building Information Model-driven design approach forms the basis for a CNC controlled file-to-factory (F2F) production process. A direct link is established between the 3D computer models and the CNC-controlled factories. This enables the production of mass-customized building components. Personalization and customi-zation can create the next shift in paradigm. The adaption of the manufacturing process creates more freedom for the designer. Can there be a shift from large corporate design studios back to independent designers? Can these events put the designer back in position as a central role in the design process?



[Figure 24. BMW Gina concept (2008). photo source: BMW Group]



[Figure 25. The styling of Gina is defined by the lines. photo source: BMW Group]

Bangle sees a possibility on the horizon. Brands and corporate identity are so dominant now that people want a name, not so much a specific design. You are not only buying a product with certain specifications, you also buy part of an image you associate yourself with. Personalization can create a shift in balance when it is supported by the manufacturing process. It would seem a logical next step in the evolution of car design and manufacturing. The personalization of the coachbuilders from the 1950s combined with production techniques aimed at providing large quantities from the 1970s onward. Gina is a first step in this process of individualization and real time adaption by using a soft tissue as bearer of the morphology. This bypasses the limitations of the rigid mass production process aimed at the production of thousands of similar elements.

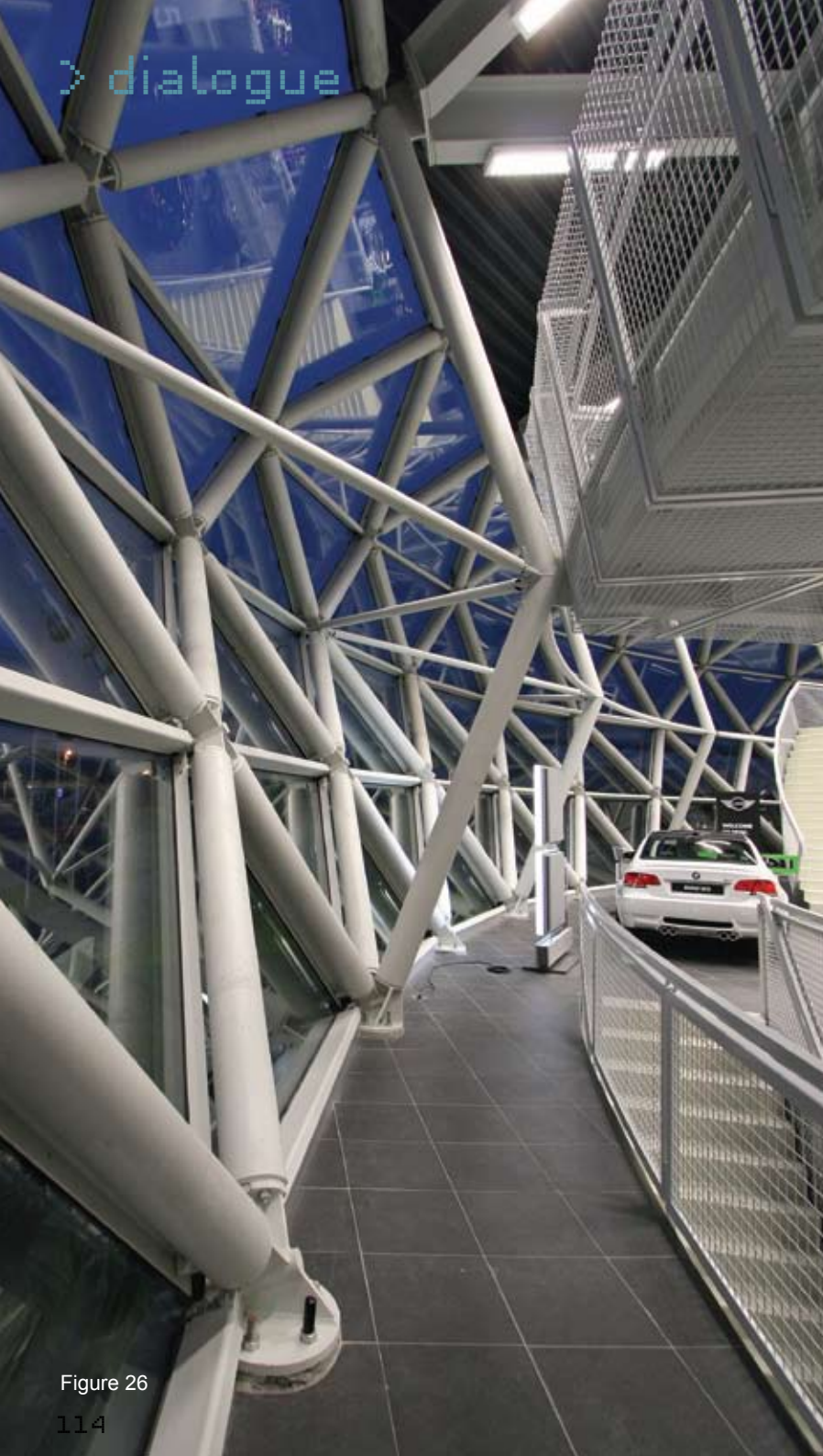


Figure 26



Figure 27

[Figure 26. ONL Ekris Headlights. All components vary in size and dimensions. photo source: Rob Hoekstra]

[Figure 27. Mass customized components in the steel factory.]

Interaction and behaviour in the future of car design and architecture

Gina and interaction are both in the experimental stage where seeing is believing. The response that Gina triggered proves a huge interest of the public and with the changing generations' behaviour and interaction, it will become much more natural. Be it your building or your car, real time personalization and adaption will be the mutual future.

It usually takes about 20 years for people to stop laughing and for radical concepts to be implemented in our every day life. A car that adapts its physical appearance is believable and is not something of the distant future. Gina has been around for almost a decade: she proves that it can be done.



www.bk.tudelft.nl/live/pagina.jsp?id=bff05884-fb66-4585-b270-0b9c4f079917&lang=en

As a prototype for an emotive wall, the InteractiveWall is an important step towards the development of an emotive architecture that is no longer a static backdrop for its users but a key component in a dynamic customizable environment. An emotive wall is a wall that responds to the user, a wall that has a character, a wall that can move because it wants to. The emotive InteractiveWall is composed of seven separate wall pieces (herein referred to as nodes) that display real time behaviour by swinging its body back and forth, displaying patterns of light on its skin, and projecting localized sound.

