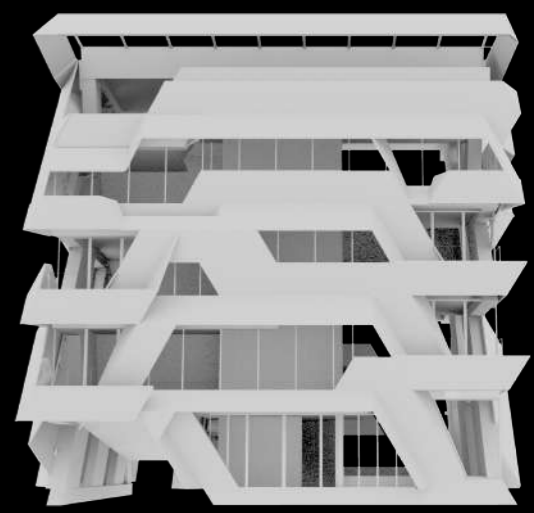
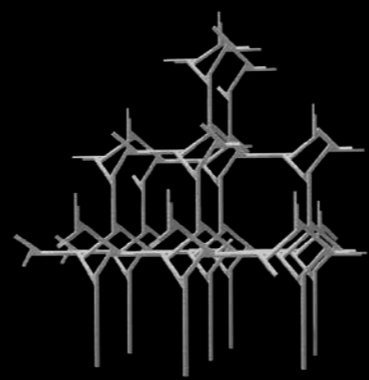
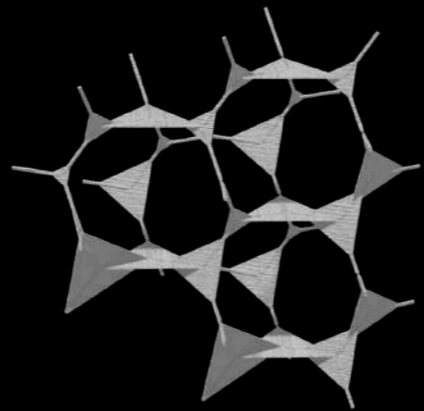
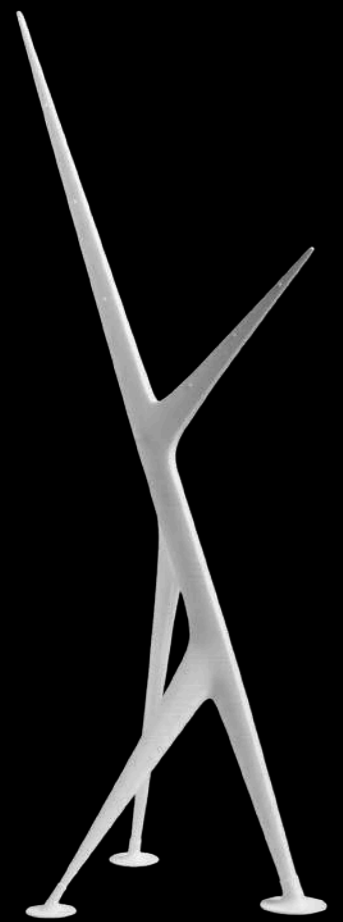
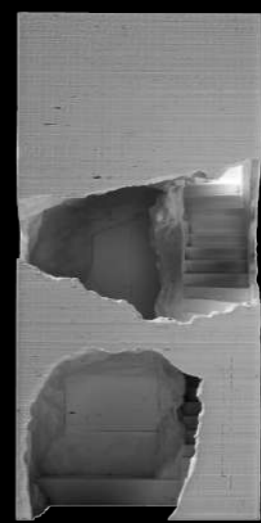
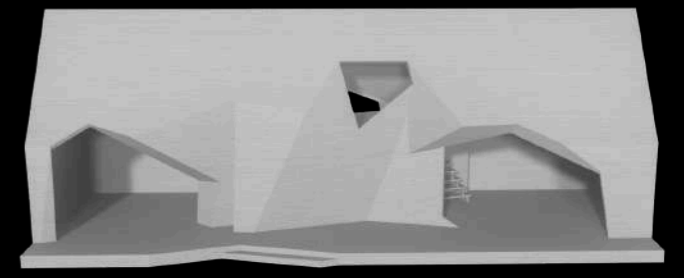
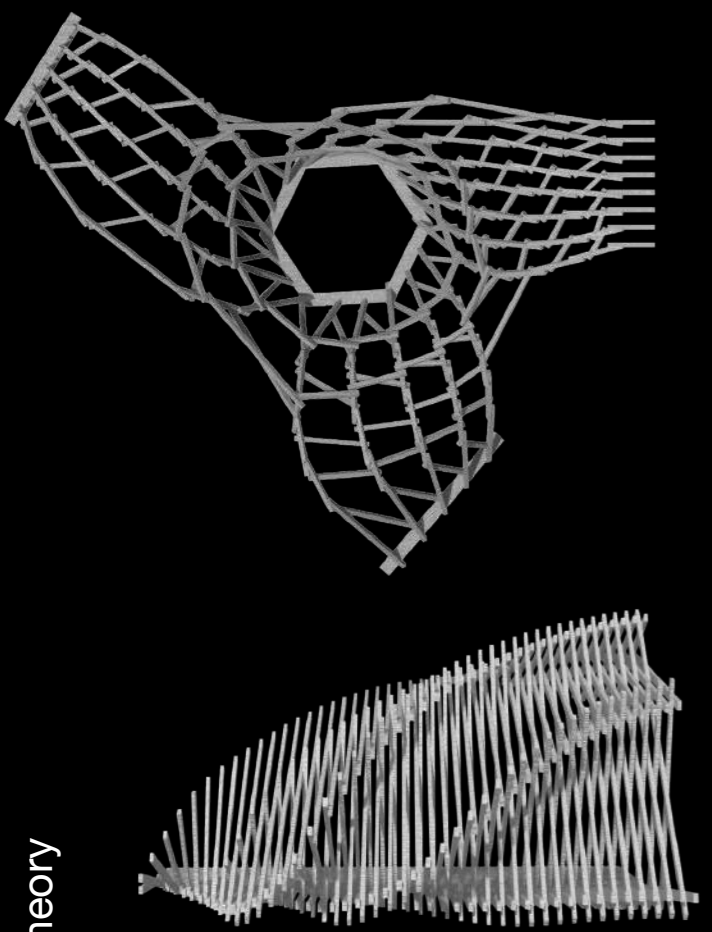


**If *sustainably* is an answer, what is the question?**  
Prototyping and protocolling modular timber architecture

Sille Pihlak

Estonian Academy of Arts Department of Architecture  
PART – Practice for Architecture, Research and Theory

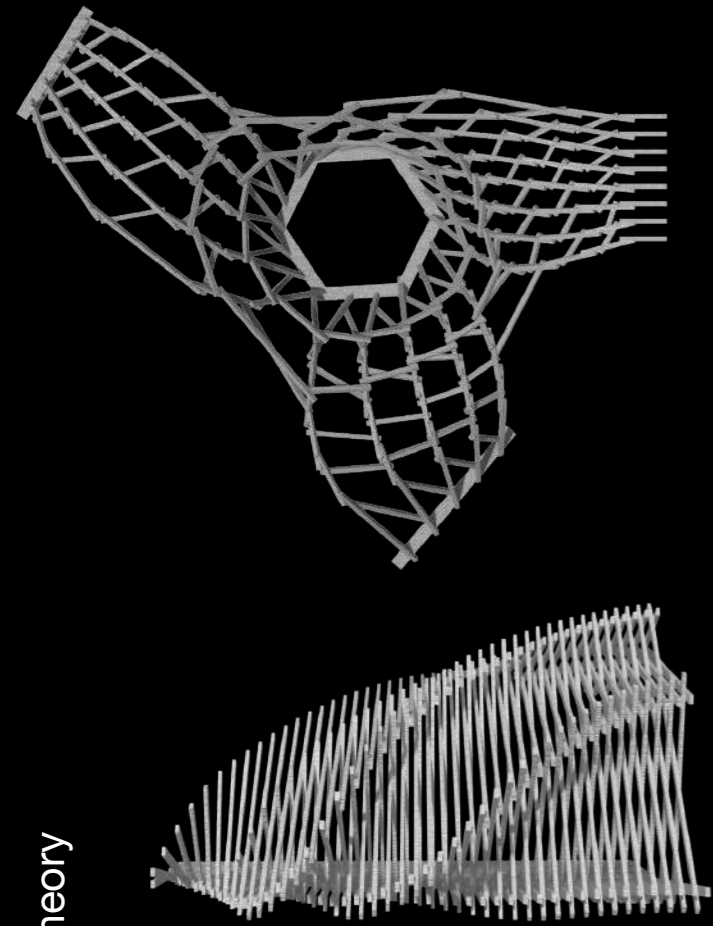
PART: Practice for Architecture, Research and Theory



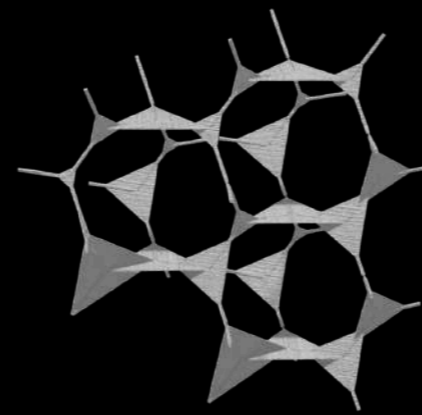
**Bespoke structures**  
Designed with top-down strategy  
2015-2017

**Aggregated structures**  
Designed with bottom-up strategy  
2017-2018

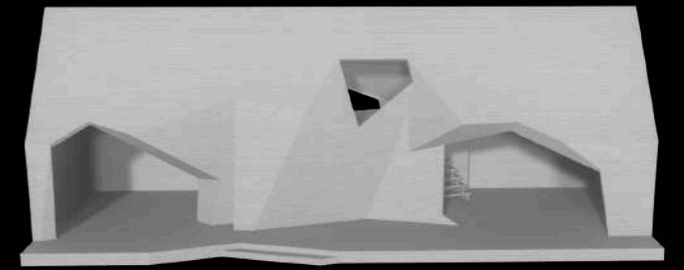
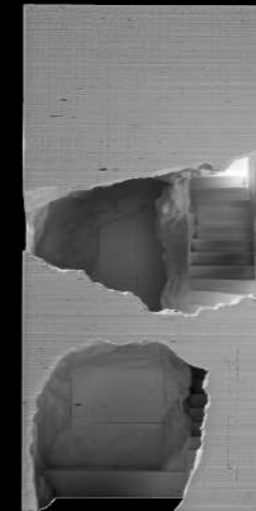
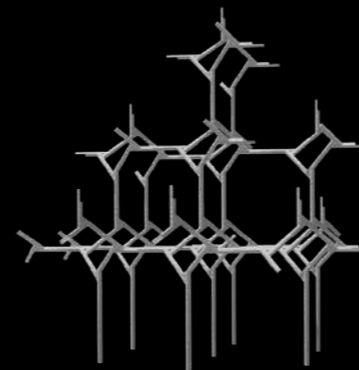
**Somatic modularity**  
Top-up-Bottom-down strategies  
2018-...



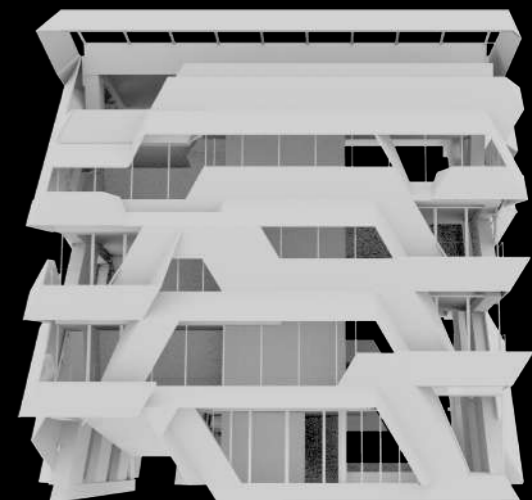
**Bespoke structures**  
Designed with top-down strategy  
2015-2017



