



Atlas of Sensations –
on Sensibilities in a Computational Design Practice

A project submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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— on Sensibilities in a Computational Design Practice

by

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Declaration

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the project is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

Sandra Manninger

21 September 2018

To my family

Atlas of Sensations

– on Design Ecologies in a Computational Design Practice

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Abstract

The driving force behind the body of work of SPAN is defined by the application of advanced computational design methodologies. This dissertation can be understood as a cartography (in the best tradition of an atlas) of the work of the practice from its founding year 2003 until 2017 – a period profoundly shaped by the progress made in technological advances. These technological means allow SPAN to discuss architectural project through a series of different lenses such as conceptualization, planning, fabrication to the maintenance of the designed objects, through the use of emerging technical opportunities wither this be the interrogation of novel geometries (Blocks, Ore, Barcelona Recursion), computational methods of rationalization (Expo Façade) or advanced methods of fabrication (Robots, as for example in Plato's Columns). In a parallel move between the necessities and desires of the practice and the ambitious studios and seminars in academia, novel toolsets and design concepts are developed to address contemporary architectural problems. These areas can be understood as different territories of interrogation, forming a landscape of opportunities, or as we describe it internally in our office: a design ecology.

The interrogation of these distinct territories, and the unique way in which SPAN assembles those various elements to something larger than its parts, is what constitutes part of SPAN's contribution to the discipline. Apart from projects and visual work, SPAN's contribution to discourse started early with papers to conferences such as IASS (International Association for Shell and Spatial Structures) in 2007, Design Modeling Symposium in 2008, and ACADIA (Association for Computer Aided Design in Architecture) in 2008, which included ideas such as the application of tissue engineering in architecture, aspects of artifact and affect, fabrication, and considerations on architectural details in complex curved geometries.

Within the Atlas of Sensations, a second ecology is defined by the contribution to the paradigm shift in the discourse from the continuous to the hyper-articulated surface, which contains an additional level of information. A surface, which describes architectural properties through the deep pochés, folds, joints, niches, and arches it generates. The question is: How does this shift in the conception of architecture affect the qualities of the design, and by extension the context these objects construct? To further investigate this question the work focuses on one part of the practice's design ecology: design sensibilities. In order to interrogate this question, the presented work observes these moments in SPAN's practice through the lens of geometrical properties. Ultimately resulting in thoughts on Postdigital design ecologies that discuss aspects of design agency in our contemporary age.

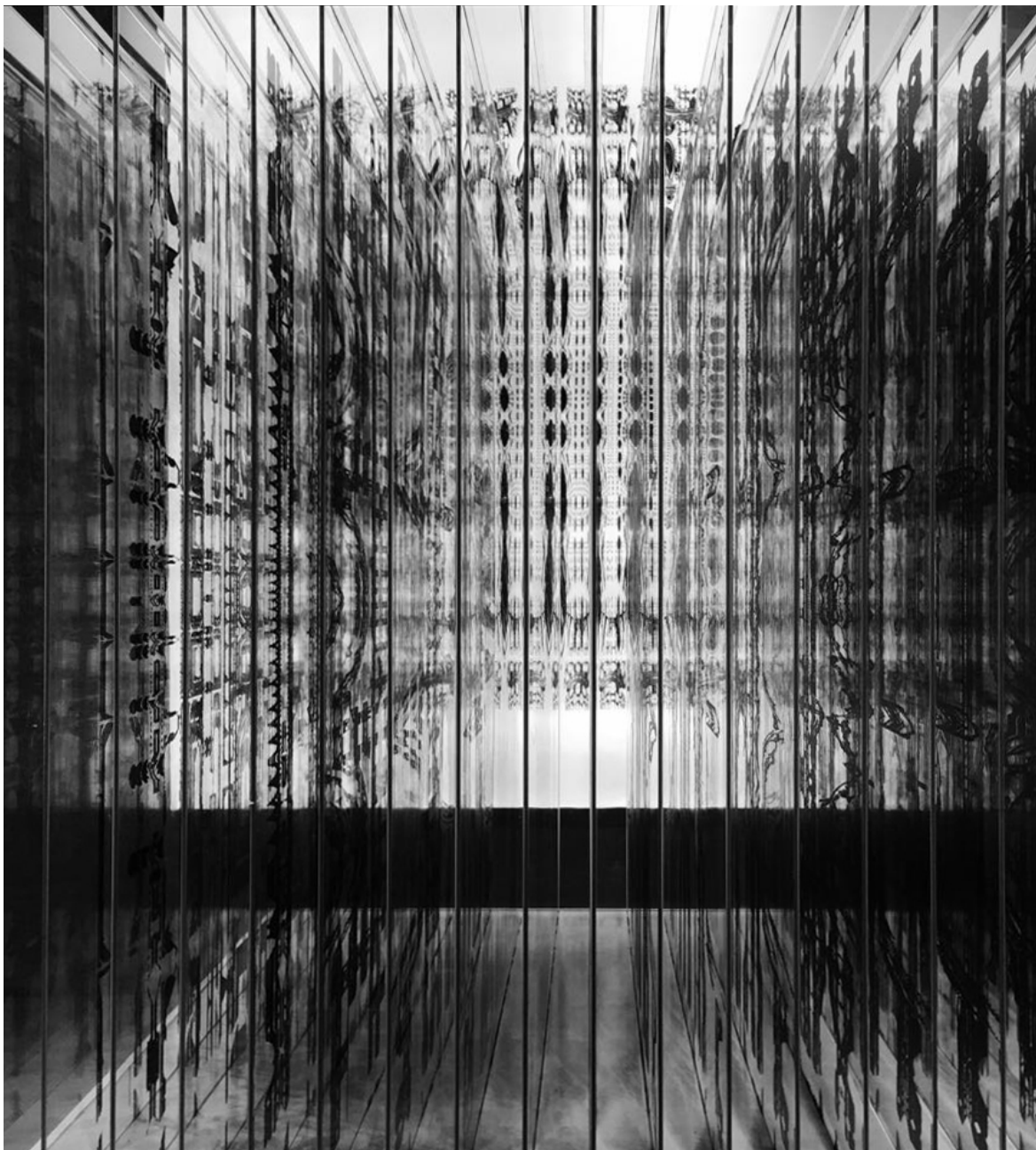


Fig 1 *Sensible Bodies* exhibition, view at *Blocks ABoxVSShapeIt01*, sectional analysis, print on acrylics, FAB-Union gallery, Shanghai,CN, 2017

Introduction

SPAN is an architectural practice that was founded in 2003, by Matias del Campo and Sandra Manninger in Vienna, Austria. The practice now operates from Ann Arbor, USA and Shanghai, China.

The architecture of SPAN has always revolved around the integration of computational tools, for the conception, design, fabrication, and maintenance of their designs. The core of the thesis is presented in two main parts: Sensibilities and geometries. Sensibilities presents the body of work created in practice and research from 2003 to 2017, a period that is determined by a shift from first to second digital turn in architecture.¹ The main question of this research is: What are the criteria that are establishing SPAN's design ecology, i.e. the design protocols and the design sensibilities developed through the years in practice.

SPAN's work does not hover in an independent space, void of any influence of peers and predecessors. There is an entire family of projects, thoughts, and desires that shaped the language of SPAN's ecologies of design. One of the strongest forces of influence is the Viennese environment itself. A space that allows to experience the exquisite lines of finely detailed Gothic rib vaults and fenestration details [Fig 2], the voluptuous hedonism of rose, golden and white Rococo interiors [Fig 3], or the delicately detailed Jugendstil facades within just a couple of steps. So much more could be said here about the influence of the environment to the thinking of an architect, but apart from the immediate surroundings there is a global tribe of peers and heroes that shaped the language of SPAN like Hans Hollein [Fig 4], Wolf D. Prix of Coop Himmelb(l)au [Fig 5], or Greg Lynn of Greg Lynn Form [Fig 7].

This network made it possible to engage in conversations with architects and theorists such as Lebbeus Woods, Neil Denari of NMDA [Fig 6], Karl Chu [Fig 8], Jeffrey Kipnis, Mario Carpo, and many more, who certainly shaped the intellectual frame of the work. Then there is the amazing work of peers and often friends who shape the current streams of architectural thinking and who serve as sparring partners

1 Carpo, Mario, 2017. *The Second Digital Turn: Design beyond Intelligence*. Cambridge: The MIT Press.

and critics of our work such as Alisa Andrasek [Fig 13], Roland Snooks of Studio Roland Snooks [Fig 11], Francois Roche of New Territories, Hernan Diaz Alonso of XEFIROTARCH [Fig 10], and many more. Within this frame there were specific interests into continuous processes and the philosophy of Deleuze² and in its extension the work of Manuel de Landa³. SPAN's design sensibilities were profoundly influenced by this frame of thinking, but every progress is also defined by a form of resistance. This resistance can express itself in a healthy skepticism to some of the approaches of peers and predecessors. The critical interrogation of related approaches, techniques and projects certainly helped to shape a very specific view towards architectural problems in SPAN's work. Greg Lynn's writings certainly had an impact to our work. One of the passages is a paragraph on phenomenal transparency: "Another model of indexical time is associated with Colin Rowe and his disciples. In Rowe's text, *Transparency: Literal and Phenomenal*, co-authored with Robert Slutzky, the idea of a formal, or phenomenal transparency is proposed along with literal transparency. Phenomenal transparency is the tracing or imprinting of a deeper formal space on a surface. Similarly, examples of formal or phenomenal time include shearing, and rotating operations. Superimposed snap-shots of motion imply time as a phenomenal movement between frames or moments. For instance, Kenneth Frampton's description of Charles Gwathmey's early work as rotational is one such example of time being used to describe the movement between superimposed, formal moments. Another example is that of the trace, a term that has emerged in the last twenty years as a graphical notation of time and motion in architecture. In such projects, a design process of sequential formal operations is recorded in the building's configuration through colors, alignments, imprints, additions and subtractions. One such example is the simultaneous presence of multiple historical ground conditions at a single moment. The intervals between the moments that are superimposed generate irresolute conditions which are exploited for their destabilizing effects on the present."⁴

The project that comes to mind reading the description in the end of the paragraph, dealing with multiple historical ground conditions, is of course the Wexner Center in Columbus, Ohio, which was designed by Peter Eisenman and opened in 1989. The multiple historical grids, directions and conditions are superimposed to create an intricate maze of intersecting grids. To the point that some traces of the historic textures are referenced in the constructed matter – such as the brick armory towers. Though this can be also read as the last remains of the postmodern technique of quoting and referencing as part of the project genesis, it is at the same time an exercise in understanding the historic dimension of the architectural project. Though I really observed that postmodern technique with a healthy dose of criticism, it might have shaped SPAN's interrogation of the historic dimension within computational work. The formal vocabulary,

2.....Deleuze, Gilles, and Félix Guattari. 2004. *A thousand plateaus: capitalism and schizophrenia*. London: Continuum.

3.....DeLanda, Manuel. (2002). Deleuze and the use of the genetic algorithm in architecture. *Architectural Design*. 72. 9-12.

4.....Rowe, Colin. Slutzky, Robert (1963) *Transparency: Literal and Phenomenal*. *Perspecta* Vol.8 45-54

even of the most radical computational project, is not without roots and remnants in the history of the discipline. The Viennese ecology of my education demonstrates the reasons for the emergence of those traits

in my work. Apart from the evident historic presence in Vienna's urban texture, there was also the presence of two main trajectories of architectural thinking during my years as a student. On the one side Hans Hollein who was teaching at the University of Applied Arts, and Leon Krier, who at the time was teaching at the Technical University, who embodied the postmodern approach with all its desires to quote from the history of architecture, on the other side Wolf Prix, Professor at the Angewandte and Helmut Richter, Professor at the Technical University, who refused any historical baggage. This vivid conversation in one city, very much supported by institutions like the MAK (Museum fuer Angewandte Kunst)⁵ and the AzW (Architekturzentrum Wien [Austrian museum of architecture]) with their respective lectures and exhibitions program, helped shape the vocabulary of SPAN. Around this time I came across Greg Lynn's book *Animate Form*⁶, which in many ways showed a possible exit strategy from the continuous vicious circle established by postmodernism and its counter cultures such as deconstructivism and architecture focused on technology and adorned details. Aspects such as indexical time and imprinting of a deeper formal space on a surface immediately became part of SPAN's vocabulary – not in terms of literal translation to physical entities, but as conceptual anchors for the approach to a project. One of our earliest projects, the Planless House, a contribution for the Shinkenshiku award in Japan, was lauded for its rigorous approach in demonstrating how external forces shape form. The catalogue to the 9th Archilab exhibition in Orleans described it like this:

“... their projects are born out of generative processes inspired by organic systems and, in the tradition of Greg Lynn, of the spatial potentialities generated by the fluxes and the forces (sunshine, weather systems, acoustic forces and the acoustic pressures of wind or sound), and combines them with tangible architectural issues such as apertures, circulation, transitions or the division of space. Their projects – whether buildings, exhibition, scenographies or furniture – are characterized by complex curved geometries, continuous surface areas, and the search for sensitive voluptuous environments. Among their first projects, Planless House (2006) is a good illustration of the studio's conceptual vision. SPAN impulses an external force to a parallelepiped and then provokes deformations of variable size ... ”⁷

5.....The Austrian Museum of Applied Arts Vienna is a decorative arts museum located in Vienna, Austria.

6 Lynn, Greg. *Animate Form*, Princeton Architectural Press, New York, NY, USA 1999

7....Migayrou, Frederic. Brayer, Marie-Ange. *Archilab 9 - Naturalizing Architecture*, HYX, Orleans, France 2013, p13

In 2004 I became a founding member of AMM – the Advanced Materials and Manufacturing network. This was primarily a peer driven network, which gave me the opportunity to exchange thoughts with colleagues working on similar problems. It became quickly apparent that our approach was different to many peers, especially in the German speaking countries. There were two main trajectories in terms of computational design at the time. The AA DRL (Architectural Association Design Research Lab) driven approach that favored a very analytical, and performance oriented design approach, as evidenced in the works of Achim Menges and Michael Hensel:

“.....Most often the utilization of parametric models in the field of digital architectural design reflects the fact that much of the architectural software in use today was originally developed for the aeronautical, naval, automobile and product-design industries. Due to an inherent emphasis on maintaining geometric control and workflow efficiency, the parametric models used in these programs are embedded with processes and constraints, which lend themselves to the post-rationalization of complicated building geometries derived from other design processes. In architecture, deploying parametric control is primarily geared towards processes of rationalizing complex geometries. The typical case being the doubly curved facades rationalized as a parametrically defined system, which can then be relatively quickly adapted to inevitable changes in the overall scheme. The geometric data relevant to manufacture and construction is contained within this parametric model and is therefore effortlessly recalculated and retrieved”⁸

The second approach, which was prevailing in the United States, favored a philosophical, or theoretical approach above a technical trajectory. Colleagues, who embraced this trajectory involved Hernan Diaz Alonso, Jason Payne, Florencia Pita, Marcelyn Gow and Evan Douglass. Greg Lynn was the one who pointed out that those are our peers in regards of our main interests, and graciously provided us with their contacts. Most of those actors were educated in Columbia University’s Paperless Studio, introduced during the tenure of Bernd Tschumi in summer of 1994, by instructors such as Bill McDonald, Shulan Kolatan, Jesse Reiser, Nanako Umemoto and Greg Lynn. In retrospect it is enlightening to read the 1994 announcement of the paperless studio and the clear vision Bernd Tschumi had about the things to come:

“.... Design studio is the core experience of architectural studies. In the fall of 1994, the GSAP will make history by instituting the Paperless Studio, a radical reversal of the standard notion of the student’s homebase as a manual drafting table in a walled cubicle”⁹

8.....Hensel, M., Menges, A., (Eds) *Morpho-Ecologies*, AA Publications, London 2006, p43

9.....Bernd Tschumi in *Columbia Newslines* Summer/Sept/Oct '94 p9

To summarize: The field of influences from peers reached from the ecology of Los Angeles to the discussions between student colleagues in Vienna. Greg Lynn can be named a formative figure when it came to develop a specific design thinking in regards of the oscillation between geometric inquiry and its cultural contextualization and influence. Based on this SPAN developed their own methodologies of inquiry through designs and written works. The solo exhibition Formations at the MAK (Austrian Museum of Applied Arts Vienna) [Fig 17] in 2011 offered the opportunity to display a shift in SPAN's design ecology. The departure from smooth and continuous to raw, complex, hyperarticulated surfaces certainly presented itself as an alternative to current trends at the time.

In spring 2016, SPAN was invited to present their work in the FAB-Union gallery in Shanghai [Fig 23 - Fig 28].¹⁰ The selection process for this exhibition provided an opportunity to review the body of work and to put it into the context of recent interests. It fans out the elements that constitute SPAN's design considerations and describes the shifting weights on authorship and design agencies of the elements that constitute SPAN's design ecologies.

SPAN is a duo, Sandra Manninger and Matias del Campo, and though both heads of the studio share fascinations, obsessions and desires in terms of style, influences and interests, there are also main differences in their approach to a project. Whilst Sandra Manninger focuses on the geometrical properties of a project and the potentialities of geometry to explain its qualities as well as its cultural signifier, and on the properties of process, Matias del Campo's focus is on the agencies of material assemblies, its speculative values and its imprint into architectural discourse.

Sensibilities

The ability to examine and interrogate potentialities for substantial architectural deportment and morphological emergence within specific geometric figurations is what defines the sensibilities in the design universe of SPAN. In this extent the work on a sensibility can be considered part of the entire trajectory of the practice. Sensibility in this case does not only comply with the definition that prescribes the ability to evoke emotional response in an observer or user by the inherent aesthetic and material qualities of the design. It also complies with the idea of the development of a sensibility, in that a continuous effort is made to develop an aesthetic language as well as a progression in spatial thinking as a device for architectural design. In SPAN's work the idea of sensibility is connected to three specific criteria: The implementation of novel design tools, the exploration of its potentialities as a generator of architectural constituents and its

10.....Fab-Union gallery is a non-profit contemporary art, architecture and cultural communication center in Shanghai, CN.

immediate positioning within the larger trajectories or the historic dimension of the discipline.

Sensibility in SPAN's universe of design thinking is defined by the ability to examine and interrogate potentialities for substantial architectural departments and morphological emergence within specific geometric figurations. The chapter on sensibilities allows for a deeper insight into the various techniques and methods of interrogation that constitute a sensibility. SPAN's discussions and conversations on the aspects of sensibilities are contained within a multitude of ever transforming design ecologies.

What is Practice Research?

According to the RMIT Practice Research Webpage practice research is defined by a persistent pursuit in regards to any endeavor combined with a specific and focussed reflection of the process and the achieved results, as long as it involves a research component. The definition discusses the value of foregrounding the research by explicitly engaging with know how mined in the process of examining the work of the practice. In particular the positioning of the own practice within the discipline is encouraged and emphasized. The question of the particular contribution of the own practice within the larger field of inquiry, in this case architecture, is designed to clearly state the position within a larger architecture universe. The resulting knowledge serves as a basis to share, and contribute the the discipline at large.

The methodology of practice research includes aspects of practice into the examination process of the candidate's body of work. Instead of observing the aspects of practice and the aspects of theory as two separated entities, practice research strives to intrinsically connect these two aspects of practice into a holistic set of methods for inquiry into the candidates work.

There are a number of disciplines that have adopted these methods of inquiry in order to extract new academic knowledge from the practice work of the candidate. Those disciplines include for example the practice-based research network (PBRN) in the field of medical research.¹¹ In the humanities as well as the arts there are a variety of conversations gravitating around the interrogation of the nature of practice research. This seems to be an ongoing process, that has not yielded yet a globally accepted definition. Even the terminology varies from case to case (practice-as-research, practice-based, practice-lead, mixed-mode research practice and practice through research)¹². The most useful working thesis for this terminology can

11 Barkham, M., Practice-based research networks: Origins, overview, obstacles, and opportunities, *Counselling and Psychotherapy Research*, Vol. 14, No.3, Routledge London, 2014, p.168

12 Little, S., *Practice and Performance as Research in the Arts*, Otago University Press, Dunedin New Zealand, 2011, p.20

be found in Sir. Christopher Frayling's paper *Research in Arts and Design*¹³ which describes alternative methods of thinking about practice research. In fact he states that research could be FOR practice, where research aims are subservient to practice aims, THROUGH practice, where the practice serves a research purpose, or INTO practice, such as observing the working processes of others.¹⁴ This PhD can be read in this lineage of inquiry. In which the work is examined and described by the author of the work, instead of by another party. So the research subject is the observation of working processes IN the practice subservient to practice aims and expressed through the body of work.

Design ecologies

Design ecologies describes the layer of architectural conversation which allows for a deeper mining of the aspects of design in the practice. Like a jungle canopy, a design ecology is not uniform in its composition. Instead it consists of a series of interwoven and interdependent processes creating a haze of design information crucial for the progress of every single project. The hierarchical, non-hierarchical, research intensive and informed design decision process forms a layer of this ecology. Constantly oscillating between computational models, cross-pollinating different software packages, interrogations on the discursive implications and considerations on practical applications are explored, categorized and implemented in the architectural design process. As important as the computational side, is the ecology of fabrication. Every machine that allows to manipulate matter through computer controlled protocols is explored in the materialization process from computational model to physical reality. In fact, processes such as Autonomous Tectonics¹⁵ emerged from a critical interrogation of the process of making and building with computer controlled machinery. In Autonomous Tectonics agency was extended from an anthropocentric universe of design thinking into an environment that accepts the design agencies of automated processes or even cognitive machines.

When observing the entire landscape of projects developed by SPAN since its inception in 2003, one specific trend or tendency becomes very conspicuous: The transformation of the design methodology from a highly controlled design technique based on the specifics of manual computational modeling techniques (Brancusi Museum [Fig 15], Austrian Pavilion [Fig 16]) towards a technique that relies heavily on the design of algorithms and processes as basis of the morphology of a project (Formations exhibition at the MAK [Fig 17], ArchiLab 2013 exhibition at the FRAC, Blocks [Fig 18]). These morphogenetic processes

13 Frayling, C, *Research in Arts and Design*, Royal College of Arts Research Paper, Vol.1 Nr.1, London, 1993, p. 2

14 *ibid.*, p. 5

15 Autonomous Tectonics is a series of research projects that interrogate authorship, index, and indexicality in autonomous and automated design and fabrication processes.

allow for explorations of models of architecture that strive away from aspects of continuity and embrace aspects of exotic modularities, strange components, discrete assemblies and familiar yet alien architectural conditions. Design pressures are applied in an emergent fashion. It can be compared in an analogue way with the shifting weights technique applied to neural networks or neural nets.

This change in the approach of the architectural project presents a major departure from the common computational design techniques at the time.

Very often in SPAN's practice a specific research direction starts with the generation of an abstract machine that can be explained in a twofold way: As a set of instructions akin to those used in computer science to speculate about the abilities of specific algorithms, operational semantics, instruction sets and models of memory. One of the most well known examples in computer science is the Turing machine¹⁶, which provided a mathematical description of a very simple device capable of arbitrary computations. It can be considered a thought experiment of a machine that can provide numerous directions or opportunities to design other machines, for example the design of complex microprocessors that has yet to be implemented – or that is intended to never be implemented. In Deleuze's reading, on the other hand, an abstract machine¹⁷ represents an object built around variables and variation, without ties to the universal or the constant. This being said, abstract machines in SPAN's work represent objects with potentialities that provide insights, but at the same time serve as reflective boards for novel thoughts and projections into possible architectural futures. Abstract machines are not architectural projects per se, they embody possible solutions to specific architectural problems. They are not scale-less, they are multi-scalar and full of dimensions. Examples of abstract machines in SPAN's work are the first topological model made for the Exquisite Corps exhibition in the MAK center in Los Angeles in 2007 [Fig 37 - Fig 40] and the project Blocks which was published in AD 2016 [Fig 18].¹⁸

The adoption of abstract machines as a method of serious inquiry in our practice SPAN, is certainly a point that differentiates our approach massively from our colleagues and peers. In opposition to the concept of preconceiving results, and then merely visualizing and discretizing them into buildable objects, utilizing digital tools, abstract machines serve as launching pads of computational research on potentialities that an abstract object offer in regards of solutions for architectural projects. Best visible probably in the abstract machine that emerged from our research stay with the Schindler Scholarship in Los Angeles that resulted in

16.....dDe Mol, Liesbeth, "Turing Machines", The Stanford Encyclopedia of Philosophy (Winter 2018 Edition), Edward N. Zalta (ed.)

17.....Deleuze, Gilles. Guattari, Felix and Stivale, Charles J. SubStance Vol. 13, No. 3/4, Issue 44-45: Gilles Deleuze (1984), p 7-19

18 del Campo, Matias and Sandra Manninger, 2016. Moody Objects: Ore Fashion Stores and Blocks. Architectural Design, 06, p55-57

an entire series of projects revolving around problems of Topology. The original abstract machine was never intended to be a specific project - it is also not just a “test of ideas” - but rather a full fledged design ecology of possibilities and opportunities.

Geometries

The bonding agent of all these considerations on the nature of sensibilities and design ecologies is geometry. This archetypal architectural mean of expression is deeply ingrained into the DNA of architectural discourse and SPAN embraces the opportunity to explore a series of geometrical rulesets to elaborate a series of projects. Working continuously on one specific geometric problem such as Euclidean, topological and recursive problems, allowed to develop a language instigated by those geometries. SPAN resists the urge to solely utilize geometries to generate a better performance in terms of structural behavior or mimicking nature to reduce material consumption etc. Instead the practice is interested in a conscious move towards understanding the sublime qualities of geometry, both in its purity as a thought process but also literally in its performance as articulation of space and its atmospheric qualities. Vagueness, ambivalence, chromatics, estrangement, defamiliarization, and speculative thinking, to name a few, are the primary elements embraced by the conversation in the practice. This resistance to research the utility of discoveries exclusively for their purpose as engineering solutions, but rather to insist on the cultural, aesthetic and sublime qualities as research field is another aspect that differentiates our work within our peer group. Both Matias del Campo and myself have been vocal about this issues as evidenced in multiple exhibition contributions, conference contributions, panel discussions and ultimately in the AD “Evoking through Design” that particularly documents this notion.

The chapter begins with an abbreviated conversation on the origin of Euclidean geometry, the sources of his renowned Elements¹⁹ and the traditions in geometrical exercises established by Plato’s school of thinking. As in many other works of SPAN, the preoccupation with geometry is characterized by a cross-pollination between the fields – Euclidean figurations collide with recursive algorithms or the vague gestures of continuous robotic toolpaths.

The conversation then progresses, in an almost chronological progression, from Euclidean geometries and Plato’s universe of conversation about the nature of geometry²⁰ to calculus and topology. In a way topology is an extension of mathematical concepts of the Baroque and Rococo era, so present in the desire for the curvilinear condition which is in itself so inherent to topological behavior. SPAN’s oeuvre includes

19 Euclid, 2002. Elements. Washington, Library of Congress.

20 Plato, 1974. The Republic. Middlesex UK, Penguin Classics, p334f.

a large series of projects dealing with topological geometry and the implementation in built form, from speculative projects and small scale projects such as the Austrian Winery Boom exhibition design [Fig 14] or the Housing in Vienna exhibition design [Fig 22, Fig 31 - Fig 36] to architectural designs such as the competition winning proposal for the new Brancusi Museum in Paris [Fig 15] and ultimately a built example, the Austrian Pavilion for the Shanghai Expo 2010 [Fig 16].

The change in focus from topological surfaces to recursive geometry was mainly triggered by the discovery of novel fractal geometry packages which allowed to explore fractals in its dimensionality. Starting with the solo show Formations [Fig 17] in the MAK, the Museum of Applied Arts in Vienna, the practice explored the various opportunities, achieving more and more control of the results over time. Though the term control is indeed relative here as one of the main goals of the recursive research was to examine algorithmic behavior as proponent of agency. Once more interrogating design agencies rather than executing a solely top down approach with full control over the process elaborating on a dialog between these two techniques.

Blocks [Fig 18]²¹ presents a further development of this conversation on the nature of recursion and its implications both in terms of an architectural design technique as much as the intellectual and discursive problems inherent in this discussion. This chapter also discusses the project Particle Hut [Fig 19]. This installation was designed and built for the Digital Futures exhibition at Tongji University, Summer 2016. However, Particle Hut is the latest member in an entire lineage of projects dealing with the bisymmetric hendecahedron and its space filling properties. Starting with experiments conducted with students at the DIA (Dessau International Architecture Graduate School 2010) where perforation and pattering strategies were explored, to seminar work at the University of Michigan. All of which can be considered examinations of techniques to dissolve the mass of the object and infuse it with lightness, porosity and transparency.

The last in a long line of speculative projects presented is Plato's Columns [Fig 20]. And here the conversation closes the circle - from the universe of Euclid's geometrical treatise Elements, and Plato's influence on this work, to the Baroque presence in topological surfaces, to a modern take on geometry in the form of recursion to ultimately the combination between a Platonic body and the gestural qualities of a robotic toolpath. Plato's columns interrogates the rigorous geometry of a quasi-platonic body in combination with the emergent properties present in fused deposition modeling. The common methods of FDM (Fused Deposition Modeling) rely on the method to strictly subdivide an object in a sequence of horizontal layers that build up the desired figuration. The speed of the disposition in this case is of regular nature – there are practically no changes in the speed, with the exception of tight corners which automatically are adapted

²¹ del Campo, Matias and Sandra Manninger, 2016. Moody Objects: Ore Fashion Stores and Blocks. Architectural Design, 06, p55-57.

in their speed to compensate for material loss. This is designed so that the layer thickness is consistent and allows for a clean build-up of the object. Plato's Columns deliberately abandons this dogma of FDM and examines the possible eccentricities in a technique which embraces variations in the deposition speed.

In conclusion it can be said that the majority of the work of SPAN is situated in challenging common conceptions on the nature of beauty or aesthetics and critically interrogate the value of this contribution to architectural discourse - which is a unique position within our peer group. Fabrication itself becomes part of the design genesis. It perverts the main notion of computational design in architecture, where a majority of energy is invested in assuring that the design conceived on the computer is translated with utmost accuracy to the material world. This has been part of the architectural discipline's obsession since the advent of the plan in the Renaissance as a tool of prediction of a material reality. The process presented in Plato's columns opposes this century old notion and embraces a combination between the precision of the robotic tool, the computational model and the intentional integration of external forces deforming and corrupting the result.

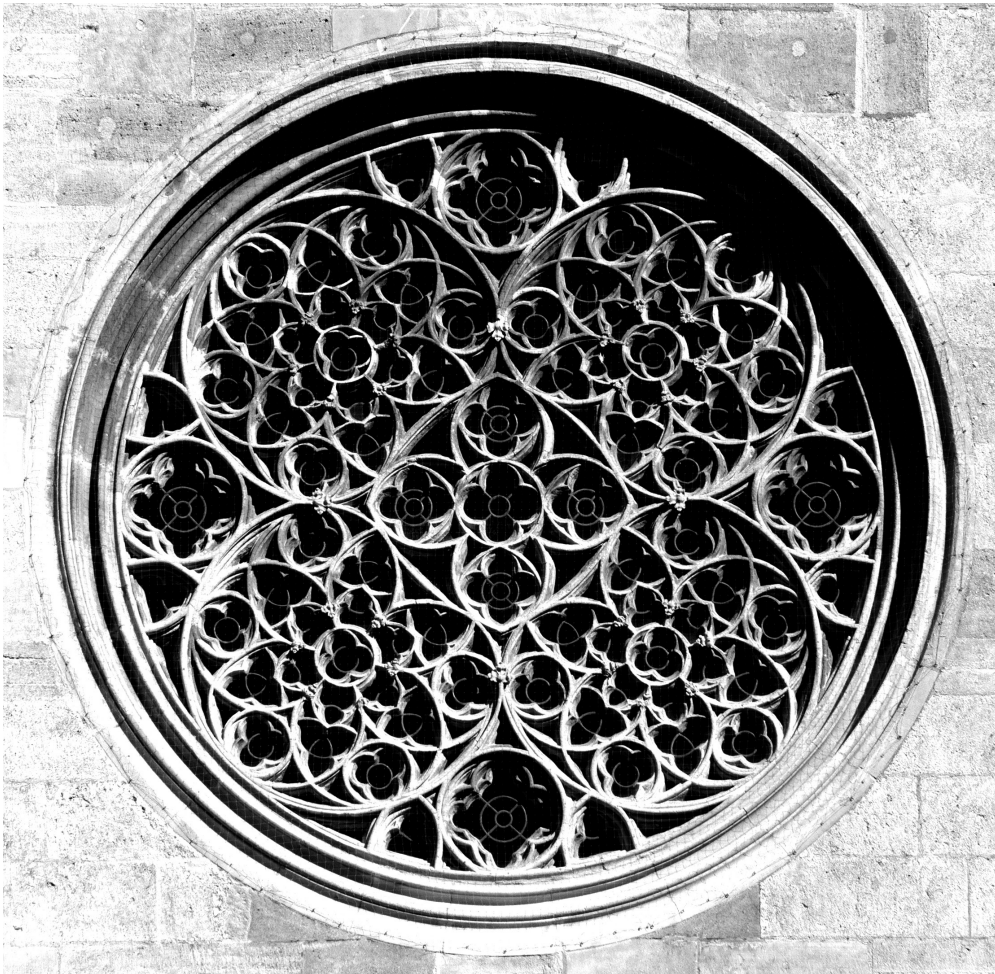


Fig 2 Rose window, St. Stephen's Cathedral, Vienna, AT, 1137-1160.

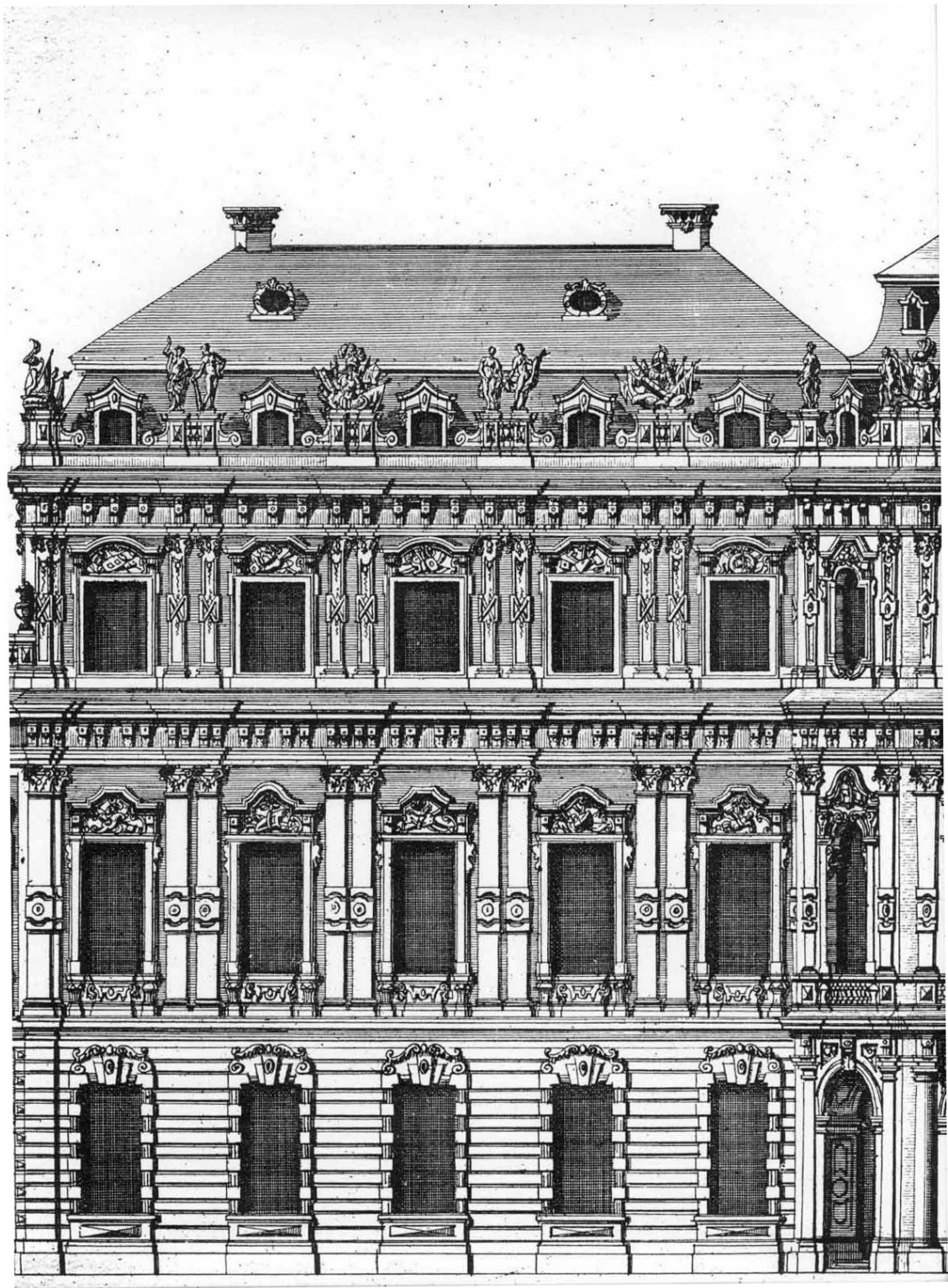


Fig 3 Belvedere facade detail, Johann Lukas von Hildebrandt, Vienna, AT, 1712-1723, courtesy Austrian National Library
engraving by Johann August Corvinus after a drawing by Salomon Kleiner



Fig 4 *Mobile Office*, Hans Hollein, 1969, courtesy hollein.com

In 1969, years before mobile-communication had developed its possibilities, Hollein proposed the inflatable mobile office, that provided take-along-workspace to blow up. In the picture you see Hans Hollein with a drawing board and phone on a stop-over at an airport.



Fig 5 Rooftop Remodeling Falkestraße, Coop Himmelb(l)au, Vienna, AT, 1987-1988, courtesy Gerald Zugmann
The law firm Schuppich, Sporn, Winischhofer, Schuppich wished to extend their office upwards. The office is situated on the first and second floor of the building on the corner of Falkestraße and Biberstraße in the inner City of Vienna.

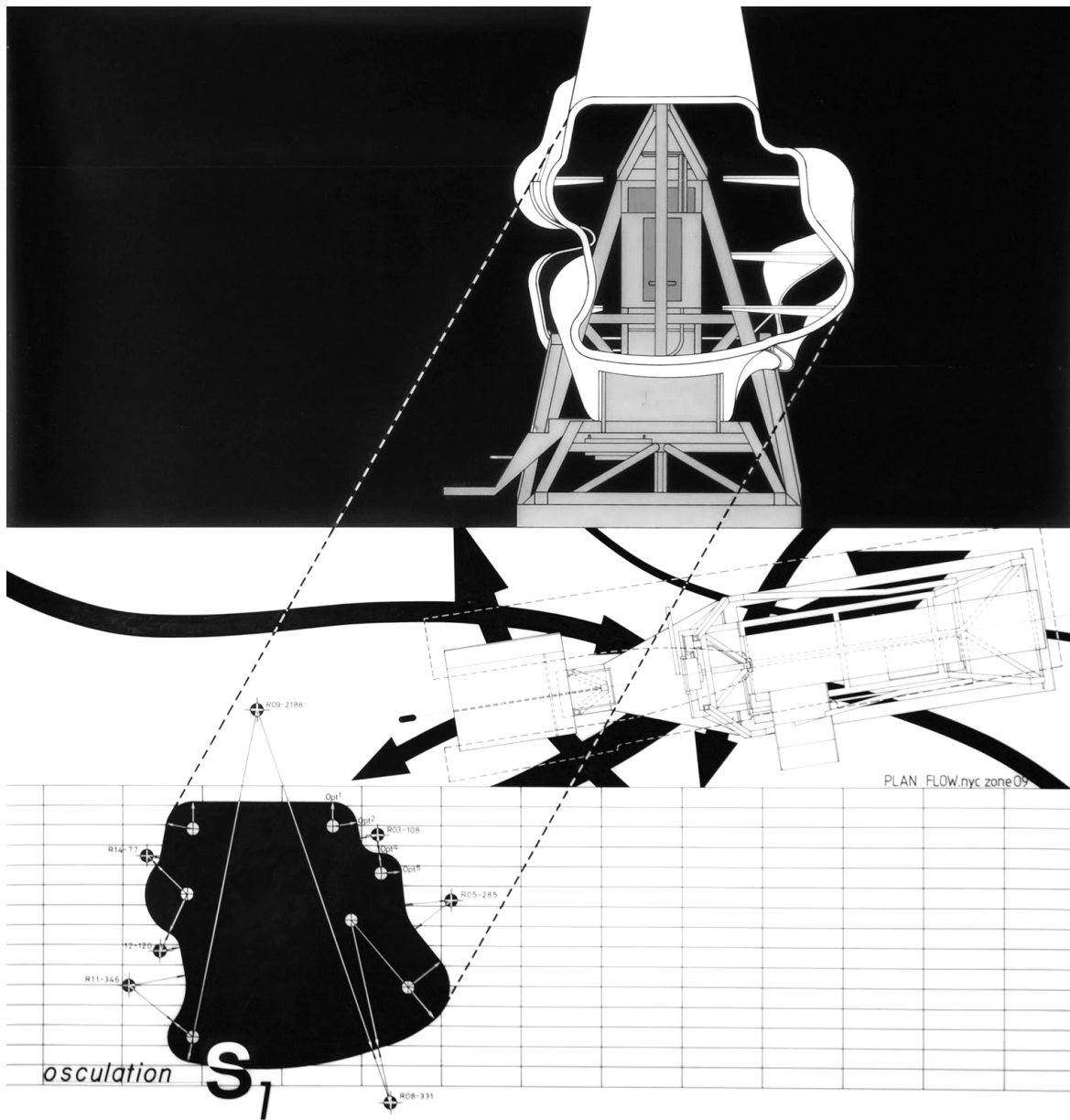


Fig 6 Para/Sites FLOW.nyc zone09, Neil M. Denari Architects, 1980 © courtesy Neil M. Denari Architects

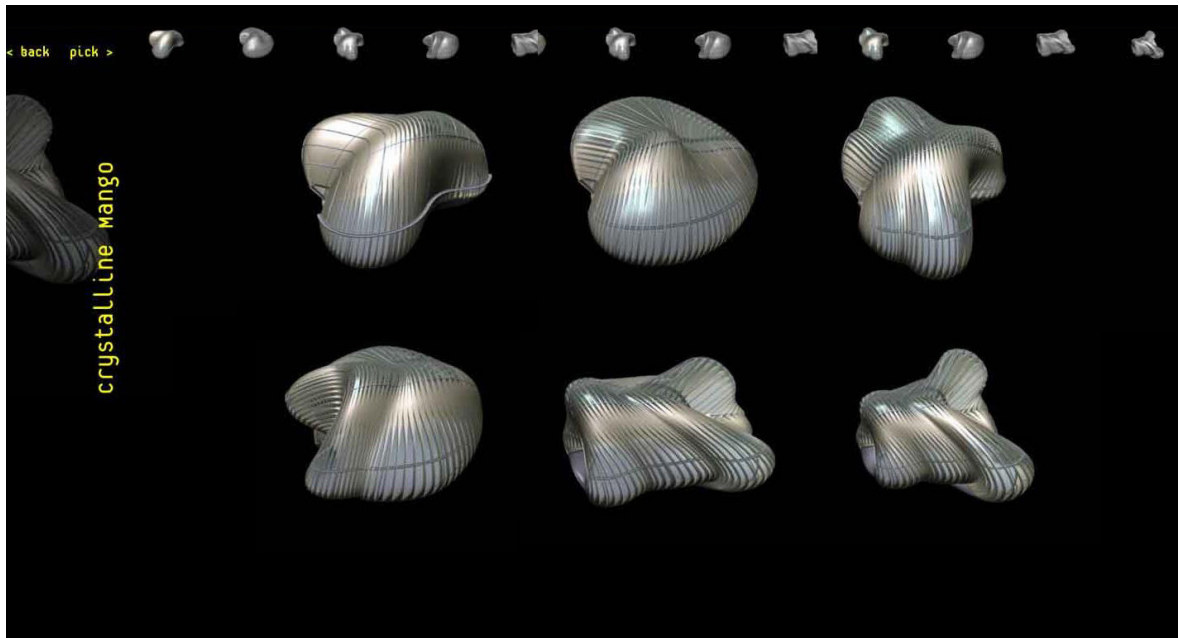


Fig 7 *Embryological House*, still frame from the animation showing the design process, Greg Lynn FORM, 1998-1999, courtesy Greg Lynn FORM.