www.youtube.com/watch?v=PVz2LlxrdKc

Video of InteractiveWall on *YouTube*.

www.festo.com/bionic

Learning from nature... How can bionics be used to improve the efficiency and productivity of automated motion sequences? Festo searches for innovative answers to this question through a diverse range of projects within

our Bionic Learning Network. The latest technology from Festo is used in experimental prototypes, such as integrated mechatronic concepts with options for remote maintenance and diagnostics, and the latest piezoelectric valves and electric drives. Festo's fluidic muscle, a long established component in manufacturing, is proving to be endlessly versatile in ever more amazing applications. The inspiration for the complex drive forms comes from natural phenomena in air and water, but above all from humanity itself. The Bionic Learning Network is part of our commitment to basic and further technical training. In cooperation with students, prominent technical universities, institutes and development companies, Festo is promoting ideas and initiatives which go beyond the core business of automation and didactics, and which may well give rise to promising areas of application in the future.

www.dumpert.nl/mediabase/476181/d648605e/kewl_bionische_pinguin.html

A promo movie from Festo. It features the Hyperbody InteractiveWall in action.

http://en.wikipedia.org/wiki/BMW_GINA

The GINA Light Visionary Model is a fabric-skinned shape-shifting sports car concept built by BMW. GINA stands for 'Geometry and functions In "N" Adaptions'. It was designed by a team led by BMW's head of design, Chris Bangle, who says GINA allowed his team to "challenge existing principles and conventional processes."

www.youtube.com/watch?v=kTYiEkQYhWY

Video of GINA on *YouTube*.

www.oosterhuis.nl

ONL has developed a state-of-the-art design method called the File-to-Factory [F2F] process to be able to realize a true Design & Build development. With the help of new programming techniques ONL controls the complex geometry and the engineering of double-curved surfaces and the supportive construction. ONL makes use of fully parametric modelling programs and has developed a new approach to parametric architectural and constructive detailing. ONL basically develops one complex parametric detail for each new building. ONL writes in-house custom-made Autolisp routines, scripts and procedures to perform the F2F process of mass-customization. ONL's motto 'Mies is too much' tells the whole story: while ONL admires the clarity and radicality of Mies van der Rohe, but finds out that Mies still needed many different details. In this sense the architecture of ONL is even more

radical than Mies van der Rohe's. ONL's parametric detail appears in a multitude of configurations, whereas no detail is the same. The direct idiot savant-style F2F process, the shortcut from the 3D model to the executive machines, forms the basis for the new paradigm of mass-customization.