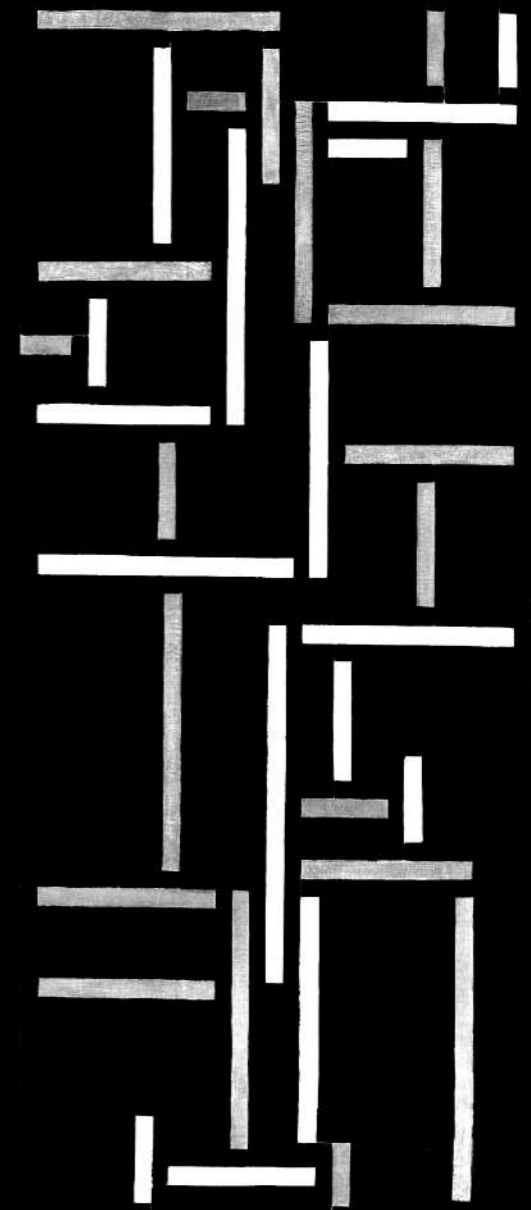
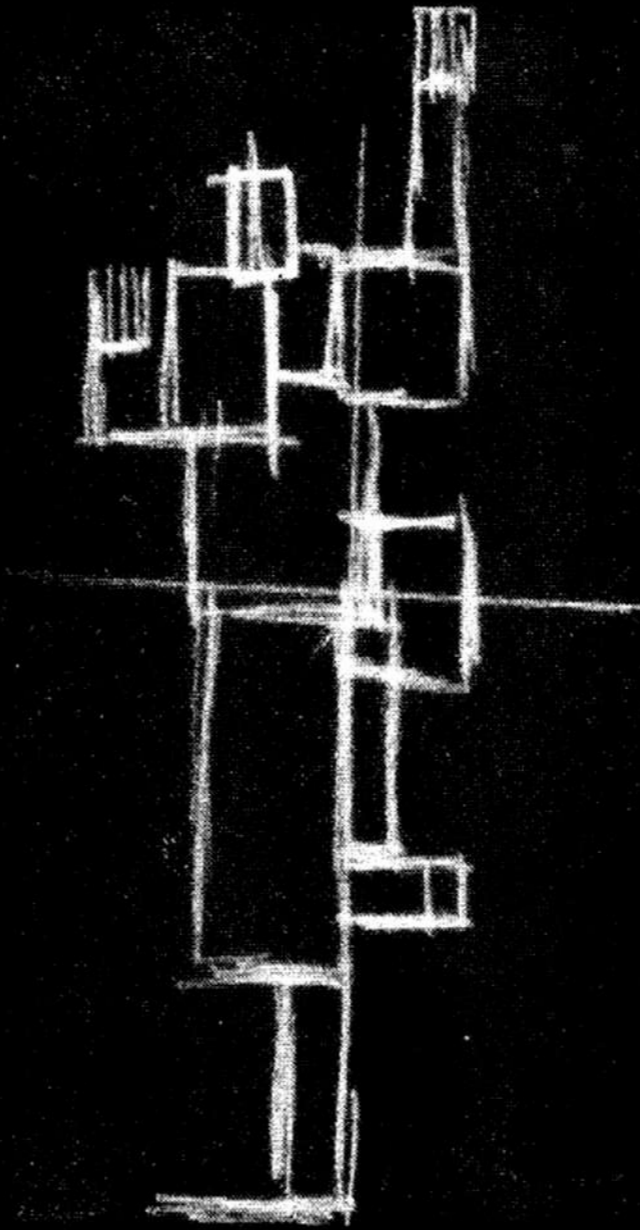
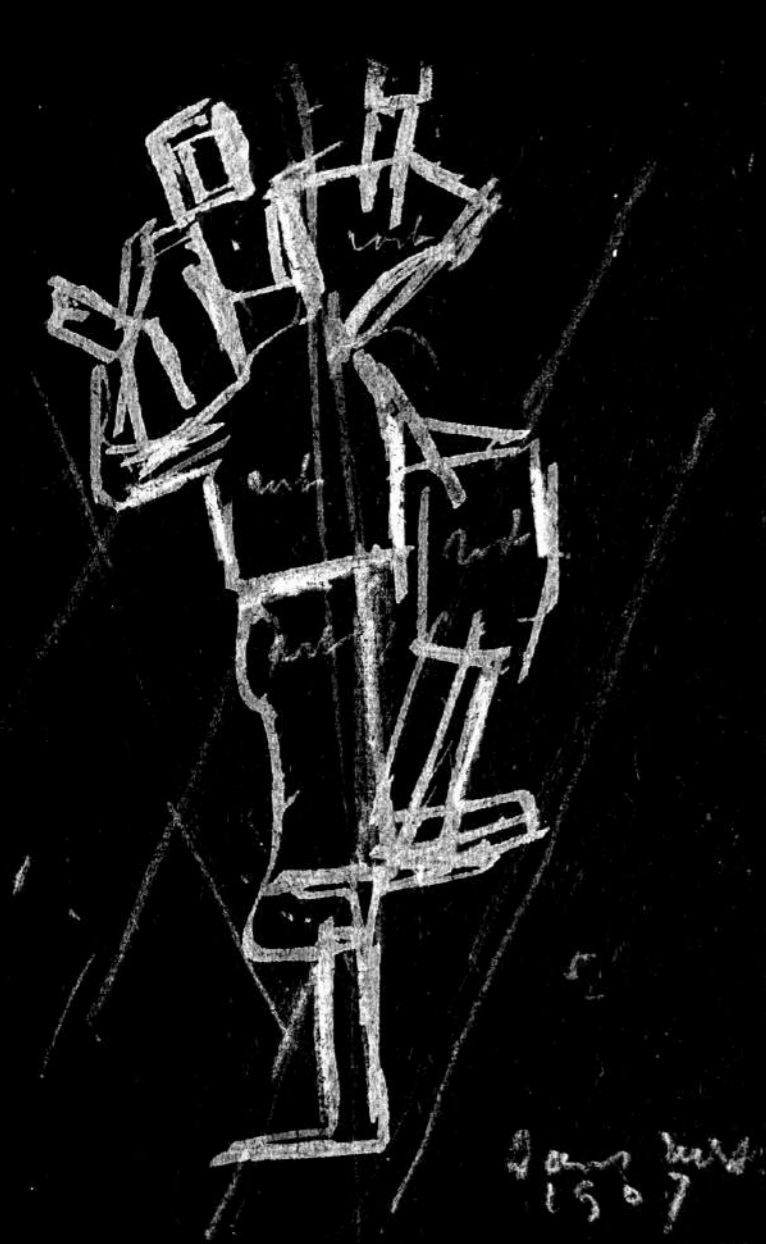
**Aggregated structures**  
Designed with bottom-up strategy  
2017-2018



**Somatic modularity**  
Top-up-Bottom-down strategies  
2018-...

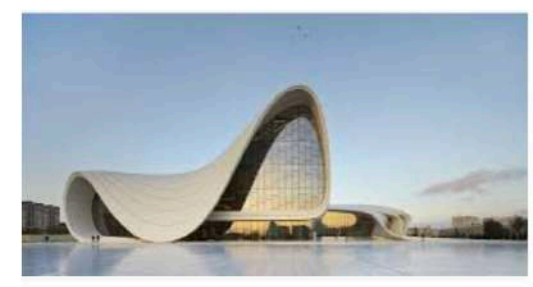


# Introduction

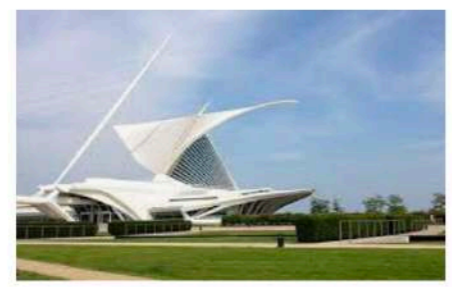


Theo van Doesburg  
Rhythm of a Russian Dance  
1918

- house
- residential
- modern
- famous
- exterior
- minimalist
- interior
- glass
- building
- brick
- concrete



Contemporary Architecture | Highbrow gohighbrow.com



Contemporary architecture - Wikipedia en.wikipedia.org



Hate Contemporary Architecture? Blame ... archdaily.com



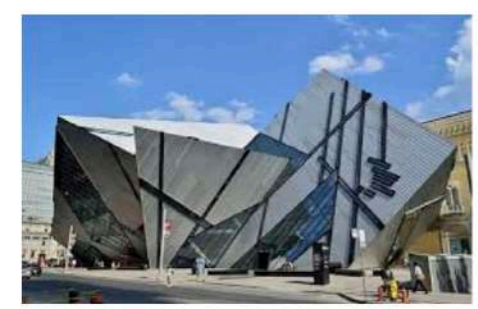
Contemporary Architecture Explained in ... developmentone.net



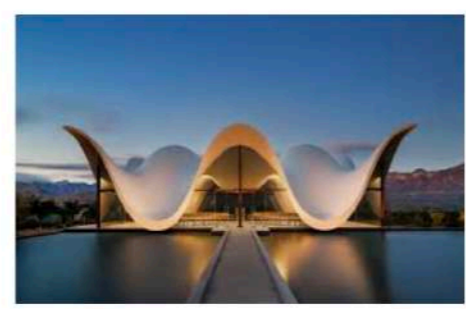
This tiny island in the Atlantic has ... curbed.com



role in contemporary architecture ... archinect.com



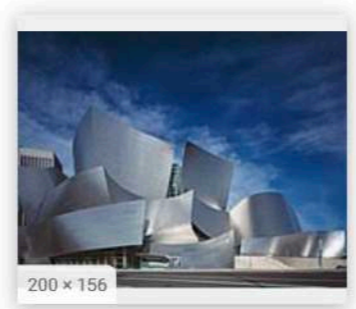
Contemporary architecture - Wikipedia en.wikipedia.org



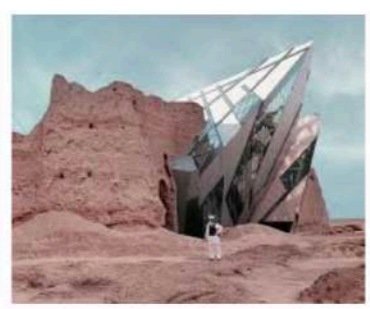
Contemporary African Architecture ... archdaily.com



Contemporary Architecture | Highbrow gohighbrow.com



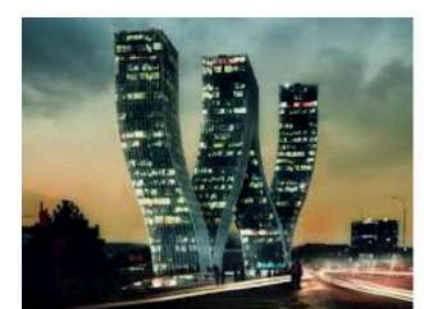
Contemporary architecture - Wiki... en.wikipedia.org



Iranian designer creates photo serie... admiddleeast.com



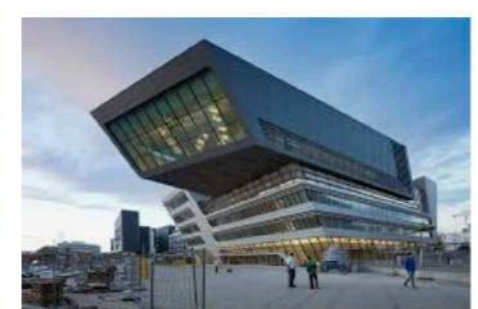
Contemporary Architecture | Highbrow gohighbrow.com



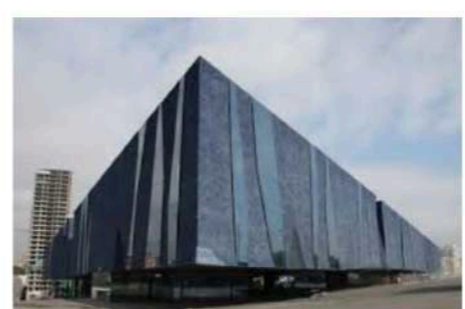
iconography in contemporary architectu... designboom.com



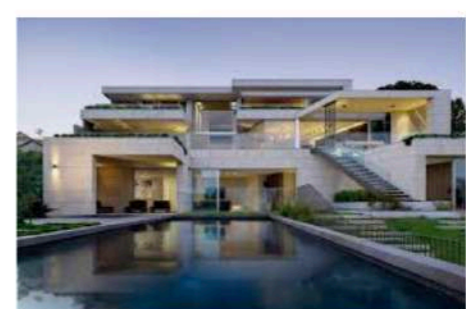
Architecture in Porto: 5 Contemporary ... theculturemap.com



Contemporary Architecture in Vienna: 5 ... travelaway.me



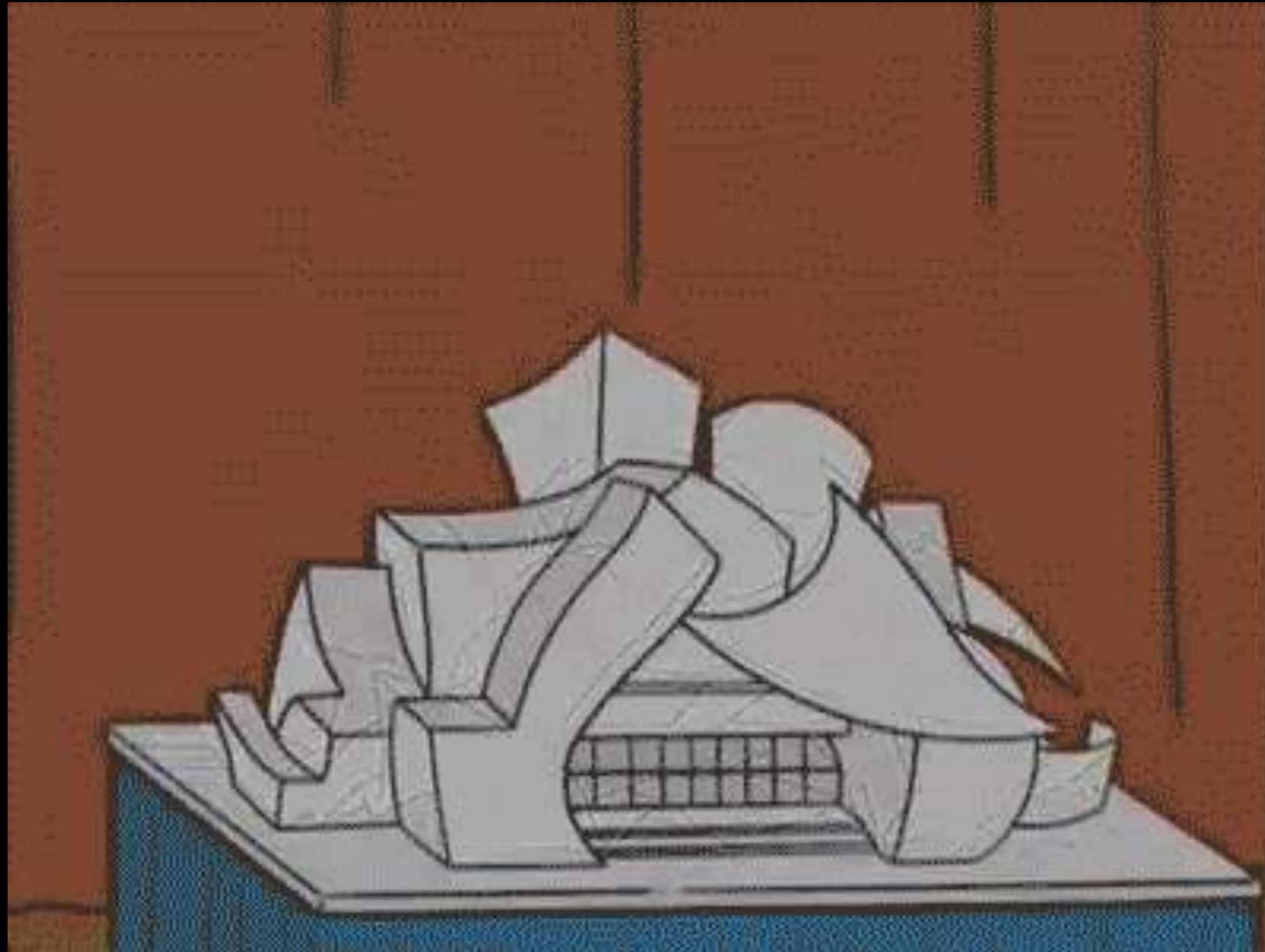
Contemporary Architecture in Barcelona theculturetrip.com