Fig 8 *X Phylum*, -Z rule-set lofted splines in perspective (left) & frontal elevation (right), Karl Chu, fonds, 1999, courtesy Karl Chu

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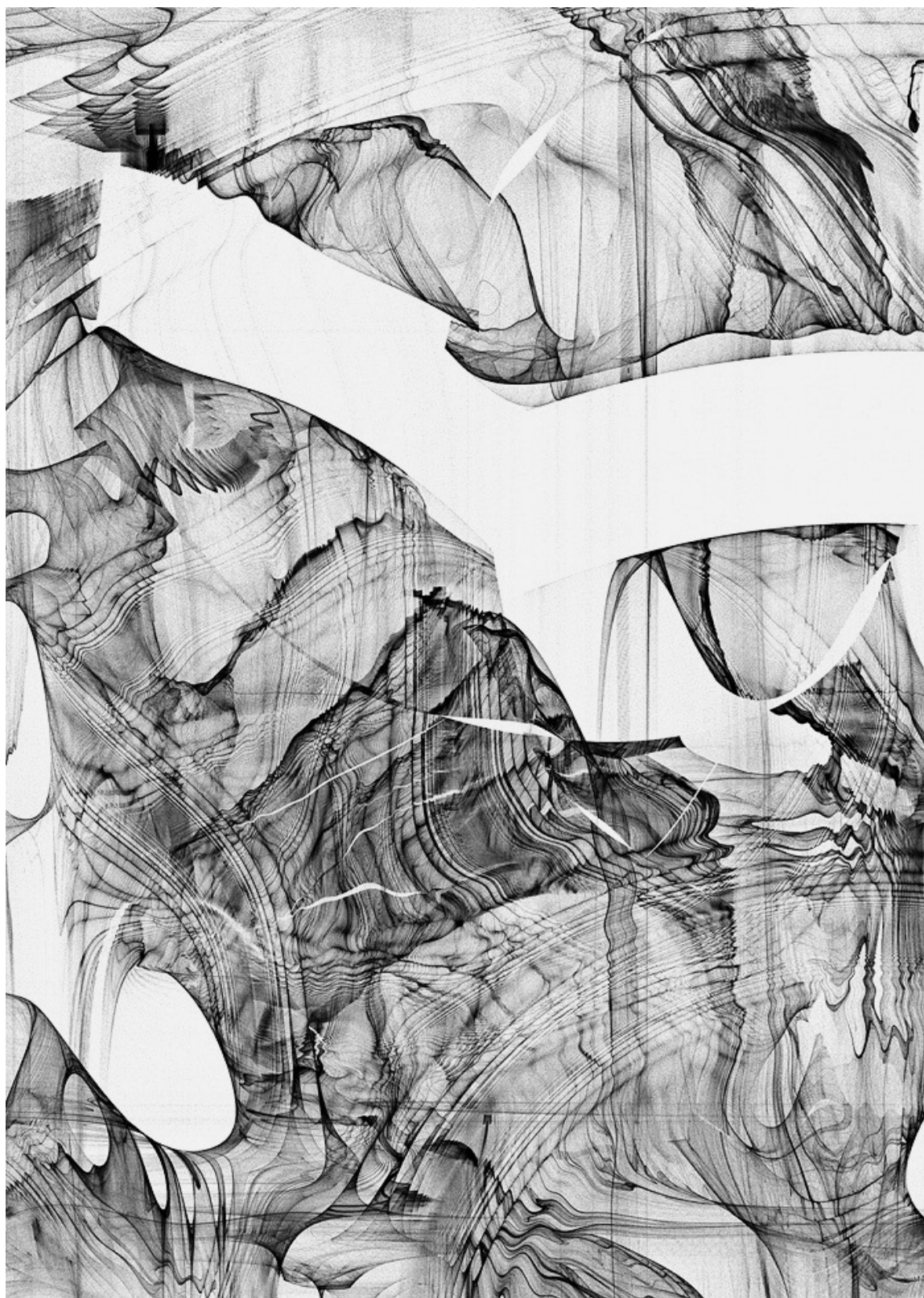


Fig 9 K456_P54_G001, Dextro, 2004, courtesy SPAN



Fig 10 PS1 MOMA, Xefirotarch, Herman Diaz Alonso, 2005, courtesy Xefirotarch



Fig 11 Composite Swarm, Kokkugia/Roland Snooks, Melbourne, AU, 2013, courtesy Kokkugia/Roland Snooks



Fig 12 Dark Markets Conference Poster, Public Netbase / t0, courtesy Public Netbase / t0



Fig 13 *BLOOM*, Alisa Andrasek and Jose Sanchez, London, UK, 2012, courtesy Peter Edwards

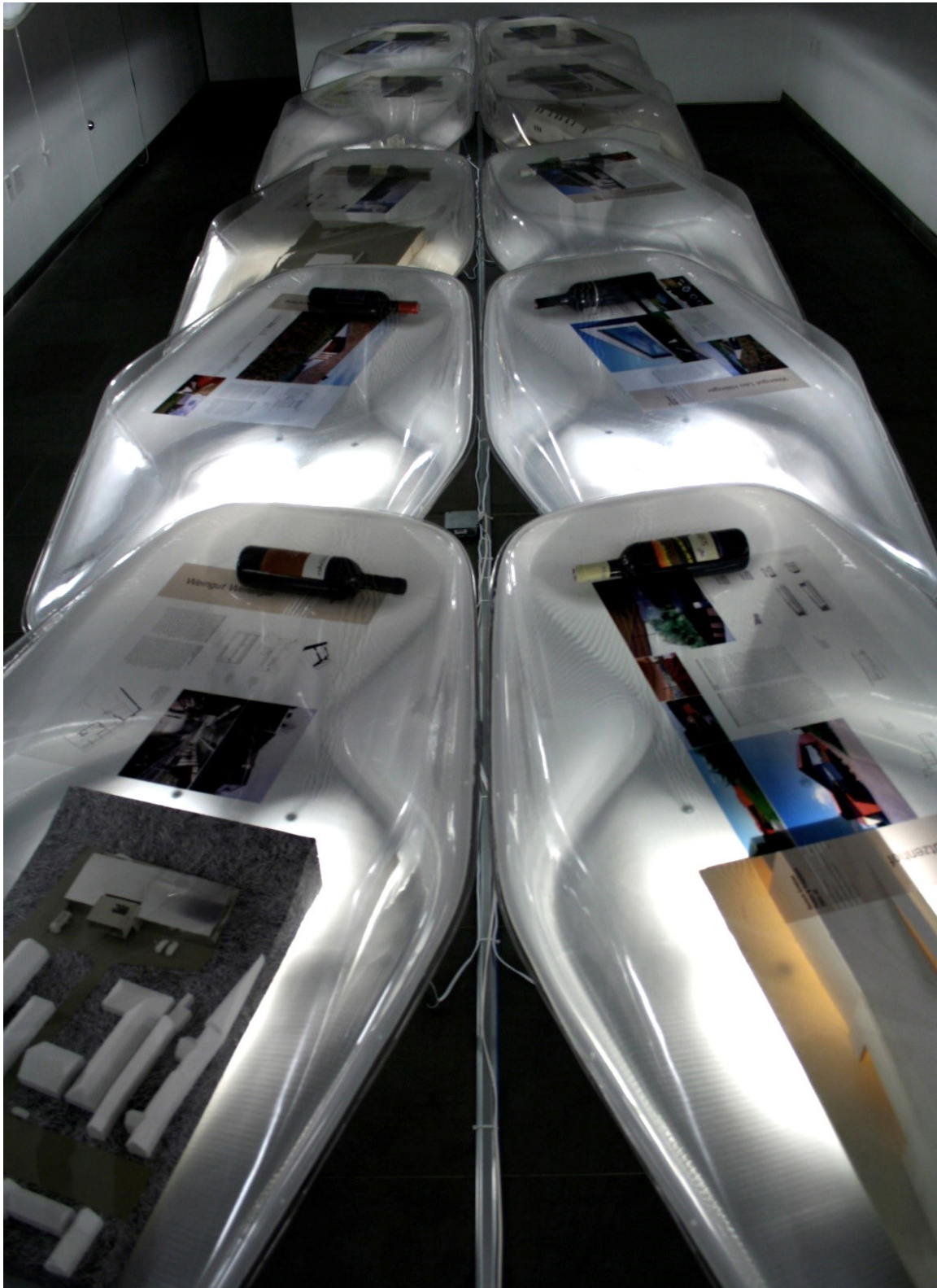


Fig 14 *The Austrian Winery Boom*, travelling exhibition design, SPAN2007.

View at the show at the Austrian Cultural Forum in New York in 2007. A family of three different topological pods constitute the assembly.

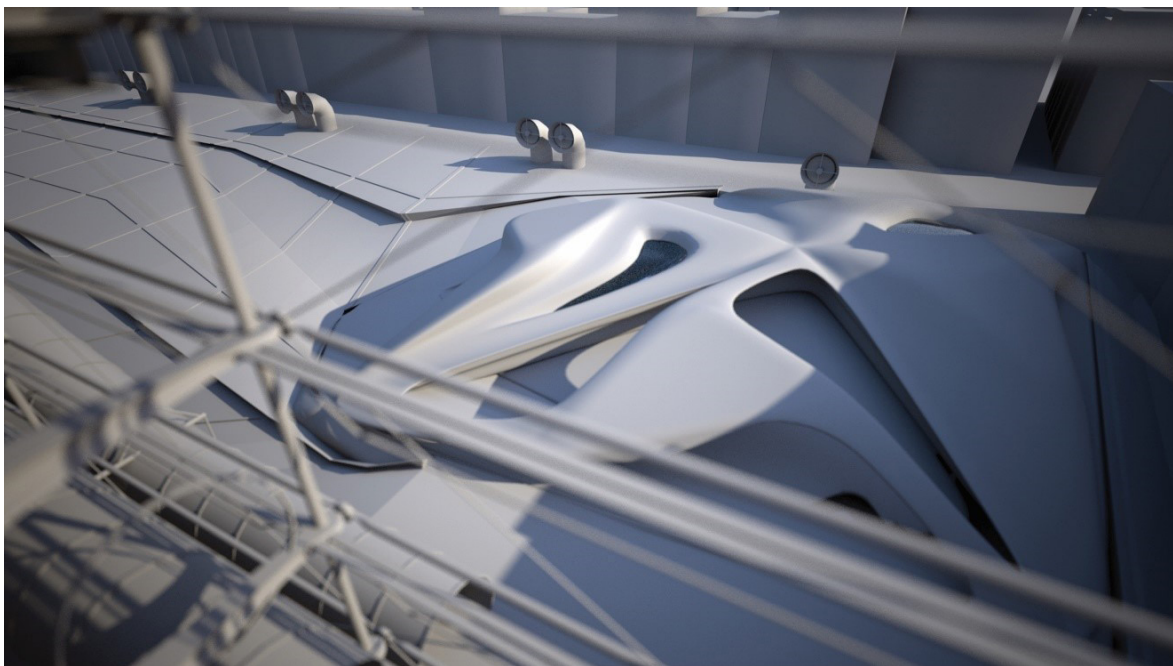


Fig 15 *Brancusi Museum*, top view render, winning competition entry, Paris, FR, SPAN 2008.
Rigorous examination on the architectural opportunities in complex topological bodies and into the construction methods applied to double curved surfaces.



Fig 16 *Austrian Pavillion*, corner view, Shanghai Expo 2010, Shanghai, CN, SPAN 2010.



Fig 17 *Formations*, solo exhibition at the MAK (Austrian Museum of Applied Arts) Vienna, AT, SPAN2011.

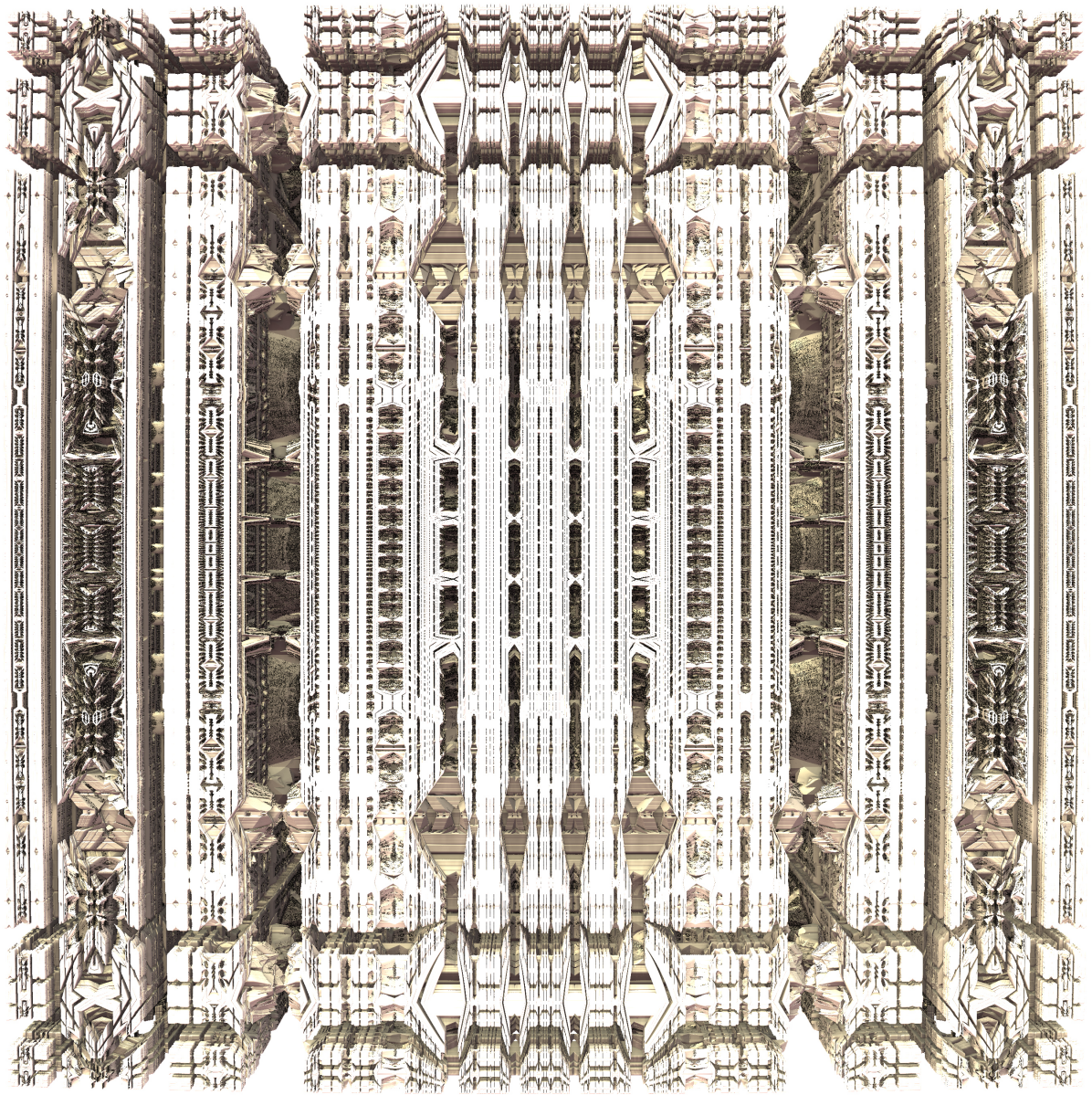


Fig 18 ABoxVSShapeIt01 from the series *Blocks*, render, SPAN2016.

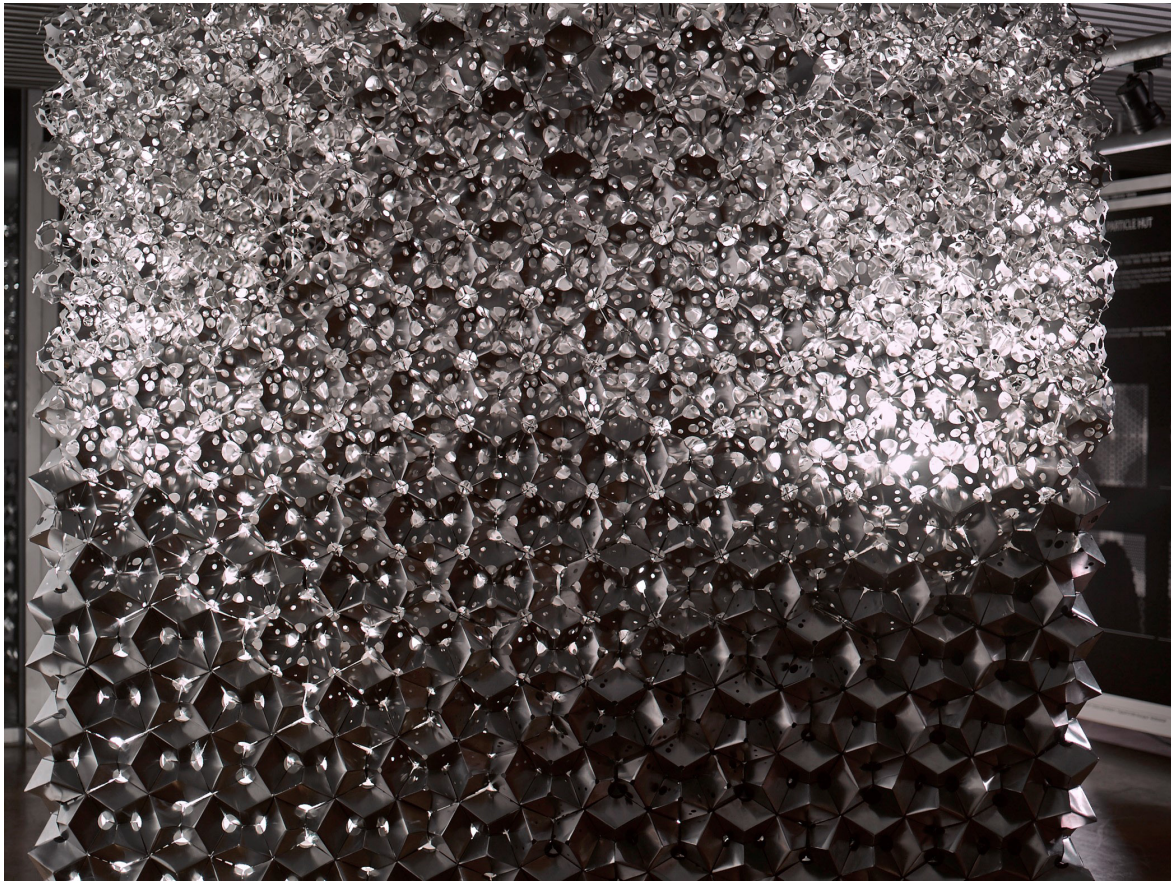


Fig 19 *Particle Hut*, photo of the exhibition at Tongji University, Shanghai, CN, SPAN2016.

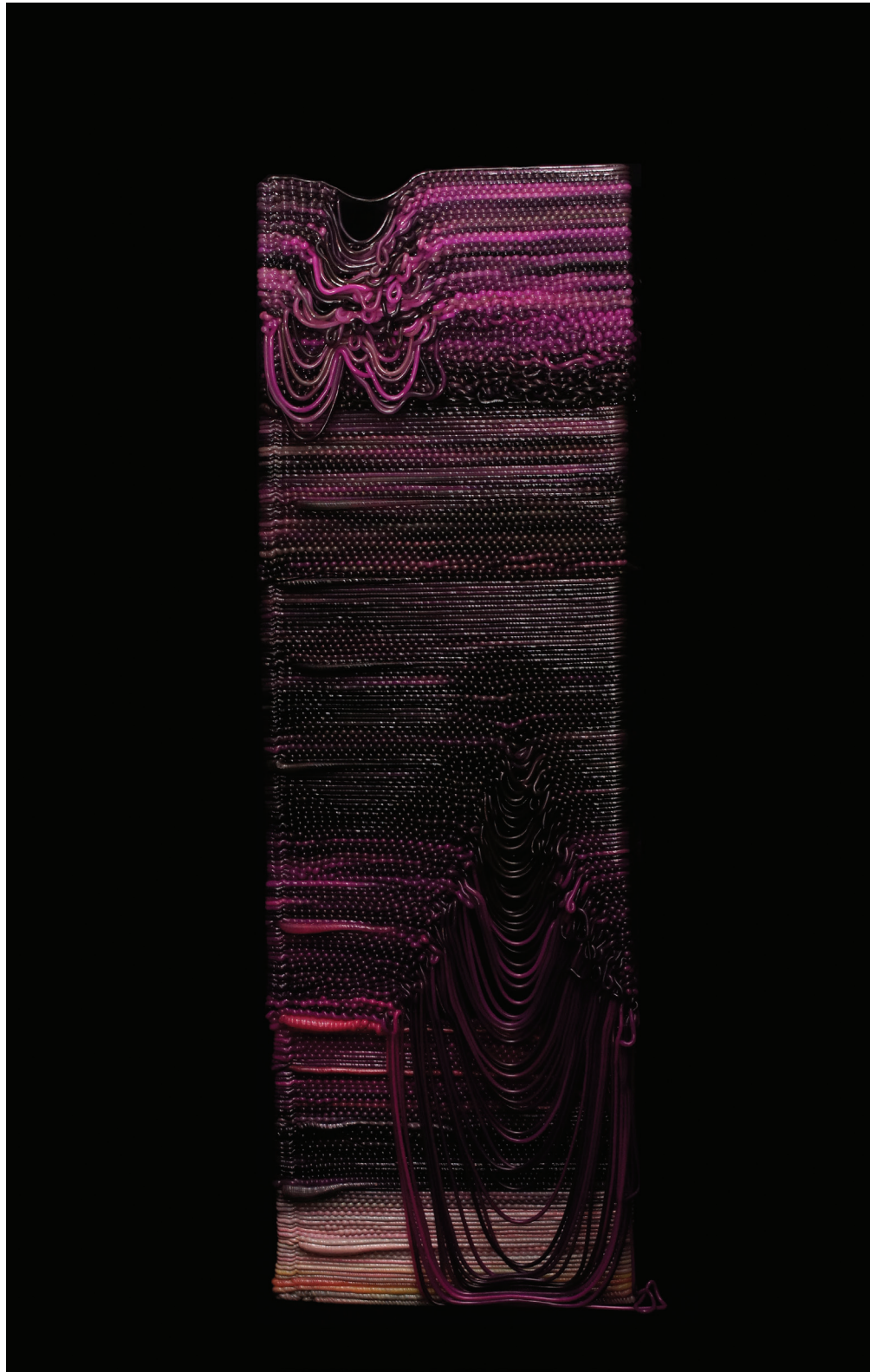


Fig 20 *Plato's Columns*, result from the *Disobedience* Advanced Architecture Studio, Summer 2016 RMIT, Melbourne, AU with students David Fitoussi, Joel Lok, Joshua Lye, Mary Spyropoulos, courtesy RMIT with Joshua Lye

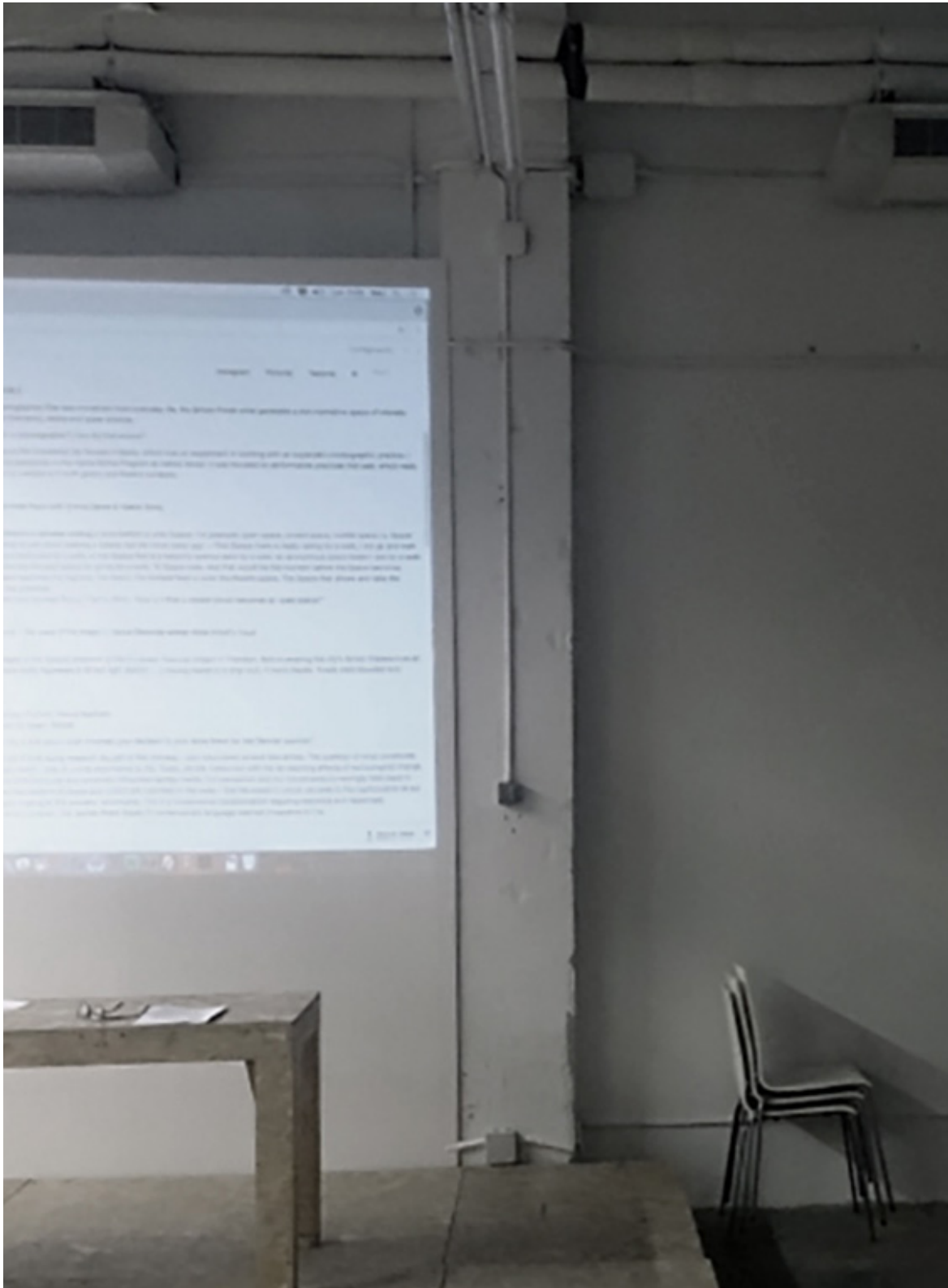


Fig 21 Detail view of the Presentation space at the BAU Design College of Barcelona, Barcelona, ES, courtesy PRS.

Methodology

In this section I will lay out the various presentations conducted in the course of the research on this dissertation and the conclusions made in regards of the presented work.

In my first PRS presentation I concentrated my efforts to explicate the work of my practice SPAN, continuing the candidacy proposal. I presented the recent interrogations of recursive geometries exemplified with the animations of SPAN's solo exhibition Formations in the MAK, the Museum of Applied Arts in Vienna. I presented these animations also to show one of the main tools of critical interrogation in my practice. Ever since our stay with the MAK Schindler Scholarship in Los Angeles, animations have become crucial in the examination of potentialities. In a way they constitute one part of what both Matias and I describe as abstract machines: An object or thing that incorporates a series of potentialities, vague but precise, unspecific but with the potentiality to become specific. Another branch of research I showed was aspects of autonomous automation in the use of robotic setups in the practice. This was in particular illustrated with the research done at Taubman College at the University of Michigan with their robotic setup. Abstract machines have become a major technique in our work as method to launch particular research trajectories. This technique of creating objects as the base of interrogation and examination differs profoundly from techniques used by our peers and constitute an important part of our contribution to the discipline. Patrik Schumacher described our work once as *abstract*.

PRS 2: 29.11.2015 Barcelona (Spain) MSt © PM, VM, JB

I started my second PRS presentation by emphasizing the importance of aspects of design sensibility in the work of SPAN, and how those are shaped and defined by aspects of geometry. I laid out the four main trajectories of architectural geometry: Euclidian, Cartesian, calculus and recursion, of which the later two have shaped the oeuvre of our practice extensively. Those two were examined and interrogated in various scales.

I continued by describing to the jury one major aspect of the work in the practice, which is the development of specific design ecologies. These describe how several parts and pieces are interlocking in a computational design environment. No more compartmentalization of problems which are treated in a sequential fashion, but rather a simultaneous tackling of various aspects at the same time, which are able to create instant information feedback loops. Like in music, where the sound of an instrument can create feedback in the speakers, producing something that is bigger than the sums of its parts. Drilling deeper into the problem I revealed how these techniques of a design ecology do not only affect aspects of the computational models but also the methodologies and strategies of fabrication. To illustrate this notion I showed the exhibition design

Housing in Vienna which was commissioned by the Az W (Architekturzentrum Wien [Austrian museum of architecture]) in Vienna in 2007. This project serves as a proof of concept in which the aspects of geometry are tightly woven into its properties as a physical object i.e. that the various limitations became part of the intrinsic qualities of the design. From the demands by the client to create a lightweight, easy to assemble exhibition design, to the small budget. I illustrated in this PRS presentation how the various limiting aspects turned into inspirations for the project, e.g. the folding of details into the surface. The exhibition pods consisted of three elements that had to be connected to each other with zip ties. However, the thin PET plastic surfaces are prone to ripping and damage in the points of perforation, where the zip ties were supposed to go. In order to distribute the stresses more evenly, so I decided to include a volcano shaped ring around the perforation points, which was included in the vacuum formed continuous surface. This allowed to connect the elements of the pods with each other, without risking damage through the stresses put on the surface. This solution turned out to be very successful, and in its entire time as a traveling exhibition there was no damage to the connection points. The Az W commissioned another batch of the same pods for an extended version of the show. The geometrical aspect of the show was profoundly shaped by its underlying rule set. The geometry the show was based on is called a Cairo tessellation. This tessellation allows for various different setups, which was necessary to adapt the show to a series of different environments. Another specific property of the design was the surface articulation. The fabrication artifacts of the CNC milling were kept in order to achieve a rippled surface in the vacuum forming process. This is an instance of an emergent pattern rather than a designed ornamentation of the surface. The information of the surface is achieved through fabrication rather than top down design approach.

I concluded my presentation by discussing one specific aspect of the design of the Austrian Pavilion at the Shanghai Expo 2010. Moving on from the scale of an exhibition design to the scale of a building the question was for us how can we achieve a continuous surface in the scale of a building. The solution was in the application of a small-scale tiling. In the beginning of the research of the problem our employees were looking into scripting the entirety of the covering of the pavilions tile by tile. This turned out to be a futile exercise for two reasons, the amount of data necessary to calculate the hundred of thousands of tiles involved, and the naïve assumption that the precision of the computational model would match the precision on the construction site. My experience, being educated in a construction high school, immediately told me that this would not work. I created a diagram for one of our briefings in the office to explain to our crew that we need to find another approach. Finally Matias came up with an elegant, very simple Grasshopper²² script that solved the problem by taking into account that the tiles are delivered glued on nets, with a dimension of ca. 50 x 50 cm. This, in combination of gradient of color that went from 100 % white to 100 % red in five

22Grasshopper is a graphical algorithm editor tightly integrated with the 3D modeling software Rhino.

different mixes allowed to create a more feasible model for the façade of the Austrian Pavilion. This in detail description of how a design ecology emerges in the practice concluded my presentation.

PRS 3: 23.04.2016 Ghent (Belgium) VM © RS, MSt, MH, AN

In my third PRS presentation, on April 23rd 2016 in Ghent, I focused on the two main geometrical trajectories that the work at SPAN has circumfenced: Topology and recursion. I stated in my presentation that my practice emphasizes the implementation of toolsets that just recently have been introduced to the discipline of architecture. Computational protocols that allow for the interrogation of spatial ideas beyond well established conventions of architectural design. This notion is paired with a deep interest in the historical lineage of the discipline, allowing for surprising and novel discoveries within the body of work. In my presentation I first addressed the way how SPAN developed the first successful topological model during our stay in Los Angeles with the MAK Schindler Scholarship.²³ This computational model was also instantly materialized with the help of Ed Tacket of the Saddlebag College in Mission Viejo, California. This has become a habit within the work of our practice that the work on computational models is accompanied by an instant speculation on the fabrication methods that can be applied to them. The advantage of a topological model lies in its ability to seamlessly connect the interior with the exterior as well as by creating continuous spatial solutions. The inherent topological quality of the model relied on the opportunity to create fenestrations and openings, without violently punching holes into the body, but rather utilize the inherent geometrical properties to introduce apertures in the geometry. Only two years after the creation of this abstract machine model I had the opportunity to realize this concept in full scale. The close relationship of the model and the proposal for the Austrian Pavilion for the Shanghai Expo 2010 is evident. The pavilion also demarcates a line between the topological research and the recursive research. At the time we started to become interested in the work of Benoit Mandelbrot. Especially because of newly available software that elevated the algorithms that Mandelbrot had developed in the early 1970s, from a purely two dimensional exercise to an almost three dimensional world. It became possible to explore complex fractal algorithms in 3D. Right at that time, in 2011, the University of Graz invited SPAN to contribute to a conversation on the density of cities. This was the first instance where I showed some of our recursion experiments. In the same year we got invited by the MAK, the Museum of Applied Arts in Vienna, to show our first solo exhibition. When the MAK invites an architect (other solo exhibitors included Lebbeus Woods, Xefirotarch (Hernan Diaz Alonso), Asymptote, FOA [Foreign Office Architects] and Greg Lynn Form) they insist that the architect has to design a specific installation or environment instead of presenting the body of work. The exhibition was titled Formations, and showed for the first time in large scale and for a bigger audience

23The Schindler Scholarship is a yearly grant provided by the Austrian Federal Chancellery in cooperation with the MAK – Austrian Museum of Applied Arts Vienna, for a six months residency at the Mackey Apartments, Los Angeles. For more information visit https://www.mak.at/schindler_scholarship.

the research conducted at SPAN on recursive geometries. The interesting property of recursion is that the algorithms themselves are quite simple, but that the continuous repetition produces complexity. I concluded my presentation by showing some of the work in progress such as the Pavilions at the Shanghai Fashion Week and the work on 3D printing concrete without a mold. I also announced our research stay at CERN,²⁴ where I would have the opportunity to talk to scientists about symmetry and the LHC Beauty experiment.

PRS 4: 27.11.2016 London (UK) VM © RS, MSt, MH, AN

In my PRS presentation on November 27th 2016 in the University of Westminster London, I made a case for the research in my dissertation on the specificities of geometry in the work of my practice SPAN. Emphasizing the qualities of geometrical interrogation and creating a specific historical lineage. To illustrate this I relied on the example of the Italian mathematician Virgilio Spada who was one of Francesco Borromini's collaborators in the construction of the villa Pamphili²⁵. In general the 17th and 18th century considered architecture an exercise in applied mathematics. I used the content page of my dissertation document to recount piece by piece the progress made throughout the research on my PhD, putting emphasis on more recent developments such as the work on 3D printed concrete, embracing the glitch as a possible source of inspiration and critically interrogating the role of the robot in the process of generating form independently from a preconceived, computational generated, form. Another example presented to the jury, that evidenced the claim, is the results of my studio at RMIT, which dealt with the relationship between specific figuration and vague fabrication. The fabrication setup for this studio consisted of a KUKA R60, and a large-scale Bohle extrusion head. The large end effector allowed for a fast progress in the fabrication process. Another main aspect of this studio was the interrogation of color. The pellet based container for the extrusion head allowed to mix different colored pellets, producing a plethora of chromatic effects in the resulting objects.

In conclusion I laid out the further trajectory of my dissertation, laying a focus on the geometrical aspects of the oeuvre of SPAN, and the methodologies developed in the practice to transform an abstract machine into a viable, comprehensive architectural project through the use of geometrical transformations.

PRS 5: 29.04.2017 Barcelona (SPAIN) PM © TK, SV

In my fifth PRS presentation I recapitulated the statements posed in the previous presentations about the

24Cern (French: Conseil européen pour la recherche nucléaire) is a European research organization that operates the largest particle physics laboratory in the world. It was formed in 1954 with 20,000 scientist and its own campus in the City of Geneva, Switzerland. CERN has a long standing tradition involving artist to develop projects related to its research. This specific grant, however, was a very rare opportunity as it was the first time that architects were invited to propose a project.

25 Camerota, F. :Architecture and Science in Baroque Rome. The Mathematical Ornaments of Villa Pamphili, *Nuncius* 15(2) 2011: p.611 -p.638

intimate relationship between geometry and the sensibilities developed by my practice. I illustrated this by explicating point by point the content page of my dissertation document entitled *Atlas of Sensations*. The title takes reference to SPAN's interest to develop an entire array of possible machines, bodies and entities, all of which are understood as architectural devices able to convey and emanate atmospheric conditions. This is achieved by the application of novel design techniques which allow to control the geometry of articulated objects. I illustrated how the aspects of control over geometry as well as the behavior of failure – such as in the magnetically controlled concrete printing processes – infuse the final outcome with specific formal qualities. Qualities that range from the meticulously precise and highly controlled (such as in the design of the exhibition designs *The Austrian Winery Boom* and *Housing in Vienna*) to the entirely bottom up approach with the use of computer controlled fabrication tools (such as in the entire *Autonomous Tectonics* research – exemplified with my *Studio at RMIT* in 2017) These examples helped me to build an argument for an *Atlas of Sensations*. In the questions of the jury I clarified that the term sensations in my universe of understanding does not imply the spectacular but rather discusses the possibility to infuse a sensorial response in the observer. A possible emotional response that can reach from the indifferent to a visceral response.

PRS 6: 29.04.2017 Barcelona (SPAIN) PM © TK, SV

In my final PRS presentation I attempted to expand the idea of the *Atlas of Sensations*, explaining how an atlas contains geographical markers that help in the orientation of the user. An atlas can be constituted in a variety of different ways: It can be a collection of maps and charts that allow to navigate unfamiliar ground in a save way. It is a collection of cartographical information consisting of drawings densely infused with additional written information such as coordinates, prevailing wind information and detailed information on the geological composition of the topography. Atlas, of course, is the name of the mythical figure that shoulders the entirety of the world. An atlas can also consist of a collection of related objects, and was already inspiration in architecture for the cartography of discursive ground. Most famously in the *Atlas of Novel tectonics* by RUR Architecture DPC, Reiser & Umemoto.²⁶

An Atlas might be the most appropriate method to summarize the work of my practice SPAN, as it consists of a complex ecology, from industrial designs, to buildings, to speculative writings to video production and graphic design. This body of work needs to be charted to be navigated safely. I specifically decided to classify the designs according to their geometrical properties. Also for the reason that geometry not only affects the spatial solutions achieved by SPAN, but also flat, two dimensional patterns, animations and graphics. The two main blocks that I identifies are topological geometry and recursive geometry. In my proposition I try to

26 Reiser, Jesse and Nanako Umemoto, 2006. *Atlas of Novel Tectonics*. New York: Princeton Architectural Press.

identify this quality in several of the projects of SPAN and also date them in a specific chronological order to show the transition that happened in the practice in several crucial projects executed in a rather short amount of time.