www.atcentre.nl

The Automotive Technology Centre. The aim of the Automotive Technology Centre (ATC) in Eindhoven is to strengthen the international technology and business position of the Dutch automotive sector, to preserve and further develop this important industry and its spin-offs within the Netherlands. The ATC target group ranges from those who need knowledge and those that can supply it. In other words, manufacturers and suppliers, service companies, research institutes, educational institutions and other organisations relating to automotive technology. One of the ways that the ATC provides these services to the automotive industry is through the development and continuous improvement of a knowledge and technology related company database of the automotive industry in the Netherlands. This useful instrument enables potential industrial or technology partners to be selected by product, know-how or technology.

www.tinkerkit.com

TinkerKit is an Arduino-compatible physical computing prototyping toolkit aimed at design professionals. The interest in physical computing

as an area in development within the creative industries has been increasing rapidly. In response to this Tinker.it! is developing the TinkerKit to introduce fast iterative physical computing methodologies to newcomers, and particularly design professionals.

www.bose.com/learning/project_sound/bose_suspension.jsp

The proprietary Bose suspension system couples linear electromagnetic motors and power amplifiers with a set of unique control algorithms. For the first time, it is possible to have, in the same automobile, a much smoother ride than in any luxury sedan and less roll and pitch than in any sports car.

<http://electric-vehicles-cars-bikes.blogspot.com/2009/02/volvo-electric-car-recharge-concept.html>

'Only about 15% of the energy from the fuel you put in your tank gets used to move your car down the road or run useful accessories, such as air conditioning. The rest of the energy is lost to engine and drive line inefficiencies and idling. Therefore, the potential to improve fuel efficiency with advanced technologies is enormous. Volvo ReCharge Concept hybrid EV with 4 wheel motors Electric Car vehicle.'

<http://i.gizmodo.com/5131414/the-cadillac-wtf-all-new-for-the-year-8000>

The appropriately titled Cadillac World Thorium Fuel or 'WTF' has features you are not going to find anywhere else. It runs on clean Thorium nuclear fuel and offers maintenance-free service for 100

years or more. Not only that, each wheel is actually six individually powered wheels aligned side by side. Now that's an absurd level of redundancy you can trust. Unfortunately, this car is only a concept by designer Loren Kulesus, but if you can hang around until the year 8000 or so, you just might be able to pick one up. In the meantime, these pretty pictures will have to do.

www.wired.com/cars/futuretransport/magazine/17-01/mf_icon_air

On the shore of Lake Isabella, about 150 miles north of Los Angeles, a crowd of flight techs, most of them either pierced or tattooed, swarms around a small white airplane. It's called an Icon A5. It's a collaboration between an F-16 pilot and a skateboard designer, and it looks like an odd, rakish sea monster.

<http://blog.wired.com/cars/2008/12/when-ford-and-h.html>

'Next-Gen Dashboards Teach Leadfoots How to Hypermile' When new hybrids from Ford and Honda roll into showrooms this spring, drivers will find flashy dashboards that turn hypermiling into a videogame. Ford and Honda's next-gen instrument clusters feature trees (a vine in Ford's case) that grow more lush as drivers learn to hypermile — the fine art of maximizing fuel economy. Leaves grow like crabgrass in springtime if you use a light touch on the accelerator and go easy on the brakes. Drive like Jimmie Johnson and they'll wither faster than General Motors stock. The idea, says Honda VP Dan Bonawitz, is 'to help drivers

improve their efficient driving skills by making the hybrid experience more fun and rewarding.'

<http://blog.wired.com/cars/2008/12/the-solar-prius.html>

Solar pioneer Greg Johanson set a world record for the fastest speed in a sun-powered car way back in 1986. That car, Sunrunner, has since been retired and its solar array relegated to some California rooftop, but Johanson is still building cars fuelled by the sun. Now you can too.