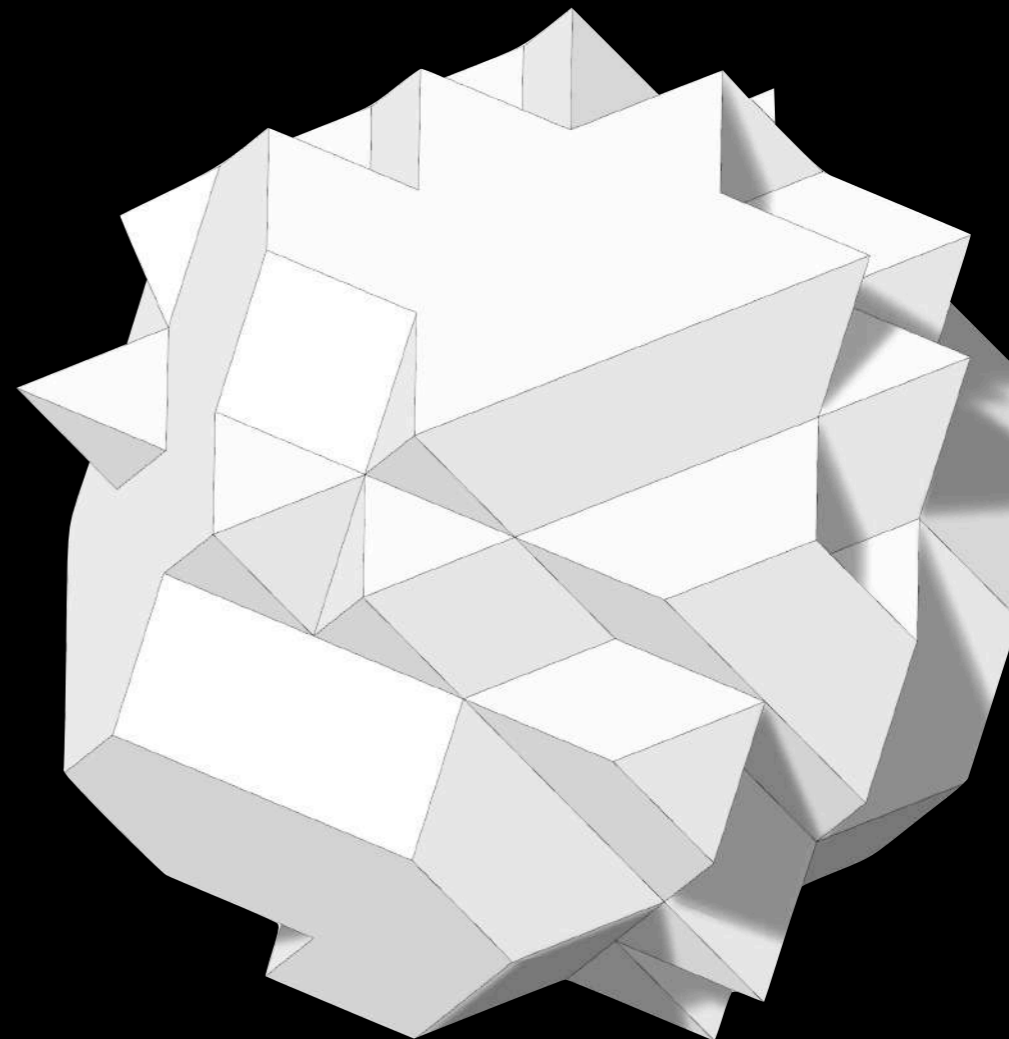
Contemporary Architecture Project with ... bocadolobo.com



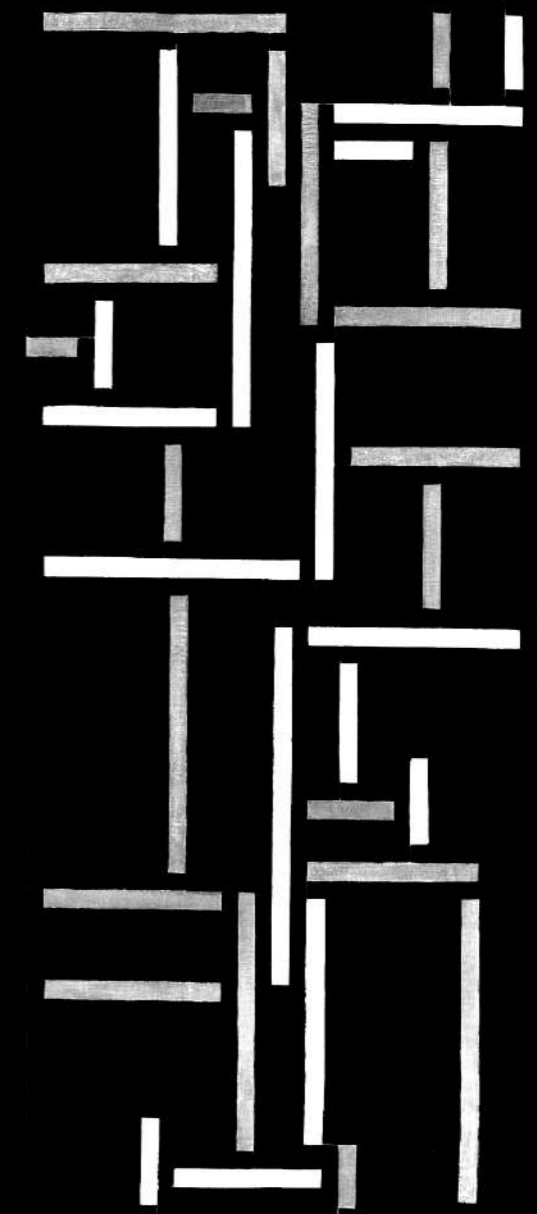
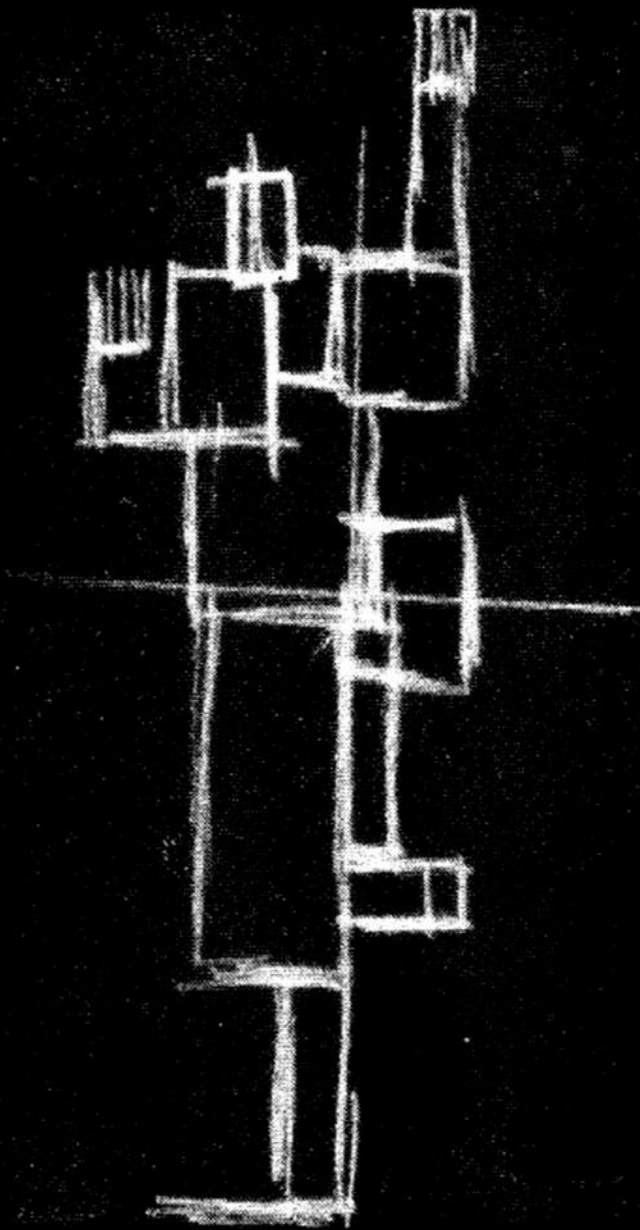
contemporary architecture in Italy ... italianbusinesstips.com



Frank Gehry designs a concert hall to Springfield  
The Simpsons  
Season 16; Episode 14  
Aired: 3 April 2005



Crumpling polygons instead of paper.  
Siim Tuksam. PART Architects.  
Modulation diagram.  
2018



Theo van Doesburg  
Rhythm of a Russian Dance  
1918



Mustamäe housing district, Tallinn, Estonia.  
Window panel. Architects Voldemar Toppel, Toivo Kallas,  
Lidia Pettai. 1962



Mustamäe housing district. Window panel. Architects  
Voldemar Toppel, Toivo Kallas, Lidia Pettai. 1962.



Acton Ostry Architects Inc. Brock Commons. 2017



TAB Pavilion 2017



ICD | ITKE Research Pavilion 2011



TAB Pavilion 2019



ICD | ITKE Research Pavilion 2015-16



TAB Pavilion 2017



ICD | ITKE Research Pavilion 2011



TAB Pavilion 2019



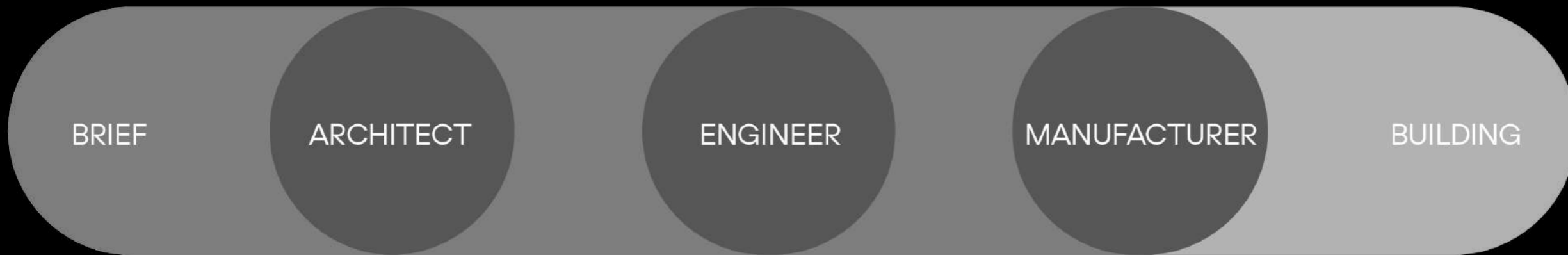
ICD | ITKE Research Pavilion 2015-16



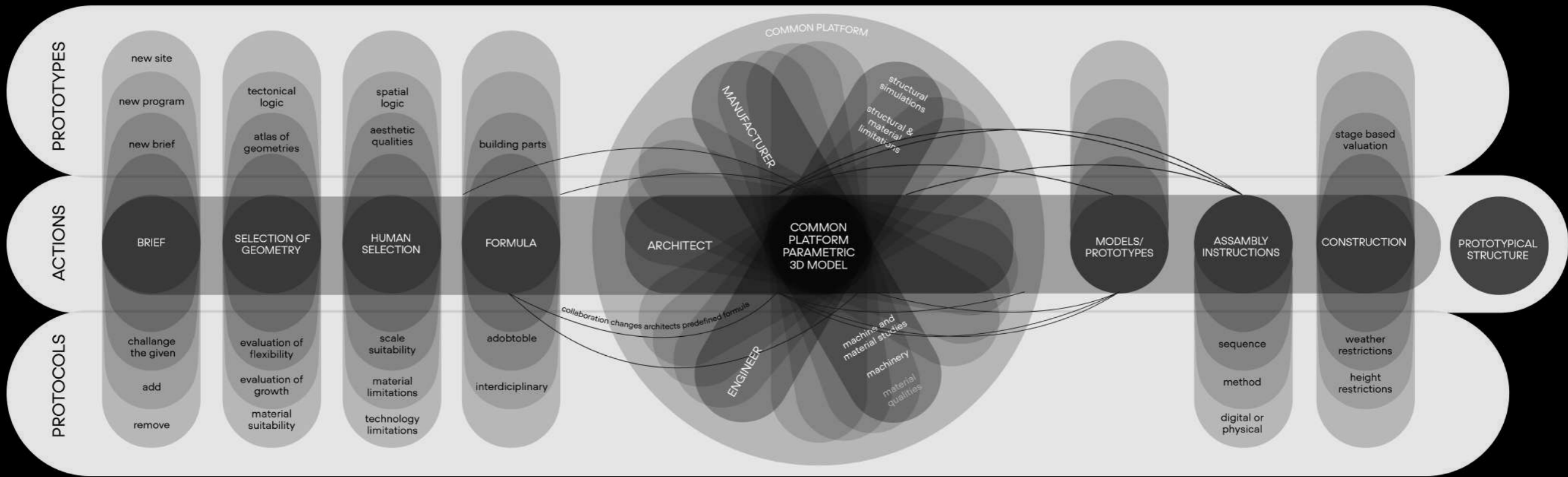


PART architects.  
Vöistluse 7 apartment building.  
Schematic design.  
2018-...

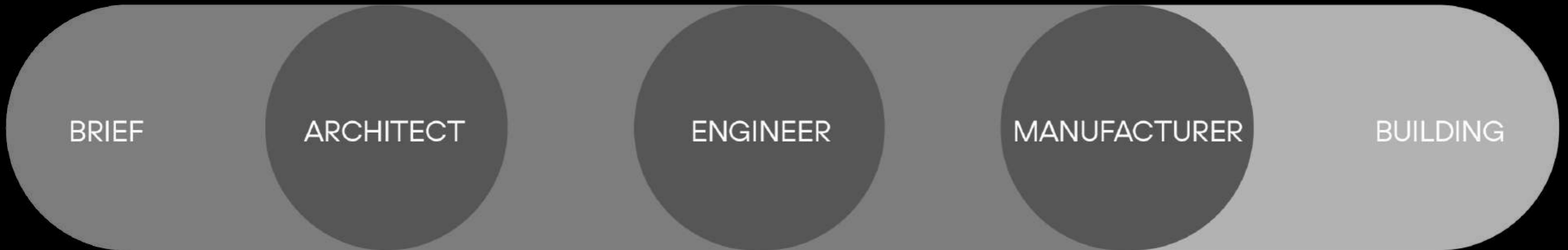
**Development of methodology:  
workflows**



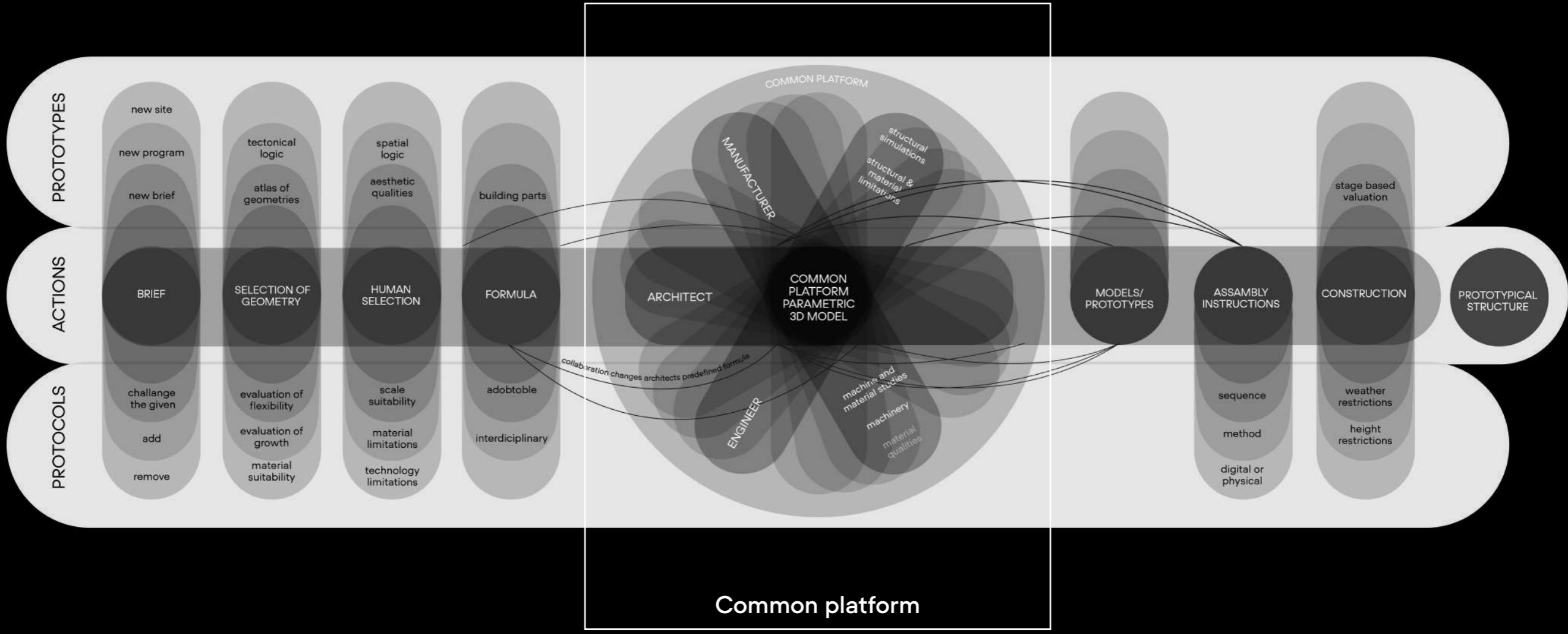
Production chain of architecture. Non-looping method.