Reflection on all PRS presentations

In retrospect I observe a specific progression within the charting of SPAN's projects and the specific trajectories that I was interested into exploring with this dissertation. Although my partner Matias del Campo and I always relied on the idea of creating blocks of work that relied on following rigorous design principles and ideas, there are specific physiognomy differences in the work. Like observing a family, the projects are clearly related in their sensibilities but are nonetheless quite individual in their expression. Through discussing these issue with the excellent juries it became quite apparent that I have to drill deeper into the core of the essence of our practice. By relying on specific geometrical principals, topology and recursion, I was able to define two specific blocks of work that together form an Atlas of Sensations. Considering the tradition of practice research I attempted to specify the contribution of our practice to the general knowledge of architecture. In the case of SPAN it is the combination of inherent sensibilities and the question wither it is possible to generate sensibilities that are outside the control of the designer. An emergent method of achieving sensibility – this idea aided the thought to be able to add knowledge to the cartography of a continent named architecture. There are still many white spots in this atlas. After the various conversations with the juries at the various PRS symposia, I consider this part of the result, as it also means that there is still room for discovery, something that I embrace.

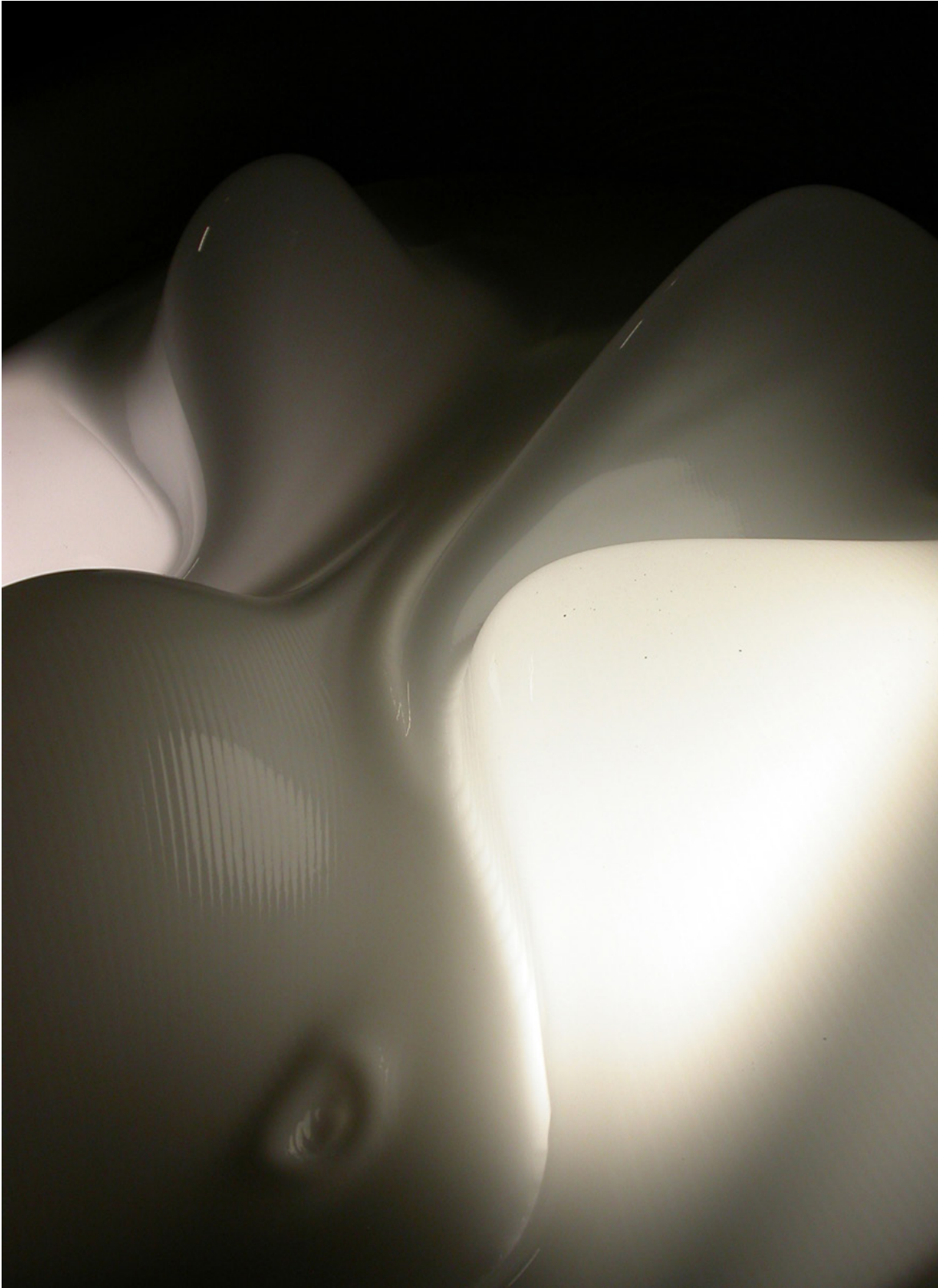


Fig 22 *Housing in Vienna*, travelling exhibition design, SPAN2008.

Sensibilities

The physiological spaces are multiple manifoldnesses of sensation. Mach, 1906²⁷

Sensibility in SPAN's universe of design thinking is defined by the ability to examine and interrogate potentialities for substantial architectural departments and morphological emergence within specific geometric figurations. SPAN's discussions and conversations on the aspects of sensibilities are contained within a multitude of ever so transforming design ecologies. The work in SPAN's practice as well as in academy is incorporating tools and instruments that have been just introduced to an architectural environment. The application of these tools provided the opportunity to develop design protocols and directives that might affect all stages of architectural production, from conceptualization to design, from fabrication to maintenance, creating SPAN's design ecologies.

During the stay in Los Angeles with the MAK Schindler Scholarship Program,²⁸ Matias del Campo and I conducted a series of interviews, one of which with Jason Payne, Associate Professor of Architecture at UCLA (University of California Los Angeles). In this interview Payne stated that 'if I'm lucky, I can develop one, maybe two sensibilities in my career as an architect'.²⁹ The matter of the development, discovery and refinement of sensibilities is crucial in the research projects of SPAN. Sensibilities emerge in the models described as abstract machines. Objects that do not possess specificity in terms of program or function but potentialities in terms of sensibility and aesthetics. The vague aspects, the inexact yet rigorous³⁰ geometrical properties of these models are reciprocal to its potentialities as architectural mean of expression. Or in the words of Jacques Derrida, discussing Husserl's ideas on geometry: 'For such a subject, the rigor of eidetic assertion (like that for determining vague essences) is not at all undermined by the necessary inexactitude of the perceived object. We must indeed beware of scientific naiv  , which causes this inexactitude of the object or concept to be considered as a "defect," as an inexactitude. Husserl writes ... : "The most perfect geometry and its most perfect practical control cannot help the descriptive scientific investigator of nature to express precisely (in exact geometrical concepts) that which in so plain, so understandable, and so entirely suitable a way he expresses in the words: notched, indented, lens-shaped, umbiliform, and the like - simple concepts which are essentially and not accidentally inexact, and are therefore also unmathematical.'³¹

27 Mach, Ernst, 1906. *Space and Geometry. In the Light of Physiological, Psychological and Physical inquiry.* Translated from German by Thomas J. McCormack. Reprint 2004. Mineola: Dover. p16.

28 The Schindler Scholarship is a yearly grant provided by the Austrian Federal Chancellery in cooperation with the MAK – Austrian Museum of Applied Arts Vienna, for a six months residency at the Mackey Apartments, Los Angeles. For more information visit https://www.mak.at/schindler_scholarship

29 Jason Payne, Associate Professor of Architecture at UCLA (University of California Los Angeles) and head of Hirsuta Architectural Design and Research, in an interview with SPAN in his office in Pasadena, CA on March 25th, 2006.

30 Lynn, Greg, 1993. *Architectural Curvilinearity: The Folded, the Pliant and the Supple.* *Architectural Design*, 102, p10.

31 Derrida, Jacques, 1989. *Edmund Husserl's Origin of Geometry: An Introduction.* Lincoln, University of Nebraska Press, p123.

Design Ecologies

Design ecologies emerged as a concept around 2006, during the stay in Los Angeles with the Schindler Scholarship program.³² The observation of the interdependencies of various creative ecologies such as the movie industry, the animation and gaming industry, the advanced fabrication industry, and the realm of architecture inspired to think about a model where these interdependencies collide at the scale of the practice. The idea of a design ecology describes a nonlinear way of approaching a project. Nonlinear in the sense that problems are not solved step by step, but very often ideas and solutions on different scales bounce back and forth on each other in a rather recursive fashion, both, in terms of geometry or program, as well as time, informing the project gradually in ever more details. The working through abstract machines, and the methodical exploration of its architectural properties sounds almost counter intuitive to the common methods of designing architecture which rely primarily on the gathering of intelligence and the implementation of these insights in a straight forward, rationalist design process.

Contemporary sensibilities can be described in a twofold way, part quantifiable special effect, partially non-quantifiable affect; the topic of sensibilities can be plotted on the charts of contemporary atmospheres.³³ These atmospheres, comprised of intensive forces that form the ground for the design, find their main trajectory, among others, on the grounds of proportions - and the distortion of those, chromatic effects, transparency, opalescence and the qualities of curvilinear bodies. The vocabulary of sensibilities is expanded or deformed by novel techniques which emerge through the thorough working on specific design problems. They are also affected by the continuous evolution of concepts, theories and discourse at large. For example: in more recent years an acute interest into the qualities of the glitch, the mishap and its abilities to induce moments of estrangement and defamiliarization into the atmosphere of a project emerged in the work of SPAN. Entering uncharted grounds, it is difficult, if not impossible, to predict the results of these explorations into the realms of sensibilities generated by digital environments and computer fed machineries.

In a way, sensibilities refer to an acute perception of or responsiveness toward something, such as the emotions of another. This concept emerged in eighteenth-century Britain and was closely associated with

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33 Mach, Ernst, 1906. *Space and Geometry: In the Light of Physiological, Psychological and Physical inquiry*. Translated from German by Thomas J. McCormack. Reprint 2004. Mineola: Dover. p16.

studies of sense and perception as the means through which knowledge is gathered³⁴. In this extent it should be considered as a plane of thought on the multitude of opportunities present in computational design to conceive emotionally responsive conditions generated by form and surface. This sensual affect of a surface condition can be described as a surface grammar, where the aspect of sensibility performs as a nonlinear way of perceiving intensive forces.

Over the years in practice SPAN has developed an acute interest in the combination of the conceptual project with the sensation project, which allows to interrogate primordial architectural problems, strange corners, deliquesce walls, flirting ceilings, firm symmetries, adventurous illuminations, a staccato of floors, hairpin columns and sublime naves, and all the intimate relationships between those objects, regardless of its scale.³⁵

Transformation of Sensibilities

Sensibilities in the work of SPAN are not defined by stability but rather are seen as a dynamic force - albeit slow moving. The morphological language of work clearly operates along the lines of geometrical rulesets that inform the design language, and the progression in the understanding of geometrical paradigms is evident in the progressively complex body of work. Complex in this trajectory of thinking should not be confused with complicated or difficult but rather addresses aspects of levels of information in the form, the relation to its surroundings, itself, and other objects and subjects. Or as put so well by the physicist Ernst Mach: 'It might be said that sensible space consists of a system of graduated feelings evoked by the sensory organs, which, while it would not exist without the sense-impressions arising from these organs, yet when aroused by the latter constitutes a sort of scale in which our sense-impressions are registered.'³⁶

I would like to highlight the change in the transformation of the practices sensibilities with two examples: The winning competition entry for the Brancusi Museum in Paris, 2008 [Fig 41, Fig 42] and the Formations exhibition in the MAK, the Museum of Applied Arts in Vienna Austria, 2011 [Fig 17]. The works are distinctively different, but also possess strong relationships in the undercurrent stream of desires. It is clear that both projects are related in their ambition to explore novel architectural opportunities. The Brancusi Museum relies heavily on the use of topological mesh modeling as driving force in the design

34 Mach, Ernst, 1906. *Space and Geometry: In the Light of Physiological, Psychological and Physical inquiry*. Translated from German by Thomas J. McCormack. Reprint 2004. Mineola: Dover. p16.

35 Ibid.

36 Ibid.

process. The smooth curvilinear language is rigorously explored throughout the entire project, and clearly displays its geometric considerations and properties. The continuous path from outside to inside, the gradient transitions, not only spatial but also in terms of coloration, show a thorough consideration of the spatial and superficial effects applied to the project. However it still follows along the lines of a modern desire for the clean, unornamented, surface. Three years later, this specific consideration is transformed into the exploration of recursive geometries. The language changed from the smooth continuous surface to the jagged, fragmented and endless repetition of ever so slightly changing recursive geometries. It represented a clear transformation in the language of the generated sensibilities, which was also immediately embraced.

In this extent it can be stated that this exhibition and the work that emerged from this trajectory of thinking can be considered SPAN's most unique contribution to the architectural discourse and the discipline at large. A successor of the work was also on show at the Archilab 9, Naturalizing Architecture, at the FRAC museum in Orleans in 2013.³⁷ The year that coincides with the end of the first digital age, as postulated by Mario Carpo in his book *The Digital Turn in Architecture 1992 – 2012*,³⁸ and the beginning of a novel chapter of computational design in architecture, wither this will be called the postdigital age or not is for historians to define. However for the sake of simplicity the term postdigital is utilized to position the current work of SPAN within a critical frame of thinking about recent architecture conditions and tendencies. Mario Carpo himself discusses the time as the second digital turn and perceives the shift from the first to the second digital turn in architecture as a shift from a sinuous and streamlined to a messy, disjointed, fuzzy, filamentous or at times excessively and weirdly figural aesthetics.³⁹

The term postdigital emerged in the digital arts discourse around the year 2000 and was coined by the musician Kim Cascone specifically in regards of glitches in digital technology as source of inspiration. Kim Cascone, an electronic music composer by trade used the term postdigital for the first time in his article *The Aesthetics of Failure: Post-digital Tendencies in the Contemporary Computer Music*.⁴⁰ In this article Cascone observes that as digital technologies have become part of the mainstream world and are deeply entangled in everything from commerce, to Hollywood 'cranking out digital fluff by the gigabyte' the initial fascination

37 Archilab 2013 - Naturalizing Architecture exhibition

Archilab was launched in 1999. The prerogative of this event is to be a laboratory for architecture, presenting the most advanced research in terms of architectural creation on each occasion. Curated by its founders, Marie-Ange Brayer, Director of FRAC Centre and Frédéric Migayrou, Deputy Director of the Centre Pompidou, MNAM-CCI, this new event 'Naturaliser l'architecture' (Naturalizing Architecture) is devoted to the interaction between digital architecture and the sciences, exploring the challenges faced in simulating the living world. from the web page http://www.frac-centre.fr/_en/archilab-492.html, captured on Jan 21, 2018.

38 Carpo, Mario, 2017. *The Second Digital Turn: Design beyond Intelligence*. Cambridge: The MIT Press.

39 Carpo, Mario, 2016. *Excessive Resolution*. In *Architectural Design*, 224, London: Wiley, p80.

40 Cascone, Kim, 2000. *The Aesthetics of Failure: 'Post-Digital' Tendencies in Contemporary Computer Music*. The MIT Press *Computer Music Journal* 24, p12-18

of designers with the digital tools per se has evaporated and made place for novel developments which do not utilize technological terms to describe the work but rather interrogate the errors and mishaps in the process as potential sources of inspiration.

Obviously, this shift in aesthetic is triggered by a variety of factors. The question is: How does this shift in the conception of architecture imprint the generated designs and by extension the matrix these objects construct? To further investigate this question the work focuses on one part of the practice's design ecologies: Geometries.

In contrast to sensibilities, design ecologies in SPAN's case refer to the methodologies that are developed through the loop of generating and cognizing objects. The focus of this work therefore is on the conception and generation rather than on the cognition and perception of the presented objects and results.

Decision making processes

Matias del Campo and I founded SPAN in 2003 in Vienna. One might think that we met at university but that is not the case. We both have quite different educational backgrounds, me graduating from the Technical University with an average of 600- 1000 students enrolling per annum out of which approximately 10% graduated, Matias del Campo studying at the University of Applied Arts, with a master class system and low student numbers. But this is not the only difference. I once asked my partner how he internally visualizes a project when starting to develop a design. His answer was that he would see shapes and forms rather quickly, he would envision the overall form and shape. When he asked me the same question, my answer was that I had a more cinematic approach to conceiving a project. I would see activity that was happening in the spaces to be designed. I would have a rather fragmentized vision, some very detailed others blurry but with the actual spatial interaction quite clear, focusing on movement, acoustics, and light. In our practice we have tried to fold these two divergent minds into a coherent and cohesive aesthetic, an aesthetic that has been developed and generated by two sets of lenses whose facets - hopefully - produce a sharper, more focused project to serve our clients, whether in academia or in the actual practice, as well as the public in general.

As laid out in the previous section design ecologies form the backbone of all decisions made in the practice, wither this may be morphological, morphogenetic, theoretical or pragmatic, they all contribute to the planning of a final material, and sometimes immaterial aggregation that represents the practice's thought trajectories.

I would like to start, in an almost chronological order with three small projects to describe the decision making processes, and then continue on to the larger projects.

The project Chex [Fig 29 and Fig 30] which was designed for the Crystal Vision Swarovski Designboom competition 2008 is a good example to show the relationship between design, geometrical properties and discursive considerations. The field resembles chess, but its field are not squares but hexagons. The game itself was invented by Edelbert Wiedman and was published in *Spektrum der Wissenschaften* in August 2007.⁴¹ The main difference between chess and chex is the philosophy behind it. If chess is a metaphor for the large armies of the middle ages battling each other in large open plains and the strategies to overcome an enemy by large scale tactics, then chex rather resembles the speed and mobility of small tactical units operating in an urban environment. Chex is certainly within the family of projects by SPAN that operate along the lines of geometrical rigor – in this case the hexagon – whilst deforming and perverting the figures of the chess/chex field until they become almost unrecognizable. Each of the game's figures in itself was the final iteration of a series of objects generated in Autodesk Maya.⁴² This entire genealogies of form are seldom visible, focusing on the result of this evolution rather than on the process, on the one that makes it onto the playing field. In most cases there is no documentation about this process, or how decisions were made which actually applies to most of SPAN's projects.

However there are very often specific technical criteria that need to be applied. In this case the main modeling technique, polygon modeling, deriving from one original model in TopMod.⁴³ The model was then brought into Autodesk Maya to generate families of the distinctive chex figures: Pawn, bishop, knight, rook, king and queen. In the process of making these genealogies there are often objects which disqualify themselves right away. Either because they are technically insufficient, for example they have too many inversed faces and would fail in digital fabrication, or because they do not comply with other criteria both practical or aesthetical. It is hard to define rational criteria to aesthetic decision making processes, if not impossible, as this relies so much on the eye of the designer.

The design for the exhibition *The Austrian Winery Boom* [Fig 14] and the design for *Housing in Vienna* [Fig 22, Fig 32- Fig 36] are two designs which were consecutively commissioned by the

41 Pöppe, Christoph, 2007. Schach auf dem Sechsecksbrett: Verkleinerte Mannschaften, ungewohntes Spielfeld, rasanteres Spiel. *Spektrum der Wissenschaft* August 2007, p98.

42 Autodesk Maya is a modelling, rendering, simulation, texturing, and animation tool originally developed by Alias Systems Corporation, which is mainly used in the film and game industry.

43 TopMod is a software developed in the visualization department of Texas A&M (Agricultural & Mechanical) University (ATM) by Prof. Ergun Akleman. The software was chosen then because of its immense repertoire of topological modeling possibilities, and especially through its capability to create surface thickness.

AzW (Architekturzentrum Wien [Austrian museum of architecture]). The Austrian Winery Boom was chronologically speaking the first of the two and was commissioned in spring 2007. The exhibition The Austrian Winery Boom was shown for the first time in the premises of the Architecture Center in 2005, the exhibition was designed then by Viola Stifter and Herwig Meier. The motivator of the AzW to conceive this exhibition was the boom in building new wineries or the remodeling and renewal of ancient ones that happened throughout the 1990s and the first years of the 21st century. This boom was triggered by three facts, the Austrian Wine scandal of the 1980s, the change in the generation of vintners to a younger generation, and the European community subsidizing the renewal of wineries. The show was curated by Martina Grabensteiner and Kerstin Gust. Our job was to turn this exhibition, its content including the graphic design by Susanne Krockner of LIGA, into a travelling show for a tour of the United States. We already had experience designing exhibitions, for example for the exhibition 5mio m3 Vienna, and the first edition of the exhibition Housing in Vienna, which we designed in 2004, but the criteria for a travelling exhibition are completely different. Several factors came into play: The reusing of existing graphic designs, the task to protect the glass wine bottles that accompanied every project on display, and the protection of the project's models. Additionally there are of course logistic considerations such as the weight of the exhibition, the volume that needs to be transported etc. A decision that was made almost in an instant was to design a vitrine system that would consist of several layers of information. A transparent top layer with the graphic printed directly on it, and an underlying layer that consisted of a mounting system for models and bottles. The idea was to convey as much information as possible without separating these elements like it is normally done in conventional exhibition designs. In conventional exhibitions you would divide these elements: The boards with plans etc on the wall, the models standing on plinths in the exhibition space. The concept of The Austrian Winery boom rather unified these elements. Vitrines in a conventional sense would have been too big to transport, especially considering that there were 60 projects on display. Not all projects had models, but all had one bottle of their respective wine. This triggered the decision to create a family of pods.

A conventional vitrine has six sides, of which the top and/or the sides is/are transparent. In order to build a cubic vitrine you need to connect six sides, screw boards with each other, or glue them etc. resulting in a lot of labor work. The family of pods, as described before, reduced and optimized the geometry of the vitrine. TopMod was used to generate the first initial models, which were then refined using Autodesk Maya. Maya was used to separate the upper and lower part of the models as well as to create the smoothness of the surface. Several attempts were necessary to find the right balance between the all-over hexagonal characteristic of the geometry and the right amount of curvature. By creating a hexagonal pod, that was separated diagonally, we could reduce the amount of elements or faces necessary to create a vitrine from six to two. Why a family of pods and not only one? This decision was made because not all of the projects had

models that needed protection, but all had bottles that needed to be protected from theft or breakage. The bottle became the defining size for the module of the pod. Three different sizes of pods were designed. One small pod for montage on the walls and two different sized pods standing on the floor. This of course had the consequence of thinking as of how these pods sit on the ground. A series of tests with various options, reaching from solid plinths, through porous plinths etc. finally revealed that thin metal legs could be an option. The legs in this case are actually legs of a very cheap IKEA chair. This remains the one and only example of some sort of upcycling in SPAN's work. The result was not very satisfying, thus the immediate abandonment of this mode of thinking. As we knew that this exhibition was supposed to go on tour, and we did not know which locations it would be shown in the decision was made to create an independent illumination system. Which was positioned between the translucent underside of the pod and a reflective panel that increased the light's output.

During the stay in Los Angeles observing how architects like Greg Lynn of Greg Lynn Form, Jason Payne of Hirsute and Marcelyn Gow, Ulrika Karlsson and then David Erdman of Servo were using the large vacuum forming facilities at the Warner Brothers studios to produce their installations were certainly a critical inspiration to solve the problem of producing light-weight, stackable vitrines for The Austrian Winery Boom travelling exhibition. Vienna doesn't have any large scale film production but it has workshops for theater and opera productions, which of course need large facilities to produce the settings, property, and backdrops for their performances. There is a large workshop in the Arsenal Vienna, that also contains a vacuum forming machine. Günther Dreger, a former student of Greg Lynn at the Angewandte, produced the molds for the vacuum forming process. They were CNC-milled out of foam in a negative mold then casted in a durable material so they could withstand repeated vacuum forming. One important aspect in the production of these pieces was the integration of the surface articulation that was an artefact of the production. The milling path imprinted in the surface was not smoothed over, but served two purposes: on the one side it created a corrugated surface in the vacuum forming process and by doing so increased the stability of the surface thus allowing for thinner panels that would decrease the weight for transportation. On the other hand it presents itself as an excellent example of machinic ornamentation. The hexagonal nature of the design allowed for various aggregations of pods. The idea of these families of hexagonal forms was also a decision reflecting the purpose as a travelling exhibition. Whereas normally an exhibition design asks for a project that fits the specific space, in this case that of a travelling exhibition the show needed to be an independent entity in every given environment. This was achieved through a flexible arrangement of elements, as well as through an independent illumination system. The exhibition was on show in the Austrian Cultural Forum in New York in 2007, in the MODAA in LA and the COPIA in Napa Valley, California USA in 2008.

Right after the design for the Austrian Winery Boom, SPAN was commissioned to design the exhibition *Housing in Vienna*. The criteria in this case were a little bit better than with *The Austrian Winery Boom* in that we were able to design the exhibition from beginning, there was no prior exhibition or graphic design we had to follow. Apart from the exhibition design we were also commissioned with the entire graphic design as well as the graphic design for the catalogue. It was the first opportunity for us to design an entire ecology. As with the Austrian Winery Boom we relied on the production of vacuum formed pods. The lessons learned from the Austrian Winery Boom were applied to this design. For example, and most visibly in the continuous material application, there are no metal legs anymore, rather the geometry of the pods themselves serve as support. The pods are divided into four components: A transparent top shell, which contained the project's description, a planar middle layer which occasionally served to show additional floors of the housing design on display, a bottom shell with bulging protrusions designed to support the planar middle layer, and the lower shell forming the feet of the pod. As with the Winery Boom exhibition we entirely relied on our own illumination concept for the *Housing in Vienna* show. The bulges between the lower two shells contained LED lights, which were concealed in the pods. In a continuation of the technique of the Winery Boom we utilized once more the milling artifacts as imprint into the vacuum formed shells in order to increase their stability. One of the benefits of these corrugated surfaces is the increased stability of the material. This allows to use thinner material in the vacuum forming process, reducing costs as well as environmental impact of the design. The aspects of corduroy surfaces were explored by Greg Lynn before us, but he observed it exclusively as a form of articulation on the surface based on the fabrication process.⁴⁴ The geometry of the pod was designed in plan as a component of a Cairo tessellation. This tessellation technique was selected as it provided the opportunity to create a continuous addition of pods in a high degree of variations. As with the Winery Boom exhibition the *Housing in Vienna* show was designed in an independent fashion, so it could operate within any exhibition space given. The Cairo tessellation allowed for high flexibility of agglomeration whilst fulfilling all the necessary criteria such as light weight, low transport volume and fast setting up. The setting up was possible in a very short time, a test set up of one pod at the workshop of the Az W was timed with under four minutes. The entire show could be set up in about a day, the pods themselves could be set up in a couple of hours, including their integrated illumination. What needed more time were panels that needed to be mounted on the walls. A lesson we certainly learned in the process of making this exhibition is to reduce the amount of elements that are mounted on walls if you design a traveling exhibition. In contrast to the Winery Boom this exhibition set up does not consist of a family of different pods, but rather just of one specific pod, that through aggregation is able to be configured in numerous different ways. One specific question when using this specifically curvilinear architectural language is in the assembly of com-

44 Leach, Neil, and David Turnbull and Chris Williams (Eds), 2004. *Digital Tectonics*. New Jersey: Wiley

ponents that form a figure. In this case we had three vacuum formed elements [Fig 36] plus one clear panel just below the top layer, per pod. The two top elements were clear the two bottom layers where opaque white [Fig 31]. Any mechanical connection with screws, washers etc, does not really work with this language. This became very clear in the Austrian Winery Boom exhibition design where the legs were attached with screws and washers to the vacuum formed plastic parts. In order to avoid this problem SPAN relied on the use of the same materiality for the connections as for the rest of the pod: PET plastic. Or to be more precise: the ever so trusty zip ties. However just perforating the shells and threading zip ties through this holes to connect them creates another problem: Stresses in the plastic that could lead to tearing and ripping of the plastic. The function of washers to distribute forces around a hole more evenly had to be replaced with something that operates with the continuous surface condition presented by these plastic shells. I came up with the idea that stresses could also be relieved and distributed by the form of the surface. Instead of adding a ring in the form of a washer that spreads the forces horizontally along the surface, a double curved bump in the surface could resolve the problem [Fig 22]. The design of this detail was very crucial for the success of the project. The bump was further deformed into something that resembles a very soft volcano. We called it stoma after the pores in leafs that allow for the exchange of carbon dioxide and oxygen in trees, as they are formally very similar. This solution held up very well over time, and even after several years on tour and several countries visited the pods still maintained their polished look. The exhibition premiered in the Palazzo Ca' Tron in Venice Italy during the Venice architecture Biennale 2008 [Fig 31, 32]. It went on to further stations such as Munich, Milan, Tallin, Zagreb and Ankara [Fig 33 - Fig 35].

One specific design technique came into major use with this project: The application of animation as a tool of evaluation and design progression. Animation became a big part of the research starting specifically after adding Maya into the tool sets of the design ecology. The animation of the topological models was first exhibited 2007 in the Exquisite Corpse II exhibition at IMNO Gallery, Los Angeles USA, as part of a group show with other MAK Schindler Scholarship fellows [Fig 38, Fig 40]. The capacities of animation to demonstrate the spatial qualities of a design, including the properties of selected materials was a big step forward. Starting with the built in Maya renderer a series of rendering engines were tested in the design process of the exhibition design. It also turned out to be an excellent tool to demonstrate not only qualities of a design to a customer but also the assembly of a project. For example we created an animation that showed the assembly of every single piece for the design of the Housing in Vienna exhibition. This animation helped enormously in securing the project for us. Decision making processes can rely on animation, on renderings but also on the 3D model itself. Both my partner Matias del Campo and myself got very accustomed to the continuous quick rotation and scaling in and out of a Maya model to observe and scrutinize every single angle, every nook and cranny of a design. Before I described the generation of genealogies in our files. Sometimes up to

100 interrelated models can populate one file – the only limit being the RAM (Random Access Memory) of the computer. Within these forests of models the instant ability to quickly check its interior as well as exterior qualities by zooming, panning and rotating around an object is a central part of the evaluation process. It is also crucial to be able to compare so many options side by side instead of in a sequential order. The problems of one model become instantly visible when put side by side with others out of the sequence. Decision making processes increase in speed because of the applied tool per se.





Fig 23 *Sensible Bodies* exhibition, FAB-Union gallery, Shanghai,CN, 2016

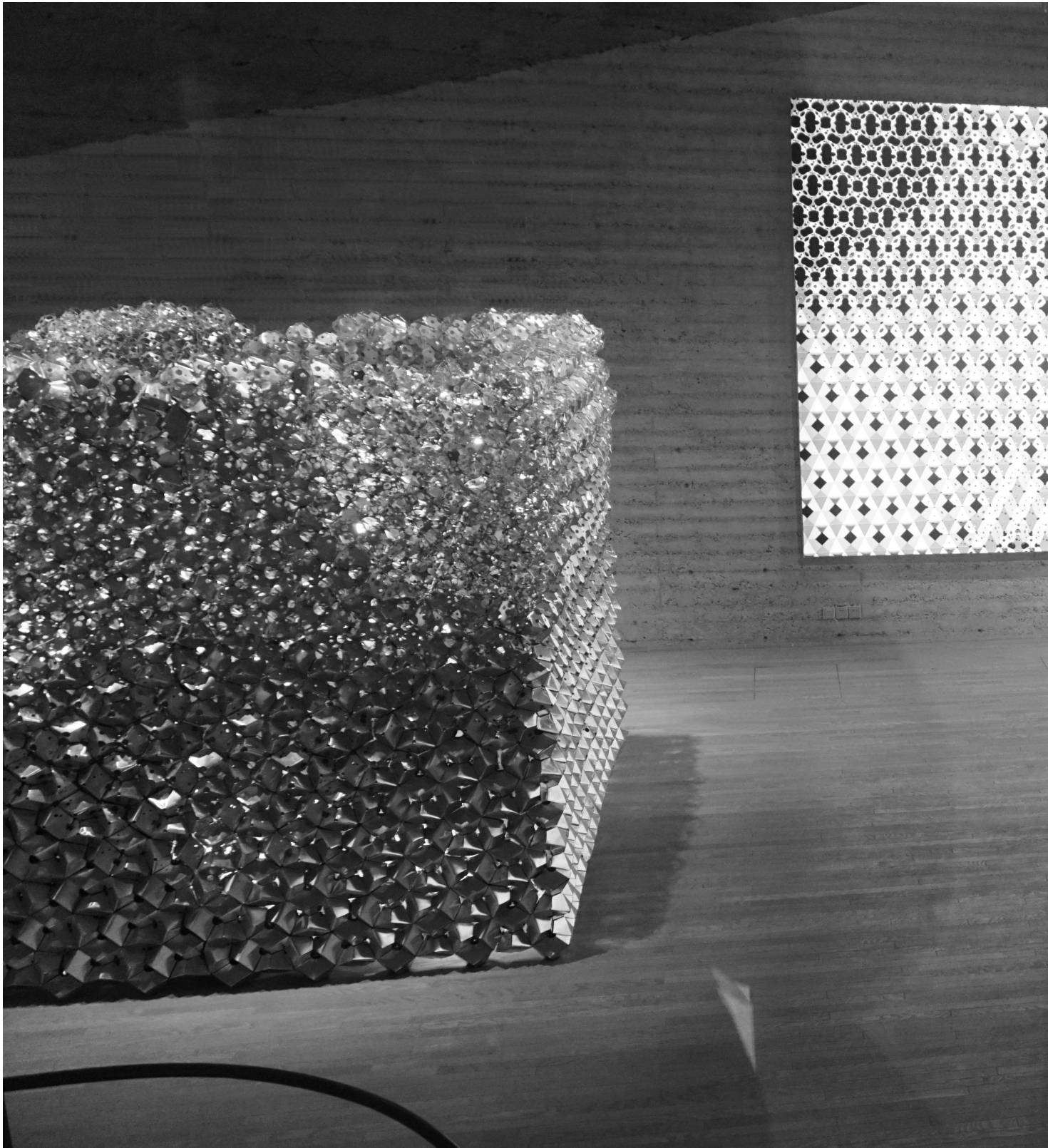




Fig 24 *Sensible Bodies* exhibition, view at the *Particle Hut*, FAB-Union gallery, Shanghai,CN, 2016



Fig 25 *Sensible Bodies* exhibition, view at the *Austrian Pavilion* and *Hawk table*, FAB-Union gallery, Shanghai,CN, 2016



Fig 26 *Sensible Bodies* exhibition, view at *Blocks*, FAB-Union gallery, Shanghai,CN, 2016



Fig 27 *Sensible Bodies* exhibition, view at *Blocks ABoxVSShapeIt01*, sectional analysis, print on acrylics, FAB-Union gallery, Shanghai, CN, 2016



Fig 28 *Sensible Bodies* exhibition, view at *Plato's Columns*, FAB-Union gallery, Shanghai,CN, 2016

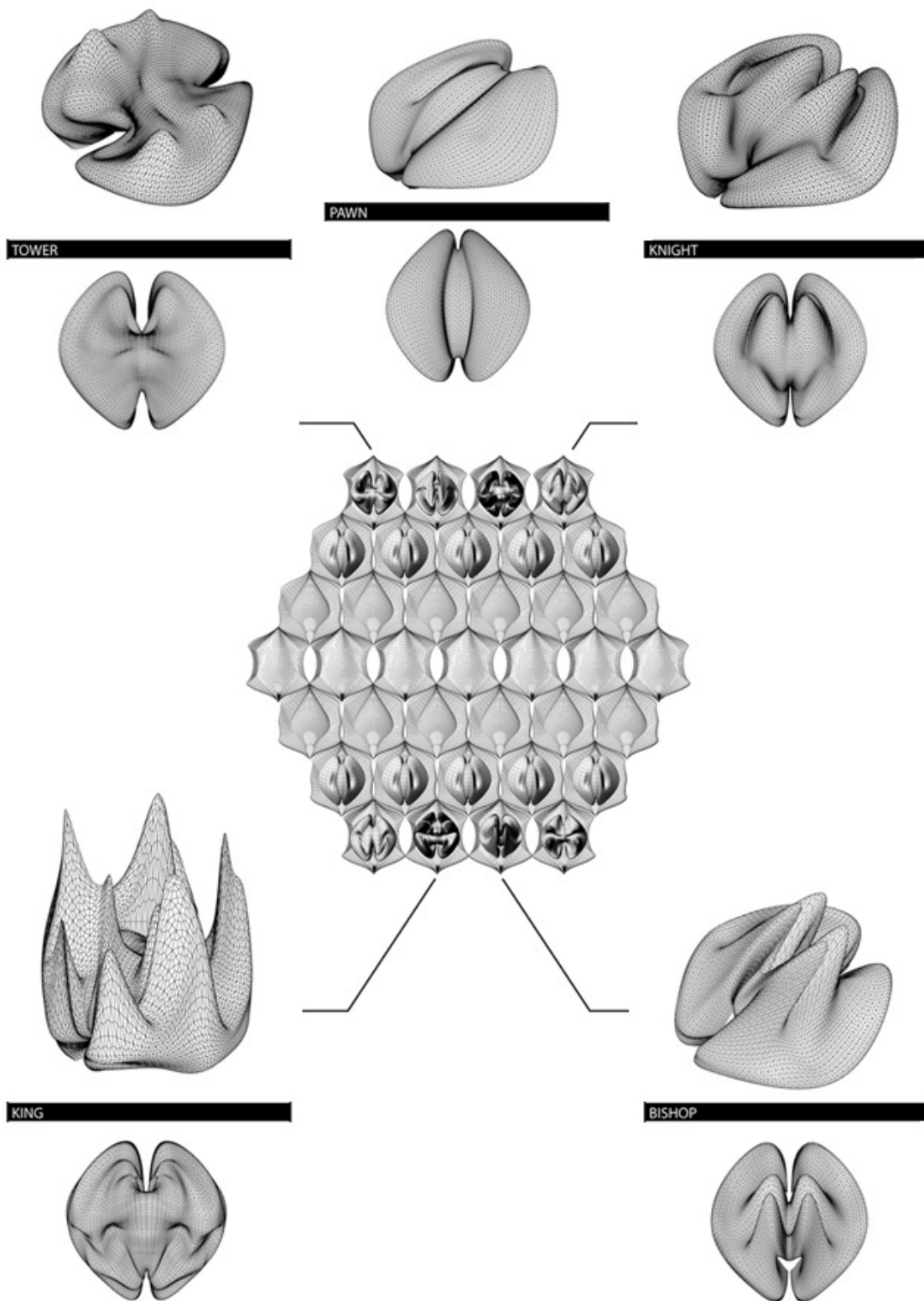


Fig 29 Chexs, Swarovsky competition, SPAN2008.

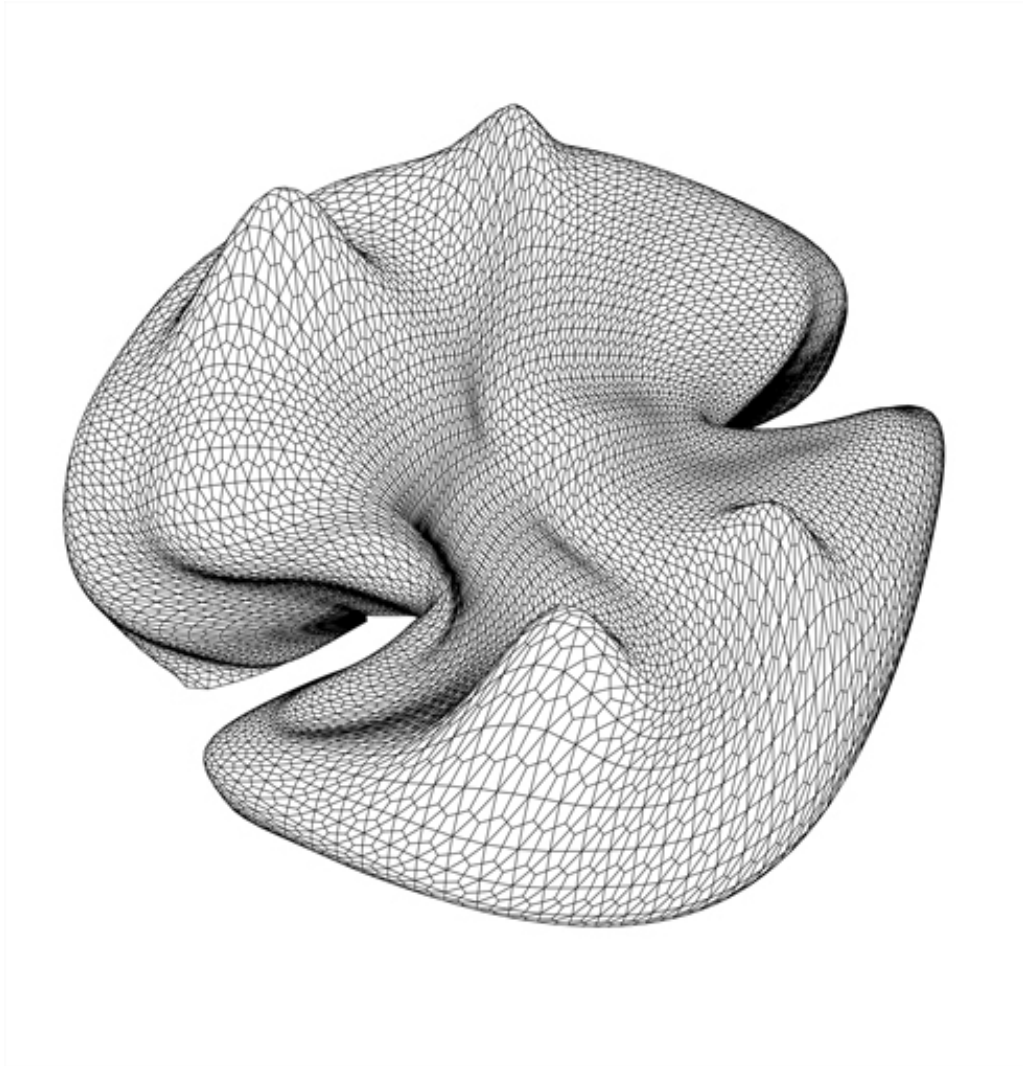


Fig 30 Chexs, Swarovsky competition, topological model of the Tower, SPAN2008.
The game Chex comprises of a hexagonal board bearing 37 hexagons that form the playfield of the Chess related game. The difference between Chess and Chex is the reduced amount of figures and the speed of the game.