<http://blog.wired.com/cars/2008/12/get-pumped-up-o.html>

Gym Car Pumps You Up - Tired of sitting in traffic doing glute squeezes to no avail? Wish Carlates provided a better cardio workout? Then check out the Gym Car. This human-electric hybrid packs an entire health club into a single seat.

www.wallpaper.com/video/architecture/sliding-house-by-drm13829144001

Sliding House, by dRMM. The brief was simple: to build a house to retire to in order to grow food, entertain and enjoy the East Anglia landscape. The outcome was as unconventional as they come. A structure that has the ability to vary or connect the overall building's composition and character according to season, weather or simply a desire to delight. Wallpaper* took a trip to the site to capture the physical phenomenon in the only medium that serves it justice - film.

<http://video.google.nl/videosearch?q=neo+cube&oe=utf-8&rls=org>

mozilla:en-US:official&client=firefox-a&um=1&ie=UTF-8&ei=k7zoSZXfl_tLR-Qbf1oHjBQ&sa=X&oi=video_result_group&resnum=4&ct=title#

It is a set of very strong magnetic balls made out of rare earth magnets, which self-organize to form strings and surfaces. A normal set is made of 216 balls, which are only connected by magnetic force and have otherwise full freedom of movement. They organize by rules of attraction, repulsion, and the diameter of their spherical shape. We could (e.g.) study ways to populate surfaces and volumes with components of similar size.

www.carbodydesign.com

Car Body Design was founded in 2004 by Marco Traverso and is owned by Rome-based company FTM Studio S.R.L. Originally started as an online resource with links to automotive design and engineering technical publications, it then extended by providing links to design tutorials and publishing selected daily news from the automotive and design world, including original projects created by emerging designers. Today CBD is a well-known online resource with more than 1 million pages visited every month.

www.carros.nl

Premium cars, prominent people.

http://ec.europa.eu/information_society/activities/intelligentcar/index_en.htm

Intelligent Car Initiative Portal of Europe's information Society 'Imagine a world where cars don't crash, where congestion

is drastically reduced and where your car is energy efficient and pollutes less. Today Information and Communications Technologies (ICT) are starting to make this dream true. Your car is becoming smarter, helping to reduce Europe's road transport problems.'

www.atonline.com/index.php:do=show/site=a4e/sid=107171469749ec5d6ab62e5726512674/alloc=3/id=7743

A Method of enhancing the detection range of Ultrasonic sensors in pre-crash applications

Conventional ultrasonic sensors for automotive applications can detect a target in a short range, but the devices must be compact and waterproof. Those requirements limit their application to user-friendly systems such as parking assist systems and rear sonar systems. For pre-crash applications, generally proposed sensors like stereo cameras, radar or lidar are able to detect obstacles at long distances, but they are much more expensive than ultrasonic sensors. This paper proposes a range enhancement method for ultrasonic sensors to make them usable in pre-crash applications.

www.tno.nl/images/shared/overtno/magazine/em_3_2007_20_21.pdf
www.tno.nl/content.cfm?context=marketing&content=product&laag1=59&laag2=216&item_id=300

PreScan. PreScan is a simulation environment for the design and evaluation of the next generation of vehicles that will have sensors to make road traffic safer. Within

PreScan, a vehicle can actually sense its surroundings and - based on the decision algorithms implemented - react to it. Typical detection systems that can be used range from radar, lidar and stereovision, to car-2-car and car-2-infrastructure communication systems.



> contributors

Cas Aalbers (the Netherlands)

Cas Aalbers graduated from the Rotterdam Academy of Architecture and Urban Design as an architect, and he worked at ONL in Rotterdam from 2001 until 2006.

Chris Bangle (United States)

'Bangle is arguably the most influential auto designer of his generation.'

Phil Patton, *New York Times*, (February 20, 2006). One only needs to look down the street for evidence of Chris Bangle's ingenuity and far-reaching influence.

A daring designer whose work has provoked endless discussion, Bangle is best known for his tenure as Chief of Design for the BMW group, where he was responsible for bringing the designs of the BMW, Mini Cooper, and Rolls Royce into the twenty-first century. Graduating from the Art Center College of Design, Bangle began his career at Opel, and then moved on to Fiat, where he designed the brazen Coupe Fiat. In 1992, he was named the first American Chief of Design at BMW. No other designer has had such a far reaching impact in the automotive industry. His mandate to 'strategize emotion' through design has energized the typically conservative brand, updating BMW's classic design with bold, sculptural lines, a far cry from homogenous car design. As a result, his daring designs have helped BMW become the global leader in premium car sales and brought in legions of new fans, spurning rivals to follow suit in emulating his distinctive style. During his time at BMW, he introduced GINA, an experimental concept roadster that seeks to replace a vehicle's static metal or fiberglass skin with a one of fabric that can change the shape and aerodynamics of the car. After pushing car design language to its limits for twenty-eight years, Bangle announced his departure on February 3, 2009 from the auto industry. He looks forward to pursuing his own design-related endeavors from his studio in Italy, focusing on new ideas and cutting-edge innovation.