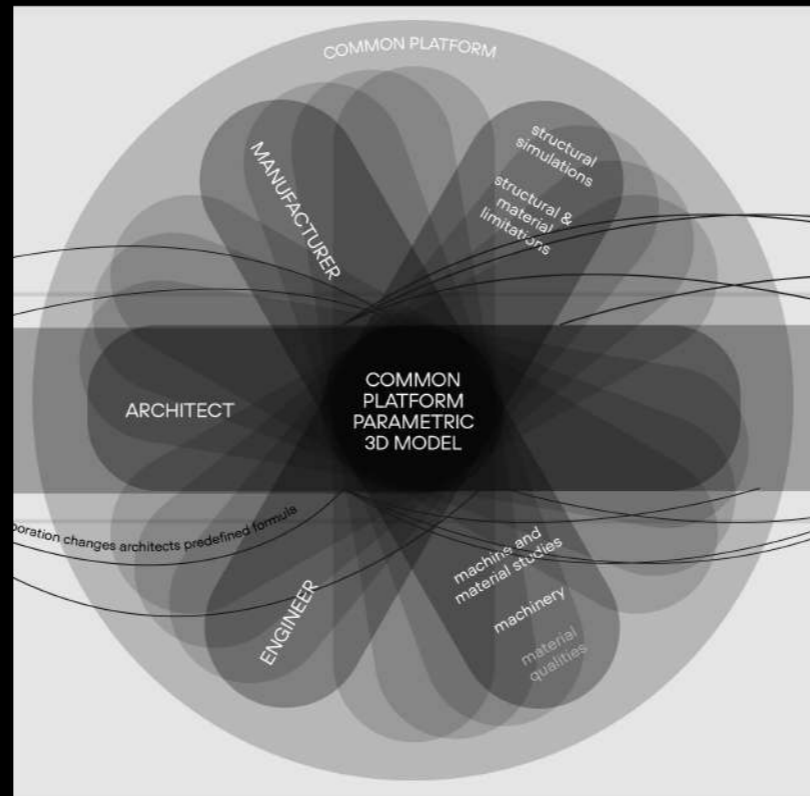


Production chain of architecture. Looping method

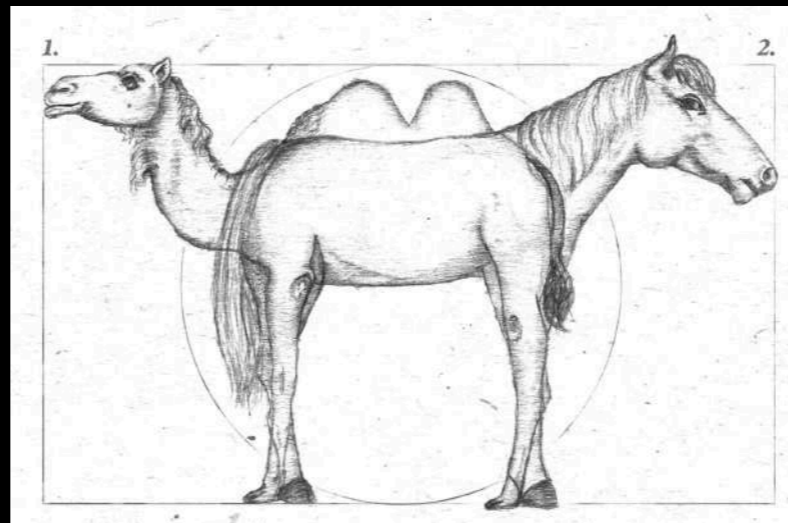
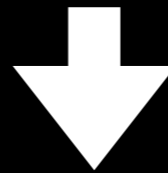


Production chain of architecture. Non-looping method.





Common platform

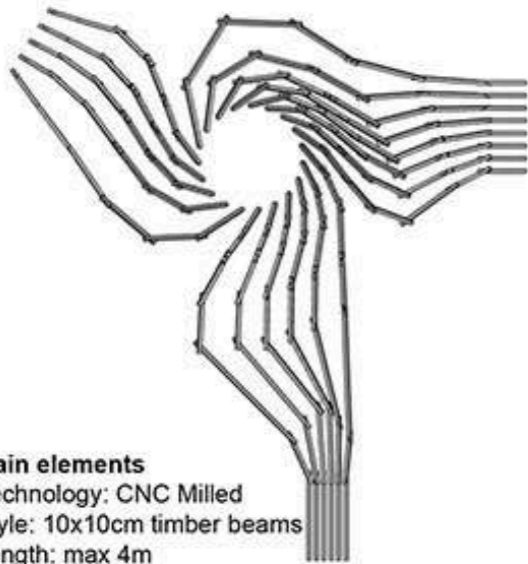


A Camel is a Horse designed by Committee

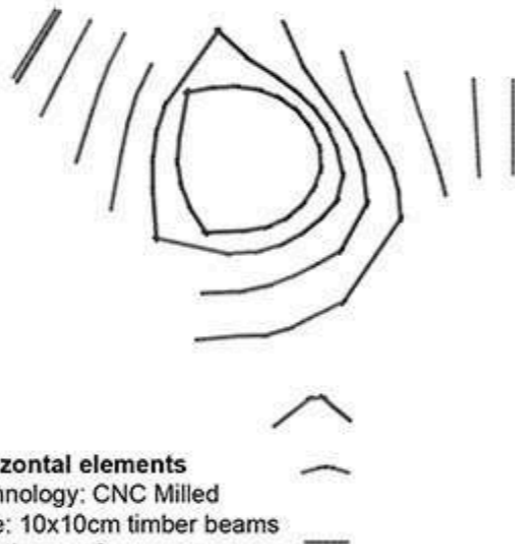




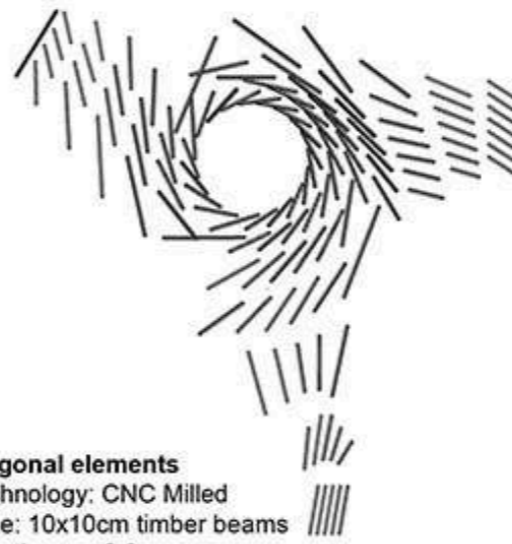
Final geometry.  
Electricity pylon. Bog Fox. 2016



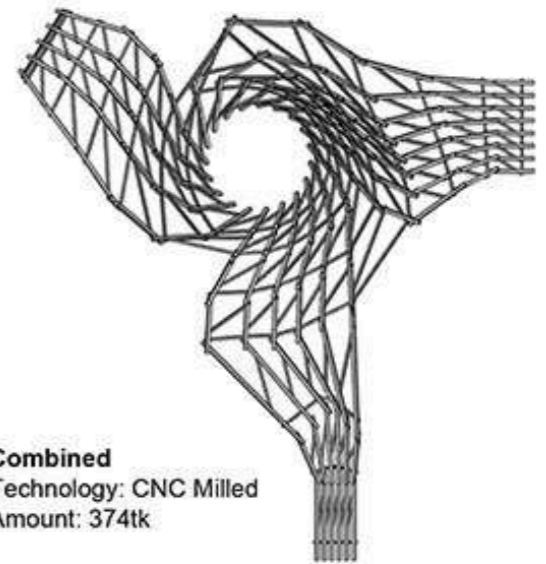
**Main elements**  
 Technology: CNC Milled  
 Style: 10x10cm timber beams  
 Length: max 4m  
 Amount: 133 pieces



**Horizontal elements**  
 Technology: CNC Milled  
 Style: 10x10cm timber beams  
 Length: max 3m  
 Amount: 120 pieces



**Diagonal elements**  
 Technology: CNC Milled  
 Style: 10x10cm timber beams  
 Length: max 2.8 m  
 Amount: 121 pieces



**Combined**  
 Technology: CNC Milled  
 Amount: 374tk

ModelView  
 Model  
 LCFactor  
 LCIIndex  
 Colors  
 Ids  
 defMesh  
 defAxes  
 defModel

Display Scales

Deformation  
 2.42

Reactions  
 0.05

Loads  
 0.20

Supports  
 0.20

Local axes

Joints  
 1.00

Render Settings

Length/Segment (m)  
 8.00

Upper Result Threshold  
 100.00

Lower Result Threshold  
 0.00

ModelView  
 Model  
 Mesh  
 Curves  
 Legend C  
 Legend T

Section Forces

Filled Numbers

Scale

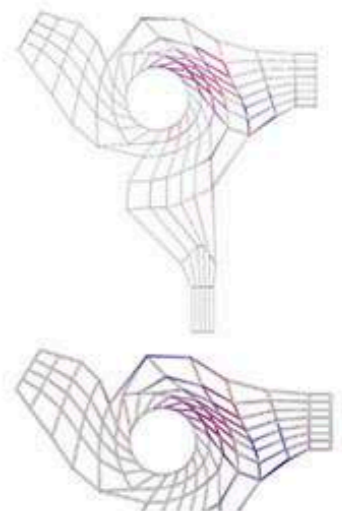
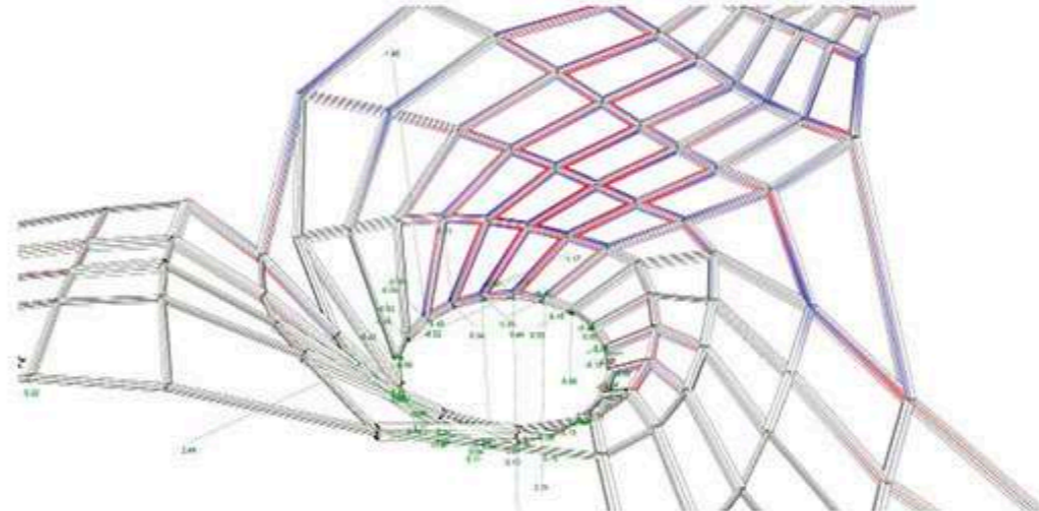
M1 M2 M3  
 N1 V1 V2

Render Settings

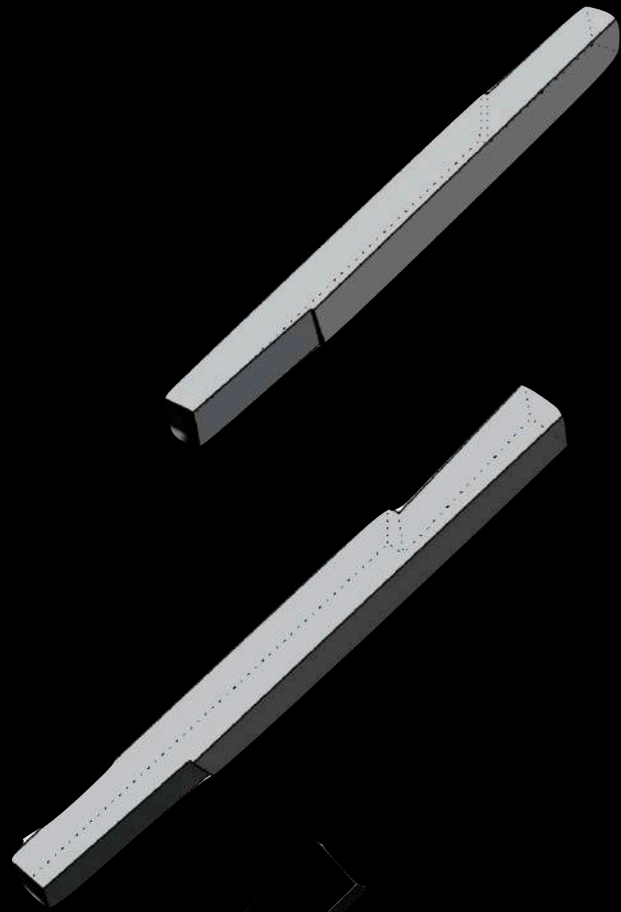
Cross section  
 Displacement  
 Utilization  
 Axial Stress

Edges/Cross section

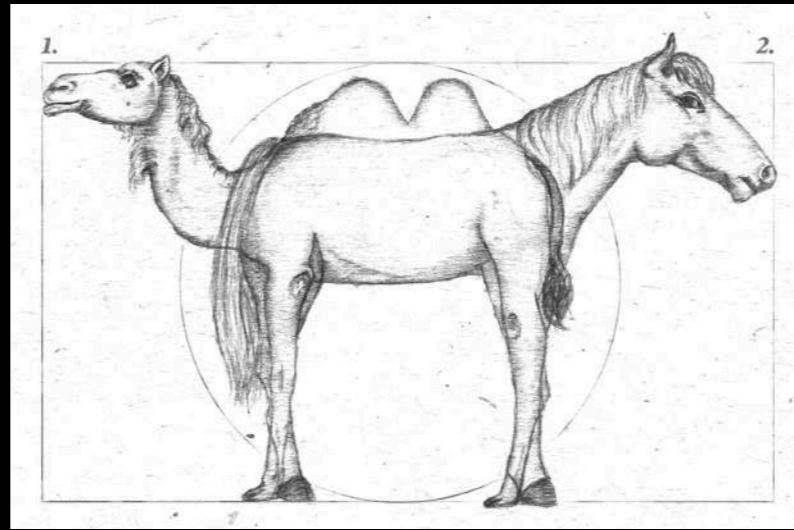
ModelView  
 stress [kN/cm<sup>2</sup>]  
 -2.60e-01  
 -1.15e-01  
 -7.70e-01  
 -2.25e-01  
 -1.80e-01  
 -1.35e-01  
 -8.99e-02  
 -4.50e-02  
 5.68e-17  
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 1.52e-01  
 1.90e-01  
 2.28e-01  
 3.04e-01