Fig 31 *Housing in Vienna*, travelling exhibition design, SPAN2008.
View at the exhibition in the Ca' Tron, Venice, IT, during the Venice Architecture Biennale.
A Cairo tessellated aggregation of topological bodies allows for various different assemblies.

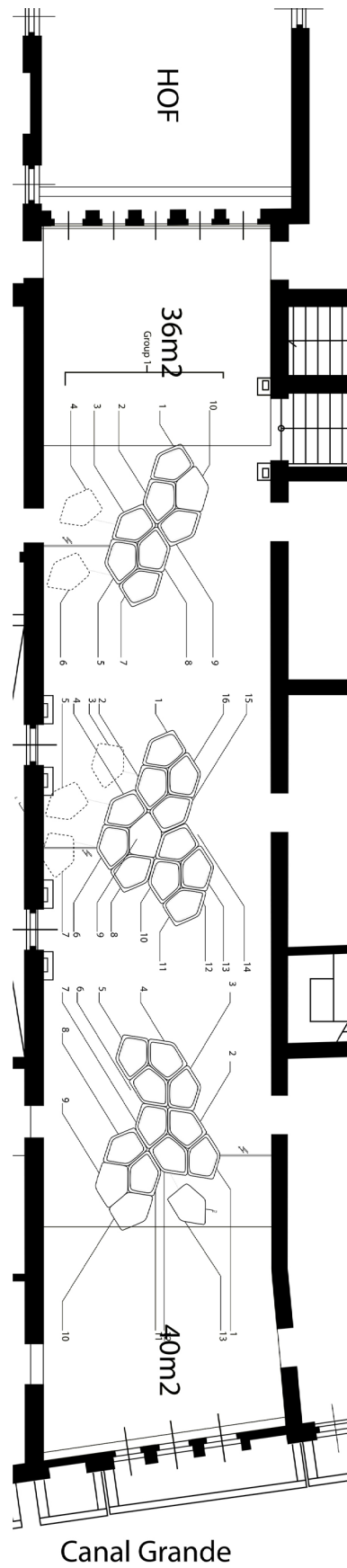


Fig 32 *Housing in Vienna*, travelling exhibition design, Ca'Tron, Venice, IT, SPAN2007

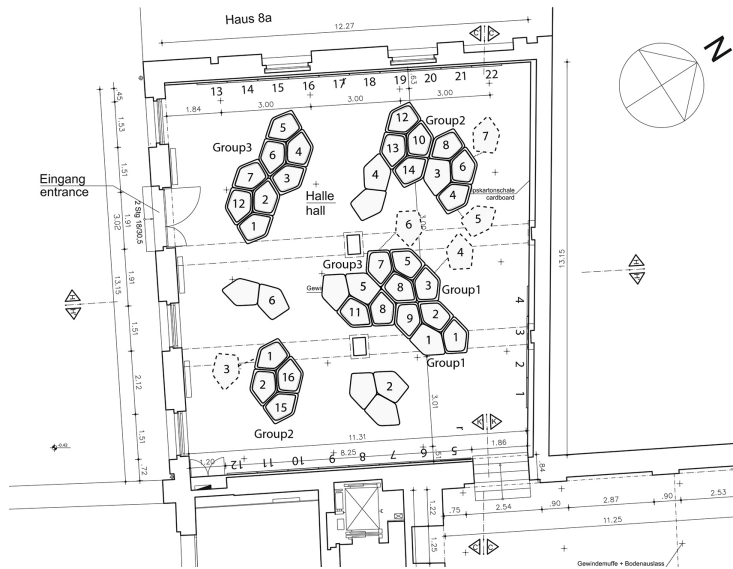


Fig 33 Housing in Vienna, travelling exhibition design, Galery Aedes, Berlin, GE, SPAN2008

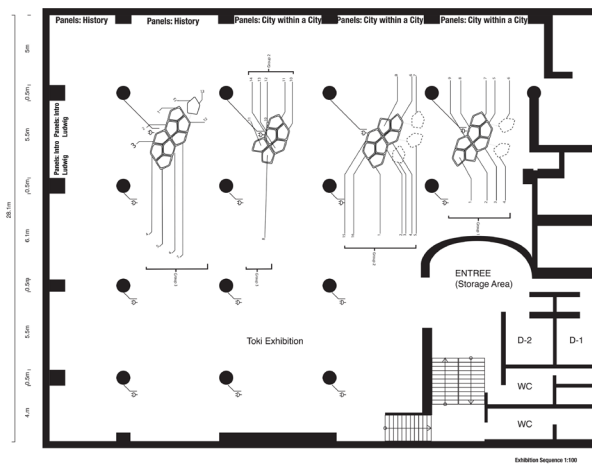


Fig 34 Housing in Vienna, travelling exhibition design, Ankara, TU, SPAN2008

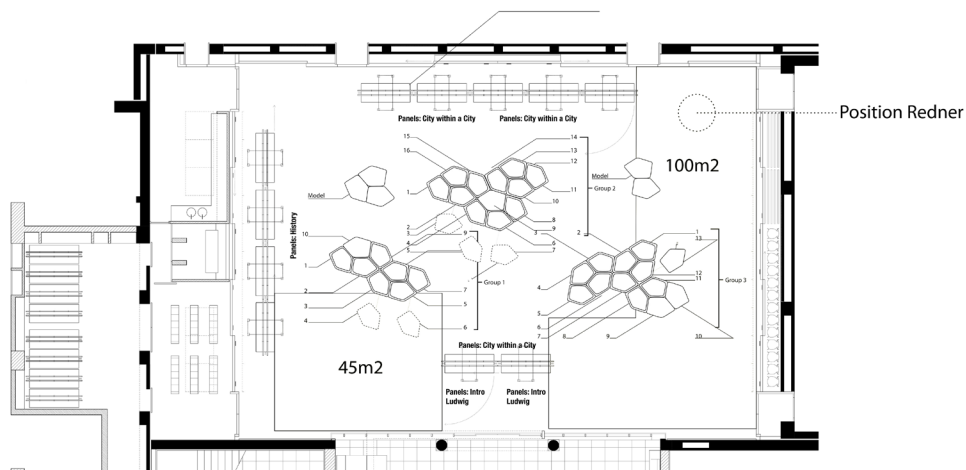


Fig 35 Housing in Vienna, travelling exhibition design, Napa, CA, SPAN2008.

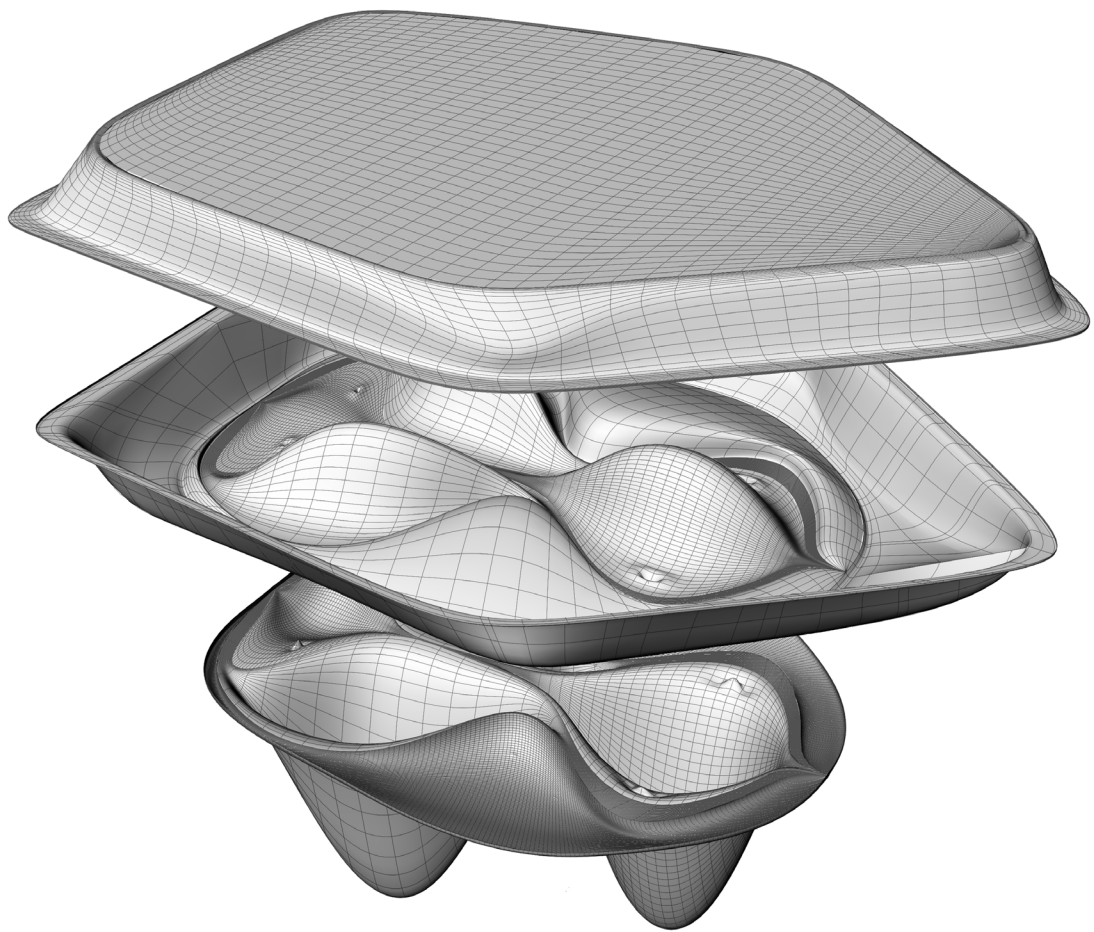


Fig 36 *Housing in Vienna*, travelling exhibition design, Pod perspective view, SPAN2007.

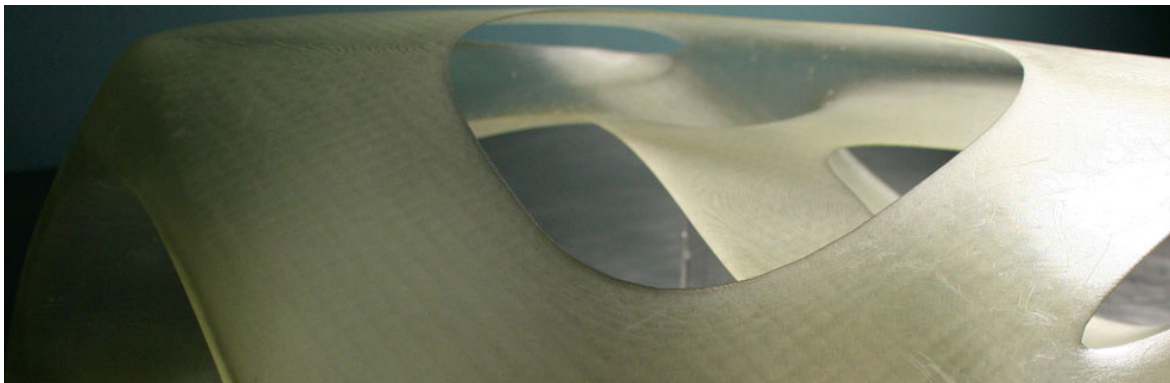
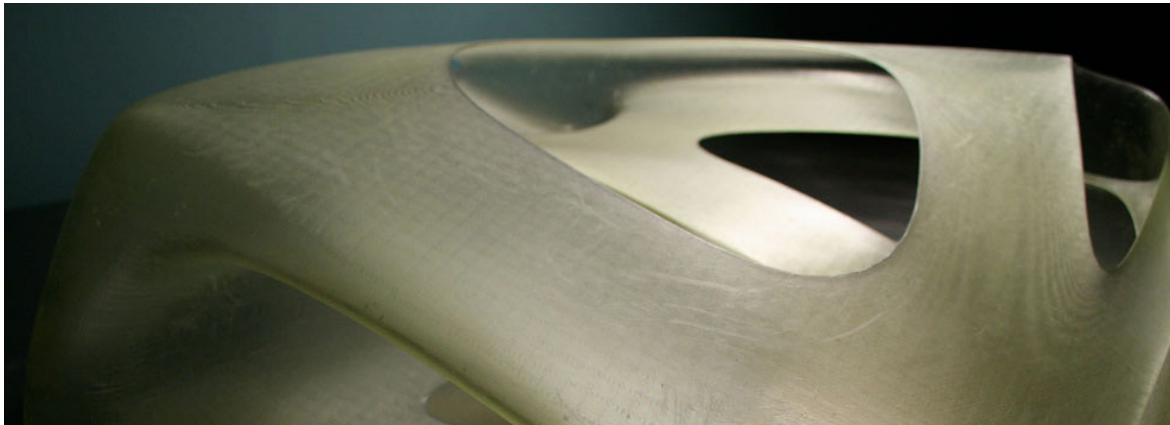


Fig 37 *Beautiful Corpse*, two detail views of the stereolithographic model, MAK Schindler House, Los Angeles, USA, SPAN2007.



Fig 38 *Topological Model*, stills from animated sequence, SPAN2007.

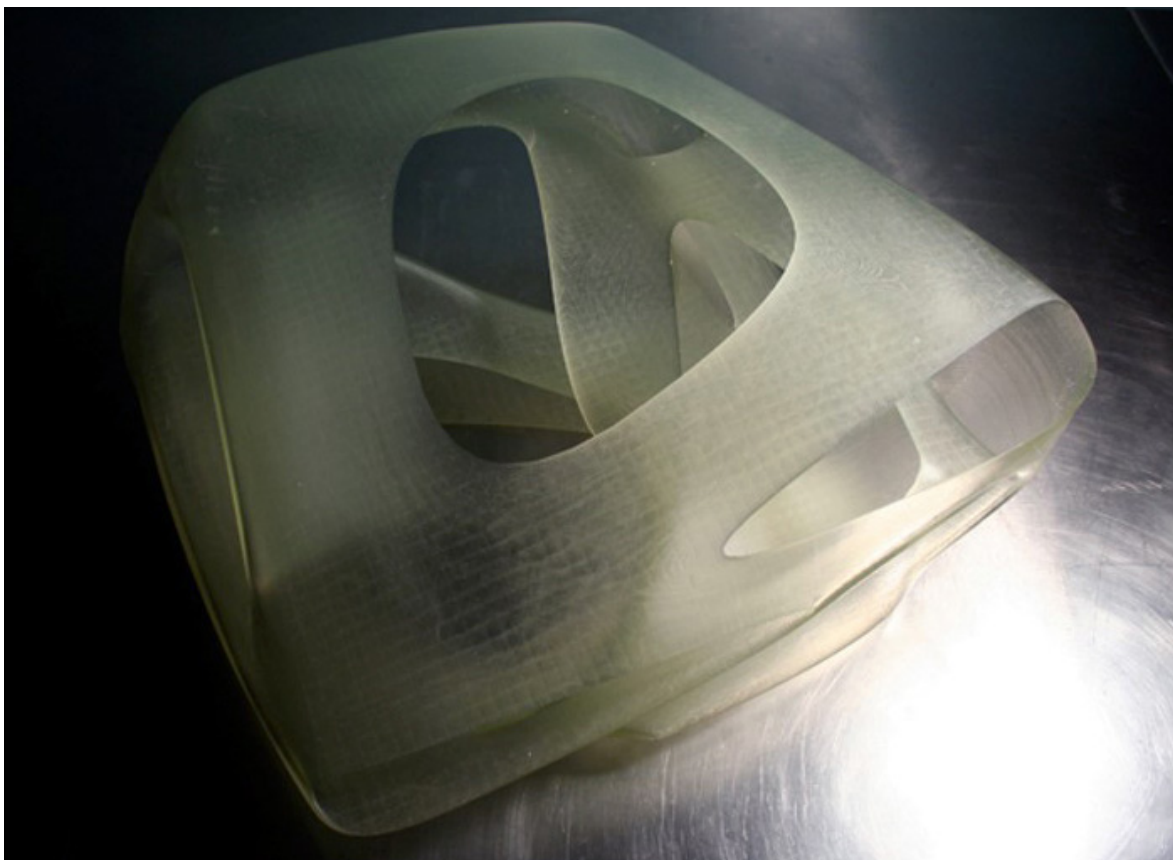


Fig 39 *Beautiful Corpse*, stereolithographic model, MAK Schindler House, Los Angeles, USA, SPAN2007.

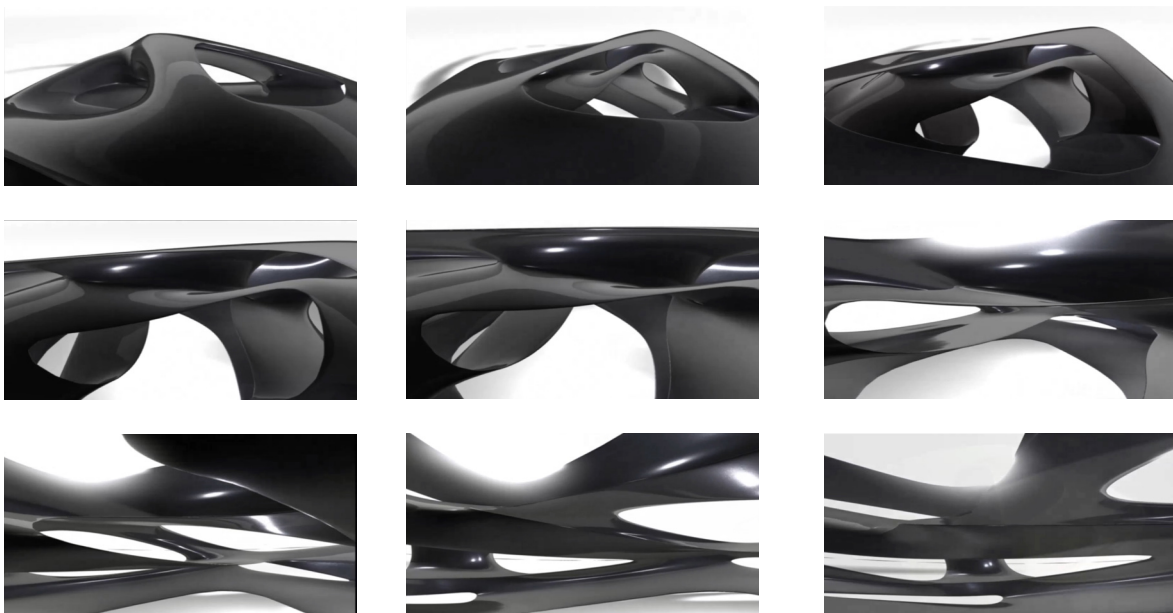
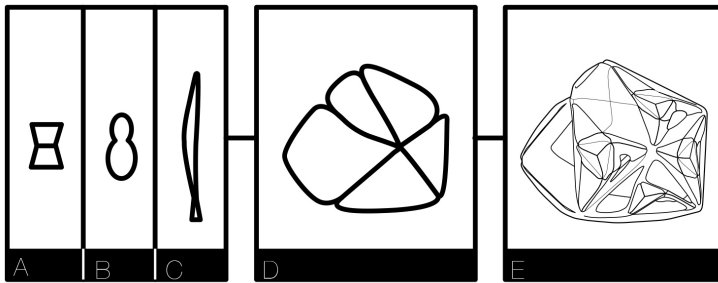


Fig 40 *Topological Model*, stills from animated sequence, SPAN2007.



Brancusi Museum, winning competition entry, Paris, FR, SPAN 2008.

Pictures A, B, and C depict abstract pictograms of three examples of constrictions found within Brancusi's body of work.

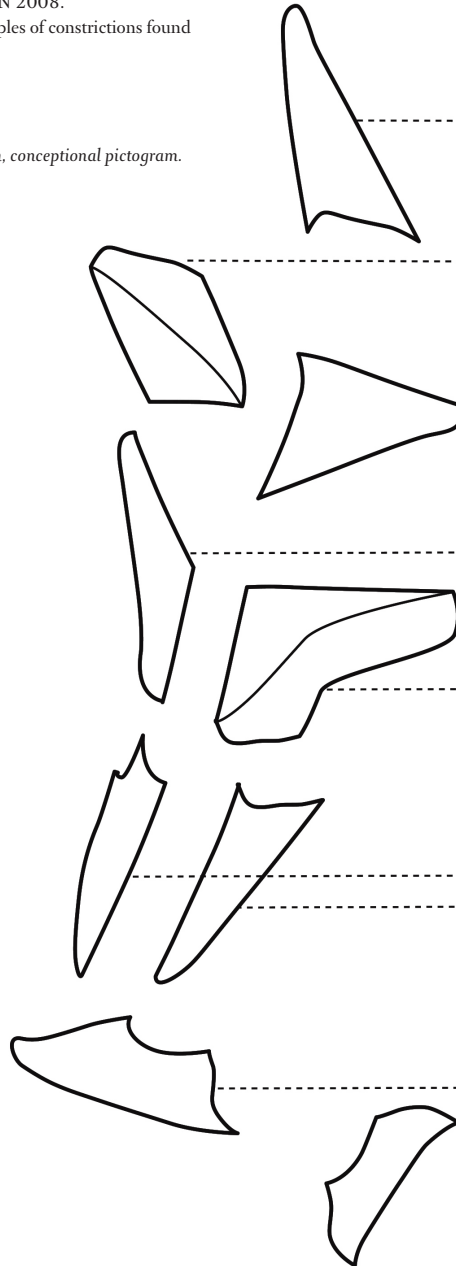
A: One component of the Endless Column

B: *La Negresse Blonde*

C: *Bird in Space*.

D: Constrictions applied as a morphogenic process in the design, conceptual pictogram.

E: Resulting geometry, top view.



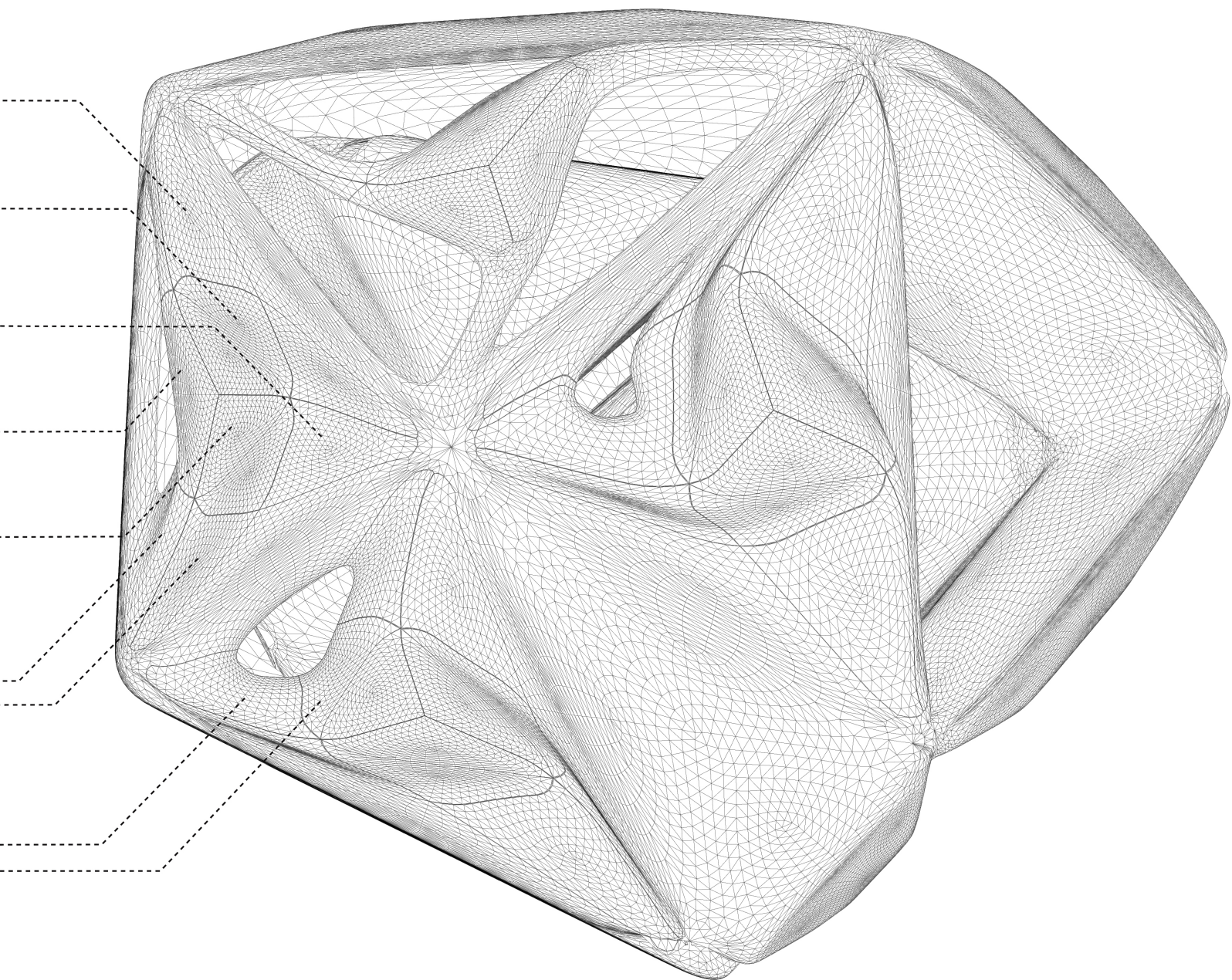


Fig 41 *Brancusi Museum*, winning competition entry, Paris, FR, SPAN 2008.
Model of the paneling systematics based on three types of geometric transformations found in Brancusi's sculptures.

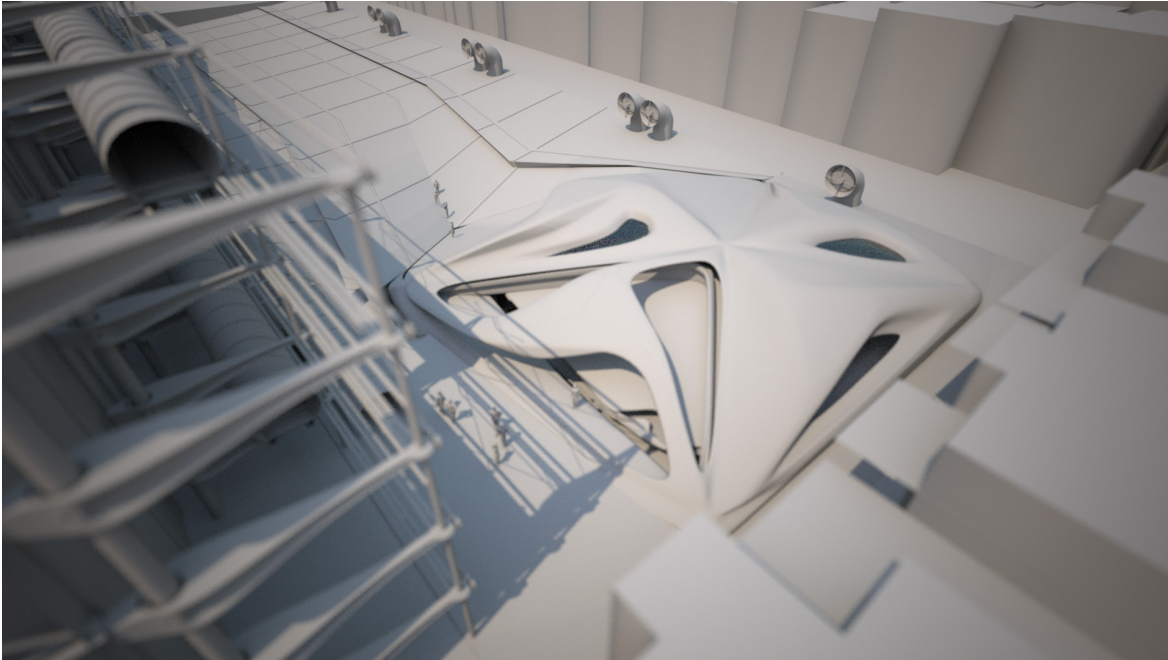


Fig 42 Brancusi Museum, top view render, winning competition entry, Paris, FR, SPAN 2008.

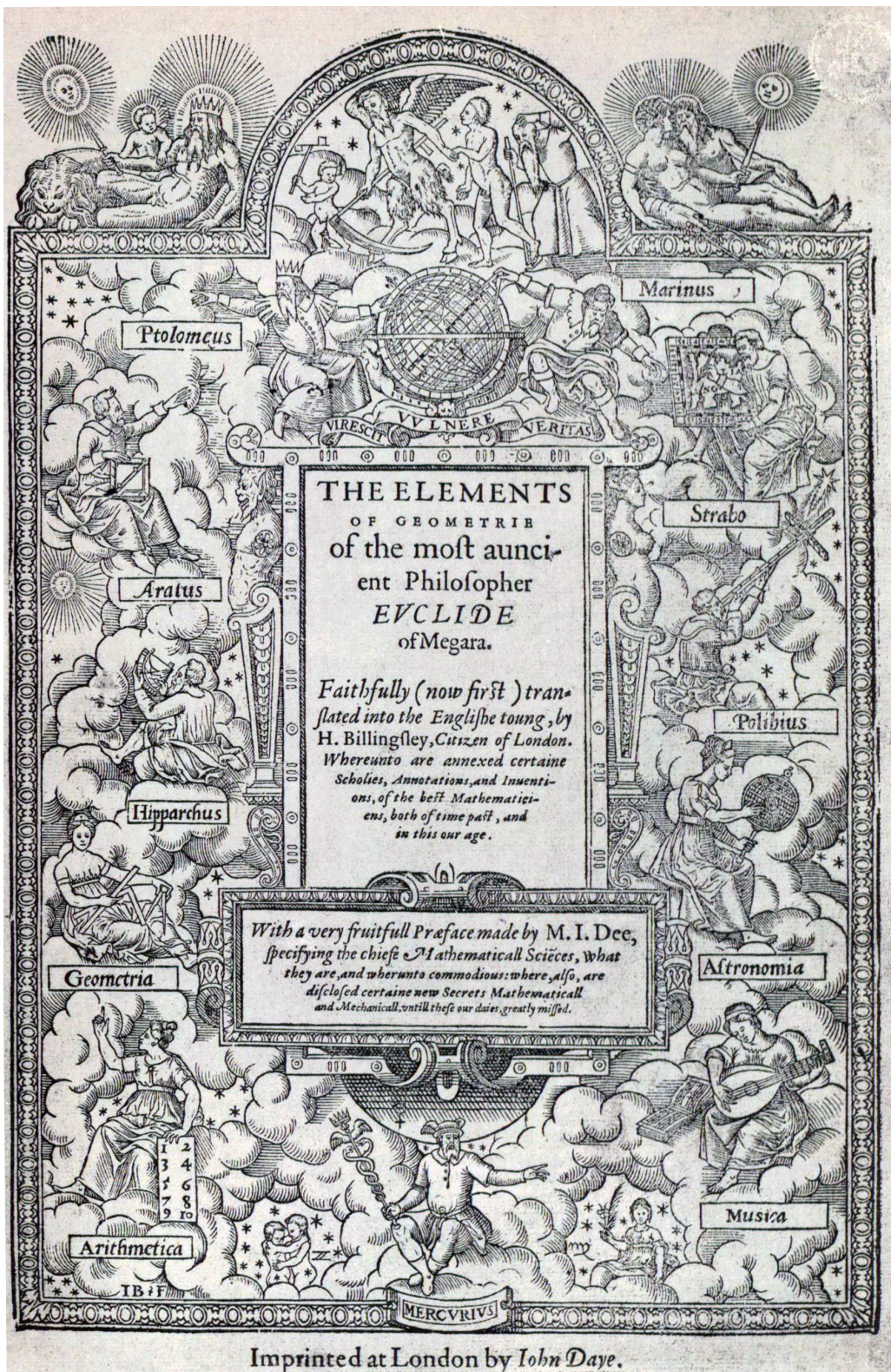


Fig 43 *Elements*, title page of Sir Henry Billingsley's first English version of Euclid's *Elements*, 1570. *Elements* is a mathematical treatise consisting of 13 books attributed to the ancient Greek mathematician Euclid in Alexandria, ca. 300 BC.

Geometries

‘... the constants of nature come from the geometry of space.’ Thad Roberts⁴⁵

‘The sensible space of our immediate perception, which we find ready at hand on awakening to full consciousness, is considerably different from geometrical space.’ Ernst Mach⁴⁶

‘We might distinguish between two kinds of spatial disposition, effective and affective. In the first, one tries to insert movements, figures, stories, activities into some larger organization that predates and survives them; the second, by contrast, seeks to release figures or movements from any such organization, allowing them to go off on unexpected paths or relate to one another in undetermined ways. We can already see that “construction” and “intuition” acquire different senses in the two cases. The first tries to draw all the lines of our various geometries from the fixed points of a prior system, while the second works through a more informal diagram that throws together odd features in a loose intuition that creates its own points as it goes along; and we may thus speak of two kinds of “geometry.” Yet the distinction remains a conceptual one, for there is perhaps no building or city space in which both kinds of geometry don’t exist at once, at least potentially. Any constructed space always reveals a tension between the two, the question being which one we put first. Thus, for example, even in pictures or buildings made from classical Albertian perspective, other things in fact go on according to the principle “God exists, therefore everything is permitted”.’⁴⁷

Geometry is a substantial part of the identity, sensibility and performance of any architectural project.⁴⁸ What in the first moment sounds like a trivial observation, reveals, layer by layer, a framework of possibilities for expressions as a device of architectural identity, sensibility and rigor. In the work of SPAN geometry is one of the main corner stones, not only in terms of its morphological and morphogenetic qualities but also for its ability to create a web of, sometimes visible, sometimes camouflaged referential system consisting as much of elements of symbolic as well as aspects of material culture.⁴⁹ One of the first projects of the practice

45 Roberts, Thad, 2010. Visualizing Eleven Dimensions. Video of a talk at TEDxBoulder. Available at: <<https://www.youtube.com/watch?v=aSz5BjExs9o>> [Accessed November 19, 2017].

46 Mach, Ernst, 1906. Space and Geometry: In the Light of Physiological, Psychological and Physical Inquiry. Translated from German by Thomas J. McCormack. Reprint 2004. Mineola: Dover. p5.

47 Rajchman, John, 1998. Constructions. Cambridge: The MIT Press

48 Ibid.

49 Ibid.

was an entry for the competition of a single-family housing unit in Japan. The Planless House⁵⁰ responded to the competition brief in that it relied purely on the transformation of geometry in combination with material properties to speculate about the subdivision, or the lack thereof, of a house into programmatic zones. The rigid geometry of a cube undergoes a continuous transformation from a complete planar surface to a vivid, highly articulated, louvered façade. In the process it inflects, in a distinctive rhythmic pattern, demarcation zones within the boundaries of the cube in an ever-increasing rate of deformation (Fig 44). In this extent it demonstrates in one single project the properties of Euclidean geometry, in a mash up with the inherent qualities of topological deformations. The intentional play with the proportions of classic modern houses such as Mies van der Rohe's Farnsworth house⁵¹, Eero Saarinen's Miller house⁵² or Pierre Koenig's Stahl House⁵³ - all low slung and massively horizontal gestures- and their desecration by inflecting the cube with deformities, is a play on the theory that architects can only create a project out of two specific conditions: Nostalgia or perversion.⁵⁴ The case of the Planless House shows the dichotomy of the interplay between Euclidean rigor and the gestural qualities of formalist conditions. The Planless House serves here as a prototypical example of SPAN's preoccupation with geometry. There were examples before the Planless House which were necessary to forge the concept of embracing geometry as a profoundly shaping attribute both formally as well as intellectually. The crucial moment when this, underlying notion, was transformed into a rigorous exploration was at the time with the MAK Schindler Scholarship in Los Angeles. The topological mesh modeling software TopMod (Fig 45, Fig 46)⁵⁵ was the main tool of exploration, at this time. One of the benefits of working with TopMod was not only the remarkable opportunities inherent in topological modeling based on polygonal mesh geometry, but also the treasure trove of documentation on the accompanying web page for the software. The documentation gives a comprehensive overview over the inherent algorithmic properties of the software and explains the underlying commands that allow the representation of curvilinear topological bodies with the aid of polygonal meshes. Subdivision techniques, or

50 The Planless House, competition entry for the Shinkenchiku Residential Design Competition, JA, 2006

From the competition brief:

"It is generally thought that the plan is a means for describing lifestyle. The fundamental principle of this descriptive technique is division. It is thought that the lifestyle inside a house is divided with the device of "walls." Therefore, if only the elements called "walls" are picked out, and given an expression in which they are emphasized, people may understand the lines on a drawing that indicate the "walls" as describing the essence of a house.

Yet should a house be "walls"? Why can we not describe a house just by furniture? Why can we not describe a house just by tableware? Or what about a descriptive method using only floor textures? As the floor is the only component that the human body directly touches (actually, there are also doorknobs and toilet seats), if we were to describe a house by a technique of scanning with the body, the house would be described as a collection of textured floors. Or it would also be possible to describe a house in terms of air temperature, or in terms of malodorous places due to wind flows".

51 Mies van der Rohe, Farnsworth House, Plano Illinois, USA, 1945 -1951

52 Eero Saarinen, Miller House, Columbus Indiana, USA, 1953-1957

53 Pierre Koenig, Case Study House 22 - Stahl House, Los Angeles California, 1959

54 Kipnis, Jeffrey, 2010. The Cunning of Cosmetics in A. Krista Sykes (Ed): Constructing a New Agenda – Architecture Theory from 1993-2003. New York: Princeton Architectural Press, p163.

55 TopMod is a topological mesh modeler. The project was initially conceived by Dr. Ergun Akleman and Dr. Jianer Chen with Dr. Vinod Srinivasan as the lead designer and developer.

remeshing tools in TopMod lingo, explore a great variety of methods to truncate faces in a polygonal mesh to achieve a variety of surface effects. The methodical exploration of the software, by generating ever increasing series of families of related objects - primarily defined through their genus - is certainly the first time SPAN applied rigorous and methodical thinking in the exploration of a specific geometrical problem.

Digital explorations in the architecture of SPAN

It is certainly true that the preoccupation with computational design tools in the work of SPAN fostered the research and explorations of specific families of geometry. A deeper understanding of the underlying rule sets and algorithms present in the modeling software allowed to achieve better results. Understanding the basic mathematical rules such as Boolean operations, automated repetition of simple procedures such as copy, move, and rotate formed the basis for later work, such as operating with topological surfaces, recursion, fractals and of course the parametric and relational properties of articulated geometries. In SPAN's vocabulary parametric refers purely to the geometric, and organizational properties of computational models. There is no intention of understanding it as the denomination of a style. Stylistic, morphological or formal ambitions are in general discussed through the lens of continental philosophy, scientific insight and architectural discourse driven by speculative opportunities, materialist notions and the interrogation of phenomenological conditions driven by possible atmospheres, intense articulation and refined spatial composites. It is therefore necessary to understand the language of geometry, and especially how computational tools and instruments interpret our reality by subdividing it into mathematical forms of expression, reconstructed in a computational space, and represented by a series of rays penetrating the plane of the computer screen.

The familiarity with the abstract computational space, and its methods to interpret geometrical problems, forms the ground on which every design at SPAN can be developed, interrogated and evaluated, with all its potentialities to materialize in the physical world. Almost perverting Ludwig Wittgenstein's assertion, aspects of logical deduction are combined with a lust for the estrangement and alternative modes of aesthetical value. If Wittgenstein proclaims 'whereof one cannot speak, thereof one must be silent',⁵⁶ then SPAN's work relies on the possibility to create the language to speak and in the process develops a distinct vocabulary, relying on the universal nature of architecture's main staple of expression: Geometry.

56 Wittgenstein, Ludwig, 2010. *Tractatus Logico-Philosophicus*. Urbana, Illinois: Project Gutenberg. p90. Retrieved February 21, 2017 from <http://www.gutenberg.org/ebooks/5740>.

Before Euclid there was nothing.⁵⁷

The book *The Elements* (Fig 43)⁵⁸ by the Greek mathematician Euclid, can be considered the first systematization of earlier knowledge on geometrical principles. The main improvement over previous collections of knowledge - such as the treatises by Hippocrates of Chios, Eudoxus of Cnidos whose treatise on proportions is said to be the base for Book V, and most famously Pythagoras⁵⁹ - was recognized very quickly thus rendering earlier collections of geometric knowledge obsolete, with the result that most of those older treatises are now lost. It is for this reason that it is mathematics oldest large-scale deductive collection and it can be considered a forming force in the development of logic and modern science. *The Elements* consists of 13 books. The Books' I, II, III, IV and VI main field of interrogation is plane geometry and contains such well regarded theorems such as the Pythagorean theorem.⁶⁰ For this thesis the most pertinent books are number XI to XIII, as those books are concerned with solid geometry.⁶¹ Unfortunately the sources for Euclid, specifically for the Books XI to XIII are lost, the best possible attribution are the Pythagorean circles or other Athenian mathematicians.

Euclid's working method consists in creating the hypothesis of a small set of intuitively appealing axioms and deducting many other propositions (theorems) from these. Although many of Euclid's results had been stated by earlier mathematicians such as Eudoxus of Cnidos, Theaetetus and Philip of Opus - all of which were part of Plato's circle in Athens. Euclid was the first to show how these propositions could fit into a comprehensive deductive and logical system. *The Elements* begins with plane geometry, profoundly familiar to everyone who attended secondary school as it is the first axiomatic system still taught today, and the first examples of formal proof. It goes on to solid geometry of three dimensions. Much of the *Elements* states results of what are now called algebraic and number theory, explained in geometrical language. For a period of more than two thousand years, the adjective Euclidean was not common because no other sort of geometry had been conceived. Euclid's axioms seemed so intuitively obvious, with the possible exception of the parallel postulate⁶² that any theorem proved from them was deemed true in an absolute, often metaphysical, sense. In our current age, however, many other self-consistent non-Euclidean geometries, such as elliptic,

57 Paraphrasing John Lennon: Before Elvis, there was nothing.

58 Euclid, (ca. 300 BC): *The Elements*, a mathematical treatise consisting of 13 books, Alexandria, Ptolemaic Egypt

59 Rouse Ball, Walter W., 1908. *A Short Account of the History of Mathematics*, 4th Ed., London: Macmillan and Co., p54.