Henriette Bier (Germany)

After graduating in architecture (1998) from the University of Karlsruhe in Germany, Henriette Bier has worked with Morphosis (1999-2001) on internationally relevant projects in the US and Europe. She has taught computer-based architectural design (2002-2003) at universities in Austria, Germany and the Netherlands. Her research focuses not only on analysis and critical assessment of digital technologies in architecture, but also reflects evaluation and classification of digitally-driven architectures through procedural and object-oriented studies. It defines methodologies of digital design, which incorporate (Intelligent)Computer Based Systems proposing development of

prototypical tools to support the design process. Results of her research have been published in books, journals and conference proceedings. She regularly lectures and leads workshops in Europe and the US and teaches design studios within Hyperbody and Border Conditions at TU Delft.

Nimish Bioria (India)

Nimish Bioria is an architect/designer from India. After completing his undergraduate education (BArch. with honours) at the Centre for Environmental Planning and Technology (CEPT) in Ahmedabad, India, he completed his graduate education (M Arch) at the Architectural Association in London, where he specialized in the field of Emergent Technologies and Design. He is currently working on a PhD at Delft University of Technology, with a focus on developing real time responsive/adaptive corporate office environments. He has also been associated with Hyperbody as a design tutor for the past three years. His research deals with attaining a synergistic merger of the fields of control systems, electronic media, computational design, kinetics and architectural design. Nimish Bioria continues his experiments that deal with the idea of interconnections and interdependence that formulate a relational network for the generation of performative morphologies.

Howard Chung Chi Ho (China)

Howard Chung Chi Ho received the Bachelor of Arts degree in Architectural Studies in the University of Hong Kong. He had working experience in both Hong Kong and Amsterdam, including one year of work in Integrated Design Associates, Hong Kong. Since 2006 he has been studying for the Master of Science in Architecture at Delft University of Technology and is graduated at the studio of Hyperbody in 2008.

Han Feng (China)

Han Feng is an architect from China. After graduating from architecture department of Harbin Institute of Technology in 2002, he has been working with L.A. International Ltd in Beijing. He obtained his Master of Science degree in architecture at Delft University of Technology, the Netherlands (2003-2005). In 2006 he has been working with several design companies in the Netherlands, including ONL [Oosterhuis_Lenard], De werff architectuur, ANT Architects and Studio 015. He is currently working on his research project in Hyperbody, TU Delft which aims at enriching architecture design philosophy with ideas and methods found in Quantum mechanics.

Ilaria Giardiello (Italy)

Born in 1982, Ilaria Giardiello lived most of her young life in the south of Italy. Trained as an architect, she completed a bachelor in science of architecture at IUAV in Venice (Italy). Subsequently, she worked in Renato Rizzi's office and continued her field training with several other small architectural offices. She is currently studying for the Master of Architecture degree in the Hyperbody

department at TU Delft. She is particularly interested in the linkages between light and space.

MarkDavid Hosale (United States)

MarkDavid Hosale is a media artist and composer with a PhD. in Media Arts and Technology from the University of California in Santa Barbara (2008). As an interdisciplinary artist and composer Hosale has found that, beyond the common language of new media, the connecting tissue between various art practices and music can be found in narrative. In particular, the kind of narrative that is structured using nonlinear representations of information, time, and space. Nonlinear narrative is an inherent aspect of new media that provides a common baseline whereby media artworks can be evaluated and understood. In addition to non-linear narrative, Hosale's interdisciplinary interest in art and music comes from the exploration of the connection between the physical and the virtual world. Whether as part of an installation work or performance work, the virtual spaces he creates are technologically transparent, sophisticated and virtuosic, as well as intuitive to experience and use.