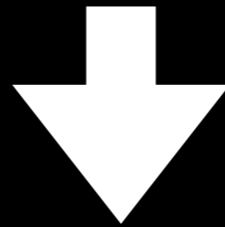
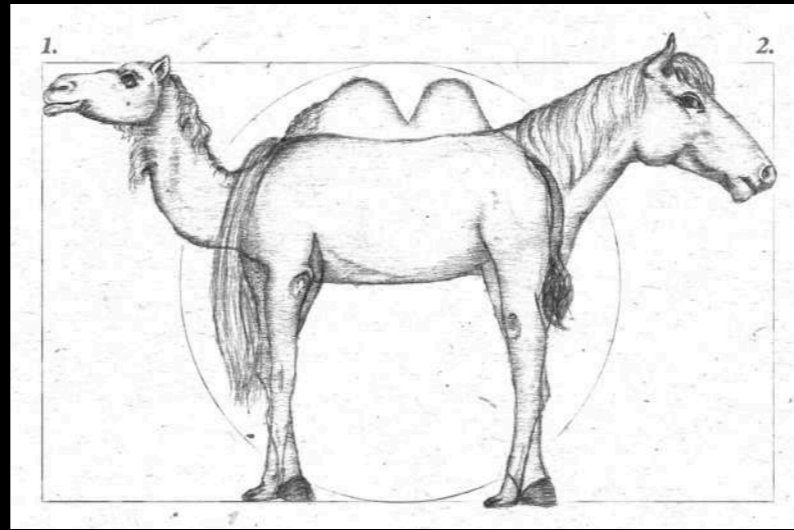


# Alive Material



Body Building installation  
Tallinn Architecture Biennale 2015



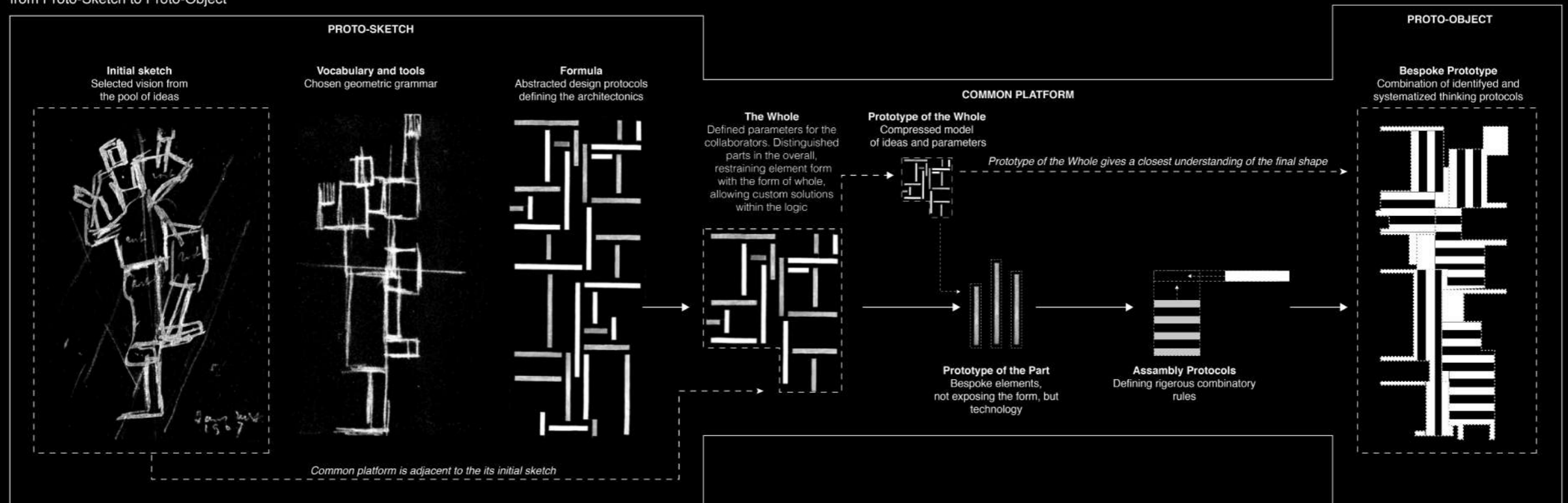


2015-2017

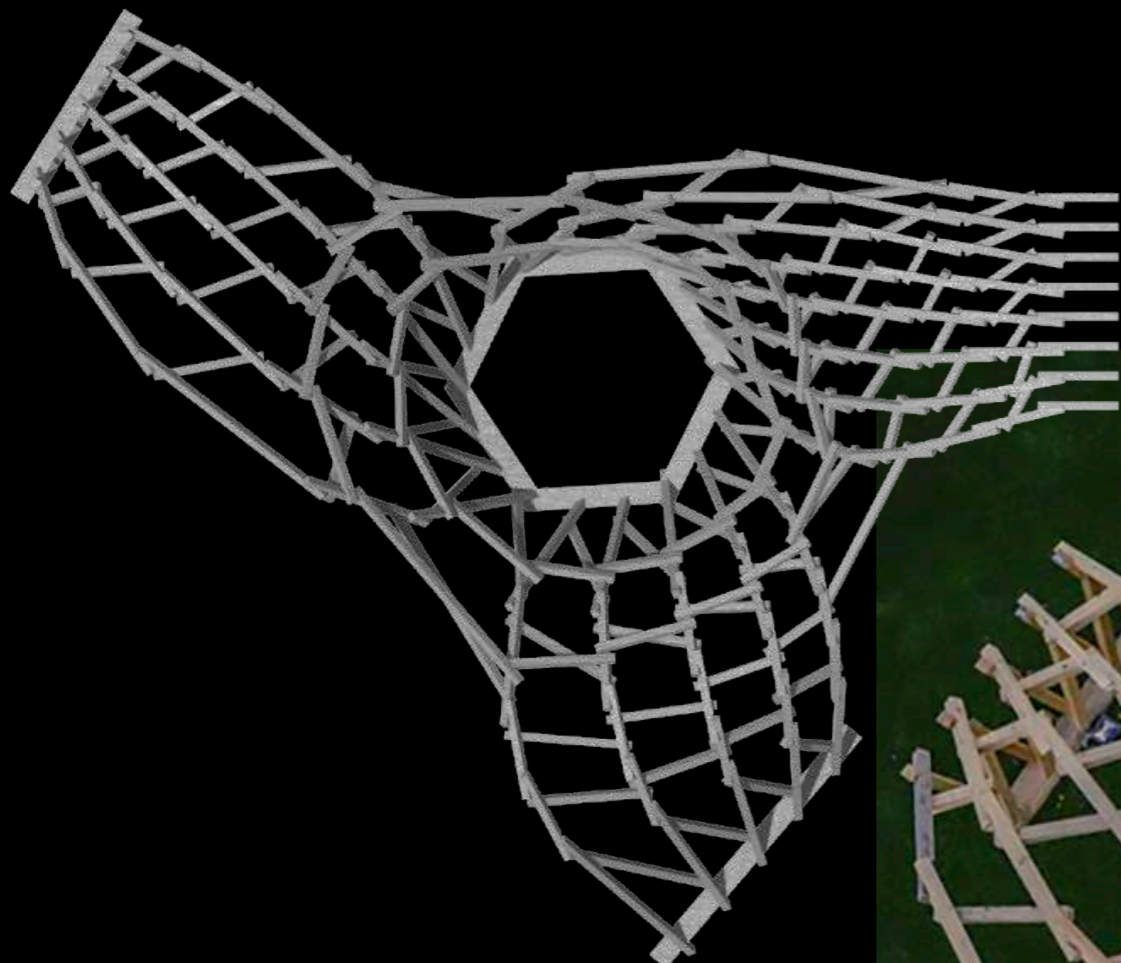
## Bespoke structures

*Bespoke [erilahenduslik]:* a custom made solution for each product. Bespoke structures are systems, where all of the element is different and have non-repetitive yet similar assembly details and logic.

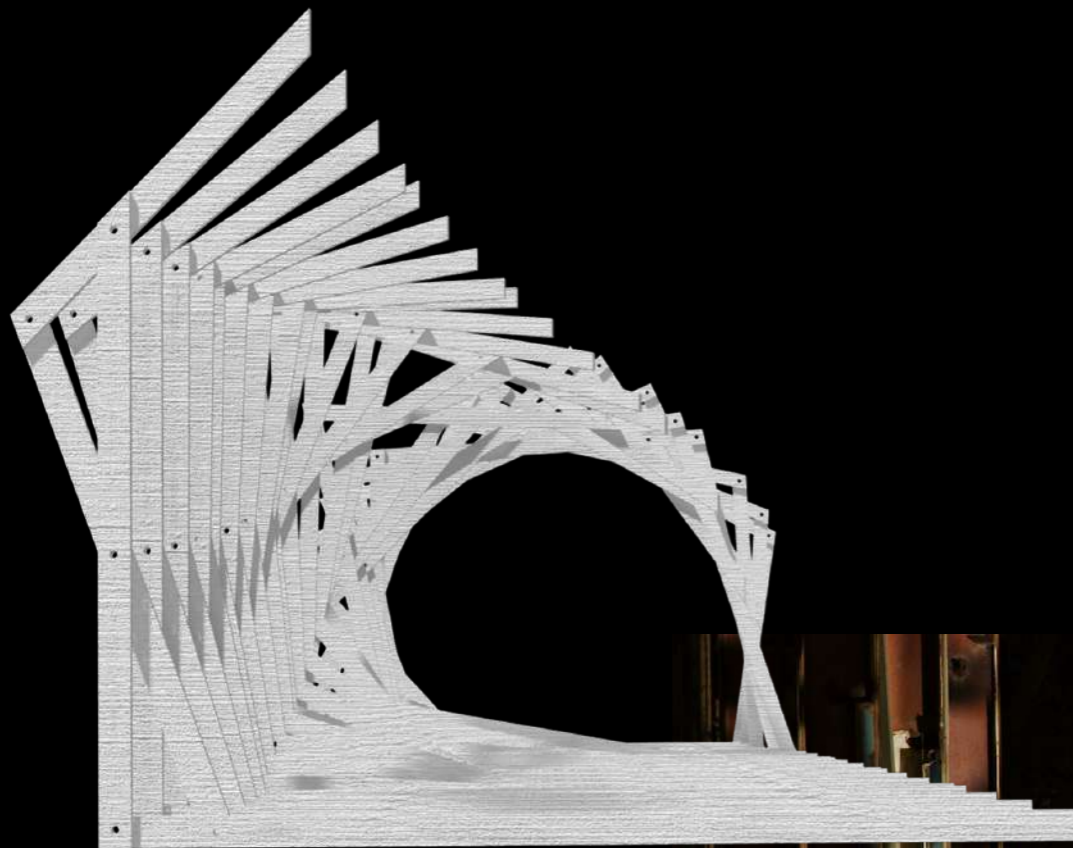
**Bespoke Thinking Methodology:**  
from Proto-Sketch to Proto-Object



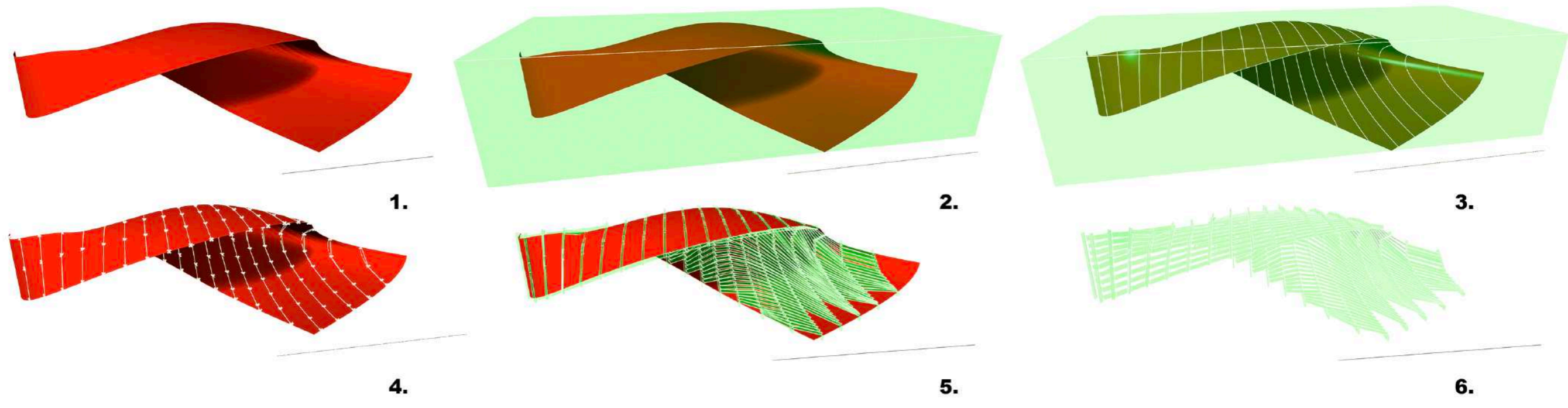
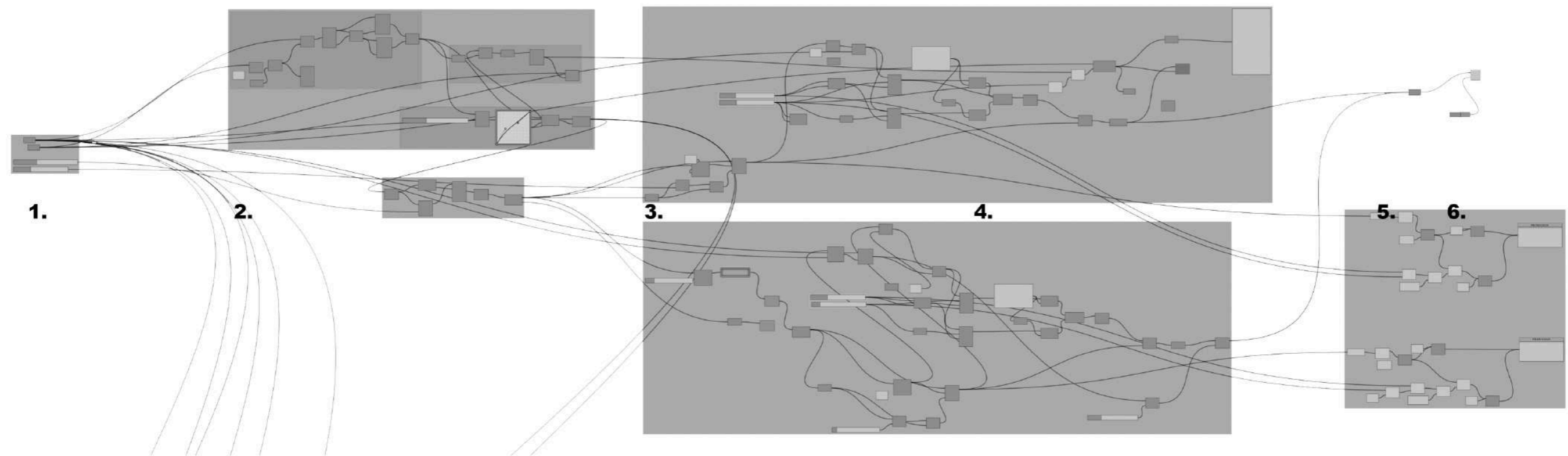
- The Figure of the methodology
- > Stages
- - - - -> Hidden connections
- .....> Hidden sequence