60 It describes the sides of a right triangle as that the square of the hypotenuse (the side opposite the right angle) is equal to the sum of the squares of the other two sides, or in other words $a^2 + b^2 = c^2$.

61 Solid Geometry is the traditional name for the geometry of three-dimensional Euclidean space. Three-dimensional space describes a setting of geometrical space where three specific values, or coordinates are necessary in order to define a position of an element in space such as a point. This description method is also known as dimension.

62 Parallel Postulate: If a line segment intersects two straight lines forming two interior angles on the same side that sum to less than two right angles, then the two lines, if extended indefinitely, meet on that side on which the angles sum to less than two right angles.

hyperbolic and three dimensional non-Euclidean geometry, are known and have found applications in every aspect of our contemporary life. From physical theory to practical applications. The critical interrogation of the problems of Euclidean geometry serves as launching pad for advanced methods of thinking about our physical environment. For example: One implication of Albert Einstein's theory of general relativity is that physical space itself is not Euclidean, and Euclidean space is a good approximation for spatial geometry only where the gravitational field is weak. Euclidean geometry is an example of synthetic geometry,⁶³ in that it proceeds logically from axioms to propositions without the use of coordinates. This is in contrast to analytic geometry, which uses coordinates.

Euclidean and Cartesian Concepts of Space, meshes and nets

Euclidean and Cartesian concepts are discussed together because in contemporary mathematics these two conceptual spaces can, given a specific context, be unified and merged, mainly as a Euclidean space with a Cartesian coordinate system.

A Euclidean space can be thought of as a set of planes, following axioms and theorems formulated by Euclid of Alexandria (300 BC). It might discuss a true line, an Euclidean plane, a three dimensional space of Euclidean geometry as well as, generalizing the principles, spaces of higher dimensions. Any point in a Euclidean space is represented through a set of polar coordinates, defined by a distance from a fixed point and an angle from a fixed direction, thus rendering an Euclidean space in its original concept, a geometric space.

The innovation of the Cartesian concept derived by René Descartes in 17th century France was that through pivoting Euclidean space around a non-ambiguous coordinate system he was able to merge or unify Euclidean geometry and algebra into analytical geometry thus laying the basis for further development e.g. calculus. The original Cartesian coordinate system consisted of three axes, x, y, and z, every point defined through its respective X, Y, and Z coordinate, restricting discussions to lines, planes and three dimensional spaces. Contemporary mathematics combines and extends the Euclidean and the Cartesian model to further discuss properties in n-dimensions.

⁶³ Synthetic geometry is that which studies figures as such, without recourse to formulas, whereas analytic geometry consistently makes use of such formulas as can be written down after the adoption of an appropriate system of coordinates.
Klein, Felix, 1898-(1904)1933: Enzyklopädie der mathematischen Wissenschaften mit Einschluss ihrer Anwendungen, Leipzig: B.G. Teubner Verlag

These geometrical principles are integrated in almost every software product for architectural design and production. Cartesian geometry and its geometric constructs, meshes or nets, are dependent on calculating capacity, as every point in the mesh is constructed individually. When this principle is applied to curved geometries it generates a vast amount of data to be processed. That is the reason why Calculus was integrated into design protocols, first, for the aviation and ship building industry in the 1960s. As faster processors became available, allowing for calculating large data sets, meshes and nets re-surfaced in design protocols, considering also that meshes and nets are easier to manipulate.

The theoretical impact though that the integration of Calculus and its implicit theoretical background had in the discipline of architecture cannot be overstated nor the effects and affects that it created when it aided designers to stretch their design sensibilities but also to develop a new understanding of space.

Euclidean Space in Practice: Base Geometries

Through the PRS research it became evident that a large range of the developed projects in the practice were initially based on rigorous geometric bodies. Most prominently in the series of projects based on topology, from the Brancusi Museum to the Austrian Pavilion for the Shanghai expo, apart from dozens of projects that did were not published widely such as the Shenzhen border Station, a highriser in HonKong, an opera competition in Korea, furniture design for HAWK and more. Other research trajectories that follow a rigorous geometrical direction include a series of installations based on spacefilling polyhedra and the series based on recursive geometries.

Calculus and Topology

Calculus is the study of change. Donald LaTorre⁶⁴

Neither the Euclidean nor the Cartesian model can resolve specific mathematical and geometrical questions, e.g. that of connectedness and change.⁶⁵ According to Wikipedia, calculus is a collection of techniques for manipulating certain limits. Infinitesimal get replaced by very small numbers, and the infinitely small behavior of the function is found by taking the limiting behavior for smaller and smaller numbers. Limits are the easiest way to provide rigorous foundations for calculus, and for this reason they are the standard

64 LaTorre, Donald R. et al, 2011. Calculus Concepts: An Informal Approach to the Mathematics of Change. Cengage Learning: Independence, p2.

65 Whitehead, Alfred, 1919. An Enquiry concerning the Principles of Natural Knowledge. Cambridge: University Press, p25.

approach.⁶⁶

When working with protocols that involve Calculus, terms like dimension as ideal units or discrete elements are replaced by relationships of the whole and parts into a continuous series. It was then that looking for an ideal form was replaced by a series of well designed objects, apart from the fact that Calculus based geometry reduces the amount of data thus using less processing power.

Topology in Practice: The Austrian Pavilion, Housing in Vienna

The Austrian Pavilion at the Shanghai World Expo in 2010 was commissioned after the successful bidding in an Europe wide design competition. The project was executed together with the Viennese architecture practice Zeytinoglu ZT GmbH.⁶⁷ The main ambition of the project was to explore the architectural possibilities of topological modeling in a rigorous fashion.

The term topology is of Greek origin combining topos (place) and logos (study) to a composite word. The term is used to describe a branch of mathematics which deals with spatial qualities that are sustained under continuous deformations. It describes spatial models that maintain their mathematical information even if they are stretched, bent, or crumpled, however tearing or gluing are not possible in this mathematical model. The main method to observe this phenomenon is by collecting subsets which are described as open sets that fulfill properties such as stretching, bulging, bending and other continuous transformations constituting a topological space. These geometrical models allow for continuous connectedness within the model, and allow for a gradient transition from inside to outside of the building.

The modern model of topology can be described as a descendent of Leibniz's concept of geometrica situ (geometry of place) as well as his theory on analysis situ (examination of space). Around the same time as Gottfried Wilhelm Leibniz, Leonhard Euler was exploring the famous problem of the Seven Bridges of

⁶⁶ Wikipedia contributors, 2017, Calculus. In Wikipedia, the free Encyclopedia. Retrieved on August 2017, <https://en.wikipedia.org/wiki/Calculus#Principles>

⁶⁷ <http://www.arkan.at/en/>

Arkan Zeytinoglu Architects is a team of distinctive personalities with a wide range of talents and skills. The team has been collaborating for many years, united by their enthusiasm and passion for architecture.

2017, Studio. Retrieved on May 2017, <http://www.arkan.at/de/studio-en/>

Königsberg,⁶⁸ which is considered the first theorem in the field of topology. Leibniz's and Euler's theorems served as launching pad for more recent examinations of the problem, as for example by Felix Klein, Bernhard Riemann and Henri Poincaré. In architectural design topology made an impact as soon as 3D modeling suites were available and affordable that could compute topological surfaces. In the mid to late 90s of the 20th century software packages such as Softimage, Lightwave, FormZ, and Maya that were able to manage topological sub sets were adopted and started to form the design ecology of the practice. The research on topological modeling started with the discovery of TopMod (Fig 45, Fig 46),⁶⁹ a small software developed in the visualization department of Texas A&M by Prof. Ergun Akleman. The software had an immense repertoire of topological modeling possibilities, and especially stood out then through its capability to create surface thickness. Previously this turned out to be practically impossible with surfaces created with NURBS (Non Uniform Rational Basis Splines),⁷⁰ which also led to aperture solutions in NURBS resembling eye lids and louvers (e.g. Embryological House,⁷¹ Bloom House,⁷² by Greg Lynn). TopMod however was following a distinctively different modeling paradigm. Instead of NURBS it relied on polygonal modeling. Suddenly apertures, and multiplicitous connections within a model were enormously facilitated. The software was extensively explored for its architectural potentialities during SPAN's stay at the MAK in

68 The Seven Bridges of Königsberg is a historically notable problem in mathematics. Its negative resolution by Leonhard Euler laid the foundations of graph theory and prefigured the idea of topology.

The city of Königsberg in Prussia (now Kaliningrad, Russia) was set on both sides of the Pregel River, and included two large islands - Kneiphof and Lomse - which were connected to each other, or to the two mainland portions of the city, by seven bridges. The problem was to devise a walk through the city that would cross each of those bridges once and only once. By way of specifying the logical task unambiguously, solutions involving either reaching an island or mainland bank other than via one of the bridges, or accessing any bridge without crossing to its other end are explicitly unacceptable.

Euler proved that the problem has no solution. The difficulty he faced was the development of a suitable technique of analysis, and of subsequent tests that established this assertion with mathematical rigor.

Wikipedia contributors, 2016, The Seven Bridges of Königsberg. In Wikipedia, the free Encyclopedia. Retrieved on March 2016, https://en.wikipedia.org/wiki/Seven_Bridges_of_K%C3%B6nigsberg

69 TopMod is a topological mesh modeler. The project was initially conceived by Dr. Ergun Akleman and Dr. Jianer Chen with Dr. Vinod Srinivasan as the lead designer and developer.

70 Non-uniform rational basis spline (NURBS) is a mathematical model commonly used in computer graphics for generating and representing curves and surfaces. It offers great flexibility and precision for handling both analytic (surfaces defined by common mathematical formulae) and modeled shapes. NURBS are commonly used in computer-aided design (CAD), manufacturing (CAM), and engineering (CAE) and are part of numerous industry wide standards, such as IGES, STEP, ACIS, and PHIGS. NURBS tools are also found in various 3D modeling and animation software packages.

They can be efficiently handled by the computer programs and yet allow for easy human interaction. NURBS surfaces are functions of two parameters mapping to a surface in three-dimensional space. The shape of the surface is determined by control points. NURBS surfaces can represent, in a compact form, simple geometrical shapes. T-splines and subdivision surfaces are more suitable for complex organic shapes because they reduce the number of control points twofold in comparison with the NURBS surfaces.

In general, editing NURBS curves and surfaces is highly intuitive and predictable. Control points are always either connected directly to the curve/surface, or act as if they were connected by a rubber band. Depending on the type of user interface, editing can be realized via an element's control points, which are most obvious and common for Bézier curves, or via higher level tools such as spline modeling or hierarchical editing.

Wikipedia contributors, 2018, Non-uniform rational B-spline. In Wikipedia, the free Encyclopedia. Retrieved on October 2016, https://en.wikipedia.org/wiki/Non-uniform_rational_B-spline

71 The Embryological House, 1997–2001, Greg Lynn Form

The Embryological House is designed using curve and vector-based surfaces, generated with software that is typically used in the animation industry. see for example <https://www.cca.qc.ca/en/issues/4/origins-of-the-digital/5/embryological-house>

72 Bloom House, Los Angeles 2010, Greg Lynn Form

The Bloom House is a single family private home in Southern California designed and realized in partnership with LookinGlass Architecture and Design, Oliver Garrett Construction, Kreysler Associates and DuPont. <http://glform.com/>

Los Angeles through the Rudolph Schindler Scholarship.⁷³ The final exhibition of the fellowship in March 2007 contained several 3D printed models, that were fabricated with the support of Saddlebag College in Los Angeles. One of which would become the ancestor/genotype of the Austrian Pavilion (Fig 37, Fig 39, Fig 48). A low-slung structure with a continuous interior space orbiting around a central open space. All openings of this model were continuously turning the corner from the outside to the inside, occluding the aspects of violent openings such as doors or windows and in favor of blending inside and outside in a continuous gesture.

In Summer 2008 it was announced that SPAN won the competition for the new Brancusi museum in Paris (Fig 41, Fig 42), and the Austrian Pavilion for the Shanghai Expo 2010 in China (Fig 49 - Fig 51, Fig 53 - Fig 55) was won in December 2008. Both projects are closely related in vocabulary as well as program, and both are clear descendants of the topological model presented in Los Angeles (Fig 48, Fig 49). The method of creating just one continuous space that is articulated through constrictions, folds, bulges, and variation of the horizon connects all three models.

The entire design of the Expo pavilion started with a cuboid that contained the volume necessary to fulfil the project's outline, and that respected the boundaries of the competition site. Through a series of iterations in TopMod more than 100 models were generated in a rapid sequence, that approximated a feasible solution for the pavilion's design. The technique relied heavily on the multi handle tool in Top Mod, which is designed to explore low genus models. The resulting model was then translated into Maya to tweak and adapt it in a way that respects the topological outcome but facilitates the implementation of the program of the building. This model then served as launching pad for a collaboration with our Partners at Zeytinoglu ZT GmbH and the Shanghai Xian Dai Architectural Design (Group) Co., Ltd.,⁷⁴ which served as the local design institute in China.⁷⁵ The starting model of the Expo Pavilion is a genus four model.⁷⁶ The interior of the project forms a clear narrative of variations in space. The experience started on the outside of the pavilion. The visitor ascends a curved ramp towards the entrance of the pavilion. A depressed area which was designed to provide shade to waiting visitors. Along the ramp a series of curved tubes outfitted with fine

73 The Schindler Scholarship is a yearly grant provided by the Austrian Federal Chancellery in cooperation with the MAK – Austrian Museum of Applied Arts Vienna, for a six months residency at the Mackey Apartments, Los Angeles. For more information visit https://www.mak.at/schindler_scholarship

74 As a state-owned enterprise solely funded by State-owned Assets Supervision and Administration Commission of Shanghai Municipal Government, Shanghai Xian Dai Architectural Design (Group) Co., Ltd was established by amalgamating the former East China Architectural Design & Research Institute with Shanghai Institute of Architectural Design & Research in March, 1998. In October 2015, it became the controlling shareholder of ARCPLUS (Stock code: 600629).

2017, Studio. Retrieved on May 2017, <http://www.xd-ad.com.cn/e/>

75 Every architectural project at that time (2010) needed to have a Local Design Institute as partner to guarantee that Chinese building standards and conventions were being met.

76 Genus hereby refers to the connectedness of the generated surfaces. A sphere would be of genus zero, a doughnut of genus one etc.

spray nozzles provided a cooling mist for the queuing visitors. As a side note: This was still not sufficient to provide refreshment to waiting guests, as people were waiting around two corners of the pavilion to enter during the Expo. From a distance the pavilion's surface shimmered and flickered in a red and white gradient coloration (Fig 51). On closer examination it revealed itself as a porcelain mosaic façade. The small size of the tiling, consisting of 30 mm sized hexagons, allowed to cover curvilinear areas in a seamless fashion (Fig 50). One special point to mention about the envelope is that it is among the first built facades (if not the first) to be designed with Grasshopper,⁷⁷ after participating in a workshop with David Rutten, where he introduced Explicit History (which is how Grasshopper was called then) to interested parties at the University of Applied Arts in Vienna, just the year before the planning of the Expo Pavilion started.

The entrance to the pavilion was situated at the highest point of the ramp. The entrance proved to be an interesting problem in terms of topological geometry as how do you introduce and define interiority and exterior in a surface that continuously and gradually deforms from the outside to the inside in the form of a gastrulated surface? The solution of the problem was to locate the glazing of the entrance exactly at the turning point of the geometry, describing a local maximum where the curve turns from positive gradient to negative gradient. This in fact describes a minimal surface in the entrance area which served as the template for the glazing. As the turning point of the geometry was intentionally and precisely positioned on a vertical plane the glazing was completely planar. The visitor progressed through a small foyer containing a world map describing the position of Austria in the world. The ramp turns downwards from this point, spiraling along a gallery towards the main space (Fig 54). All along this ramp Austrian landscapes were presented in an interactive video installation by Peyote.⁷⁸ The central space of the pavilion served as event space, primarily for music performances. On a technological level it was a challenge to create an acoustically well-rounded space for classic music live performances without artificial amplification. The main shaping force for this space was acoustic forces which were simulated in Autodesk Ecotect Analysis⁷⁹ repeatedly and in conjunction with the acoustic engineering office Müller-BBM⁸⁰ to achieve a balanced reverberation time in this, rather low-slung, space. The steps, curving along the western wall of the main audience chamber, served as much as acoustic diffusers, as the ceiling which featured a calculated perforation pattern allowing to absorb enough of the sound to allow for a round and mellow acoustics of the space. The plan resembled a curvy, distorted lozenge, in terms of acoustics a challenging form as the curvilinear walls could create spots where acoustic rays could focus, thus creating uneven acoustics. The problem was solved by positioning objects in

77 Grasshopper is a graphical algorithm editor tightly integrated with the 3D modeling software Rhino.

78 <http://www.peyote.cc/en/blog.php>

79 Autodesk Ecotect Analysis is an environmental analysis tool that allows designers to simulate building performance from the earliest stages of conceptual design.

the way of the acoustic rays, such as the DJ booth or the conductor's stand serving as wave breakers to diffuse the sound.

Stepping out of the main chamber the visitor passed the souvenir shop left hand (Fig 55), and the Austria information desk on the right with the exit straight ahead. A sharp left turn lead to the staircase towards the restaurant on the upper floor. One of the main characteristic features of the upper floor were the columns dealing with the teething problem. First described by Greg Lynn in the design for the Lords Clothing Store on Sunset in Los Angeles in 2001 (Fig 52). It presents itself as a solution for the question as of how to create columns in a topological space. As topology does not lend itself towards perforation but rather towards continuous conditions the two columns in the pavilion's upper floor are not discrete objects but are created through the deformation of floor and ceiling, thus creating interlocking teeth that allow to transport loads from the roof, through the restaurant space and below (Fig 53). It certainly is one alternative methods of celebrating the transport of loads, or celebrating the column, one of the main staples of architecture. No attempt is made here to hide, or avoid it. In the spirit of full disclosure though it has to be said, that what you see in the space is not the load bearing portion of the column. It is rather a wrap around the centrally positioned steel column, consisting of CNC (computer numerical controlled) milled⁸¹⁸²⁸³ foam panels, that allow to blend the horizontal ceiling with the vertical gesture of the column.

Following the allover topological concept, the entire furnishing of the pavilion, such as exit desk, restaurant bar and VIP bar where custom made, and designed by SPAN. The idea certainly follows the Viennese tradition of a Gesamtkunstwerk up to the point where designs were submitted for graphic designs and the outfit of the crew. The central space of the restaurant is occupied by a sunken court. This court, glazed on all four sides in a frameless construction, illuminates the entire upper floor. With exception of the kitchen there are no windows to the exterior in the entire building. The idea was to shut out the visual and acoustic noise of the Expo to create a calm atmosphere in the court of the upper floor. It turned out to be particularly popular among journalists writing about the Expo, as they could sit outside in a shaded court, and write their articles sipping a cold Austrian beer. The upper floor contained the restaurant and its kitchen, the office spaces of the pavilion as well as the VIP area. Right next to the restaurant bar was another exit and a straight staircase on the outside of the pavilion. Once the visitor stepped through the glazed exit doors he was

81 <https://www.muellerbbm.com/homepage/>

82 CNC (computer numeric controlled) machining are manufacturing processes where pre-programmed computer software feeds the movement of factory tools and machinery.

83 Milling, in particular CNC milling pertains to the practice in which a drilling bit cuts material according to a pre programmed path in order to translate a computational model in to a physical reality. The Computer Numerical Control aspect of the process allows for precise translation of a digital model into a physical reality (Sandra Manning 2018)

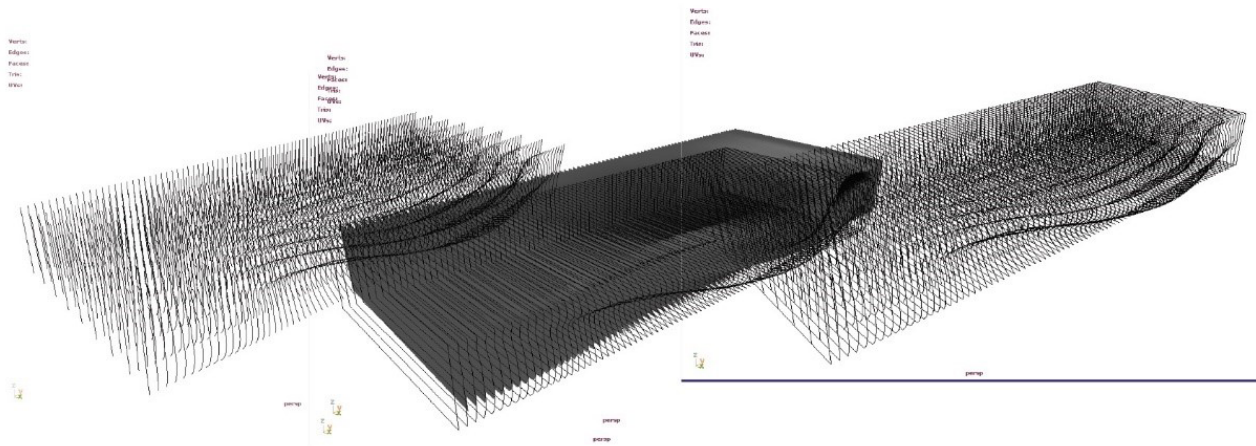


Fig 44 *Planless House*, Competition entry, perspective views, SPAN 2006.

The rigid geometry of a cuboid undergoes a continuous transformation from a complete planar to a vivid, highly articulated, louvered surface. In the process it inflects, in a distinctive rhythmic pattern, demarcation zones in an ever-increasing rate of deformation.

On a Family of Symmetric, Connected and High Genus Sculptures

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Abstract

This paper introduces a design guideline to construct a family of symmetric, connected sculptures with high number of holes and handles. Our guideline provides users a creative flexibility. Using this design guideline, sculptors can easily create a wide variety of sculptures with a similar conceptual form.

1. Introduction

In this paper, we present a design guideline to create a new sculptural family with interactive topological modeling. Using this design guideline a large set of sculptures that have a similar conceptual form can easily be created (see Figures 1 and 2). We have tested the design guideline in a computer aided sculpting course [2]. We observe that, using the design guideline, students can rapidly create a wide variety of shapes. Although these shapes are completely different; they can be perceived as belonging to the same family and having a similar conceptual form. Figure 5 shows some examples of shapes that were created by some of the students using our design guideline, as one of the biweekly assignments of the computer aided sculpting course.



Figure 1: Photographs of 3D prints of two of the first symmetric high genus shapes (shapes with high number of handles and holes) designed by Ergun Akleman. For each sculpture, we took two photographs from slightly different point of views. The sculptures are photographed on a mirror. Background is eliminated. These shapes are made from ABS plastic and printed using a Fused Deposition Machine (FDM). They are later painted using an acrylic paint.

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Fig 47 *Topological Model*, still from animated sequence, SPAN2007.
The examination of opportunities inherent in TopMod in terms of producing architectural prototypes was explored during the stay with the Schindler Scholarship by the MAK (Austrian Museum of Applied Arts) in Los Angeles. The model above was considered a successful abstract machine in that it is the origin for projects such as the Brancusi Museum and the Expo Pavilion at the Shanghai Expo in 2010.

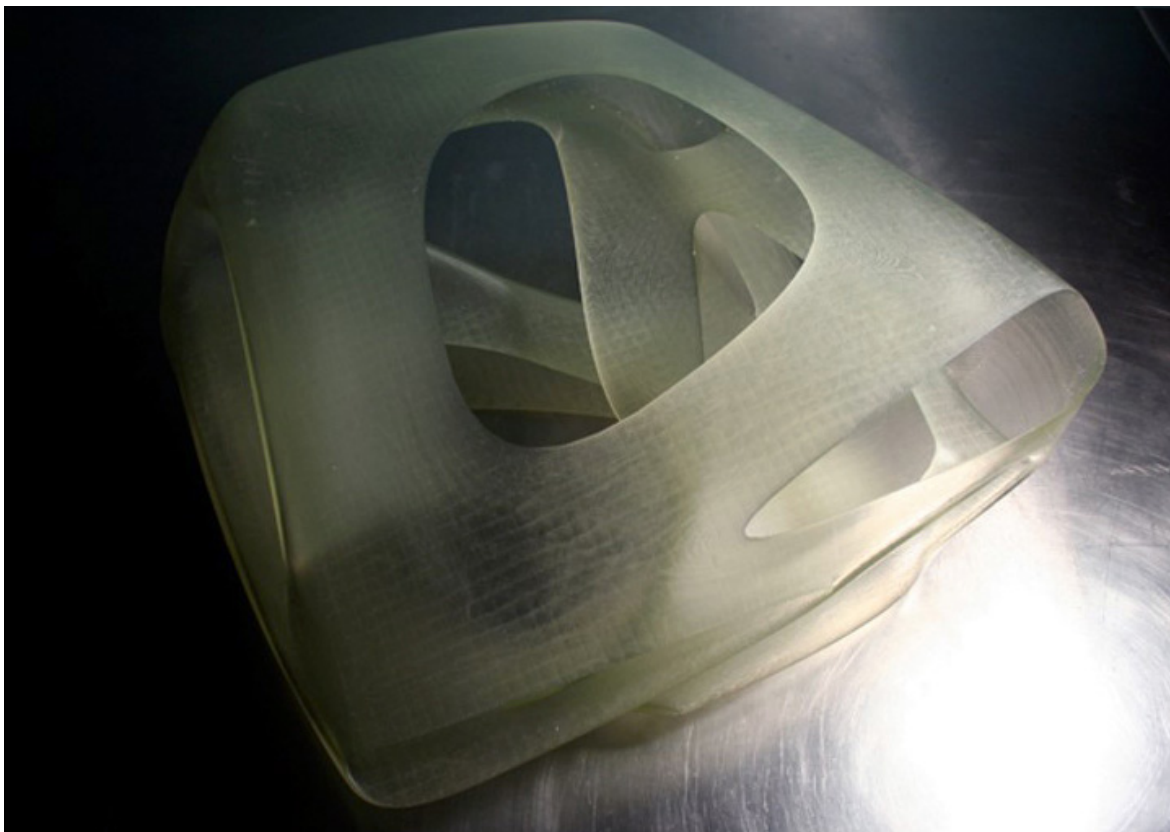


Fig 48 *Beautiful Corpse*, stereolithographic model, MAK Schindler House, Los Angeles, USA, SPAN2007

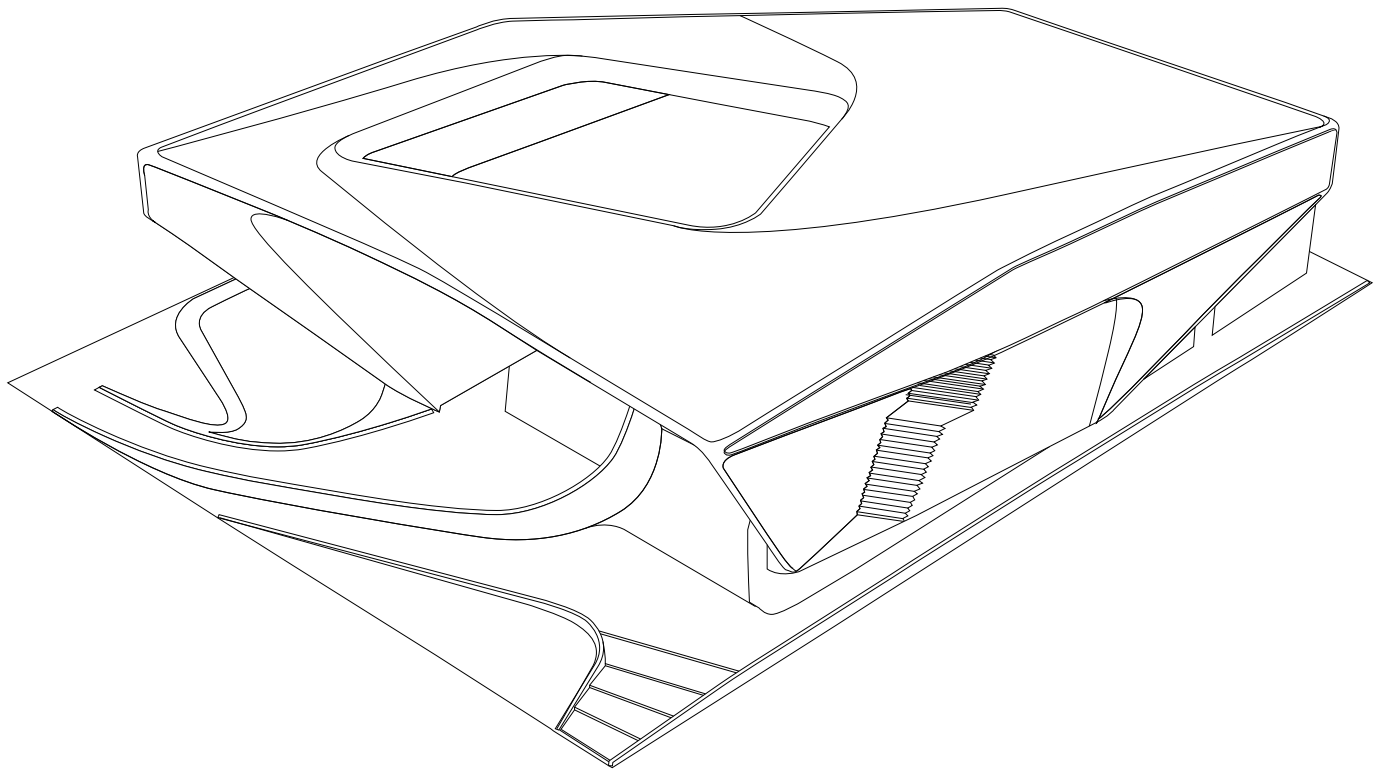


Fig 49 *Austrian Pavilion*, axonometric view, Shanghai Expo 2010, Shanghai, CN, SPAN 2010

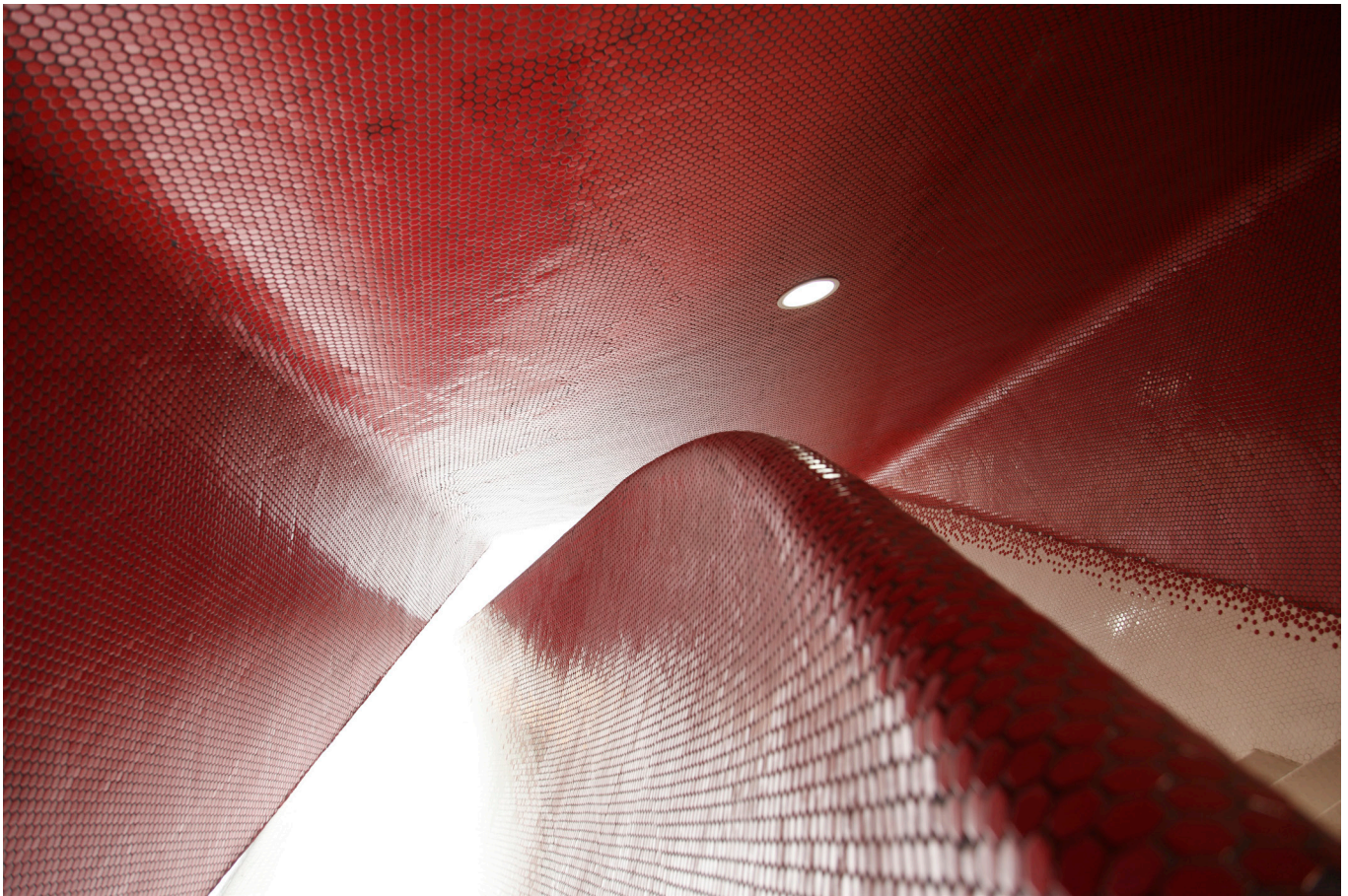


Fig 50 Austrian Pavilion, staircase view, Shanghai Expo 2010, Shanghai, CN, SPAN 2010



Fig 51 Austrian Pavilion, corner view, Shanghai Expo 2010, Shanghai, CN, SPAN 2010

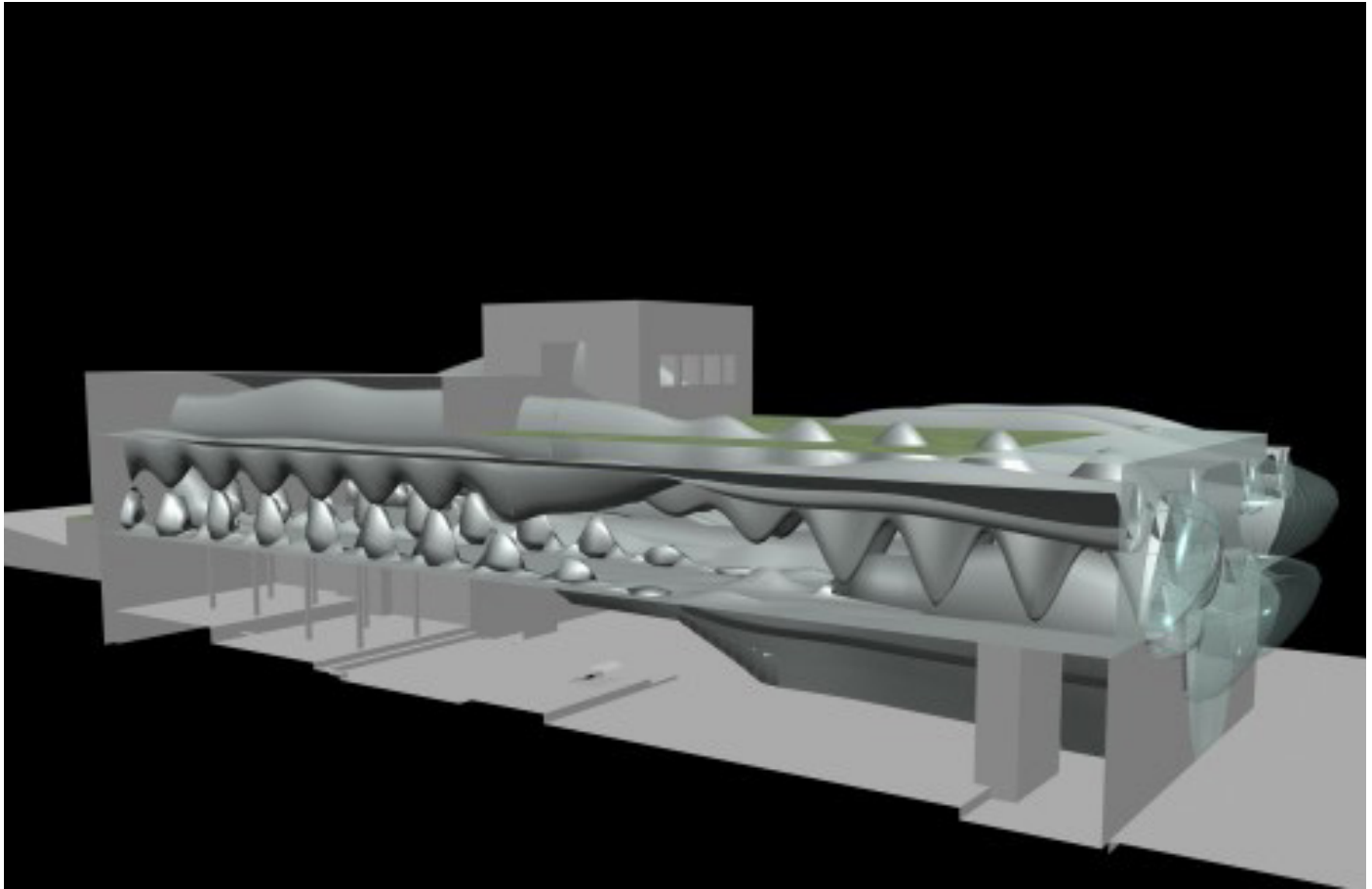


Fig 52 *Lords Clothing Store*, render of perspective view, Los Angeles, USA, Greg Lynn FORM 2001, courtesy Greg Lynn FORM



Fig 53 Austrian Pavilion, restaurant , Shanghai Expo 2010, Shanghai, CN, SPAN 2010



Fig 54 Austrian Pavilion, auditorium, Shanghai Expo 2010, Shanghai, CN, SPAN 2010



Fig 55 Austrian Pavillion, shop, Shanghai Expo 2010, Shanghai, CN, SPAN 2010

engulfed in a deep red porcelain cavern, forming a protective overhang of the building (Fig 50). Stepping down the deep red surface gradually transforms into white until you reach the last step of the stair. Standing on the plinth of the pavilion, the visitor has reached the end of the tour.

The Expo pavilion was a crucial project for SPAN. It was a proof of concept that it is possible to rigorously apply topological models to a building project.

Recursion

Throughout the work on topology, hierarchical ordering systems like patterns and subdivisions became a topic that could not be avoided. So it was a natural process to start investigating other mathematical concepts for solutions to architectural problems that led to explore fractal geometry.

An image often drawn to explain recursion is that of a set of two parallel mirrors that create an effect of endless mirroring of the reflected entity. Mirroring and symmetry are canonical effects in architectural design.⁸⁴ Recursion is also a procedure native to scripting and coding languages which renders it interesting for architectural design protocols. There are different approaches to calculate recursions one of which is a constant recalculation at every point or every unit closer to the underlying or initial geometric entity.

Another well known example to visualize recursion is the Koch snowflake or Koch curve. It is created when a straight line is divided into three equal segments and the middle segment is replaced by two sides of an equilateral triangle of the same length as the segment being removed (Fig 56). It is only when you repeat the process an infinite number of times though that you end up with a fractal. It is something that you can't draw because it is a line with two end points and an infinite length.

It can have an infinite length because it's not actually a line. A line is strictly a 1D object. Instead, it's a fractal object with dimension $\frac{\log(4)}{\log(3)}$, or 1.2619. So it is an entity between a 1D object (line) and a 2D one (square).⁸⁵

Another specifics that is important to note, specifically for the project Particle Hut are fractal dimensions.

84 Semper, Gottfried, 1860-1863. *Der Stil in den technischen und tektonischen Künsten oder Praktische Ästhetik*. Frankfurt am Main: Verlag für Kunst und Wissenschaft.

85 From: Algorithmic Universe contributors, 2014, Koch Curve – Fractal Thought Experiment. In *Algorithmic Universe, Thoughts on Algorithms*. Retrieved on February 2017, <http://algorithmicuniverse.com/2014/02/12/koch-curve-fractal-thought-experiment/>

Dimensions are independent descriptors of position. You can move a sphere in one direction, e.g. x, without changing its position in other dimensions, e.g. y, and z.

In mathematics, more specifically in fractal geometry, a fractal dimension is a ratio providing a statistical index of complexity comparing how detail in a pattern (strictly speaking, a fractal pattern) changes with the scale at which it is measured. It has also been characterized as a measure of the space-filling capacity of a pattern that tells how a fractal scales differently from the space it is embedded in.⁸⁶

Recursion in Practice: Formations, Blocks, Particle Hut

Formations exhibition at the MAK (Museum of Applied Arts), Vienna, AT

Formations was an invited solo exhibition at the MAK (Fig 17). The MAK does not exhibit the artist's body of work in this specific space. Instead the call invites architects to create a specific proposal providing a great opportunity to continue and elaborate the research on recursion.

At that time tools to develop and manipulate Mandelbrot 3D sets became available allowing to create a series of objects. Just like with the topological approach animation was a first tool for exploration. The technique was very analytical but the result created a series of very lush bodies that revealed extremely architectural constituents or conditions of some of the fractal formulas.