Tomasz Jaskiewicz (Poland)

Tomas Jaskiewicz is an architect and urban designer. He graduated as an architect, with a specialization in urbanism, at the Technical University of Gdansk. He obtained his master's of science degree in architecture at the Delft University of Technology. His working experience includes projects with bAR architects and Prof. Jacek Krenz design studio. Since 2001, he has been in close cooperation with diaade, and ar+di, a dialogic design research lab in Gdansk. In 2003, he joined Hyperbody at TU Delft, first as a student assistant, and eventually as an associate researcher. In January 2007, he started a PhD thesis, which he has titled 'Complex Systems in Interactive Architecture'. Since 2005, he has been working as an architect and project manager with ONL [Oosterhuis_Lénárd].

Gijs Joosen (the Netherlands)

Born in Chaam (1975) Gijs Joosen graduated in both Architecture and Design Systems at the Eindhoven University of Technology in 2003. His graduation project received a nomination for the Dutch Archiprix 2004. Prior to joining ONL [Oosterhuis_Lénárd] he has been employed at the Faculty of Architecture, TU Eindhoven and has been a student assistant on several courses in 3D modelling and the CAAD futures conference 1998. He is currently working at ONL as a senior architect and engineer specializing in the development of parametric 3D models and the implementation of ICT processes in the workflow of building projects. He has taken application of new technologies in architecture and in architectural parametric design to another level. As a senior architect he worked on the F-Zuid residential area in Amsterdam (NL) and the twin buildings BMW Ekris Headlights in Utrecht (NL). At ONL he is currently working on the Al Nasser HQ building in Abu Dhabi (UAE) and the Haarrijn Soundbarrier in Utrecht

(NL). From his graduation on he has been involved in several workshops and lectures including the Speed and Friction workshop at the ESARQ institute of architecture in Barcelona (ES) and has been a guest tutor on several occasions at the Delft University of Technology.

Chris Kievid (the Netherlands)

Chris Kievid is an architect and interaction engineer who studied at the Faculty of Architecture of TU Delft and graduated cum laude in 2006. His graduation project received a nomination for the Dutch Archiprix 2007. He works as a freelance architect and interaction designer for the multidisciplinary design office ONL [Oosterhuis_Lénárd] on a variety of innovative projects that include Trans-ports, TT Monument, Swinging Lights and Space Xperience Curaçao. He has been associated with Hyperbody since its beginning in 2001 and since 2007 has a fulltime position of ProtoSpace researcher. This position was created in the context of a new research project ProtoSpace, the revolutionary design environment for collaborative design and engineering in real time hosted in the iWEB pavilion. His work includes building real-time parametric environments and interactive interfaces to communicate with these active worlds. He developed the interactivity for the road show Philips Transitions II project iLite in 2007. At present he is project manager at Hyperbody and the responsible project architect for the InteractiveWall project as exhibited at the Hannover Messe in 2009 and the the rebirth of Hyperbody's ProtoSpace Laboratory. Since 2009 he is the coordinator of the Hyperbody MSc2. This programme focuses on the design of a non-standard and/or interactive project within an internationally relevant practice.

Sander Korebrits (the Netherlands)

Sander Korebrits is a student at the Faculty of Architecture of T Delft, working on his graduation project at Hyperbody. He has been a student assistant at Hyperbody as well, since 2003, where he started out giving Virtools courses. His tasks soon extended into developing applications for several research and education projects. His interests in web applications, over time gave him proficiency in developing web applications using php, html, CSS, JavaScript, MySQL and Ajax. In 2007 he cooperated with a video artist in the Warum 2.0 project that focused on a web application interacting with a Max MSP patch, further developing his software skills.

Kas Oosterhuis (the Netherlands)

Born in 1951 in Amersfoort Kas Oosterhuis studied architecture at the Delft University of Technology. In 1987-1988 he taught as unit master at the AA in London and worked/lived one year in the former studio of Theo van Doesburg in Paris together with visual artist Ilona Lénárd. Their design studio is in 2004 renamed into ONL [Oosterhuis_Lénárd]. As from 2007 Oosterhuis is a registered architect in Hungary, executing as General Designer the CET project. Since 2000, Oosterhuis has been appointed professor of digital design methods at