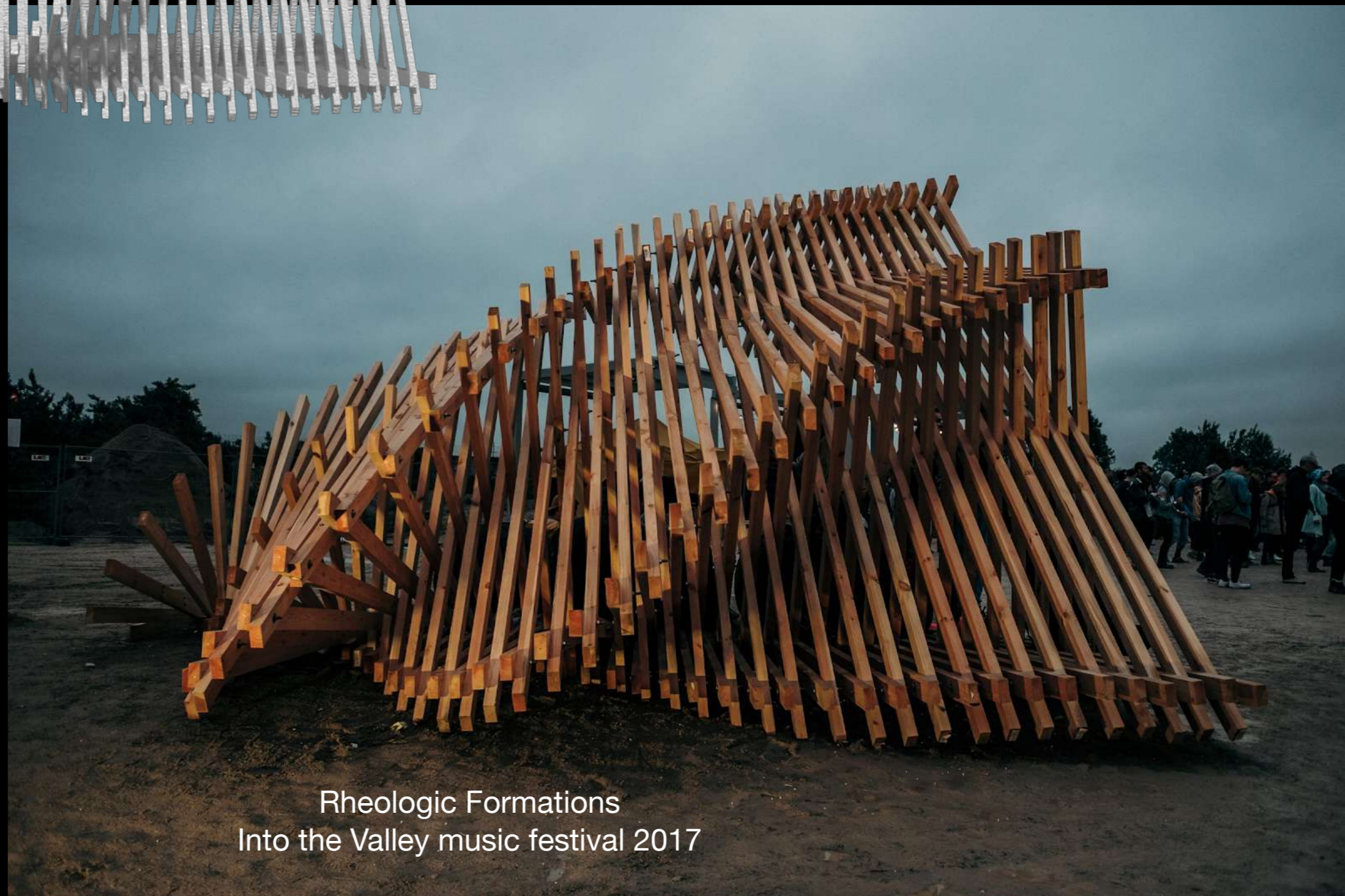
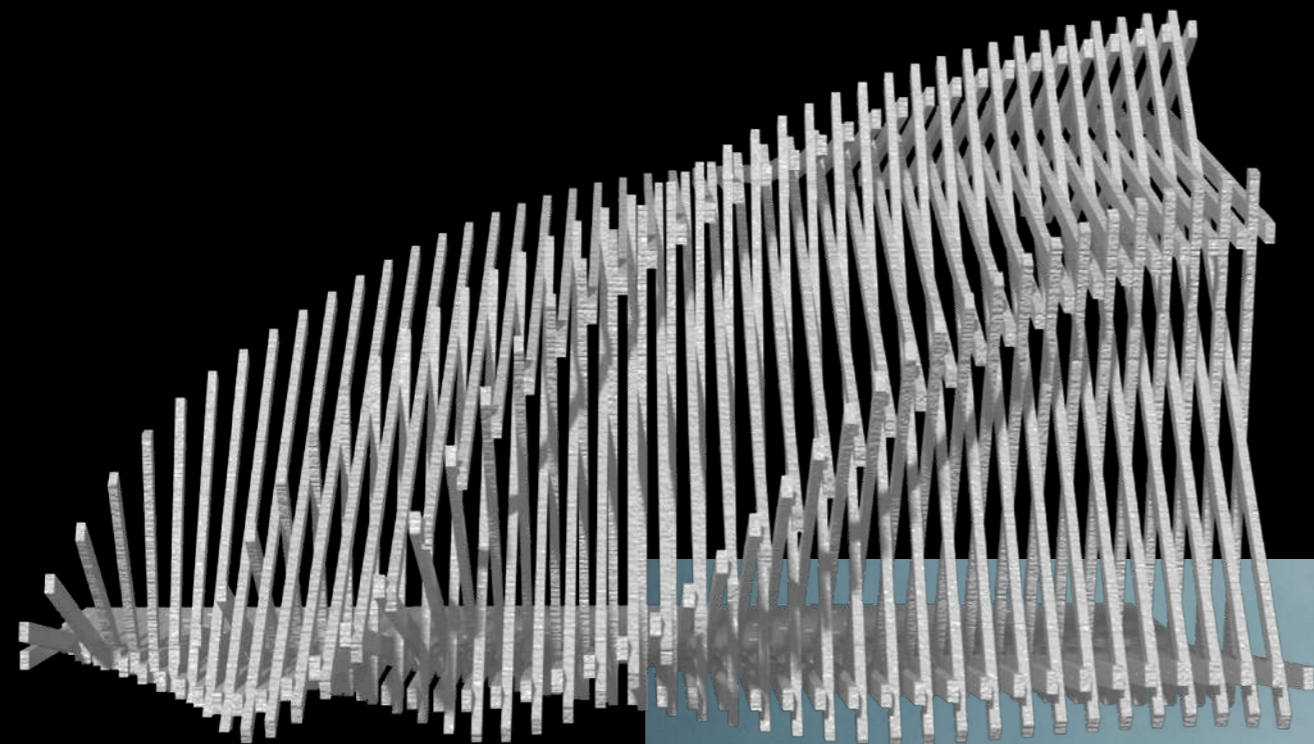


Body Building installation  
Tallinn Architecture Biennale 2015

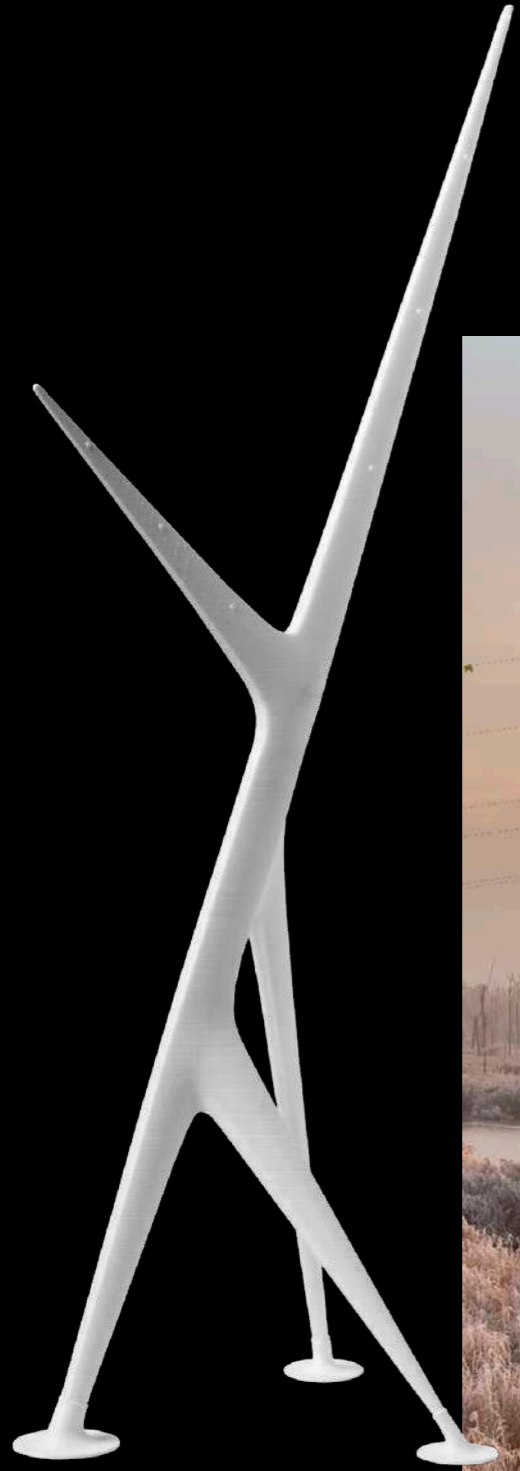


Soundwaves  
Tallinn Music Week 2016





Rheologic Formations  
Into the Valley music festival 2017



Electricity pylon. Bog Fox. 2016  
under construction



The concrete version has 63m<sup>3</sup> Concrete with 150€/m<sup>3</sup>, Reinforcement 350kg/m<sup>3</sup> with 1.2€/kg, 305 m<sup>2</sup> Surface area with 250€/m<sup>2</sup> Formwork (this is all relatively high values), this sums up to 112.500€. I would add the 10.000€ for connection details as for the steel version. 122.500€



The timber version has 59m<sup>3</sup> (Accoya 2850€/m<sup>3</sup>), hollow cross sections – I think we need to add at least 15% of material which will be milled of the laminated parts, so this is 194.000€. I would add the 10.000€ for connection details as for the steel version.



The steel version has a weight of 23 tons, plus 10% for ribs and connections ca 2 tons = 25 tons total, I think 5€/kg should be right which is 125.000€

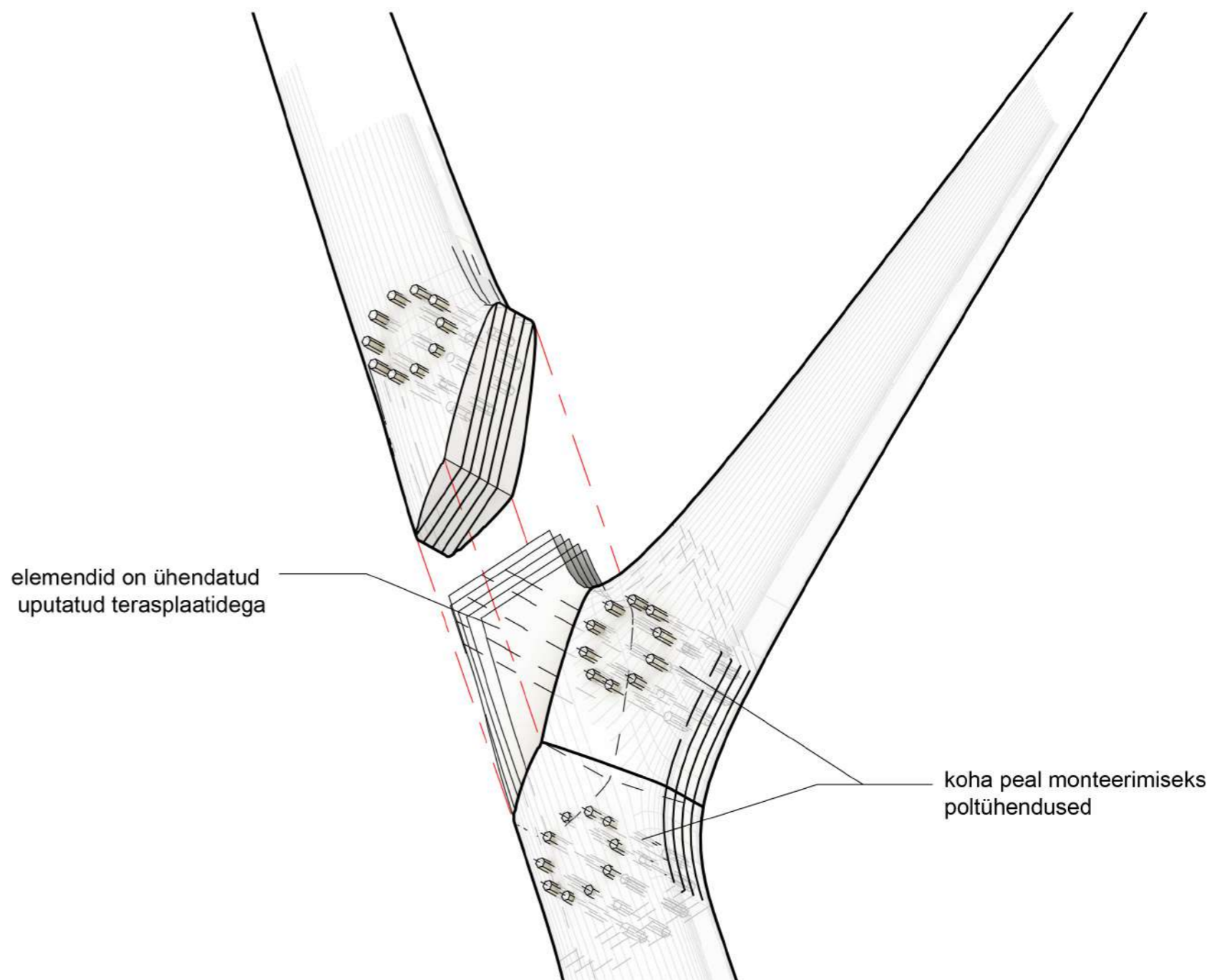


# SÕLMED

Puitkonstruktsioonidel on sõlmed kriitilise tähtsusega. Peamiseks ohuks on vee pääsemine sõlme sisse, mistõttu oleme kõik sõlmed katnud piisavas ulatuses plekiga ja pööranud tähelepanu õhutusele.