Blocks

The project Blocks can be counted into the series of projects and speculations on recursive geometrical conditions executed since 2010 (Fig 62, Fig 63). Following the focused research on topological modeling that was conducted between 2005 and 2010, the research focus turned towards recursion, fractals and repetition. Similar as in the case of the topological research the main driving force behind the research on recursive geometries was the discovery of fractal 3D modeling software, e.g. Mandelbulber, developed by Polish mathematician Krzysztof Marczak. This software, among others, made an enormous step forward from 2D Mandelbrot sets to quasi 3D Mandelbrot sets. The main interest was to discover and explore the agencies of algorithmic design procedures and protocols which would allow for the creation of highly articulated surfaces and spaces, without relying entirely on the imagination or the talent of the designer but rather through a collaborative approach, in a dialog between human imagination and computational prowess. Blocks can be seen in the tradition of the abstract machine. In many ways SPAN has utilized

86 Mandelbrot, B.B. The Fractal Geometry of Nature, W.H. Freeman and Company 1983

abstract machines as the point of origin for a series of projects. They represent a collection of possible architectures and are as much plan, section and perspective as they are detail, house or urban block. These vague denominations form the ground for the relationship between all these objects. Blocks certainly operates outside specific contextualisation, wither these be historic or urban, it rather embraces an abstract niche within the architectural canon. The scale-less nature, and the recursive properties of objects such as Blocks are interrogated intensively for their ability to fuse the conceptual project with the sensation project, and their contingencies to propose specific architectural bodies.⁸⁷

The physiognomy of this project can be read in a twofold manner. There is a vagueness regarding its programmatic or functional aspects. Aspects that play a minor role in the allover existence of an abstract machine in any case. This diffuse quality in relation to the question “What is it?” stands diametrically opposite the question “What does it do?” This question can be answered in an ample and detailed fashion. It is rather a forensic examination of its morphological qualities, than a question about its practical use. Practicality is not the goal here. To understand its intensive condition, it can be anatomized into specific parts that are discussed in the resulting model. First of all, there are the primordial architectural elements at play. Columns, joints and minuscule fenestrations constitute a repetitive formal rhythm (Fig 63). Deep fissures divide the entire volume into rigid vertical figurations crowned by a corniche defined by a massive, and deep, horizontal crevice. This corniche is riddled with deep crenellations, balistraria and pock marks of porous apertures. At closer examination the surface reveals its recursive quality. The motive of the elongated vertical joint is repeated in delicate vertical lines that resemble the quality of the fluting of columns or the articulation of bundled Gothic mullions. The vertical rhythm of joints, flutings and bundles is repeated in a series of horizontal, rhythmically distributed lozenges in various scales, down to the utmost microscopic level. The relentless repetition of the recursive algorithm informs the articulation of the project, this allows to zoom into the project deeper and deeper without losing the amount of detail. This project, which was first published in the edition of AD (Architectural Design) *Evoking through Design, Contemporary Moods in Architecture*, was also on show at the SPAN solo exhibition *Sublime Bodies*, in the FabUnion Gallery in Shanghai China (Fig 18). In the gallery three images of the series were displayed in large scale prints 3m x 3m. This large scale, backlit images allowed visitors to experience the level of detail of this images in a very physical manner. Instead of zooming in and zooming out on a screen, visitors were able to wander around the image and move up close to scrutinize the image’s deep dimensions. The exhibition also included the first attempt to spatialise the problem. All the projects dealing with recursive geometries in SPAN’s work where primarily expressed through two dimensional imaging. Starting with the exhibition *Formations*

87 del Campo, Matias, 2016. *Moody Objects, Ore Fashion Stores and Blocks*. In *Architectural Design*, 224, London: Wiley, p53-57.

in the MAK, the Museum of Applied Arts, in Vienna where a large scale ceiling print was presented (Fig 17). But until the show in the FabUnion Gallery, there was never a 3D representation of the problem. A series of acrylic panels was printed for the show, which contained layers of the tomographic mapping of one of the Blocks (Fig 26, Fig 27). This spatial tomography, akin to the forensic exploration of a body, revealed architectural opportunities. They demonstrated a strong interplay between mass and void, that allows for programmatic speculations, and novel methods of subdivision of space. The fractal properties of the geometry allow for a deep speculation in various scales. As the nature of fractals does not support any specific scale it can operate from the scale of a product design to the scale of cities – a property that SPAN recognized early on in the research on fractals geometries and that was already discussed in the MAK exhibition Formations.

The opposition of the questions “What is it?” and “What does it do?” is profoundly rooted in Deleuzian thinking and interrogates - instead of finding a Positivist notion in this work - the intensive qualities in a speculative project. It is however a strange case of intensities. Estrangement is a crucial term in the examination of this project. As much as there is the *déjà vu* of specific architectural figurations such as columns, crevices and fenestrations, they are strange and weird columns, crevices and fenestrations. There is a proximity to ideas of the estrangement of the real, or the quest for other architectural aesthetics. This seems to be like a red thread undulating through the majority of SPAN’s work. A desire for the moments of estrangement as powerful tools of critical interrogation of architecture’s ballistic trajectories.

Particle Hut

Space filling polyhedra form one of the most basic building blocks in architecture, as also the brick can be understood as a special case of a space filling polyhedron in the form of rectangular block. However, there are other polyhedral bodies that fulfil the criteria to fill space without leaving any gaps between them. Some of those examples include the combination of tetrahedra and octahedra, convex polyhedral as well as triangular prisms and hexagonal prisms. Within the family of space filling polyhedra it was the bisymmetric hendecahedron that was scrutinised for its capacities in design since 2008.

This installation Particle Hut was designed and built for the Digital Futures exhibition at Tongji University, in summer 2016 (Fig 58, Fig 59). It is however the latest member in an entire lineage of projects dealing with the bisymmetric hendecahedron and its space filling properties. Starting with experiments conducted at the Bauhaus Dessau in 2010, where perforation and pattering strategies were explored, to seminar work at the University of Michigan. All of which can be considered examinations of techniques to dissolve the mass of the object and infuse it with lightness, porosity and transparency. Similar to the brick, it is possible to build rectangular walls as much as it is possible to build vaults or cupolas. The main difference being the

surface articulation possible with this component. Of course the application of repeating component lends itself towards discussing part to whole relationships. In contrast to the modernist ideals of the subdivision of a specific project in a completely top down fashion, the Particle Hut combined two approaches: A top down paired with a bottom up approach. A cubic envelope of space was combined with an interior vault (Fig 59, Fig 61) followed by a profound interrogation for a variety of criteria, such as the minimum of components necessary to build the largest envelope, or the reduction of weight at the top in favor of solid components on the bottom. In the Pantheon in Rome the reduction of weight towards the top of the dome was achieved by reducing the wall thickness in combination with a lighter concrete mixture containing more volcanic tuff, a porous and lightweight stone. This combination of geometric and material property was applied in the Particle Hut in a small prototype.

The name Particle Hut derived after a month long stay at CERN in May 2016 through the Accelerate@CERN fellowship awarded from the Federal Chancellery of the Republic of Austria.⁸⁸ The inspiring visit helped to understand the basic composition of matter, and the importance of particles as the building blocks of our universe. Atypical for SPAN the term took a metaphorical role for the installation Particle Hut in order to provide an alternative explanation model for building with discreet components instead of trying to achieve a continuous, smooth gesture. The Particle Hut within the body of work of SPAN can be positioned in closer proximity to projects such as Blocks (Fig 62, Fig 63) and ORE (Fig 66 - Fig 69) which can be considered attempts to escape the paradigm of continuous transformation which were so strongly present in projects such as the Brancusi Museum (Fig 41, Fig 42) or the Austrian Pavilion for the Shanghai Expo (Fig 49 - 51). Instead emphasis is given to articulating and exploring an alternative morphological condition.

Emphasis was given to the atmospheric qualities of the design. Mood is a difficult topic to describe in a scientific fashion. Its elusiveness may be one of the reasons why architectural discourse shies away from embracing the topic. There is no theory of mood, just hints, and short discussions. Often it is labeled as being part of a phenomenological conversation, but this denomination does not live up to the profound possibilities of the project. How do you discuss it as an ontological problem? How does it comply to epistemological considerations?

The atmosphere of the project was designed to be observed in darkness, the play of blurry shadows, and the quality of a metallic forest canopy being part of its identity. The interplay between rigorous stacking and variation of perforation results in the cuboid's transforming from a rigid base to hazy, blurred boundaries

⁸⁸ Cern (French: Conseil européen pour la recherche nucléaire) is a European research organization that operates the largest particle physics laboratory in the world. It was formed in 1954 with 20,000 scientist and its own campus in the City of Geneva, Switzerland. CERN has a long standing tradition involving artist to develop projects related to its research. This specific grant, however, was a very rare opportunity as it was the first time that architects were invited to propose a project.

on the top. The basic morphology of the object consists of a box with a shell structure on the inside, in between these two spaces are hollow *pochés* void of particles (Fig 61). The exterior cube is supported by the vault on the inside. The transformation of the particles results in effects that can be described as a transformation from a *muqarna*, an Islamic vault (Fig 60), to a forest canopy consisting of an aluminum foliage. The rigorous but distinctively formal geometry of the *muqarna* serves as model, and explains the method of the interior vault of the Particle Hut. The *muqarna*, and the system applied to the Particle Hut, is a so called corbel vault, one of the most archaic methods of spanning interiors. The corbel vault consists of components that are horizontally sliding inwards, increasingly cantilevering till they connect at the pinnacle. This primitive method does not allow to span large spaces, in contrast to the semicircular arched vault. The combination of prototypical architectural method, such as the corbel vault, and advanced computational and fabrication methods is of interest of this project as cutting edge technology can inform novel trajectories in architecture, but still be able to communicate with long-term trajectories of the architectural discipline.

The project consists of 3200 components which were fabricated in Shanghai by laser-cutting sheets of aluminum and folding them into hendecahedra components. The components are attached to each other using double-sided tape. Apart from the adhesive qualities the tape also includes an elastic neoprene layer which allowed the entire installation to respond actively to pressures, meaning that the connection areas were less prone to breaking, ripping or tearing. There is in total a family of five different particles. They are identical in their base geometry, a bisymmetric hendecahedron, but are differentiated by the amount and size of circular perforation. The Swiss cheese-ing of the components allowed for a gradual change in the porosity of the object as well as a progressive reduction in weight towards the top of the object.

As with the entire family of projects starting with the MAK exhibition *Formations* in Vienna 2011, this exhibition project negotiates between the familiar and the unfamiliar, exploring realms of estrangement as much as dealing with aspects of the postdigital age. The speculative nature of the project, and its ambitions to deal with aspects of mood in a physical environment position the project in a realm of speculations on the nature of a world oscillating between digital information and the ontologies of physical presence. As much as this project is a child of the digital realm, it also emphasizes the qualities of semblance, mannerisms and atmospheres of physical objects.

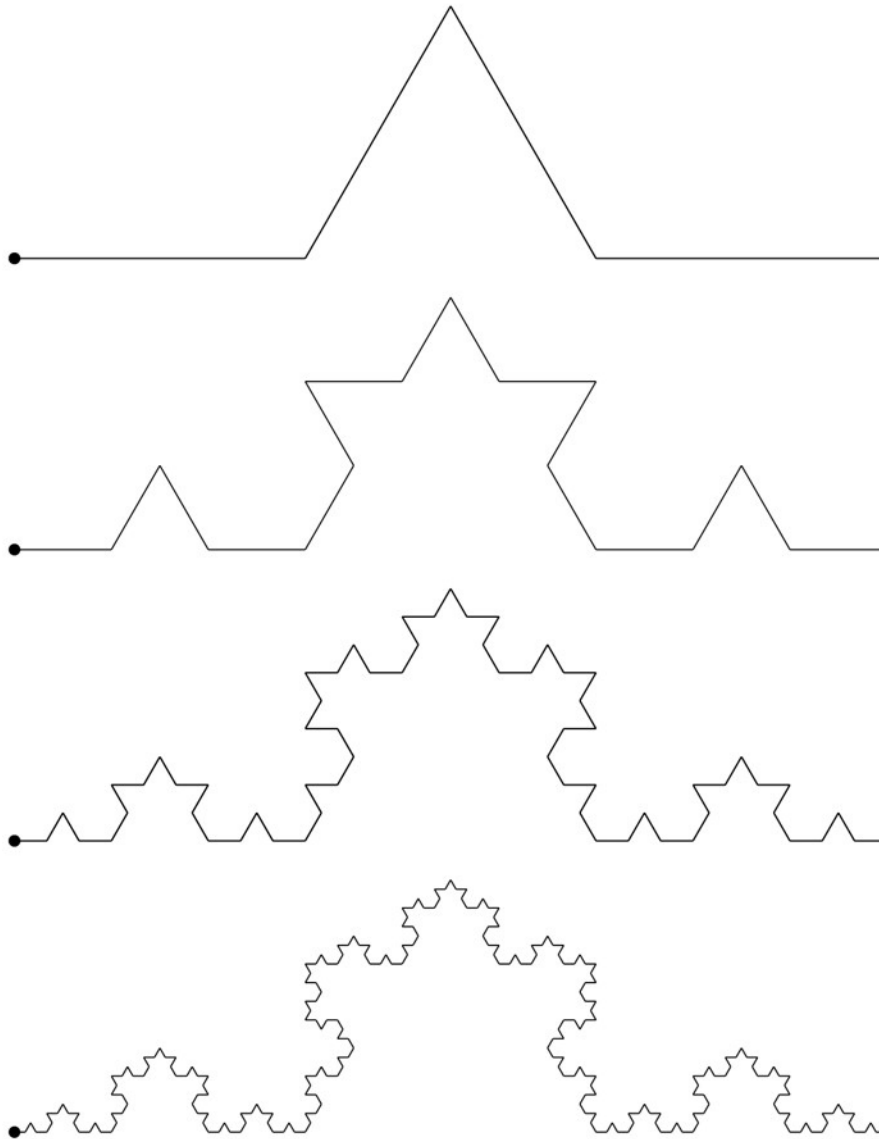


Fig 56 *Koch Curve*, named after Helge van Koch

A straight line is divided into three equal segments and the middle segment is replaced by two sides of an equilateral triangle of the same length as the segment being removed. This set of instructions can be iterated an infinite amount of times rendering the distance between two points infinite.

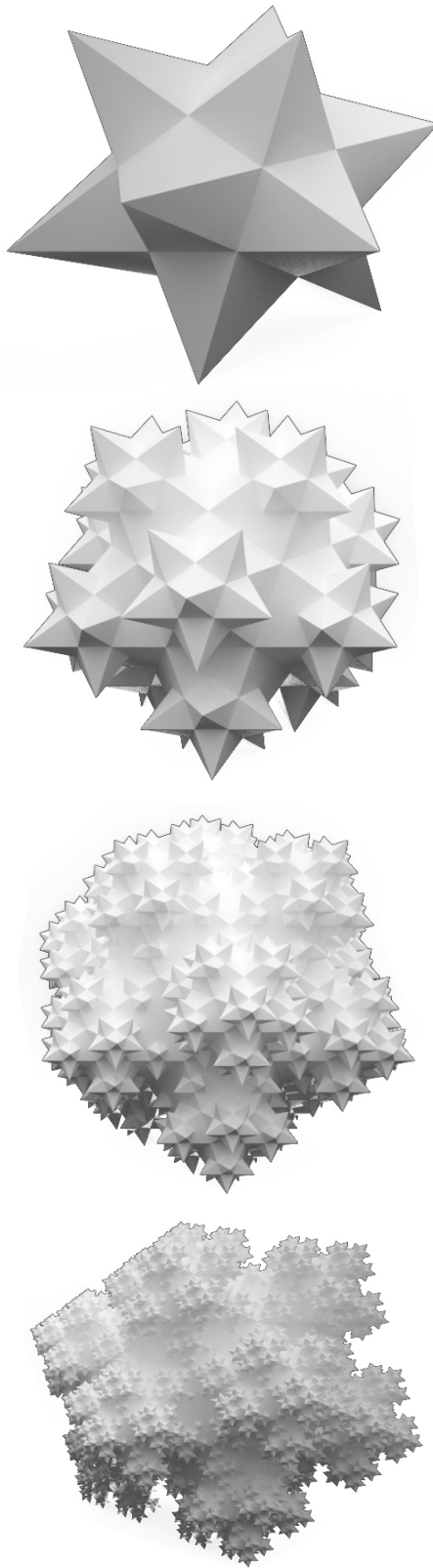


Fig 57 *Stellated Decahedron*, three iterations over the initial geometry, courtesy James Coleman



Fig 58 Particle Hut, exhibition at Tongji University, Shanghai, CN, SPAN2016

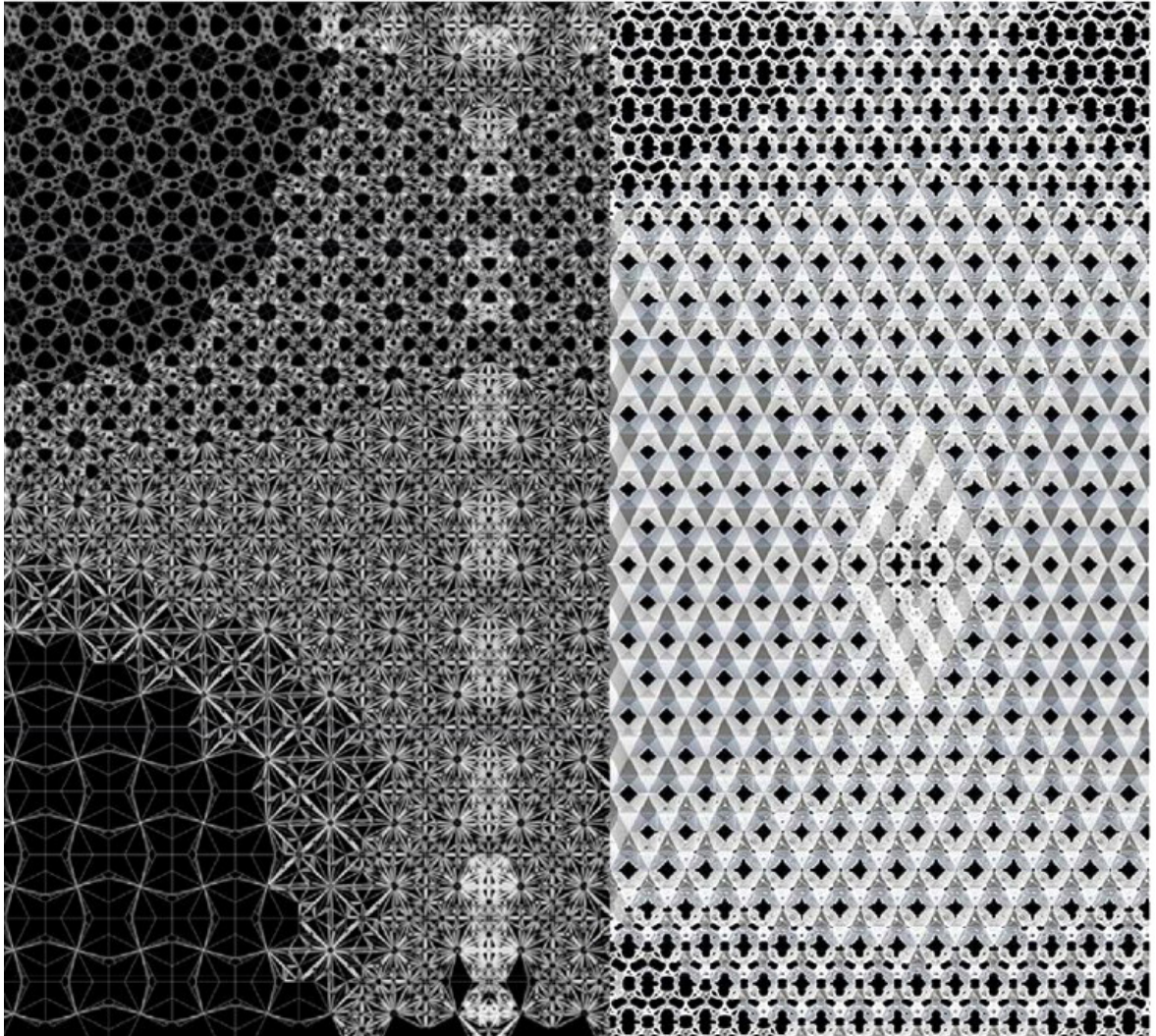


Fig 59 Particle Hut, image of the pattern development based on growing fractal dimensionality, SPAN2016

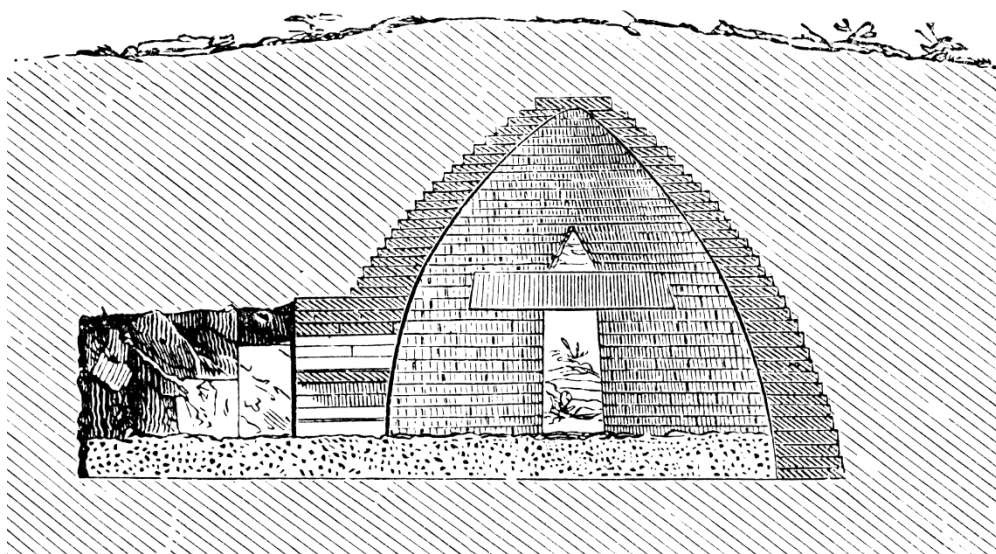


Fig 60 The Treasury of Atreus, sectional analysis of the corbel vault, Mycenae, GR, courtesy of Wikimedia.

The corbel vault consists of components that are horizontally sliding inwards, increasingly cantilevering till they connect at the pinnacle.

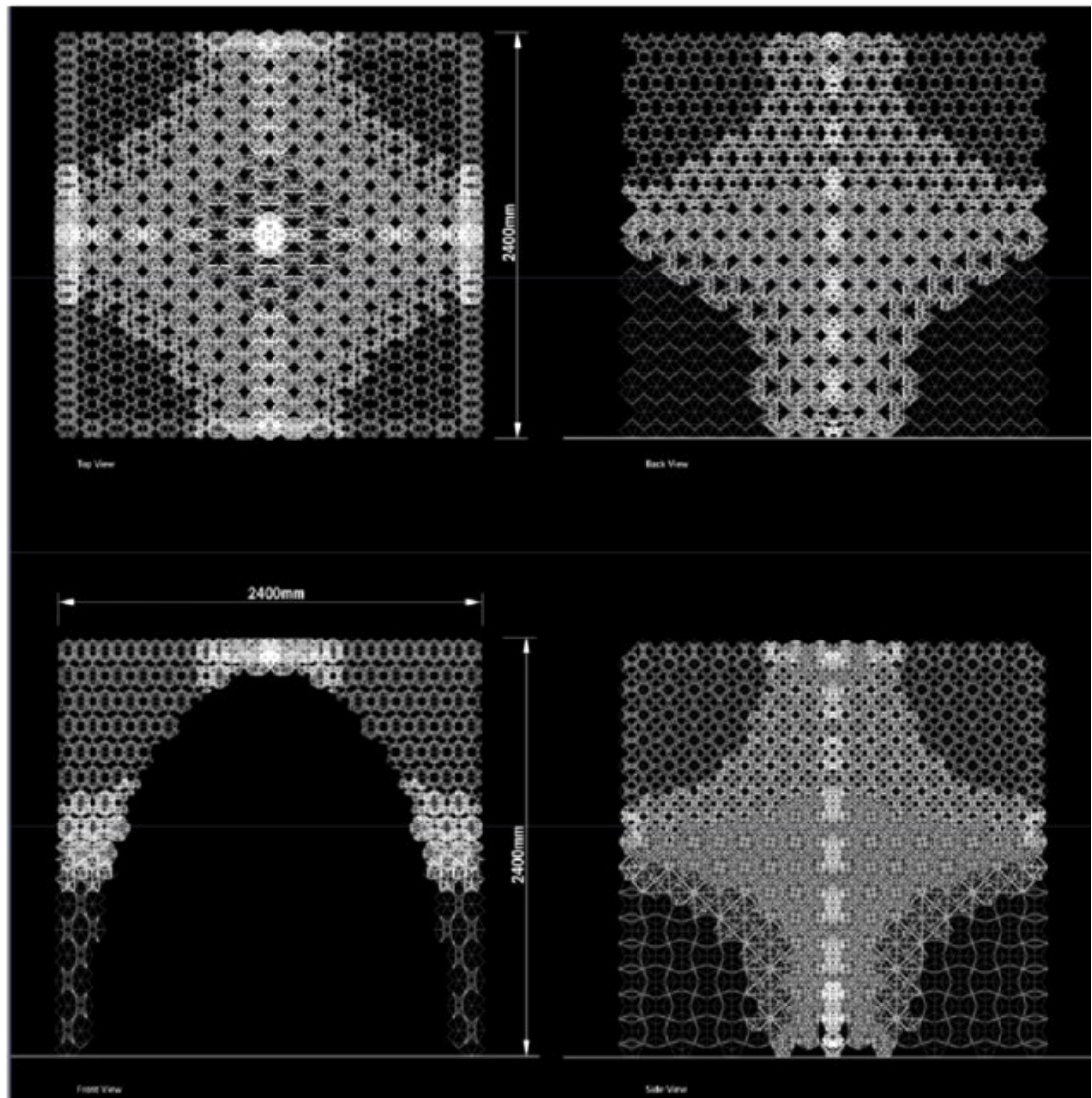


Fig 61 Particle Hut, image of the top view (image top left) and three elevations, SPAN2016

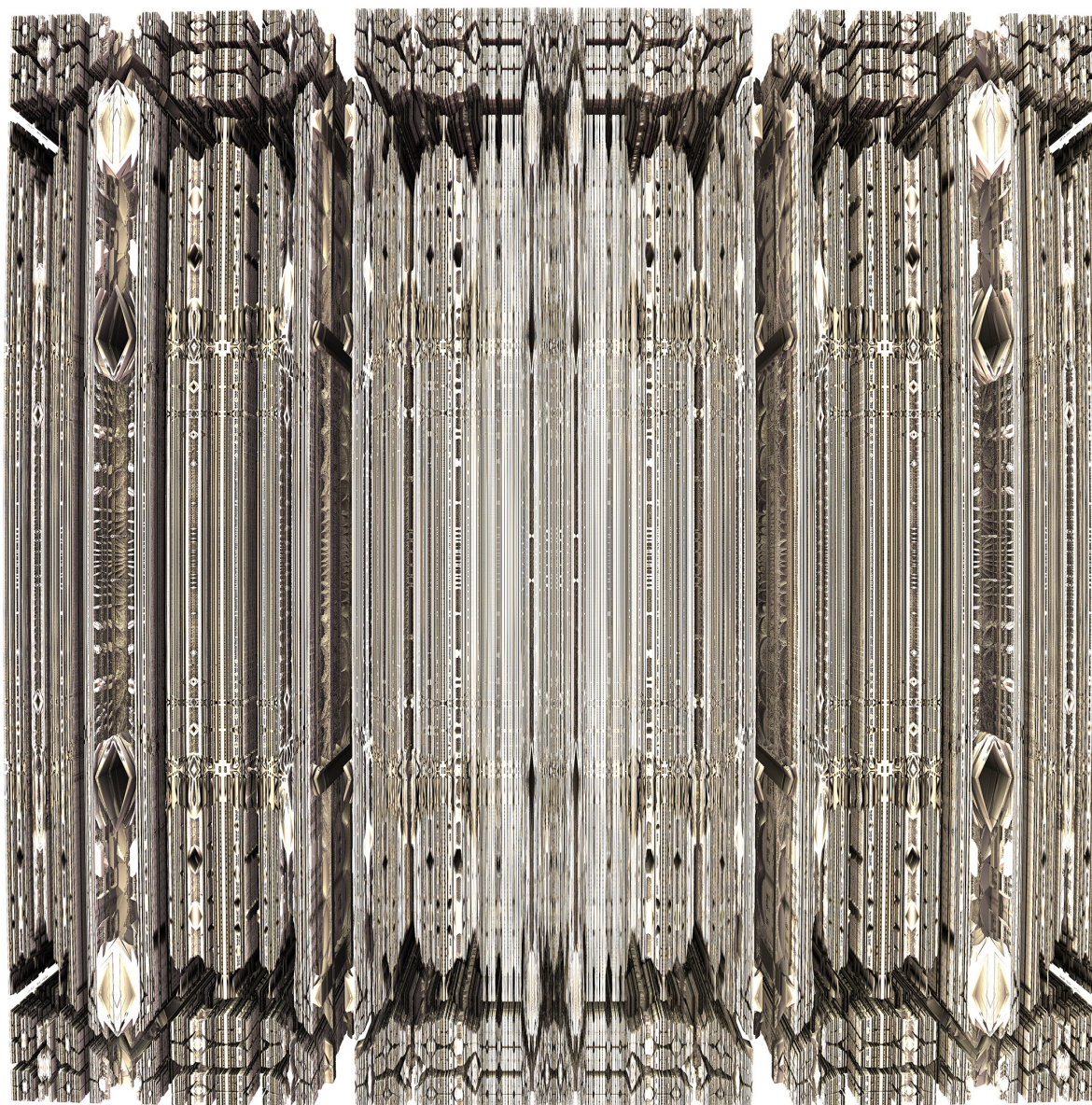


Fig 62 Blocks ABoxVSShapeIt03, render, SPAN2016

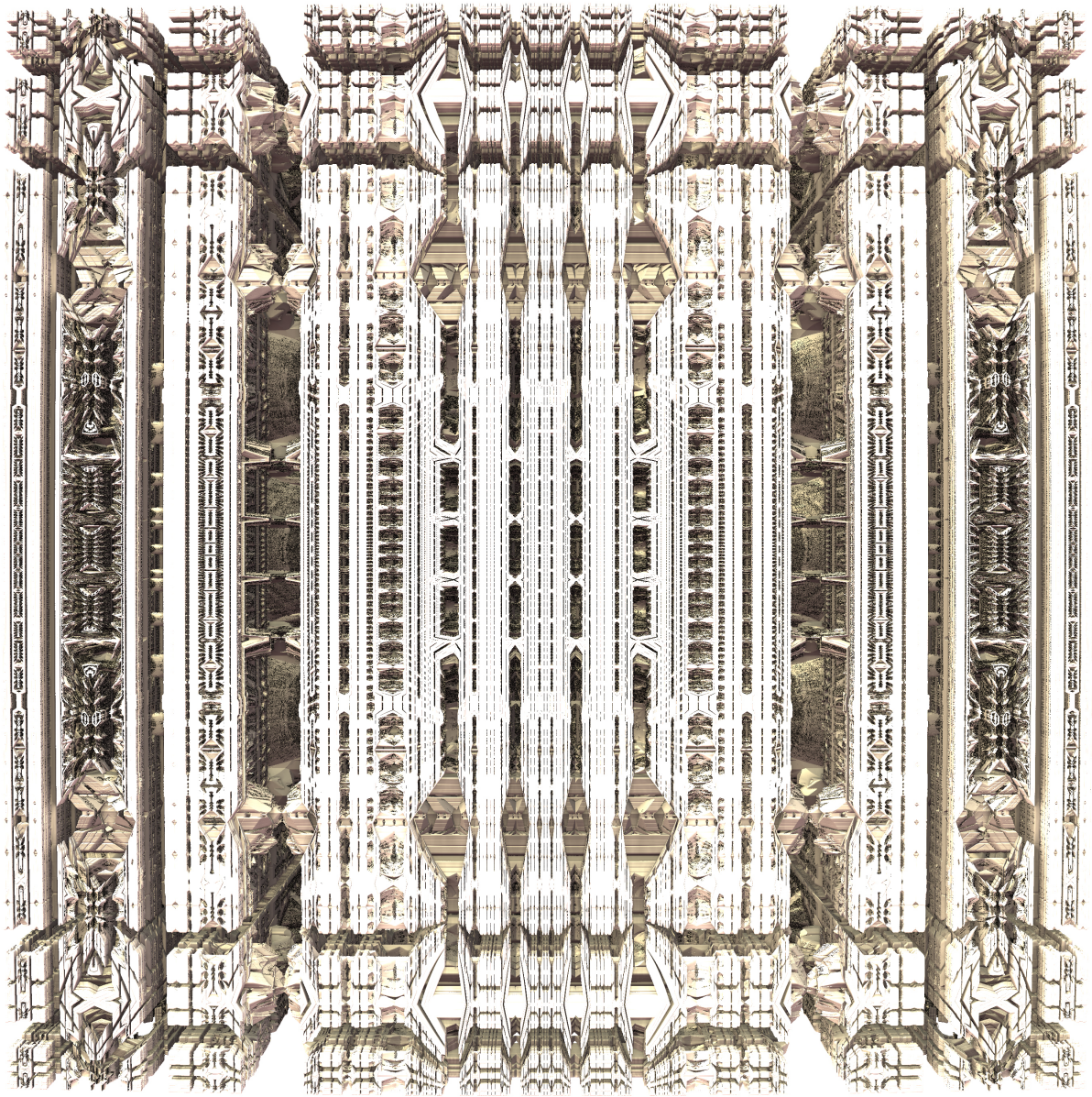


Fig 63 Blocks ABoxVSShapeIt01, render, SPAN2016

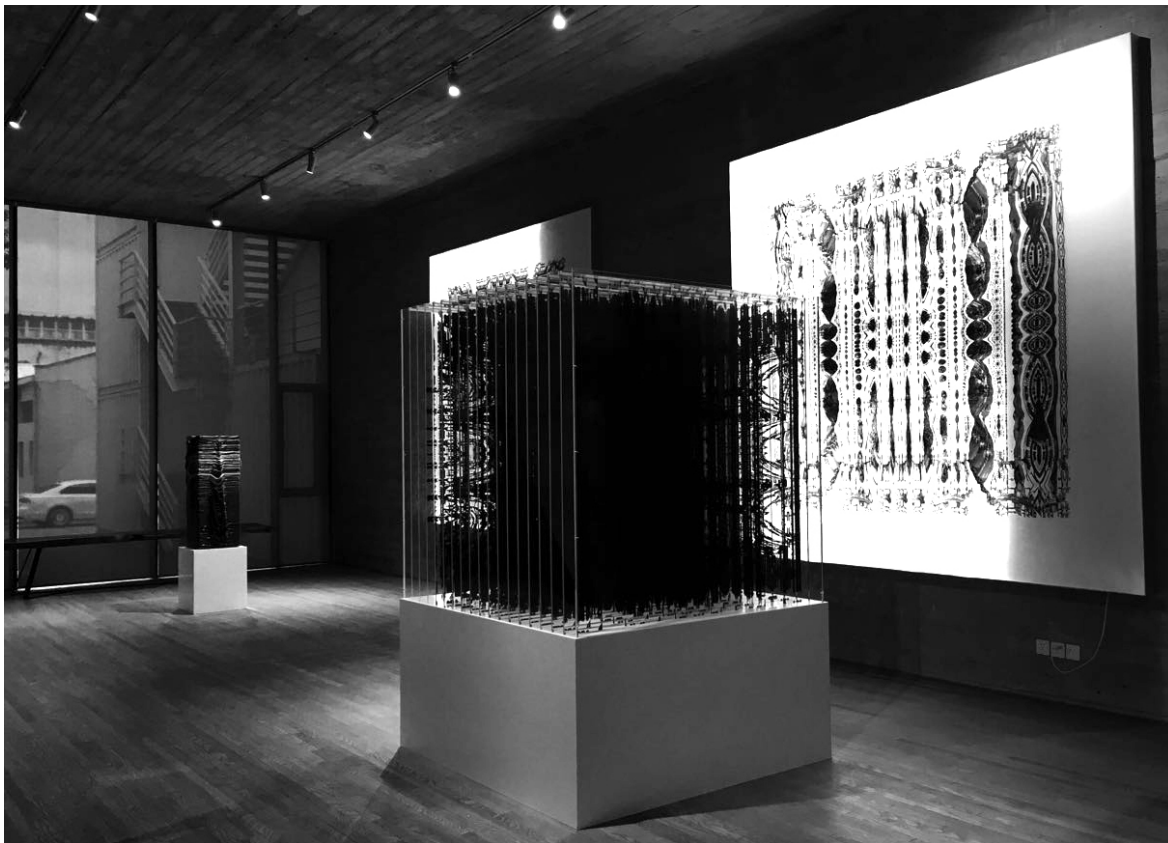


Fig 64 *Sensible Bodies*, view at *Blocks and Plato's Column*, FAB-Union gallery, Shanghai, CN, SPAN2016

G-Coded Gestures

‘The inherent discreteness of nature (which, after all, is not made of dimensionless Euclidean points nor of continuous mathematical lines, but of distinct chunks of matter, all the way down to molecules, atoms, and electrons) is then captured and kept as it come, ideally, or in practice as close to its material structure as needed, with all the apparent randomness and irregularity that will inevitably show at each scale of resolution.’ Mario Carpo⁸⁹

Material Extrusions in Practice: Extruding Concrete

ORE – design for Popup Fashion pavilions for the Shanghai Fashion Week, Shanghai, China 2015

In 2015 SPAN was commissioned with the design of a series of pop up stores for the Shanghai Fashion Week. The brief asked for eight shops with approximately 20m² each positioned around a square close to the famous Bund on the shores of the Huangpu River. Further research unveiled that the square in question is one of the oldest parts and is considered the nucleus of the Bund. Framed by the former Union Church, the palatial embassy of the British Commonwealth and the slightly curving Yuanmingyuan Road the square provided an excellent stage for the Shanghai fashion week. Instead of locating the shops at the periphery of the square the shops are positioned as free-standing objects on the square, subdividing it and allowing for a more intimate circulation through the plaza (Fig 65). The organization in a porous carrée resulted in a layering of the experience of the square with an exterior and an interior circulation. The design proposed an elliptic basin in the center of the carrée, a mirroring surface for the pop up stores. The stores themselves were housed in four cubic objects surrounding the basin. They were positioned to allow for specific views between their massing. The views at the existing square are rather unique in that they allow to experience a variation of depth of perception. The fashion pop up store ORE explores the problem of contextualisation and precise positioning of an object in space. The four volumes on the square creating the views from the central basin. They were specifically designed to balance long distance views and short distance perception. The analytical plan, shows how the positioning was defined, and how the view can wander from close objects such as the church and the art nouveau industrial buildings along the Yuanmingyuan Road to the distant high-risers of Pudong district and the shores of the Huangpu River.

As the program, defined by the customer, asked for eight shops in total, each one of the four cubes interior was divided diagonally. Leaving two shops per cube with a triangular plan. This can be described as the

89 Carpo, Mario, 2016. Excessive Resolution: From Digital Streamlining to Computational Complexity. Architectural Design, 86(6), p81.

basic morphology of the ORE stores. The cubes primitive form was counterbalanced by the exploration of three main questions: The question of the corner problem, the question of points in space and its opportunities to define mass and the nature of continuous toolpaths as method of formal expression.

The interrogation of the corner problem once more demonstrates SPAN's interest in combining a common problem from architectural discourse -the corner- with novel design and production opportunities in order to attempt a progression in architectural design. In the case of ORE the corner is defined by a spatial inflection, pushing into the corner condition in an unstable way. To destabilize the corner is a profoundly counter intuitive gesture in architectural thinking. The consideration of the corner is a long-term obsession in the discipline, to discuss the history and the myriad of solutions designed to solve the simple question as of how material makes a 90 degree turn (or any turn, for that matter). In the case at hand the design agency was handed over to an agent based model which populated the corner with random points that were covered in an isomesh that resulted in the wildly porous corner condition. To celebrate and highlight the fragility of the condition the corners are gilded. Picking up on the Viennese tradition to emphasize architectural elements such as window frames, door frames and columns by gilding them, this project celebrates the corner in a very traditional way.

The problem of points in space and their agency in design was explored with this project. In order to provide an alternative mode of thinking about cubes, an algorithmic, emergent design method was chosen. As already discussed with the Particle Hut, the idea is to combine a top down design approach with the agencies of bottom up techniques, or emergent design properties. The primordial figuration of a cube was populated with points off varying density and organization. Observing the side walls of the cubes it becomes quite evident that the points are most rigorously organized in the middle of the wall and become increasingly random approaching the corners, resulting in the weirdly contorted and porous formations of the corners. The amassing orbiting the points was achieved by applying a marching cube algorithm⁹⁰ to the point distribution by applying the Cocoon components in Grasshopper.⁹¹ This marching cube algorithm is the base for stretching an isomesh over the resulting metaballs and transforming it successfully into a polygon mesh, which again forms the basis for the fabrication strategy. The random point definition did not only provide the forming strategy for the exterior and the corners of the cube but influenced also the formation of the interior. Acute attention was given to the morphology of the wall dividing the two stores in one cube. The hypotenuse of the triangles forming the shops' plans was intentionally undulated and curled to provide

90 Lorensen, William E.; Cline, Harvey E. (1 August 1987). "Marching cubes: A high resolution 3D surface construction algorithm". *ACM SIGGRAPH Computer Graphics*. 21 (4): 163–169.

91 Grasshopper is a graphical algorithm editor tightly integrated with the 3D modeling software Rhino.

space in its folds for functions such as storage, changing booth, displays etc., also the floor and ceiling following the same methodology.