the Delft University of Technology and he is currently leading a staff of twenty researchers at Hyperbody, the knowledge centre for Non-Standard and Interactive Architecture. Oosterhuis is Director of the ProtoSpace Laboratory in the iWEB pavilion. He is member of the Dutch Building Information Council and has been a Member of the Board of Witte de With Center of Contemporary Art in Rotterdam and of the VCA (Computerusers Architectural Offices) until 1989. He has been the co-founder of the Attila Foundation, responsible for the groundbreaking Sculpture City event in 1994 and the ParaSite web lounge in 1996. He has lectured worldwide at numerous universities, academies and international conferences since 1990. Oosterhuis has initiated two GameSetandMatch (GSM) conferences at the Delft University of Technology on the subjects' multiplayer game design, file to factory design and build methods and open source communication in the evolutionary development of the 3D reference model. Award winning building designs include the Saltwaterpavilion at Neeltje Jans (Gold Award 1997 for innovative recreational projects, Zeeuwse Architectuurprijs 1998, nomination Mies van der Rohe Award 1998), the Garbagetransferstation Elhorst/Vloedbelt in Zenderen (Business Week/ Architectural Record Award 1998, OCE-BNA Award for Industrial Architecture 1996, Aluminium Design Award 1997) and the Hessing Cockpit in Acoustic Barrier in Utrecht (National Steel Award 2006, Glass Award 2006, Dutch Design Award for Public Space 2006, nomination Mies van der Rohe Award 2008, nomination Golden Pyramid 2006).

Marthijn Pool (the Netherlands)

Marthijn Pool has received his Master of Science in Architecture at Delft University of Technology (2005). On the basis of programming and parametric modelling, a design tool was developed to propose a synthesis on the integration of Infrastructure and Architecture on a high-density integration of static and dynamic space. After studying he is tutoring Master students at the University of Delft. He has been working at ONL from begin 2006. On the architectural level his focus lies in the field of building 3D parametric models in early design stages. As an architect/ engineer he has contributed to the realization of F-Zuid Housing project, iWeb Research&DesignLab and he has been the responsible project architect for the Berlin Landscape Lounge, ONL-Philips Transitions II and is currently leading the Kaiserslautern Landmark.

Owen Slootweg (the Netherlands)

Owen Slootweg has received his Masters degree from Delft University of Technology [1999-2007] with an honourable mention. His graduation project was nominated for the Dutch Archiprix 2008. During his student career Owen Slootweg worked for five years at the chair Technical Design and Informatics of the department of Building Technology, where he was a tutor and did several research- and commercial projects. He worked with ONL [Oosterhuis_Lénárd] from medio 2007 where on the architectural level his focus lied in creating parametric 3D models and he worked closely with the structural engineers to

design and optimize building constructions. Combining his hobbies with his work he developed an extensive knowledge of the principles behind 3D modelling, software and programming and is greatly experienced with 3D rendering and visualization, as well as several scripting languages involving 3D platforms.

Kyle Steinfeld (United States)

Kyle Steinfeld is an architect and educator specializing in digital design technologies. He lives and works in New York City. Currently a Visiting Instructor at Pratt Institute in Brooklyn, he directs the Digital Futures Group in the undergraduate department and assists architecture design studios that focus on digital design techniques.

Kyle spent one year as a PhD researcher at TU Delft in the Netherlands, and currently holds a Masters of Architecture from MIT as well as a Bachelor's Degree in Design from the University of Florida.

Professionally, he has worked with and consulted for a number of design firms, primarily in New York. These include Skidmore Owings and Merrill, Acconci Studio, Kohn Petersen Fox Associates, Howler/Yoon, Diller Scofidio Renfro, TEN Arquitectos, and others.

Xin Xia (China)

Xin Xia studied at the Nanjing Arts Institute for Decorative Art Design. In 2000, she moved to the Netherlands for postgraduate studies, where she completed master's degrees at both the Dutch Art Institute (Visual Art) and Amsterdam University (Film and Television Studies). Her practice was mainly in painting and installation. Her research was focused on Cognitive Film Theory and Contemporary Video Art Installations. She was involved with ONL [Oosterhuis_Lénárd] on art projects and publicity. In 2005 she joined Hyperbody as a researcher and she is working on book editing, publicity and event organization.

Ke Zou (China)

Ke Zou is a registered Dutch architect. He studied in Architecture department of Harbin Institute of Technology University and got his Bachelor degree in 2004. Between 2004 and 2006, he worked as an junior architect in China Northeast Architecture Design and Research Institute in Shezhen, China. In August 2006, he began his study of architecture in Delft University of Technology and received his Master degree in 2008. During his study at the TU Delft, he worked for Botgeroushoorn architecture studio and Studio 015 as an intern. In 2009 he started his own office 'ZOO' studio. Meanwhile, he also worked for Christian-Muller office as a trainee in Rotterdam.



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