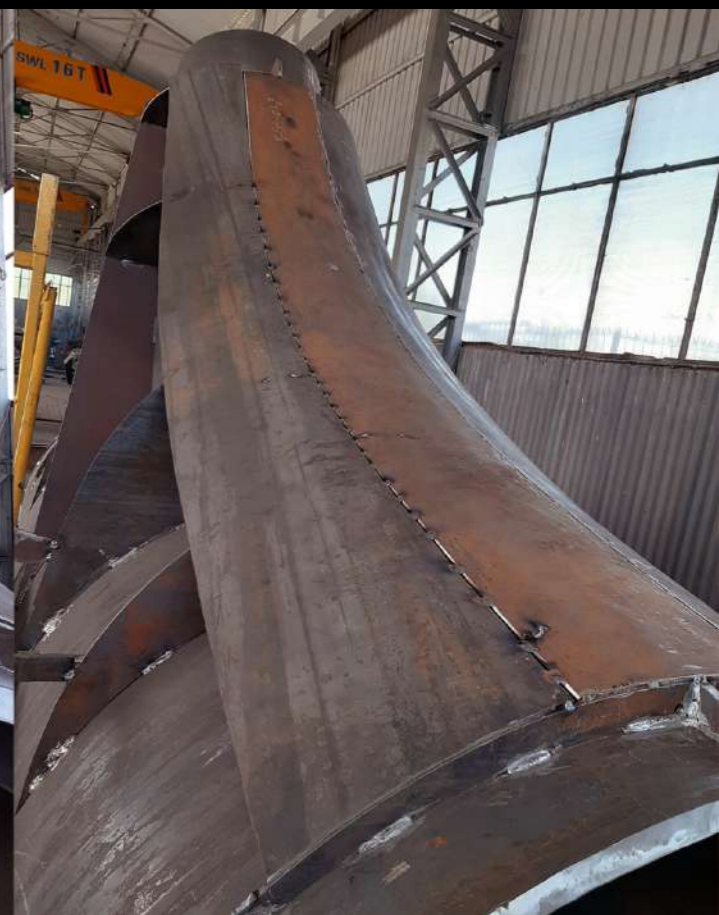
Meil on 3 peamist sõlme: liimpuit-vundament, liimpuit-liimpuit ja liimpuit elektriliin.

Vundamendi ühendus on lahnedatud liigendsõlmena. Detailide omavahelised kinnitused toimivad uputatud teraslehtedega ja poltidega, mis tagab jäiga monteeritava ühenduse. Kõrgepingeline liini isolatsioon ketid kinnituvad konstruktsiooni külge läbistavate varrastega.

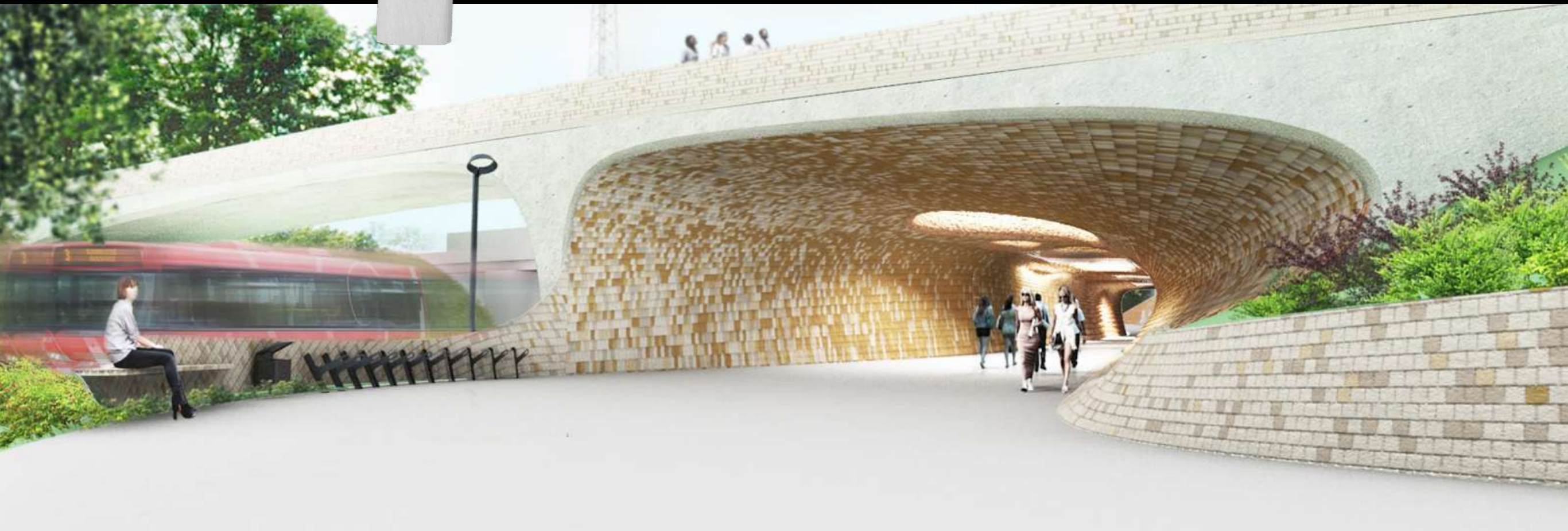


elemendid on ühendatud  
uputatud terasplaatidega

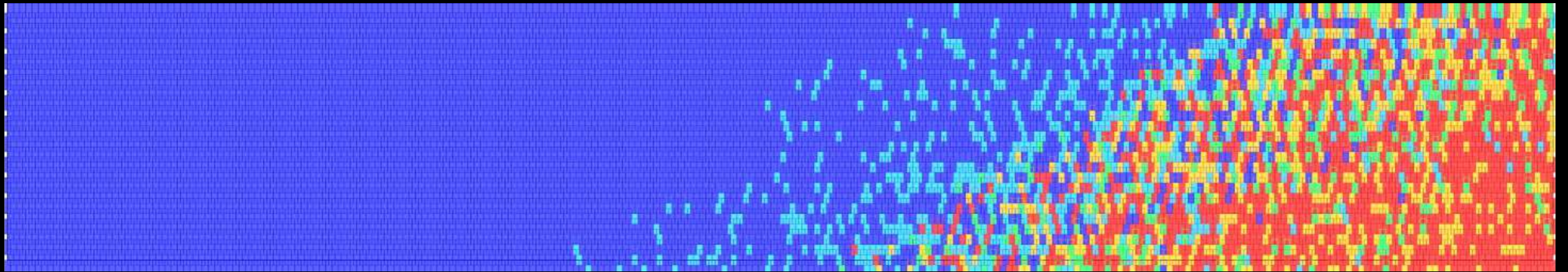
koha peal monteerimiseks  
poltühendused



Electricity pylon. Bog Fox. 2020  
Mega-components



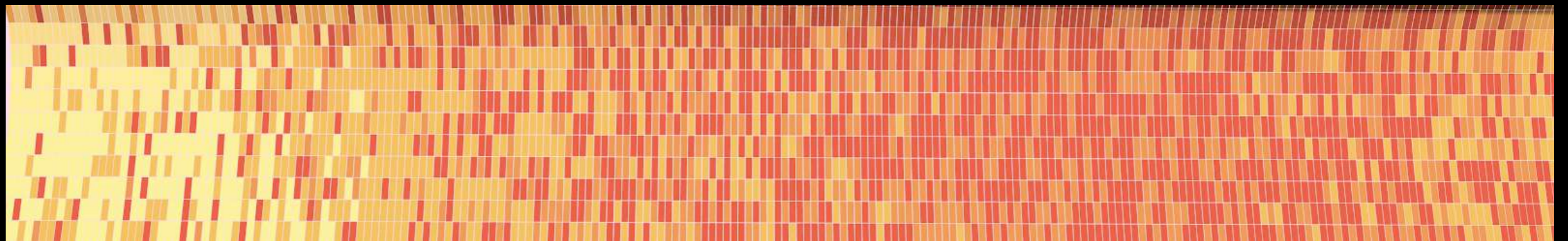
Tartu pedestrian tunnel and bridge. 2016  
under construction



UV kiirguse analüüs elementidel

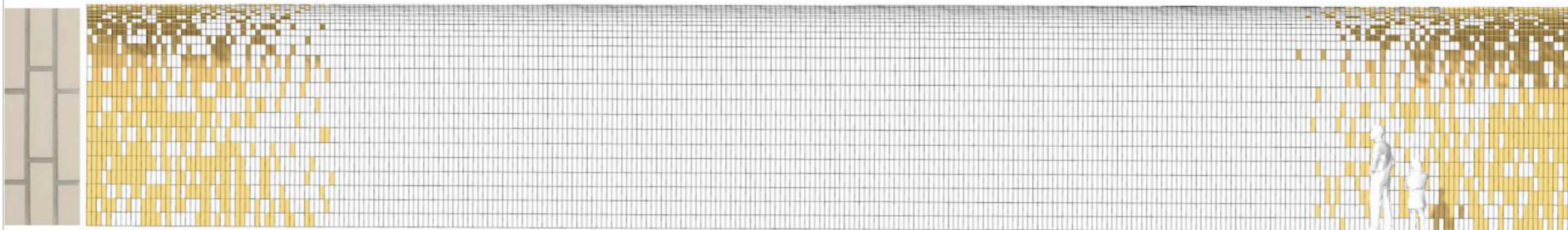


Puidust elemendid. Eskiis

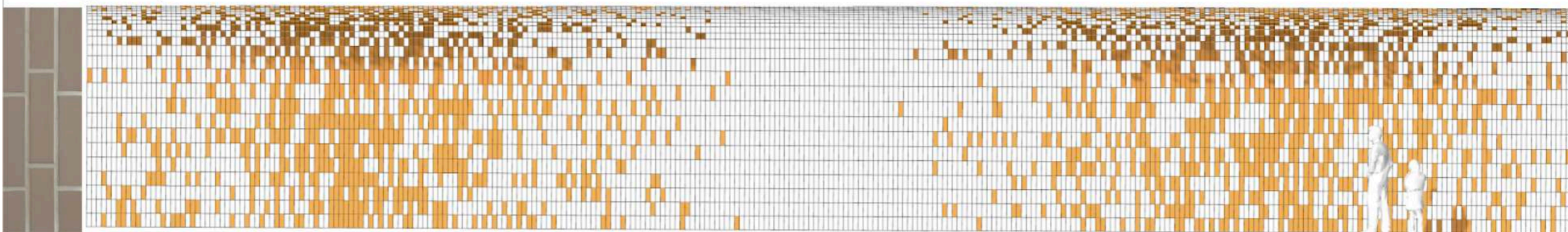


Vertikaalsed telliselemendid. Eelprojekt

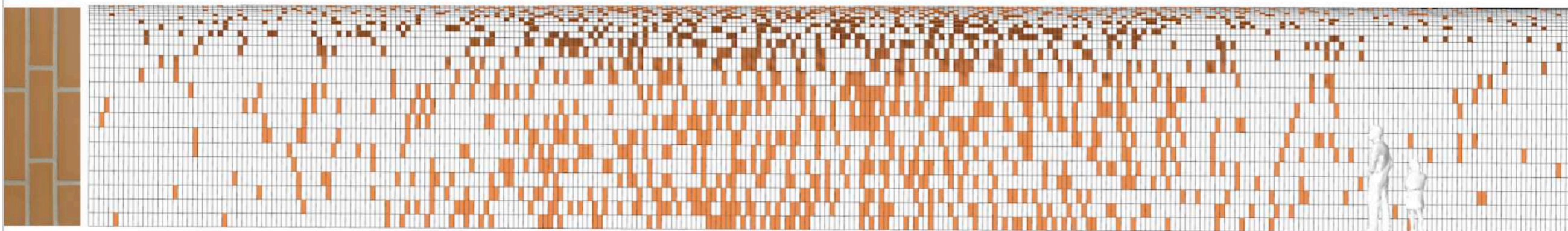
# Toonide värvid TELLISPANEELID



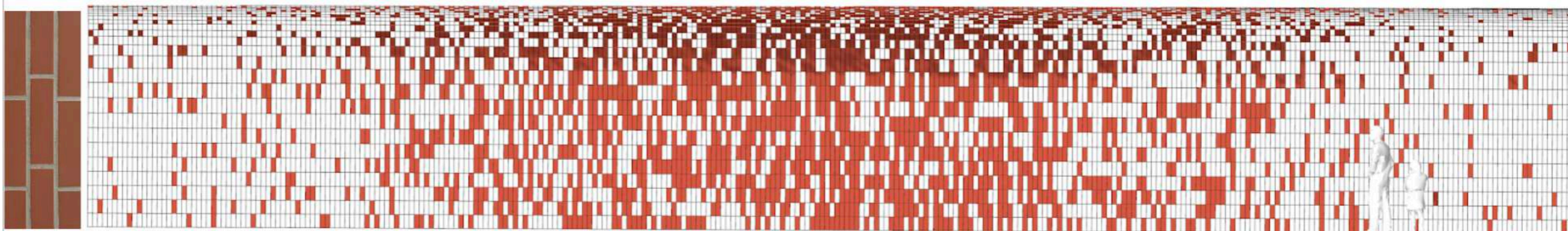
Valge tellispaneel



Hall tellispaneel



Oranz tellispaneel



Punane tellispaneel



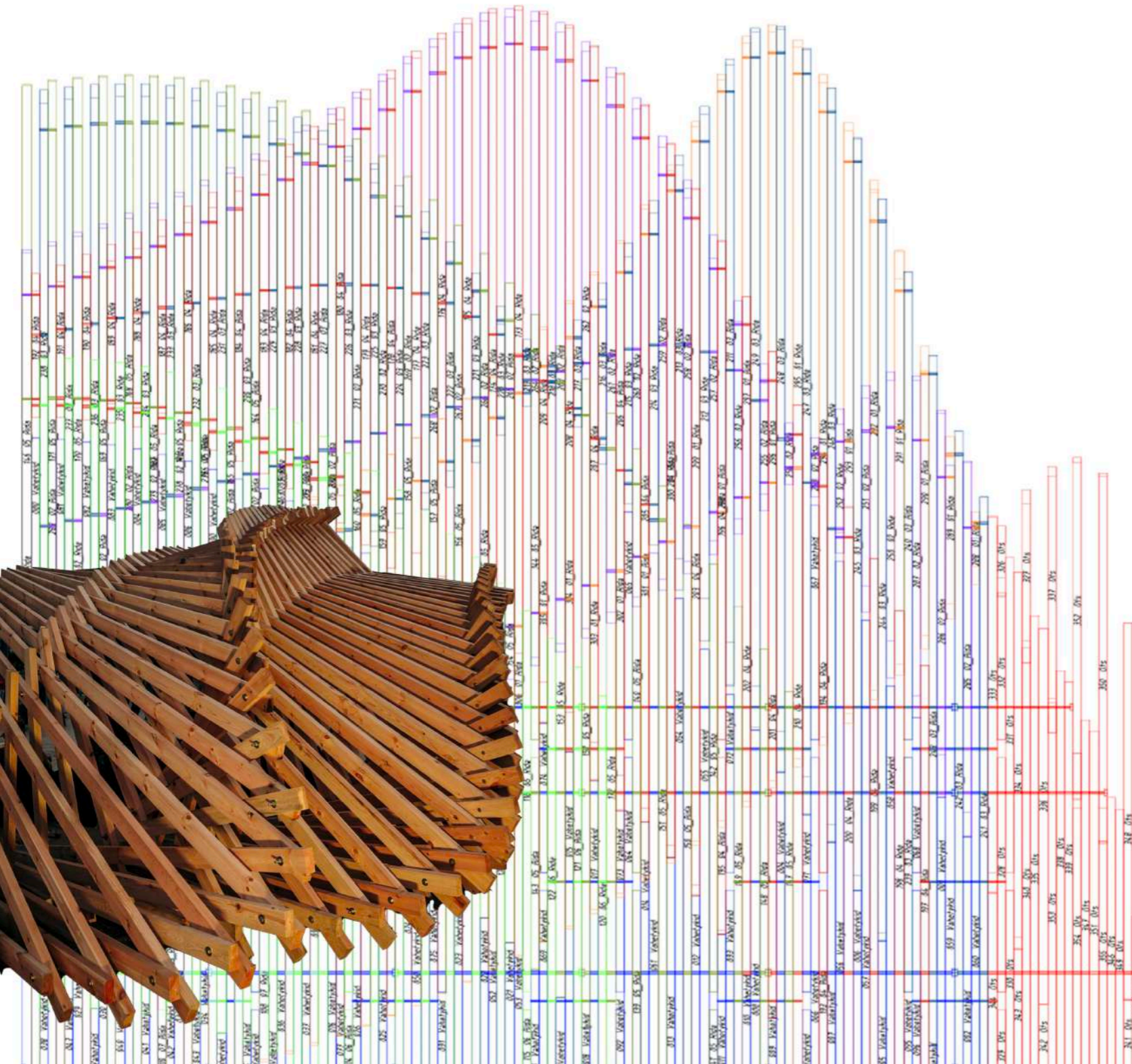
## Bespoke systems

+

- Experimental and formally intriguing
- Raised attention and started collaborations
- Were pushing the envelope of production methods and technology available