The nature of continuous toolpaths forms the third pillar of thought in this project. The four pavilions of this projects are designed as an ephemeral installation that can move location. It was intended to build up this stores for the time of the fashion week only. Populated by designers interested in novel design and fabrication methods such as 3D printing and laser-cutting the shops design was to follow up and express this interest also in its method of making. The most common method to subdivide a complex figure for digital fabrication is the layering method – a widely used method in 3D printing. Picking up on this notion the fabrication strategy of the pavilion was based on layering concrete. The project was divided into components that can be stacked. The fabrication was envisioned in 3D printed concrete, providing hollow walls with *pochés*. The resulting toolpath of the design served as template for a division of the object, at the same time its artifacts of subdivision form an example of digital ornamentation, and the play between the bulging curvilinear properties of the isomesh and the strict horizontality of the bands defined by the contours necessary to create the toolpaths, provide to the aesthetic quality of this design (Fig 68, Fig 69). The plan reveals the quality of the interior articulation where the motif of the continuous undulating line starts to jump from the walls and infects the floor conditions. The result is a glue that holds the interior space together, the geometry of the cube is infused by the inflection of spatial subdivisions and wall undulations. The entrance to the cubes is also positioned in the corners. The deep inflection into the corner does not only provide a porous corner but also denotes the position of two quasi-corner columns flanking the entrances. Apart from the geometric and aesthetic properties this project discusses the opportunities in an architectural paradigm that negotiates between the technological agencies within a design such as agent based modeling, algorithmic modeling, advanced fabrication and the overarching discursive implications of a postdigital age which is interested in trajectories outside a purely technical conversation but is rather interested in the disciplinary trajectories of architectural design in our contemporary age. The corner, the subdivision of space and the agencies of mass in a contemporary design ecology. What is the result for the design of our contemporary synthetic ecology?

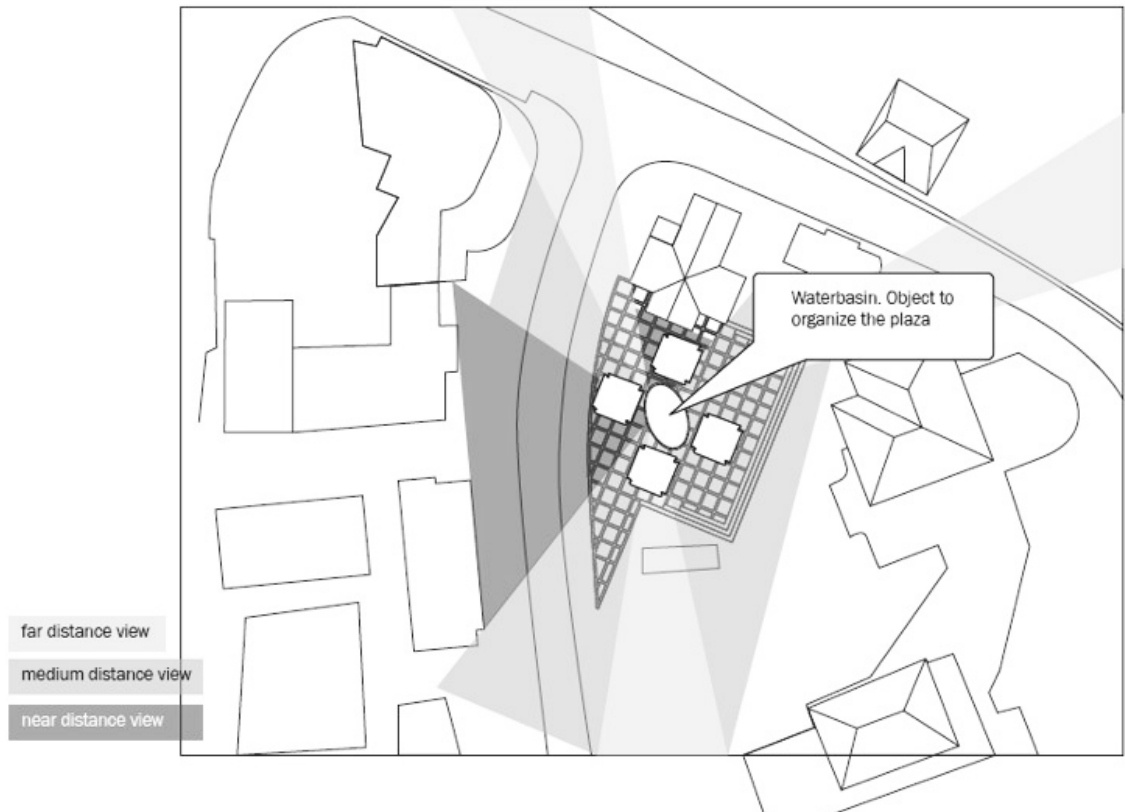


Fig 65 ORE, Popup Fashion Stores Shanghai Fashion Week, Shanghai, CN, site plan, SPAN2015

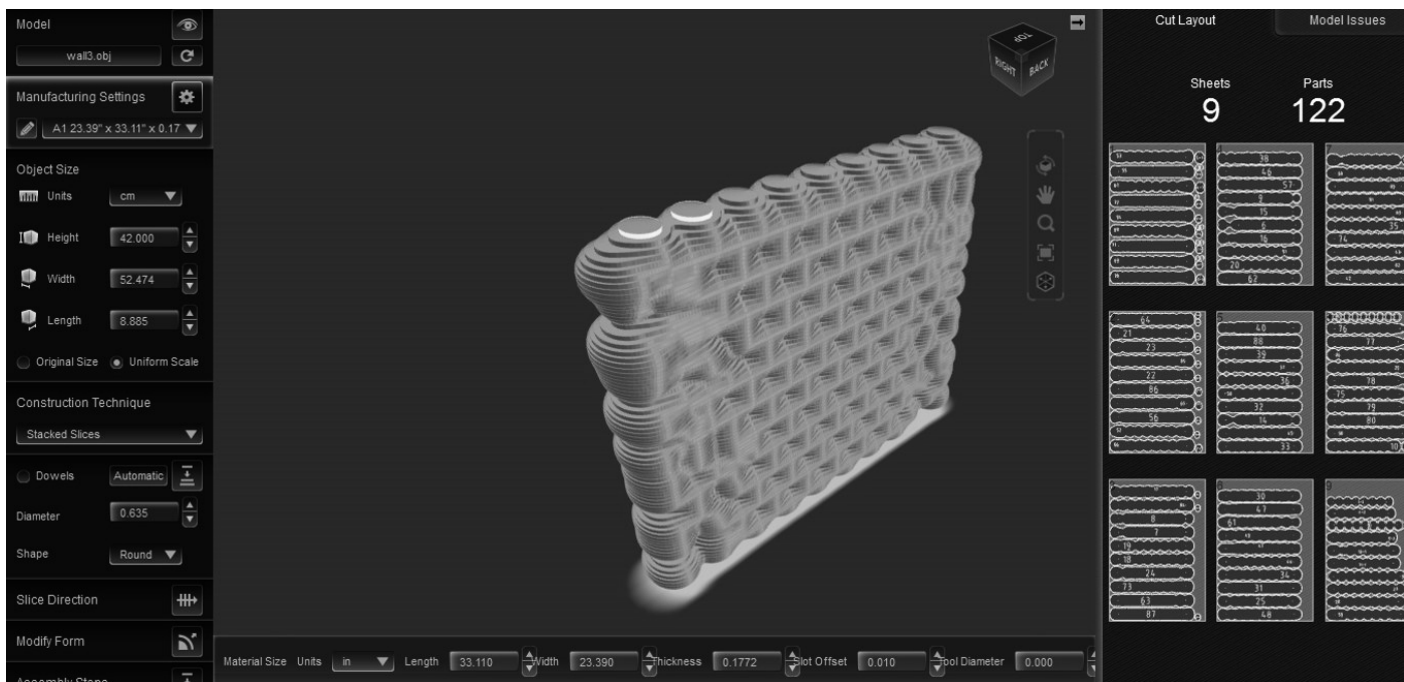


Fig 66 ORE, Popup Fashion Stores Shanghai Fashion Week, Shanghai,CN, SPAN2015
Screenshot of a wall element prepared to be printed in concrete.

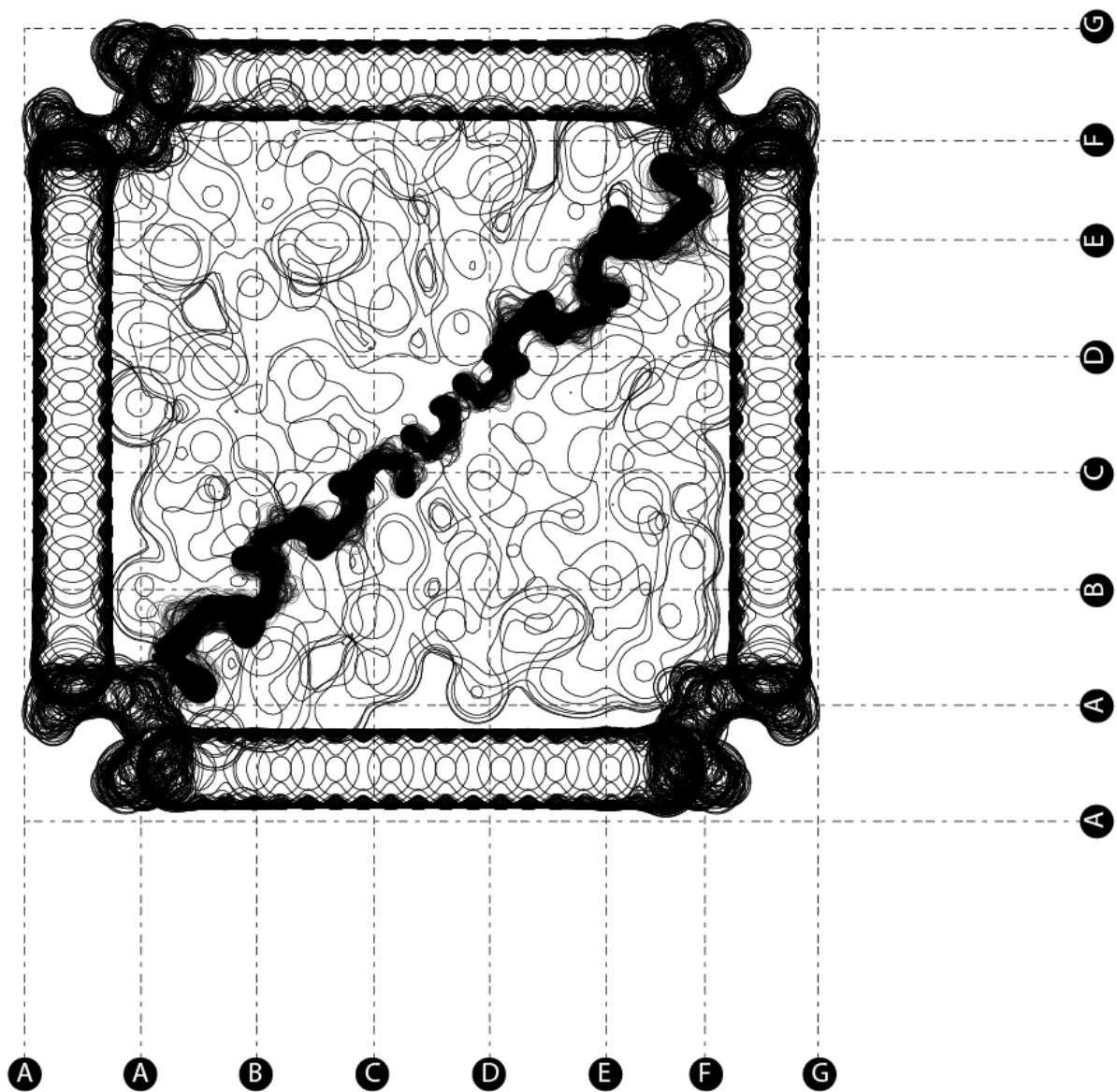


Fig 67 ORE, Popup Fashion Stores Shanghai Fashion Week, Shanghai,CN, SPAN2015
Floor plan generated by the machinic toolpath.

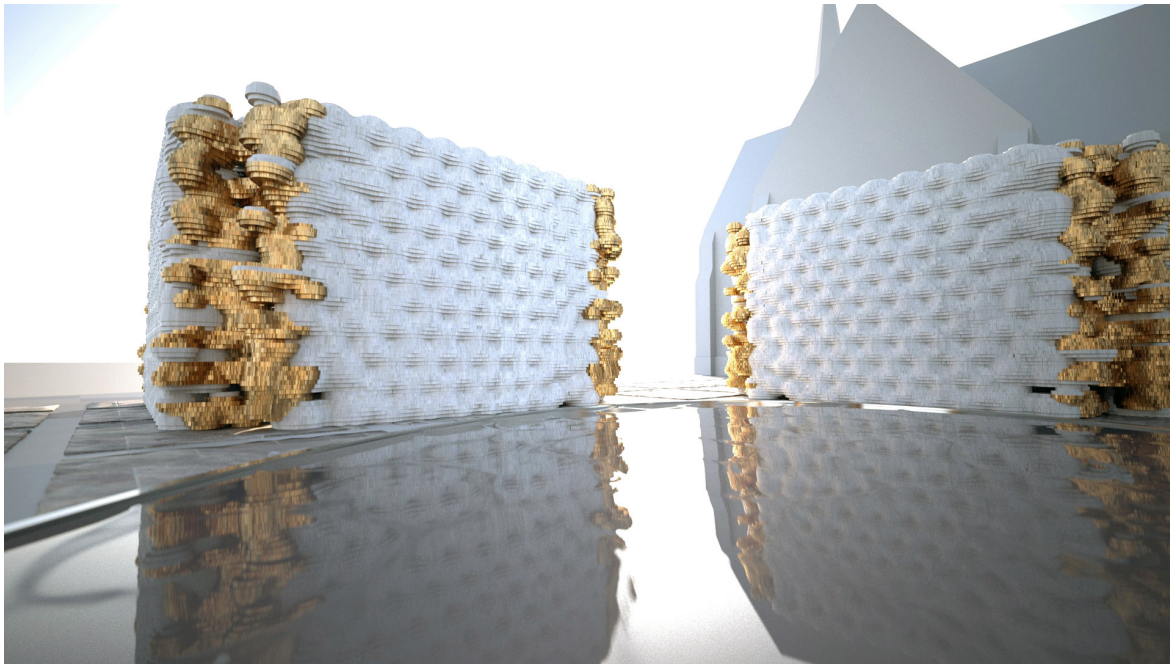


Fig 68 ORE, Popup Fashion Stores Shanghai Fashion Week, Shanghai,CN, rendered view, SPAN2015

Fig 68 and Fig 69 displaying how the fabrication process differentiates the surface articulation through the application of different step sizes.

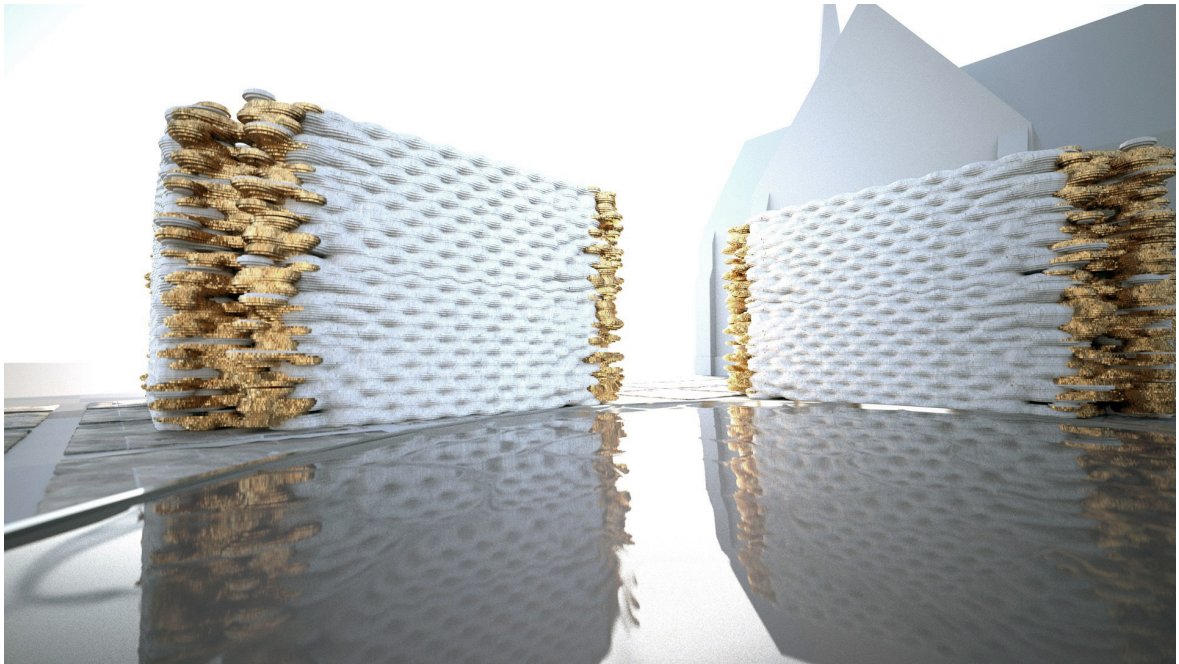


Fig 69 ORE, Popup Fashion Stores Shanghai Fashion Week, Shanghai,CN, rendered view, SPAN2015

Material Extrusions in Practice: Extruding Plastic

Plato's columns was the result of the Disobedience Advanced Architecture Studio in the Winter term 2016 at RMIT, Australia. In a certain extent it's a close family member to projects such as ORE and Blocks as it explores the potentialities in emergent behavior. The main difference being the application of emergent properties in material conditions instead of relying on a computational model alone. The project's skepticism towards the pure translation of a computational model into a precise physical representation is its main source of inspiration. The methodology strives for a combination of computational properties and the impact of environmental forces on the materialization of the project.

Plato's columns interrogates the rigorous geometry of a quasi-platonic body in combination with the emergent properties present in fused deposition modeling. The common methods of FDM (Fused Deposition Modeling) rely on the technique to subdivide an object in a sequence of horizontal layers that build up the desired figuration. The speed of the disposition in this case is of regular nature – there are practically no changes in the speed, with the exception of tight corners which automatically are adapted in their speed to compensate for material excess. This is designed so that the layer thickness is consistent and allows for a clean build up of the object. Plato's Columns deliberately abandons this dogma of FDM and examines the possible eccentricities in a technique which embraces variations in the deposition speed. In order to make these exotic behaviors visible the strict geometry of a platonic solid was chosen.

The project was executed utilizing the robotic setup of RMIT's Design Hub.⁹² The setup consisted of a KUKA KR200 industrial robotic arm and a large-scale plastic deposition head. The deposition head used pellets instead of the more common rods, which allows to mix colors in the pellet chamber. In a series of small scale models students were able to explore the technique using conventional FDM printers. The jump in scale and especially the change to colored pellets used with a large-scale deposition head produced a series of brightly colored highly articulated columns. The play with speed and temperature produced a pallet of results reaching from fatly knurled, pearling and pastose surfaces in remarkable pastel colorations to hirsute, finally woven fibrous boundaries in gorgeous cobalt and manganese violets, tangerine orange as well as crimson, cadmium and vermillion reds.

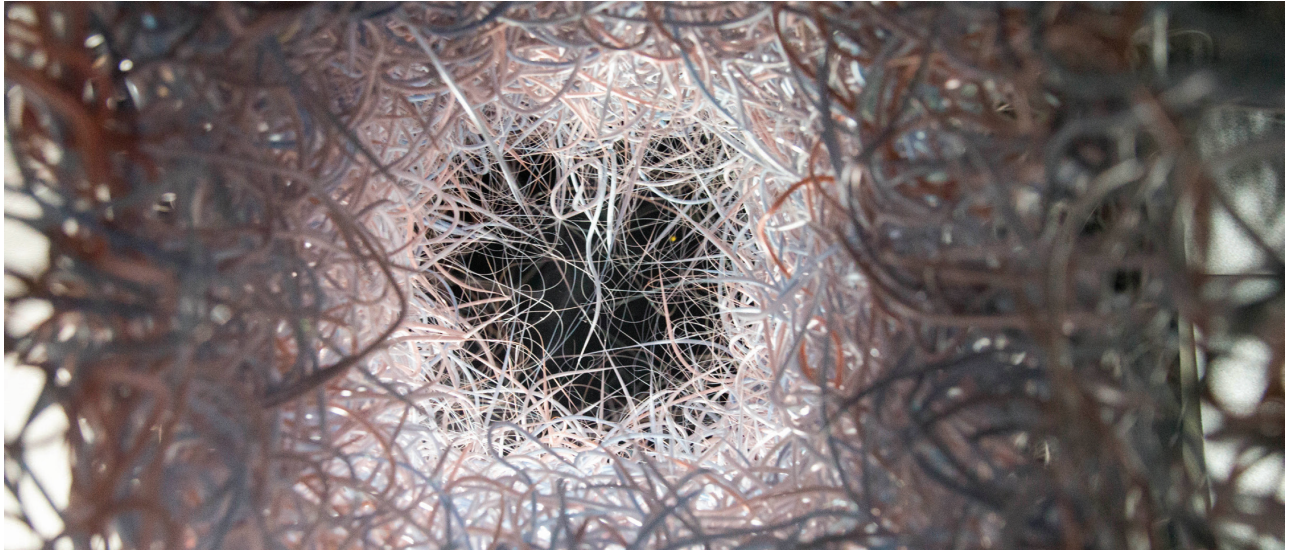
The speed of lines in combination with the forces of gravity were the primary agents shaping the

92 RMIT Design Hub is a progressive educational environment. It houses a community of architects, designers, curators and students for collaborative, interdisciplinary design research and education within a purpose-built, 10-storey building that also includes RMIT University's School of Architecture & Design and the RMIT Design Archives. <http://designhub.rmit.edu.au/>

morphology of the object. Students were encouraged to embrace glitches and mishaps as part of the aesthetic currency of the project. In contrast to the predominant method of FDM fabrication -the horizontal slicing of the figuration and the perfect replication of the computational model- Plato's Columns embraced the glitch and the mishap as part of the design process. The relative unpredictability of the materials behavior, especially under the stresses of varying deposition speeds and changing environmental conditions, is what creates the formal result. These results might at times be surprising, unusual, and not necessarily close to common canons of aesthetics. The property to challenge common conceptions on the nature of beauty or aesthetics is what makes them a valuable contribution to architectural discourse. In a way the fabrication process itself is the design process. It perverts the main notion of computational design in architecture, where a majority of the energy is invested in assuring that the design conceived (on the computer) is translated with utmost accuracy to the material world. The process presented in Plato's columns opposes this century old notion and embraces a combination between the precision of the robotic tool, the computational model and the intentional integration of external forces deforming and corrupting the result.

The results of the studio were presented in the paper Plato's Columns⁹³ at the ACADIA 2017 (37th Annual Conference of the Association for Computer Aided Design in Architecture) in Boston, Massachusetts. Writing papers and hosting and participating in conferences has become part of the architectural environment depicting the change the profession is about to undergo. Writing papers has become a tool to conceive, discuss, or evaluate design and fabrication protocols and directives and forms one part of SPAN's design ecology. To present this important aspect the following eight pages display the presented paper.

93 Manning, Sandra and Matias del Campo, 2017. Plato's Columns – Platonic Geometries vs. Vague Gestures in Robotic Construction in Proceedings of the ACADIA Conference 2017, Nov 2-4, Disciplines & Disruption, MIT Cambridge, MA, USA



1

ABSTRACT

1 Hirsute column, interior view.

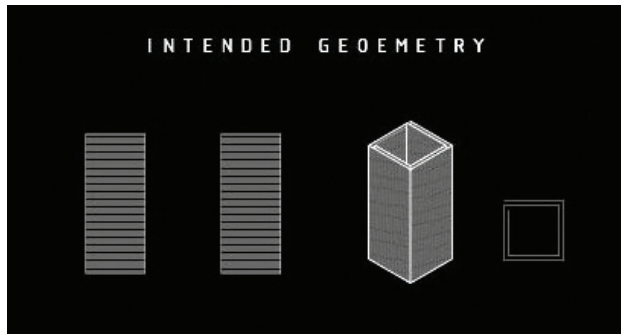
Platonem ferunt didicisse pythagorea omnia.

Cicero

This paper examines the inherent possibilities for architectural production in automated deposition modeling techniques. Primarily explored by the application of industrial robots in combination with plastic deposition heads. These robots, in combination with various polymers, toolpaths and colorations served as a design ecology for the exploration of emergent behaviors in robotic construction. The relationship between geometry (Euclidian, topological, fractal), mechanical properties of material (plasticity, elasticity, viscosity, resilience) optical properties (color, absorbance, transmittance, scattering) and the gestural qualities of robotic toolpaths constitute the palette adopted for the presented project. The project combines the rigor of a Platonic body (Fig.2) with the emergent properties of vague gestures. The introduction of moments of uncertainty in the process produces glitches which are embraced as an opportunity to find novel aesthetic conditions. The profound entanglement with the Postdigital realm is discussed as the discursive plane of thinking applied to the project.

Fig 70 Image file of page 2 of:

- 2 Manninger, Sandra and Matias del Campo, 2017. Plato's Columns – Platonic Geometries vs. Vague Gestures in Robotic Construction in Proceedings of the ACADIA Conference 2017, Nov 2-4, Disciplines & Disruption, MIT Cambridge, MA, USA



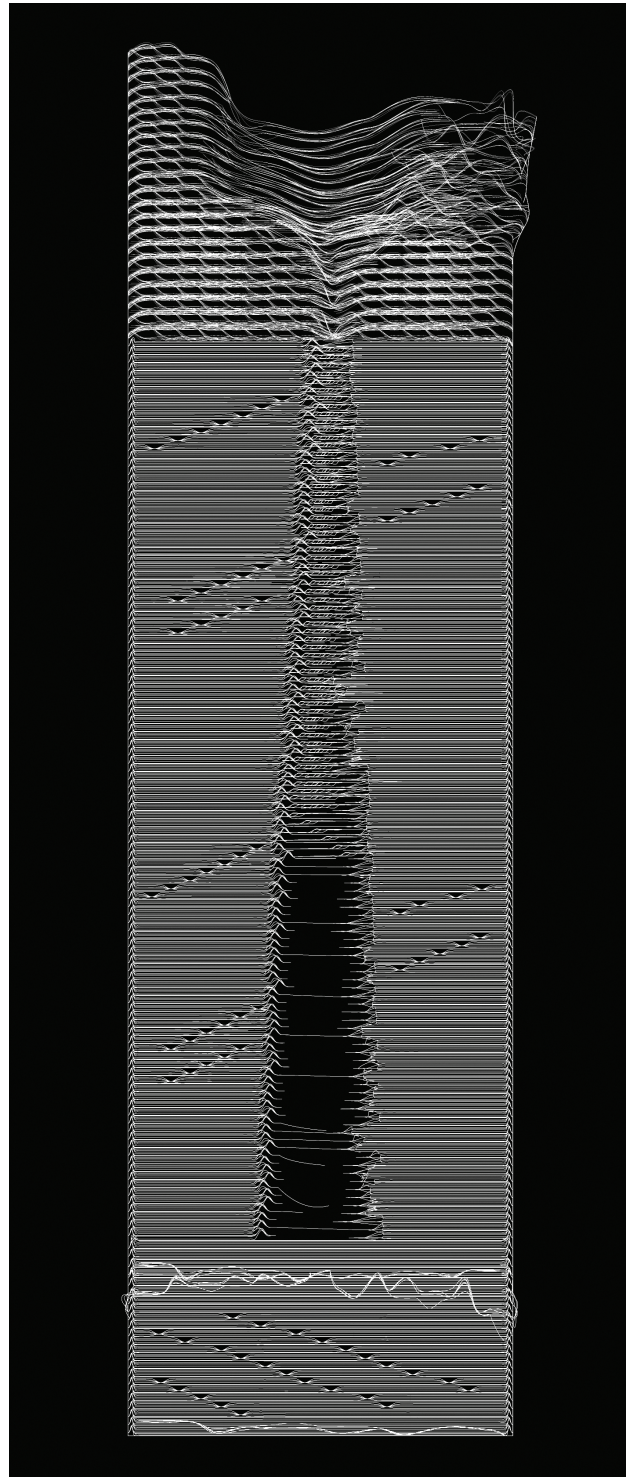
2

INTRODUCTION

An excursion into Postdigital thinking

When discussing the emergent properties of automated processes, it is essential to touch on the topic of Posthuman and Postdigital conditions. Posthuman does not entail a condition after the dominance of the human species or without humans, but rather emphasizes an alternative perspective on design that shifts the focus away from an anthropocentric position of observation and control. Posthuman design practices decentralize the role of human judgement and embrace the notion that creative agencies can be conferred to nonhuman entities such as objects, tools, materials, other species (organic or machinic) and environmental forces. Externalized knowledge begins to take identity and instrumentality, and participates in the process of generating novel design ecologies and alternative design agencies for architecture at large (Velikov et al. 2016).

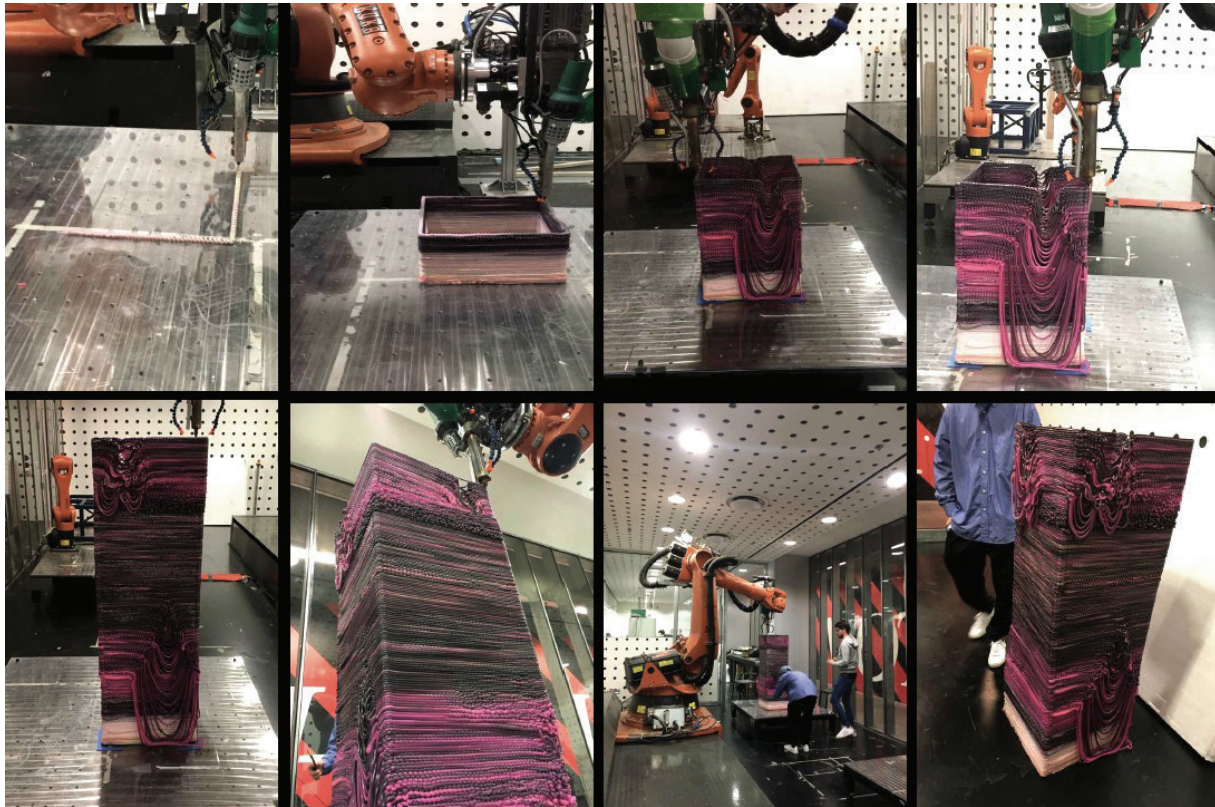
The term Postdigital emerged in the digital arts discourse around the year 2000 and was coined by the musician Kim Cascone specifically in regards of glitches in digital technology as source of inspiration. Kim Cascone, an electronic music composer by trade used the term Postdigital for the first time in his article *The Aesthetics of Failure: "Post-digital" Tendencies in the Contemporary Computer Music*. In this article Cascone observes that as digital technologies have become part of the mainstream world and are deeply entangled in everything from commerce, to Hollywood cranking out digital fluff by the gigabyte the initial fascination of designers with the digital tools per se has evaporated and made place for novel developments which do not utilize technological terms to describe the work but rather interrogate the errors and mishaps (Fig.3) in the process as potential sources of inspiration (Cascone 2000; del Campo Manning 2014).



3

2 Extruded square as initial definition. 3 Mapping of the deposition result post facto.

Fig 71 Image files of page 3 of:
Manning, Sandra and Matias del Campo, 2017. Plato's Columns – Platonic Geometries vs. Vague Gestures in Robotic Construction
in Proceedings of the ACADIA Conference 2017, Nov 2-4, Disciplines & Disruption, MIT Cambridge, MA, USA

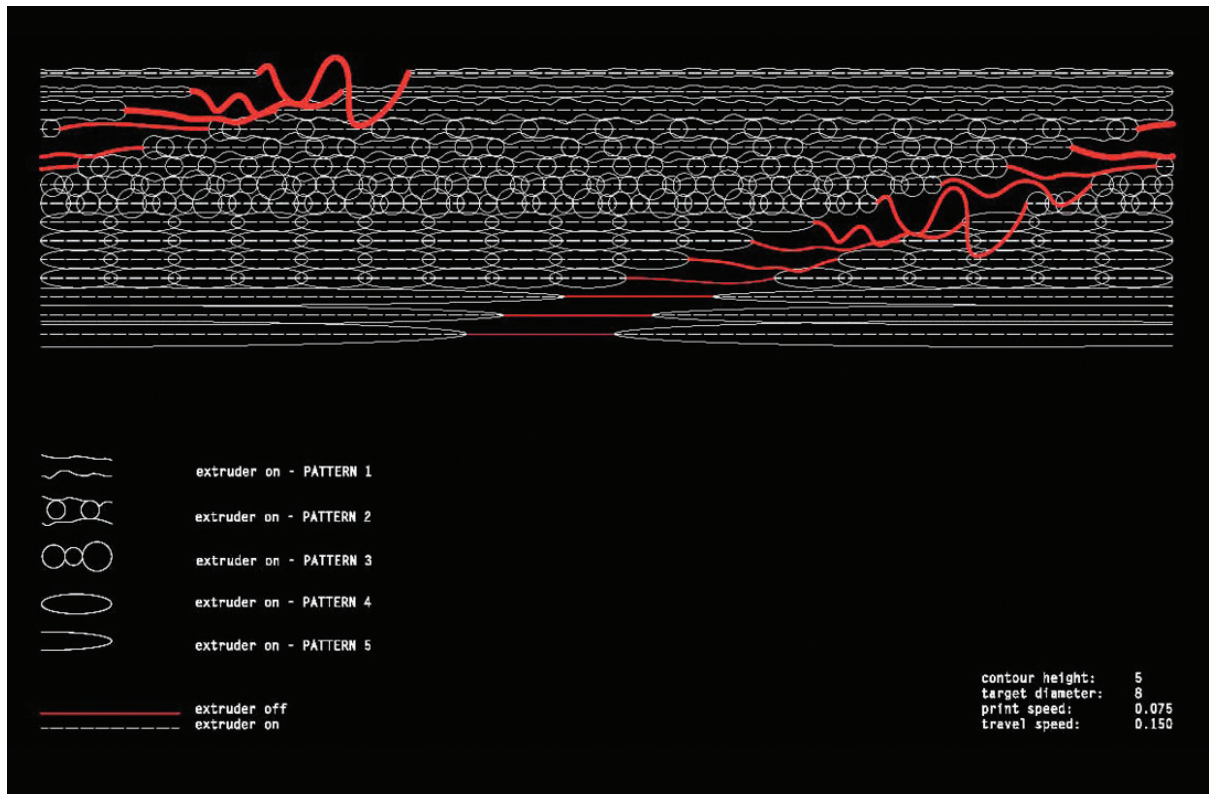


4

In this light, the term inherently approaches the explosive evolution of digital technologies in the arts and how it mutates the relationship to the human condition. It explores the notion of creative disciplines in which computational tools have become standard practice, and the emergence of novel insights do not rely on the tool as mode of explanation. A tendency that can also be observed in the architectural discipline, where the notion of explaining a project (of any kind) by highlighting the applied toolset is observed with an increased amount of suspicion – a suspicion that in best case produces novel lenses of observation for architectural problems. On closer examination of the paradigm of consensus, there is a selection to be made: Either there is intrinsic meaning in a Postdigital society, or it is swallowed into a contextualized paradigm of consensus that includes art and architecture as a totality. It is probably best summarized in Roy Ascott's averment that the discernment separating the Digital from the Postdigital is part of the economy of reality (Ascott 2003). In this sense, it does not represent a disruptive moment of cultural change but rather demonstrates a continuous slow transition from one state to the other, or in Heideggerian terms from Ereignis to Sein (Heidegger 2003).

In terms of architectural discourse the ballistic trajectories of conversation can be put in perspective by Mario Carpo's book *The Digital Turn in Architecture* which serves as an excellent marker to define the time frame of the Digital, and Postdigital lineages in Architecture (Carpo 2012). Carpo's book defines the period of the Digital Turn as occurring from 1992 to 2012. The time between 2012 and 2103 marks a shift in the architectural conversation with the emergence of alternative theoretical constructions such as object oriented ontologies, speculative realism and an elevated interest in aspects of phenomenology. These tendencies most certainly frame a paradigmatic shift in architectural discourse from the computational, seamless and continuous narratives of Deleuzian thinking to a critical interrogation of the toolsets developed in the process. As to the definition of the term paradigm, Giorgio Agamben might be helpful here with his description of paradigms as something that we think with, rather than a condition, thing or object that we think about (Agamben 2002). In this extent the Postdigital can be described as a paradigm, comparable for example to Posthumanism, which does not describe a universe after the digital, but rather characterizes the contemporary attempt to examine the consequences of the digital age. The emanations of the human enhancement achieved with computational tools

Fig 72 Image file of page 4 of:
Manninger, Sandra and Matias del Campo, 2017. *Plato's Columns – Platonic Geometries vs. Vague Gestures in Robotic Construction* in *Proceedings of the ACADIA Conference 2017, Nov 2-4, Disciplines & Disruption*, MIT Cambridge, MA, USA



5

- the ramifications of the globe spanning prosthetics that are

In the age of Big Data and 3D printing, decoration is no longer an addition; ornament is no longer a supplemental expense; hence the very same terms of decoration and ornament, predicted as they are on the traditional western notion of ornament as supplement and superfluity, do not apply, and perhaps we should

CELEBRATING THE GLITCH

In the project Plato's Columns the notion of the glitch is celebrated as a failure of the machine.

One of the main questions posed by this research is the interrogation of the necessity to create a novel method of architectural notation that does not rely on the manifestation of a unique, specified, condition - as is the case with traditional recording methods of architecture such as plan and section - but rather utilizes a system that only punctually defines design specifics and leaves the rest to the emergent properties of the fabrication method and the material qualities.

side the G-code of the toolpath which fluctuates between the precise figuration of a rigorous geometry, on the other side the response of material properties. The combination between the inherent precision of the robotic setup and the vague deposition created by the infusion of variable speeds as well as fluctuations in the materials response to the laws of thermodynamics and to gravitational forces result in glitches in the morphogenetic process (Fig. 4, 5). The initial figuration in the form of an extruded square is intentionally chosen to demonstrate how a distinct and precise form can achieve intricacy by variations in the material's response, as well as by mixing colorations in the pellet chamber of the deposition head. It was one of the more telling moments in the very beginning of this research when students suddenly stopped the deposition process every time

an error started to emerge. It was difficult for them to grasp in

an initial moment that this was precisely what the studio was

looking for. Not the prevailing tendency for the perfect replication of a computational model but rather a dialogue between

and superfluity do not apply, and perhaps we should

in forms informed both by binary code as much as by environmental forces.

The moment students got the task to just keep going, interesting

things started to happen. First and foremost a self-healing quality

holes in the platonic figure, started to incrementally close again.

This behavior allowed for the introduction of an alternative

method of creating apertures in platonic geometries which are

neither violently inserted into the body nor elegantly inserted

in accordance with the underlying geometry in a topological

fashion but rather emerged through a procedural approach to

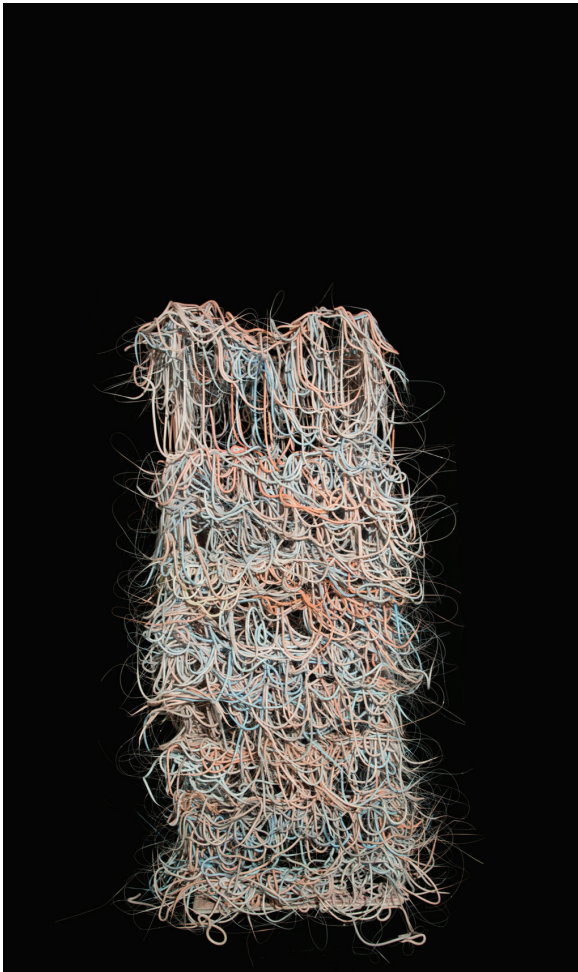
material deposition, akin to the emergence of holes in leaves

4 Image sequence displaying the fabrication process.

5 Analysis of the deposition result post facto to refine the G-code.

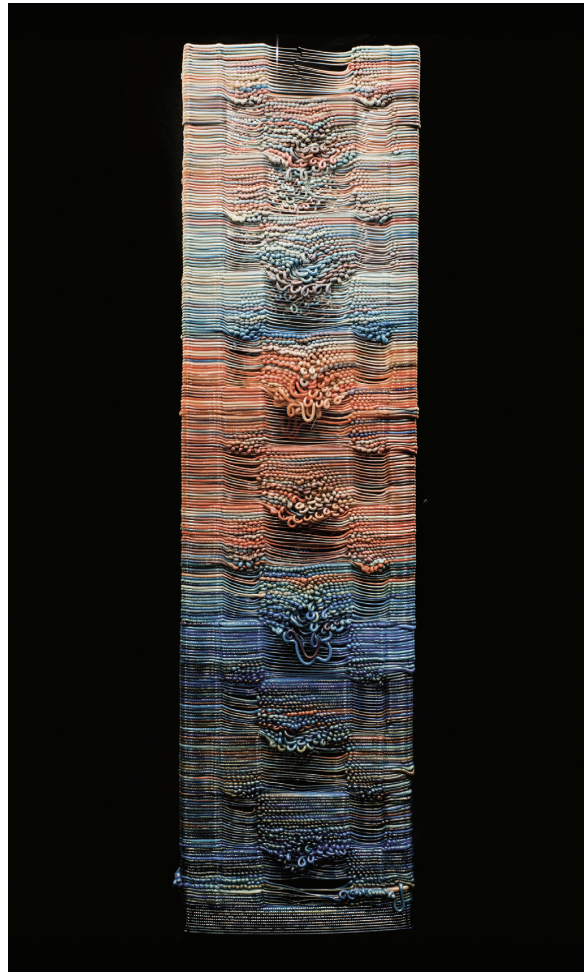
Fig 73 Image files of page 5 of:

Manninger, Sandra and Matias del Campo, 2017. Plato's Columns – Platonic Geometries vs. Vague Gestures in Robotic Construction in Proceedings of the ACADIA Conference 2017, Nov 2-4, Disciplines & Disruption, MIT Cambridge, MA, USA



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of plants which happen due to the lack of nutrients in specific areas. Students then were encouraged to develop strategies that involved designing deposition paths that implemented variation in the deposition speed. A regular deposition speed will always result in identical deposition thicknesses of the utilized polymers. A variation in speed yields results that range from bulbous, pearly chains to ultrathin, fibrous sections of paths. The interplay of both can be read regarding painterly techniques as a crossbreed between impasto, thick and expressive strokes and the finesse of delicate glaze painting. In contrast to the intuitive expressive gestures found in Jackson Pollock's oeuvre this approach relies on the rigorous toolpath of an extruded square. These impressions are enhanced through the bold use of color. The opportunity that the colored polymer pellets could be mixed inside the container of the deposition head was utilized to create bold colorations that gradually change from one color to the other. The color palette was intentionally tuned to resemble baroque color schemes.



7

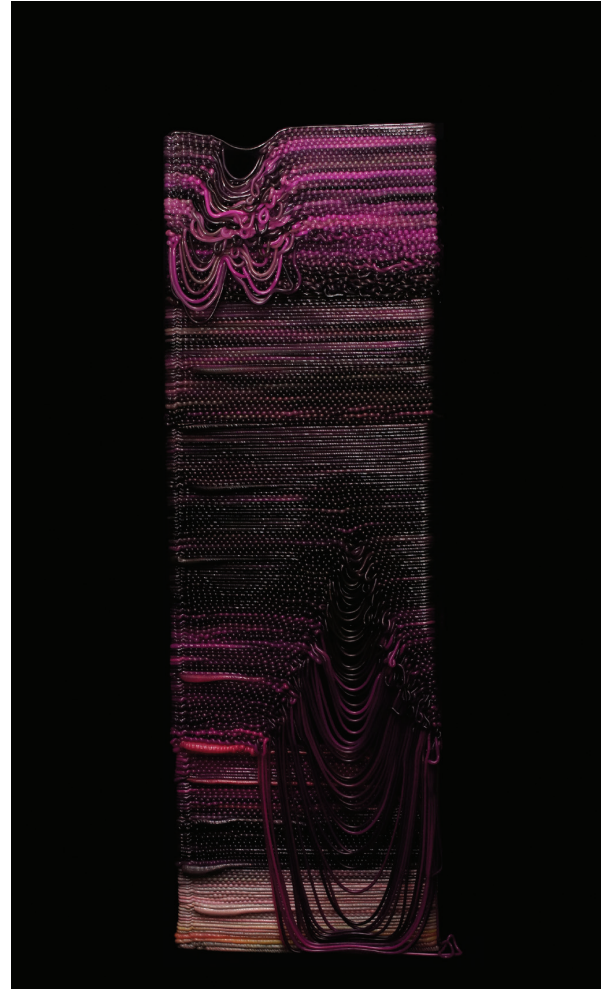
Probably one of the more interesting column results is the Hirsute Column (Fig.6). This column has a very interesting tool-path in that it is not of continuous nature but starts and stops in a random cross hatch fashion, vaguely following the original Platonic form. In a computational model this random set of lines does not produce a result that can be perceived as a possible project. It only starts to make sense once the column starts to emerge in the fabrication process.

The setup consists of robotic arm in combination with a plastic deposition head as depicted in Figure 10. The material for the explorations are various synthetic granulates with color additives. The deposition head was outfitted with a pellet feeder which allows to create continuous color changes as it avoids discrete feeding of the deposition head such as with uniform filaments. The basic architectural archetype of the column served as a testing ground for the combination of a rigorous geometric body

Fig 74 Image file of page 6 of:
Manninger, Sandra and Matias del Campo, 2017. Plato's Columns – Platonic Geometries vs. Vague Gestures in Robotic Construction, in Proceedings of the ACADIA Conference 2017, Nov 2-4, Disciplines & Disruption, MIT Cambridge, MA, USA



8



9

with the gestural qualities of sensible robotic toolpaths. The basic prismatic shape of an extruded square (Fig.2) forms the origin for all the conducted tests and was chosen as to facilitate the comparison between the models. The range of results, from tight rhythmic patterns to fluffy hirsute clouds demonstrates the panorama of possible design options with this technique (Figs.6-9). The common motif in all models is the application of alternating sequences as forming method. This pulsation is achieved through a rhythmic variation of speed of deposition. These fluctuations in the deposition speed proved to be a successful method to achieve a variety of effects, starting with the introduction of apertures in the prismatic proto body - by applying higher speeds - to the introduction of curls and pearls on the surface by reducing the speed. In combination with the saturated coloration of the material the process results in richly informed surfaces which make the process of modelling matter highly readable:

In the age of Big Data and 3D printing, decoration is no longer an addition; ornament is no longer a supplemental expense; hence the very same terms of decoration and ornament, predicted as they are on the traditional Western notion of ornament as supplement and superfluity, do not apply, and perhaps we should simply discard these terms, together with the meanings they still convey (Carpo 2012).

One of the main questions posed by this research is the interrogation of the necessity to create a novel method of architectural notation that does not rely on the manifestation of a unique, specified, condition - as it is the case with traditional recording methods of architecture such as plan and section - but rather utilizes a system that only punctually defines design specifics and leaves the rest to the emergent properties of the fabrication method and the material qualities.

6-9 Designing the G-code resulted in varying articulation qualities.

Fig 75 Image files of page 7 of:
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10 The robotic setup consisting of a 6-axis industrial robot and an extrusion head.

Fig 76 Image file of page 8 of:
Manning, Sandra and Matias del Campo, 2017. Plato's Columns, – Platonic Geometries vs. Vague Gestures in Robotic Construction,
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CONCLUSION

In borrowing from the Postdigital discourse in music, an alternative method of thinking about the architectural production of our contemporary age also calls for alternative methods of describing the current work. In this extent, the Postdigital can be described as a paradigm, comparable for example to Posthumanism, which does not describe a universe after the digital, but rather characterizes the contemporary attempt to examine the consequences of the digital age. The emanations of the human enhancement achieved with computational tools - the ramifications of the globe spanning prosthetics that are achieved by the application of software - all of which present themselves as exquisite specimens for speculative interrogation and theoretical inquiry. The project Plato's Columns combines the rigor of a Platonic body with the emergent properties of vague gestures. The introduction of moments of uncertainty in the process produces glitches which are embraced as an opportunity to find novel aesthetic conditions.

ACKNOWLEDGEMENTS

This work was made possible through the generous support by the Royal Melbourne Institute of Technology (RMIT), Australia. The authors would like to thank Professor Dr. Richard Blythe, Professor Dr. Vivian Mitsogianni, Dr. Roland Snooks, Cameron Newnham and the students of the Advanced Architecture studio: Nicolas Deflandre, Pan Feifei, Dylan Findlay, David Fitoussi, Paris Johnson Isabelle Jooste, Hibah Khodr, Leonidas Koutoulas, Joel Lok, Joshua Lye, Mary Spyropoulos, Mirabela Vasilie, Rime Yachfine, Tianbo Zhou

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IMAGE CREDITS

Figure 1-10: Royal Melbourne Institute of Technology, 2016

Sandra Manninger is a registered architect, teacher, and researcher. She is coprincipal of SPAN. The focus of the practice lies the integration of advanced design and building techniques that fold nature, culture, and technology into one design ecology. Her work is part of the permanent collection of the FRAC Collection, the Luciano Benetton Collection, the MAK & the Albertina in Vienna. She has written and presented papers at numerous conferences and her work has been published extensively in numerous magazines and books. She currently serves as Assistant Professor at Taubman College School of Architecture and Urban Planning, University of Michigan.

Matias del Campo is a registered architect and designer. His exploration of contemporary architecture is fueled by methods of materialization in nature, advanced technologies and philosophical inquiry, forming a design ecology. He is the cofounder of the practice SPAN, whose work was featured at the 2012 Venice Architecture Biennale, ArchiLab 2013, and in multiple group & solo exhibitions. Most recently he was awarded the Accelerate@CERN fellowship and guest edited an edition of AD, published by Wiley, UK. He serves as Associate Professor of Architecture at the A. Alfred Taubman College of Architecture and Urban Planning at the University of Michigan.

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Manninger, Sandra and Matias del Campo, 2017. Plato's Columns – Platonic Geometries vs. Vague Gestures in Robotic Construction in Proceedings of the ACADIA Conference 2017, Nov 2-4, Disciplines & Disruption, MIT Cambridge, MA, USA

Discussion and Conclusion

- a critical comparison within the community of practice

In order to reiterate the meaning of practice research I would like to quote from the RMIT Practice Research webpage:

“To practice is to subject any endeavor to persistent pursuit and active, reflective development. By virtue of that active development, all practicing intrinsically involves research enquiry. Practice Research brings that research activity to the foreground through activating explicit enquiry into the know-how of practitioners. This occurs through doing and reflecting on their endeavours, and by situating that know-how and its contribution in broader issues and fields of practice. In this way, shareable knowledge is developed and contributes to domains of practice, supporting new, innovative and impactful projects.”⁹⁴

The methodology of practice research includes aspects of practice into the examination process of the candidate's body of work. Instead of observing the aspects of practice and the aspects of theory as two separated entities, practice research strives to intrinsically connect these two aspects of practice into a holistic set of methods for inquiry into the candidates work,

There are a number of disciplines that have adopted these methods of inquiry in order to extract new academic knowledge from the practice work of the candidate. Those disciplines include for example the practice-based research network (PBRN) in the field of medical research.⁹⁵

In the humanities as well as the arts (the relevant field for this dissertation I would argue) there are a variety of conversations gravitating around the interrogation of the nature of practice research. This seems to be an ongoing process, that has not yielded yet a globally accepted definition. Even the terminology varies from case to case (practice-as-research, practice-based, practice-lead, mixed-mode research practice and practice through research).⁹⁶ The most useful working thesis for this terminology can be found in Sir Christopher Frayling's paper Research in Arts and Design⁹⁷ which describes alternative methods of thinking about practice research. In fact he states that research could be for practice, where research aims are subservient to practice aims, through practice, where the practice serves a research purpose, or into practice, such as observing the working processes of others⁹⁸ This PhD can be read in this lineage of inquiry. In which the

94 From: RMIT University, Architecture & Urban Design. About, What is Practice Research? Retrieved on February 2018, <https://practice-research.com/about/>

95 Barkham, M., 2014. Practice-based Research Networks: Origins, Overview, Obstacles, and Opportunities in Counselling and Psychotherapy Research, 14, London: Routledge, p168

96 Little, S., 2011. Practice and Performance as Research in the Arts. Dunedin New Zealand: Otago University Press, p20

97 Frayling, Christopher, 1993. Research in Arts and Design. in Royal College of Arts Research Paper, London, p2

98 ibid, p5

work is examined and described by the author of the work, instead of by another party. So the research subject is the observation of working processes in the practice subservient to practice aims and expressed through the body of work.

This dissertation presents evidence that the architecture of SPAN has always revolved around questions of the integration of computational tools for the conception, design, fabrication, and the agencies of geometric conditions as crucial point of departure for every design. Regardless of its programmatic or typological needs. On the contrary, if there is anything that the digital turn achieved, it is the transformation in the thinking about the values of the discipline, away from the actual, to an understanding of the architect as co-author in the creation of artifacts as tools for communication.

Critical Comparison within the community of practice

In order to clarify the traditional stance of architecture in contrast to the the way SPAN perceives authorship I would like to rely on a quote by Mario Carpo: “.....More momentously for the history of architecture, Alberti’s pursuit of identical replications is also inherently intertwined with his invention of the modern design process. In Alberti’s design process. In Alberti’s theory a building is the work of the architect that designed it (but did not build it) only if the building and its design can be seen as notationally identical. As mentioned above, Alberti’s design process depended entirely on cultural mediators, such as scaled drawings, measurements, and projections, and their respective mathematical underpinnings, and did not call for any mechanical underpinnings, and did not call for any mechanical technology, nor require any new instrument or machinery. There is some evidence that in his exclusive reliance on recorded and transmissible projects notations Alberti may have once again misjudged the performance of the tool at his disposal, as well as the intensity of the social resistance to his new authorial (and authoritarian) mode of design. Nonetheless, albeit initially resisted by some, Alberti’s notational method was eventually adopted by most.....The constraints that Albertian notationality imposed upon architectural design were a determining factor throughout the history of modern architecture – and have been equally relevant to the recent history of digital design.”⁹⁹ Mario Carpo discusses here two main aspects that have been challenged by the body of work of SPAN, on the one side the aspects of authorship, and on the other side the nature of notational systems in architecture. For both instances the nature of geometry is the crucial ingredient of the critical interrogation – a position SPAN shares with peer such as Francois Roche who embraced the possibility to questions the central role of human authorship for example in projects such as Bachelor Machines (2018), a project that exploits the possibilities of autonomous tectonics analog to SPAN’s project Plato’s Columns (2017) and Autonomous Tectonics (2012) as just two examples under many. Other peers who operate in related fields include Roland

99 Carpo, Mario, 2011. *The Alphabet and the Algorithm*. Cambridge MA: MIT Press, p70

Snooks and Alisa Andrasek, both interrogating methodologies to generate intricate aggregations of matter, based on agent based modeling. Both oscillating between emergent computational models and computer controlled machines to produce spatial objects. The contrast could not be bigger to the environment of Vienna during my time as a student – it might be one discovery of this practice research that the opposition to the previous generation of architects in Austria might be one of the forming agents in the design thinking of SPAN. The work has certainly very little to do with the Postmodern antics of Hans Hollein, or the historic quoting of Leon Krier, both seminal teaching figures in Vienna during my time as a student. Before studying I attended a Construction High School, together with the technically heavy study at the TU Vienna, it allowed me to develop a very specific knowledge about building processes. I would argue that this profound education in matters of construction is one of the qualities that differentiates my work at SPAN from many of my peers. I have a very developed sense of how to build things, this behavior is almost automatized, and has become core in developing projects. This became most visible with the project for the Austrian Pavilion in Shanghai, were this knowledge could be implemented at a larger scale. It is easy to render a curvilinear, flowing body, it is a different story when you have to invent methods of seamlessly integrate gutters, implement fire sprinklers invisibly and explain the advantages of BIM to contractors. If I would have to analyze the current condition, I would position our practice within a specific generation of architects shaping contemporary design culture, in regards of computational methodologies. My partner, Matias del Campo, counts among the most outspoken figures of our generation, as evidenced through a continuous stream of lectures, that allow to demonstrate our position. The main aspects that differentiates our work from other practices interested in computational design is the insistence to position the work within larger historic trajectories of the architecture discipline. Matias and I don't see our work as an insular position, but rather as part of a larger picture. One that shares strains of Gothic and Baroque architecture and connects to them by a rigorous application of geometric and mathematical rule sets. No matter how exotic the morphology, geometry still serves as the starting point to describe any architectural entity and its spatial conditions.

The manifold lenses of observation, akin to a kaleidoscope, allow to understand our built environment not only as a biophysical reality manifested in objects, but also comprises the actual embodiment of computational ecologies. The substantial core of this thesis is presented in two main flavors: Sensibilities and geometries. Sensibilities presents the body of work created in practice and research from 2003 to 2017, a period that is determined by a shift from first to second digital turn in architecture. The main question of this research is: What are the criteria that are establishing SPAN's design ecology, i.e. the design protocols and the design sensibilities developed through the years in practice, and how do they demonstrate an acute interest in the aspects of geometry -and specifically advanced geometrical problems- as point of origin for the

conception of the project. Sensibilities on the other hand operate in the realm of the non-quantifiable, the vague, the sublime, the moment of estrangement, the atmospheric etc. The combination of this two realms is what positions this methods of work between the scientific and the speculative. As demonstrated for example in spring 2017, when SPAN was invited to present their work in the FAB Union Space gallery in Shanghai. The selection process for this exhibition provided ample opportunity to review the body of work and to put it into the context of recent interests. A great opportunity to classify and organize the body of work along the lines described above. It fans out the elements that constitute SPAN's design ecologies and lays out the shifting weights on authorship and design agencies of the elements that constitute SPAN's design ecologies.

Sensibilities as a matter of fact

The matter of the development, discovery and refinement of sensibilities is crucial in the research projects of SPAN. Sensibilities emerge in the models described as abstract machines. Objects that do not possess specificity in terms of program or function but potentialities in terms of sensibility and aesthetics. In this extent it operates exactly along the demarcation lines outlined in this dissertation. The vague aspects, the inexact yet rigorous geometrical properties of these models are reciprocal to its potentialities as architectural mean of expression.

A sensibility in SPAN's universe of design thinking is defined by the ability to examine and interrogate potentialities for substantial architectural departments and morphological emergence within specific geometric figurations. SPAN's discussions and conversations on the aspects of sensibilities are contained within a multitude of ever so transforming design ecologies. Design ecologies describe the layer of architectural conversation which allows for a deeper mining of the aspects of design in the practice – in the best meaning of its Latin origin *designo*, to mark out, to describe, to point out. A design ecology is not uniform in its composition, instead it consists of a series of interwoven and interdependent processes creating a haze of information crucial for the progress of every single project. The hierarchical, nonhierarchical, highly research intensive and deeply informed design decision process forms a layer of this ecology. Constantly oscillating between computational models cross pollinating different software packages, interrogations on the discursive implications and considerations on practical applications are explored, categorized and implemented in the architecture design process. As important as the computational side is the ecology of fabrication. Every machine that allows to manipulate matter in a computer controlled fashion is explored or even exploited in the materialization process from computational model to physical reality.

Geometry, in this universe of thinking, serves as a bonding agent for all the considerations on the nature of sensibilities and design ecologies. This archetypical architectural mean of expression is deeply ingrained into the DNA of architectural discourse. SPAN embraced the opportunity to explore a series of geometrical

rule sets and elaborate a series of projects. Working continuously on one specific geometric problem such as Euclidian, topological and recursive problems, it allowed for the development of specificity and expertise with the language those geometries provide. SPAN resists the urge to find excuses in working through families of geometries to utilize them solely to generate a better performance in terms of structural behavior or mimicking nature to reduce material consumption etc. Instead a conscious move is taken towards understanding the sublime qualities of geometry, both in its purity as a thought process but also literally in its performance as articulation of space and its atmospheric qualities. Vagueness, ambivalence, chromatics, estrangement, defamiliarization and speculative thinking are the primary elements embraced by the conversation in the practice. The thesis utilizes, as a launching point, an abbreviated conversation on the origin of Euclidian geometry, the sources of Euclid's renowned Elements and the traditions in geometrical exercises established by Plato's school of thinking. As in many other works of SPAN the preoccupation with geometry is characterized by a cross pollination between the fields – Euclidian figurations are allowed to collide with recursive algorithms or the vague gestures of continuous robotic toolpaths.

The conversation then progresses, in an almost chronological progression, from Euclidean geometries and Plato's universe of conversation about the nature of geometry to calculus and topology. In a way topology is an extension of mathematical concepts of the Baroque and Rococo era, so present in the desire for the curvilinear condition which is in itself so inherent to topological behavior. SPAN's oeuvre includes a large series of projects dealing with topological geometry and the implementation in built form, from speculative projects and small scale projects such as the Austrian Winery Boom exhibition design or the Housing in Vienna exhibition design to architectural designs such as the competition winning proposal for the new Brancusi Museum in Paris and ultimately a built example, the Austrian Pavilion for the Shanghai Expo 2010.

The change in focus from topological surfaces to recursive geometry was mainly triggered by the discovery of novel fractal geometry packages which allowed to explore fractals in its dimensionality. Starting with the solo show Formations [Fig 17] in the MAK, the Museum of Applied Arts in Vienna, the practice explored the various opportunities, achieving more and more control of the results over time. Though the term control is indeed relative here as one of the main goals of the recursive research was to examine algorithmic behavior as proponent of agency. Once more interrogating design agencies rather than executing a solely top down approach with full control over the process elaborating on a dialog between these two techniques.

The project Blocks presents a further development of this conversation on the nature of recursion and its implications both in terms of an architectural design technique as much as the intellectual and discursive

problems inherent in this discussion. This chapter also discusses the project Particle Hut. This installation was designed and built for the Digital Futures exhibition at Tongji University, 2016, however the Particle Hut is the latest member in an entire lineage of projects dealing with the bisymmetric hendecahedron and its space filling properties. Starting with experiments conducted with students at the Bauhaus Dessau, to seminar work at the University of Michigan. All of which can be considered examinations of techniques to dissolve the mass of the object and infuse it with lightness, porosity and transparency. The last in a long line of speculative projects presented in this dissertation is called Plato's Columns. And here the conversion closes the circle -from the universe of Euclid's geometrical treatise Elements, and Plato's influence on this work, to the Baroque presence in topological surfaces, to a modern take on geometry in the form of recursion to ultimately the combination between a Platonic body and the gestural qualities of robotic toolpaths. Plato's columns interrogates the rigorous geometry of a quasi-Platonic body in combination with the emergent properties present in fused deposition modeling. The common methods of FDM (Fused Deposition Modeling) rely on the technique to subdivide an object in a sequence of horizontal layers that build up the desired figuration. The speed of the disposition in this case is of regular nature – there are practically no changes in the speed, with the exception of tight corners which automatically are adapted in their speed to compensate for material excess. This is designed so that the layer thickness is consistent and allows for a clean build up of the object. Plato's Columns deliberately abandons this dogma of FDM and examines the possible eccentricities in a technique which embraces variations in the deposition speed.

In conclusion it can be said that the majority of the work of SPAN is situated in the challenging of common conceptions on the nature of beauty or aesthetics and critically interrogate the value of this contribution to architectural discourse. In a way the fabrication process itself is the design process. It perverts the main notion of computational design in architecture, where a majority of the energy is invested in assuring that the design conceived (on the computer) is translated with utmost accuracy to the material world. The process presented in Plato's columns opposes this century old notion and embraces a combination between the precision of the robotic tool, the computational model and the intentional integration of external forces deforming and corrupting the result.

All of this is in flux, it is a work in progress. The obsession with the agencies of geometry as a source of inspiration does not end with this dissertation. The rigorous cartography, mapping and categorization of the lineages on geometry already examined in SPAN's work reveals the potential of the idea of possible novel agencies, yet to be discovered, and yet to be introduced to the discipline of architecture.

Project List

- 2018 Fountain Design, Taiyuan, CN
- 2018 Kindergarten, interior design for a Kindergarten in Taiyuan, CN
- 2017 *A New Day*, mobile stage design and technical design proposal, Vienna, AT
- 2017 Guangfuling, shop and cafe design proposal for Guangfuling Bakery and Souvenirs, Shanghai, CN
- 2017 HAWK, interior design for a private bar, Suzhou, CN
- 2017 *Holkar Mustek Bridge*, competition entry for a bridge design, Prague, Czech Republic, 2017
- 2017 Pending lamp design proposal for the Radisson Hotel, Shanghai, CN
- 2017 *Vessel Chinatown Gate*, competition entry for the Gateways to Chinatown competition, New York, NY, USA
- The project *Vessel* strives to transform the gate into a multilayered object which creates an amalgamation of various parameters. Contextualization is probably the most visible one. Situated between Canal and Baxter Streets the triangle is well known to visitors and locals. The project intentionally embraces the vertical dimension to generate a highly visible element, creating a focal point on Canal Street and providing the architecture with a chance to serve as marker as well as orientation point in the visually loaded environment. The object is intentionally lifted from the ground to creating a social space underneath, which consists of the area demarcated by the existing Ginkgo trees as well as the occasional concrete element that serves as bench and meeting space.
- 2016 Cipondoh Housing Project, design proposal for a housing project in Jakarta, ID
- 2015 ASIS, Flagship store design proposal for ASIS Furniture Co.Ltd., Guangzhou, CN
- 2015 *Bauhaus Museum*, competition entry for the Bauhaus Dessau Museum Competition, Dessau, GE
- 2015 *Bubble Chair*, furniture design proposal for Xuberance, Shanghai, CN

2015 HAWK, interior design for the headquarters and R&D department of HAWK Co. Ltd., Shanghai, CN

The space design is based on the ideas of continuity, seamless surfaces and smooth transitions between spaces. A concept that is located within the realm of fluid flow, motion, and its materialization in a different aggregate condition throughout the four building floors. Complex curved geometry on the first and second floor, continuous surface areas on the third floor and the search for sensitive, voluptuous environments in the fourth floor CEO apartment and bar.

2015 *New Vienna Museum*, awarded competition entry (4th place) for the New Vienna Museum, Vienna, AT

2015 ORE, research project and design proposal for Shanghai Fashion Week Pavilions, Shanghai, CN
The ORE project provided the opportunity to continue the design and fabrication process on 3D printed concrete without a mold that started with the Teahouse project in 2014.

2015 *Ripple me Softly*, tea set design for Jindeshen Ceramics, CN 2015

2015 SIVA interior remodeling for the Shanghai Institute of Visual Art (SIVA) department of fashion and dance, Shanghai, CN

2015 *SIVA Pending Lamp*, product design for the remodeling of the SIVA Fashion School, Shanghai, CN

2015 SIVA Task Desk, furniture design for the remodeling of the SIVA Fashion School, Shanghai, CN

2014 *Bubblehotel*, commissioned interior design proposal for a hotel and spa, Wuhan, CN

2014 Folding Chair, design research project, Ann Arbor, MI

2014 *Guggenheim Helsinki*, competition entry for the Solomon R. Guggenheim Foundation, Helsinki, FI

2014 Hong Kong, Shopping Mall & Highriser, research project, design proposal for a department store in Hong Kong, CN

2014 *Pleated Pavilion*, design research project for Digital Futures 2014, Shanghai, CN

2014 *Teahouse*, design proposal for a public bath, Wuhan, CN

Teahouse is a proposal for a series of tea houses for the spa area at a public bath in Wuhan, China. The design proposed a 3D printed concrete structure and was developed in collaboration with a Chinese 3D printing company that resulted in a prototype of one segment that was on show at Tongji University's summer workshop exhibition.

2014 *Xenocultures* Exhibition, Design Matters gallery, Los Angeles, USA, 2014

2013 *Bangalore Club*, invited competition entry for a sports club, Bangalore, IN

This proposal suggests the fusion of landscape and architecture to provide a subtle frame for the colonial buildings. Solutions of sustainability are provided by the form of the design. Patterns are used as both generative device as well as architectural intervention.

2012 *The Pearl*, competition entry for the Busan Opera Competition, Busan, SKR

The architecture of this project oscillates between historic lineage and most advanced contemporary atmospheres. Advanced computational techniques collide with romantic desires to produce an elegant space for the performance of historic and contemporary performances.

The project is organized in layers. The entire project oscillates between protective coats and programmatic elements. The outmost protective layer creates the connection between the island and the urban landmass. It also incorporates the entire back of house area. Nested within this volume is the pearl: The Opera house. The house itself is organized in subsequent radial strata. On the one side to provide the audience chamber with the necessary sound insulation, on the other hand it allows to create an effective structure for the ovular shape of the building as well as a clearly organized circulation for the front and the back of house.

2012 *Shang Haus*, design proposal for a single family house, Beijing, CN

The research of the subdivision elements resulted in the development of a prototype that was on show at the *ArchiLab 2013* at the FRAC Centre, Orléans in France.

2011 *PUGA*, winning competition entry for a public gallery, Vienna, AT

2011 *SPA*, commissioned design proposal for a hotel on Noor Island, Sharja, UAE

2010-

2016 Strategic Partner for HP Hewlett Packard as part of the Experts & Mentors program, INT

2010 *Austrian Pavilion*, Shanghai Expo, Shanghai, CN

The Topology of Sound. The main driving force behind the design of the Austrian Pavilion for the EXPO in Shanghai 2010 can be described as acoustic forces. Music as a concept that reflects continuity in terms of architectural articulation that seamless connects the various spaces within the program. The space unfurls from within the topological body, from the main space to the exterior epidermis. This process creates pockets and poches, which include the concert hall in the center, the top floor restaurant, bar, and roof garden, the offices, and shop.

The main qualities for the project formed the main frame of the origin of the topological surface. The software output consisted of an extensive array of subtly varying surface conditions. According to their performative behavior, the population of over one hundred individual entities were scrutinized for their fitness according to different criteria, such as the potential to fulfill the program, the performance as structural entity and the effect generated by its appearance. This process reduced potential candidates to a very small number. Finally these candidates ran through a series of algorithms (various re-meshings, subdivisions, optimizing the size of the spatial pockets etc.) which eliminated all candidates but one.

2010 Chair design proposal for the restaurant of the *Austrian Pavilion*, Shanghai Expo, CN

2010 Plates design proposal for the restaurant of the *Austrian Pavilion*, Shanghai Expo, CN

2010 Flower vase design proposal for the restaurant of the *Austrian Pavilion*, Shanghai Expo, CN

2010 Standing table design for the restaurant of the *Austrian Pavilion*, Shanghai Expo, CN

2010 Hexaseats, furniture design for the bar of the *Austrian Pavilion*, Shanghai Expo, CN
Seating Design VIP Room

2010 Furniture design for the interior garden of the *Austrian Pavilion*, Shanghai Expo, CN

2010 *DAM*, competition entry for the *New Maribor Art Gallery* competition, Maribor, SI

The main driving forces for the design of the New Maribor Art Gallery is based on a the concepts of continuity and gradients, creating a seamless connection between the outside garden areas of the New Maribor Art Gallery, the open plan ground floor level, and the river Drava. The trajectory of the curvilinear stream continues in a vertical motion along the ramp, rising into the upper levels creating a vertical cyclone, which serves as the main circulation hub for the gallery. Radiating out of the central space, the different

elements of the program can be reached easily, all those elements, such as the children's museum, the architectural center and the library are directly connected to and through the open inner core. To achieve a maximum of flexibility, and the possibility for future re-configurations of the program, the space between the central core and the outside skin is kept very simple. In terms of construction, the basic idea is to establish a concrete table, featuring double curved undulating surfaces that provide enough strength for a steel frame box sitting on top of it. This steel frame box provides the necessary freedom for future changes within the program.

2010 *Foxtable*, furniture design for Organic Design, Stainz, AT

2010 competition entry for the *Hong Kong Shenzhen Border Station* Competition, Hong Kong, CN
The project is responsive to the nature of the site on multiple levels. The architecture of the border station reflects various environmental pressures: flow of goods and people, solar radiation and topographic pressures. The perforation of the roof provides an optimized illumination within the halls of the border station, simultaneously controlling the shading system.

2010 *Info Stela*, design for Organic Forms, Stainz, AT

2010 *Microlava*, lounge design proposal for Microsoft, Vienna AT

2010 *Penrose Bowl*, product design proposal for Alessi, Omegna, IT

2010 *Python Bar*, design proposal for a floating bar at the Wörthersee, Carinthia, AT

2010 *Rainbow Tower*, invited competition entry for the Highrise Competition, Chicago, IL

2010 *Solarstore*, design proposal for a exhibition retail space for solar panels in St. Veit an der Glan, Carinthia, AT

2010 *Villain Chair*, furniture design proposal for Organic Design, Stainz, AT

2009 *Crock, Bracelet*, jewellery design proposal, Vienna, AT

2009 *Funjet*, chassis design proposal for a quad bike, Vienna, AT

2009 *Microblur*, design proposal for the Microsoft Art Space, Vienna, AT

Contemplation space for Microsoft Austria which is in possession of one of the largest contemporary and media art collections in Austria. The contemplation pavilion is designed to hold the video art collection and serve as a small meeting space.

2009 *Sonnwendgasse*, competition entry for a residential apartment building, Vienna, AT

2008 *Brancusi Museum*, winning competition entry for the *Brancusi* competition, Paris, FR

The project is based on the curvilinear forms of Brancusi's sculptures, used to inform the spatial design. Situated in front of the Centre Pompidou, the museum proposal engaged with a sloped hardscape, resulting in a wedge shaped design which aimed to embed itself into the sloped plane to create a seamless interaction between building and ground. The morphological outer surface provides structure, minimizing the need for internal support and freeing up space for exhibits. The building proposed pre-fabrication and assembly on site, mirroring the construction systematics of the Centre Pompidou in the environment of 21st century technologies

2008 *Chex Game*, competition entry for the *Crystal Vision* Swarovski Designboom Competition, international;

The game Chex, invented by Edelbert Wiedmann, comprises of a hexagonal board bearing 37 hexagons that form the play field of the chess related game. The difference between chess and Chex is the reduced amount of figures and the speed of the game. Whilst traditional chess is orientated on ancient armies standing across each other on vast battlefields, Chex applies modern tactics of urban warfare.

The applied digital design method allows for a fast fabrication process as the polygon modeling tessellation serves as a guideline for the bevelling process, and is intended as a main design quality.

2008 *Exhibition Pods*, exhibition design for the Beijing Architecture Biennale, Beijing, CN

2008 *Housing in Vienna V.2*, traveling exhibition design for the Az W, (Architekturzentrum Wien [Austrian museum of architecture]), international

2007 *The Austrian Winery Boom*, traveling exhibition design for the Az W, (Architekturzentrum Wien [Austrian museum of architecture]), international

picture taken at the Austrian Cultural Forum, New York, USA

The mobile exhibition design provided SPAN with possibilities to explore performative surfaces and economy of form. To fulfill the multiplicitous demands, SPAN relied on the concept of minimizing the number of elements, implying the tasks into two surfaces. The design process resulted in an elegant topology of the surfaces, subsequently encoding the form.

The machinic process caused undulating patterns, created by the milling path of the router, ensuing a highly performative, corrugated surface. The population of forty-three members comprised a family of three different types of pods, colonizing the floors and walls of the exhibition space. Manifold groups achieved the effect of continuous differentiation.

picture taken at the Ca'Tron, Venice, IT

2006 *Lampano*, research project, CNC milled prototype for a lamp shade design proposal, Vienna, AT

2006 *The Planless House*, competition entry for the Shinkenchiku Residential Design Competition, JA

2004 *5 Million Cubic Squares of Vienna*, exhibition design for the Az W, (Architekturzentrum Wien [Austrian museum of architecture]), Vienna, AT

2004 *Canada Pavilion*, competition entry for a temporary street art exhibition space, CA

2004 Remodeling the offices of the Az W, (Architekturzentrum Wien [Austrian museum of architecture]) Vienna, AT

2004 Remodeling the offices of instant™, Design GmbH, Vienna, AT

2003 *Housing in Vienna V.1*, traveling exhibition design for the Az W, (Architekturzentrum Wien [Austrian museum of architecture]), international

2003 *Red Angel*, design proposal for a rooftop bar, Frankfurt, GE

2003 *Flex*, design proposal for a floating bar on the Donaukanal for the club Flex, Vienna, AT

GLOSSARY

Abstract Machine

The term is borrowed from the universe of thinking of Gilles Deleuze and Felix Guattari both of whom understand the term “the abstract machine” as a subject that is overdetermined insofar as it comprises an indefinite sphere of “virtual” possibilities that may be actualized under certain conditions – the subject is always already more than what has been historically actualized. Moreover, such a theory allows for the “deterritorialization” of the subject along “nomadic” “lines of flight” that effectively resist its endless “territorialization” by the “state apparatus”.

Automaton

The word “automaton” is the Latinization of the Greek automaton - “acting of one’s own will”. This word was first used by Homer to describe automatic door opening, or automatic movement of wheeled tripods. In a contemporary context it describes computer controlled machines that follow specific sets of programmed behavior.¹⁰⁰

Automation

Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provides human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well. Automation plays an increasingly important role in the world economy and in daily experience.¹⁰¹

Extensive

According to French Philosopher Gilles Deleuze there are two main substances to differentiate: Those with intensive properties and those with extensive properties. That which you can grasp, cut, twist, and turn are extensive.¹⁰²

Index

Index, from the Latin *indico*, means to show, mark, point out, recommend advice or to indicate, but also to discover and to spy. Index is used in a multitude of meanings that range as far as from the realms of

100 From: Merriam-Webster.com, 2018, Automaton. In Merriam-Webster . Retrieved on May 2018, www.merriam-webster.com/dictionary/automaton

101 From: Merriam-Webster.com, 2018, Automation. In Merriam-Webster . Retrieved on May 2018, www.merriam-webster.com/dictionary/automation

102 Manuel de Landa in his Seminar ARCH-712-001 Topics in ARCH Theory II: Philosophy of Materials and Structures, PennDesign, 2012

mathematics, expressing the raise of a suffix indicating the power, to economics, as a single number calculated from an array of prices or of quantities; to programming where it indicates an integer or other keys defining the location of data within an array, vector or database table, to an alphabetical listing of items and their location, such as terms and names in a book.¹⁰³

Indexicality

Indexicality, whilst closely related to Index, has a different set of meanings. Whereas the index clearly points to an existing set, or list, of operands (objects, rules, numbers, names, materials, ideas, terms) Indexicality operates within the realm of the trace, the artefact, the imprint and ways to read this within the manifested material condition.¹⁰⁴

Intensive

According to French Philosopher Gilles Deleuze there are two main substances to differentiate: those with intensive properties and those with extensive properties. That which affects you, but does not yield to your attempt to contain it, is, like wind in your face can be described as intensive. Intensive differences are, as Deleuze points out, indivisible.¹⁰⁵

Machine

A machine uses power to apply forces and control movement to perform an intended action. Machines can be driven by animals and people, by natural forces such as wind and water, and by chemical, thermal, or electrical power, and include a system of mechanisms that shape the actuator input to achieve a specific application of output forces and movement. They can also include computers and sensors that monitor performance and plan movement. The term machine can be used in a metaphoric sense describing ideas and concepts.¹⁰⁶

Metaphor

A word or phrase that means one thing and is used for referring to another thing in order to emphasize their similar qualities. A metaphor is a type of figurative language that expresses a comparison between two entities without using any comparison words. A metaphor is figurative language. Therefore, its meaning is figurative, not literal. A metaphor compares two things but it does not use any comparison terms (such

103 Grammer dictionary of the writingexplained.org visited 12.01.2019

104 Manuel de Landa in his Seminar ARCH-712-001 Topics in ARCH Theory II: Philosophy of Materials and Structures, PennDesign, 2012.

105 Manuel de Landa in his Seminar ARCH-712-001 Topics in ARCH Theory II: Philosophy of Materials and Structures, PennDesign, 2012. 107

106 From: Wikipedia contributors, 2018, Machine. In Wikipedia, the free Encyclopedia . Retrieved on May 2018, <https://en.wikipedia.org/wiki/Machine>

as like, as, resembles, than) to do so. In writing, metaphors are used to express deeper meaning, convey complexity, and add appeal.

Posthuman

Posthuman in the context of this dissertation refers to a design ecology that does not support the anthropocentric approach to design agencies but rather allows for a dialogue with computational methods in order to achieve design solutions which otherwise would not be possible to achieve through pure human creativity. It gives agency to alternative methods of design.

Matias del Campo and Sandra Manninger, based on several published papers such as *Autonomous Tectonics*, *Autonomous Tectonics II* and *Plato's Columns*.

Postdigital

Postdigital pertains to a contemporary discussion about the phase after the nascent state of computational, or digital design. The postdigital considers computational design tools as a given, mainstream production method in the architectural discipline and critically interrogates contemporary architectural production through the lens of the disciplinary, discursive problem, rather than through the lens of technological fetishization.

Matias del Campo and Sandra Manninger, based on several published texts such as the introduction to the book *Sublime Bodies, Architectural Problems in the Postdigital Age* published by Tongji Press 2017

Tectonics

Greek in origin, the term tectonics derives from the word tekton, signifying carpenter or builder. The corresponding verb is tektainomai. This in turn is related to the Sanskrit taksan, referring to the craft of carpentry and to the use of the axe. Remnants of a similar term can be found in Vedic poetry, where it again refers to carpentry. In Greek it appears in Homer, where it alludes to the art of construction in general.¹⁰⁷

Robot

A robot is a machine—especially one programmable by a computer— capable of carrying out a complex series of actions automatically. Robots can be guided by an external control device or the control may be embedded within. Robots may be constructed to take on human form but most robots are machines designed to perform a task with no regard to how they look.¹⁰⁸

107 Frampton, Kenneth, 1995. *Studies in Tectonic Cultures*. Boston: The MIT Press, p25.

108 From: Wikipedia contributors, 2018, Robot. In Wikipedia, the free Encyclopedia . Retrieved on May 2018, <https://en.wikipedia.org/wiki/Robot>

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