-

- overly expensive (standardised units still more feasible)
- labor intensive sorting and assembly
- in case of complex systems, there is a need for architects participation

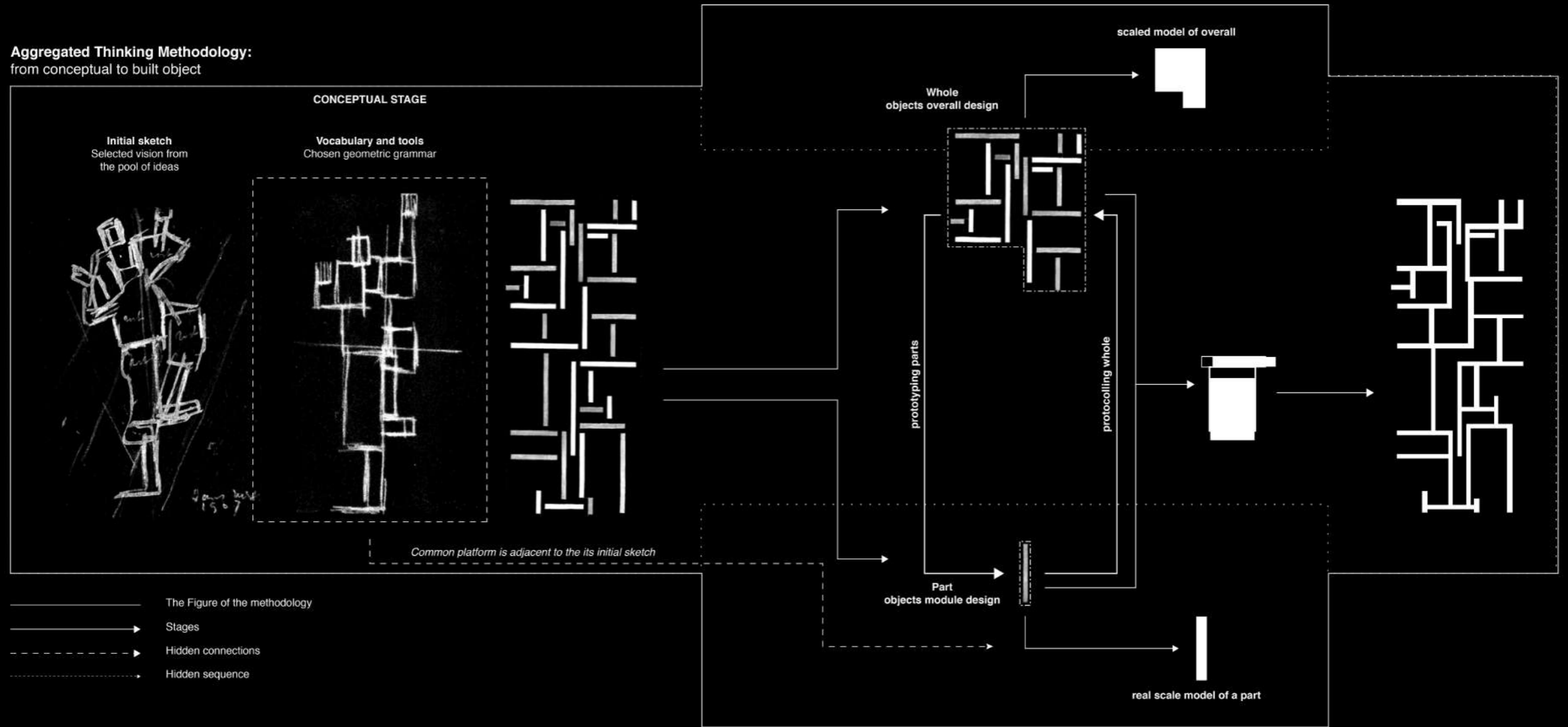


2017-2018

## Aggregated structures

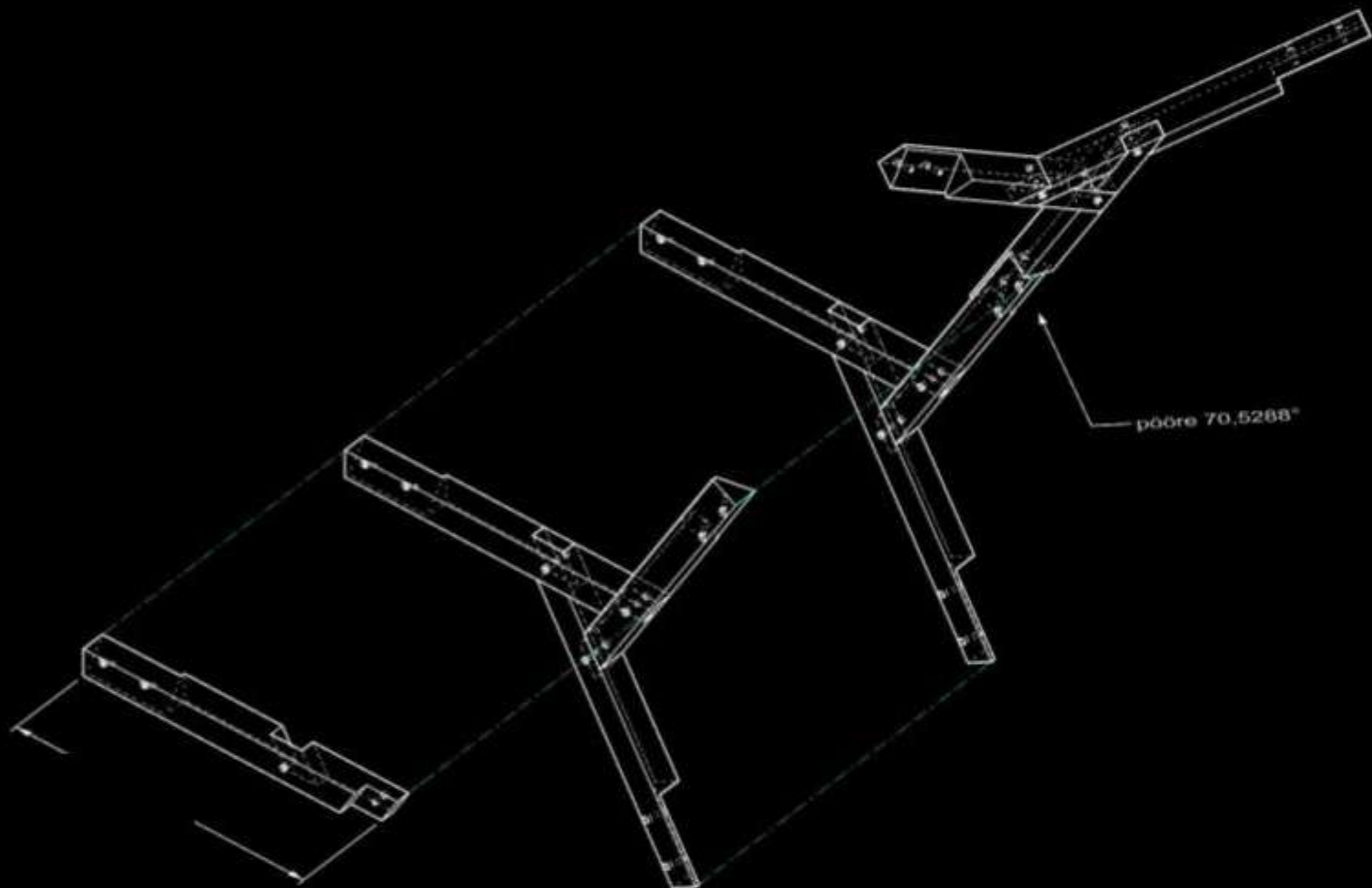
*Aggregated structure* [liitstruktuur, agregeeritud struktuur]: spatial skeleton, formed from one or minimum amount of elements, this method enables participatory architectural structures, which remain rearrangeable.

**Aggregated Thinking Methodology:**  
from conceptual to built object

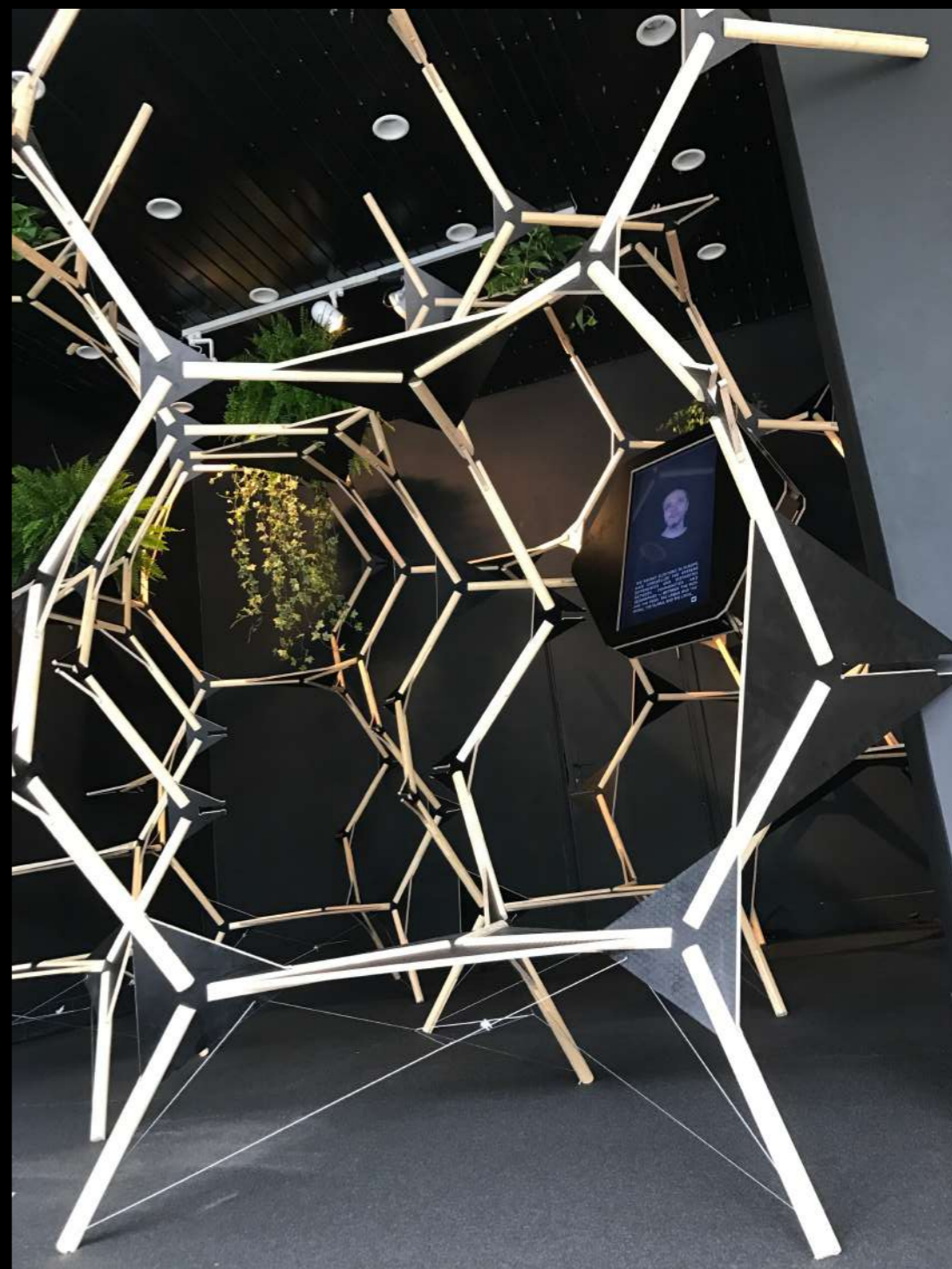
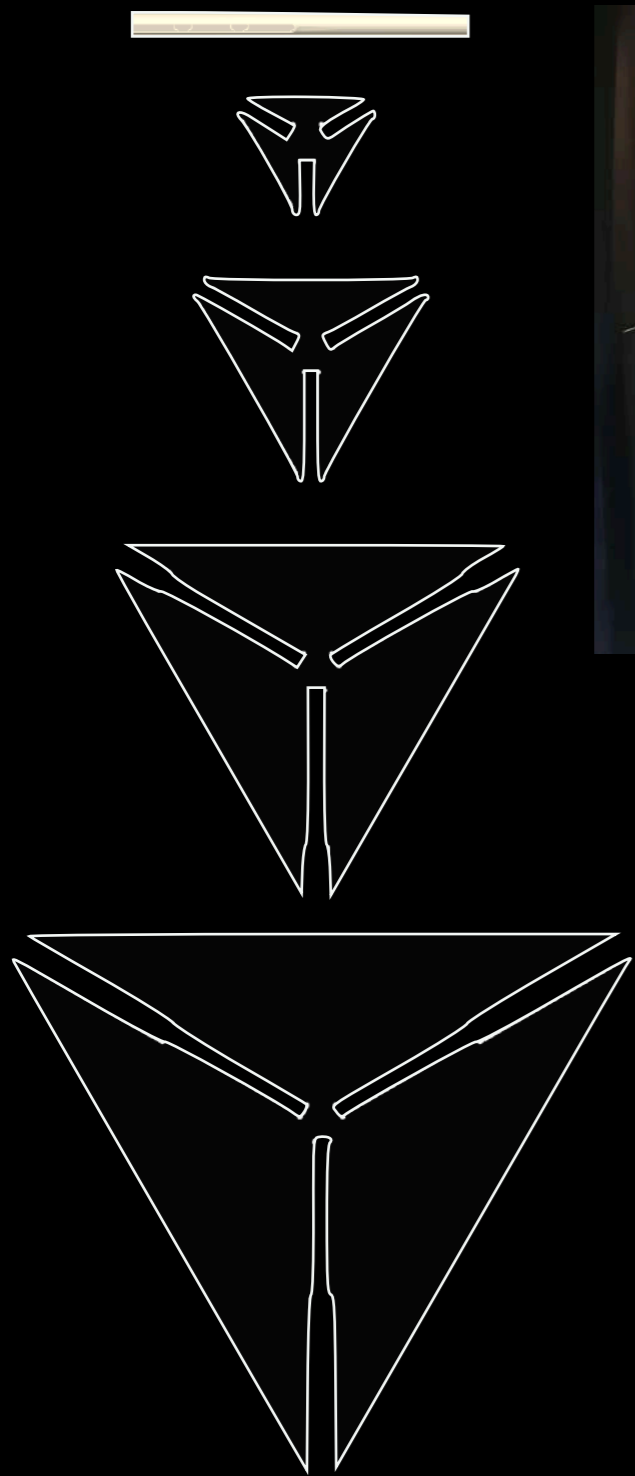




Digital Thicket installation  
European Union Residency opening ceremony.  
Freedom square. Tallinn. 2017



põõre 70,5288°



“BEL:EST. A Laboratory for Europe in Brussels”  
BOZAR , Brussels, Belgium. 2017

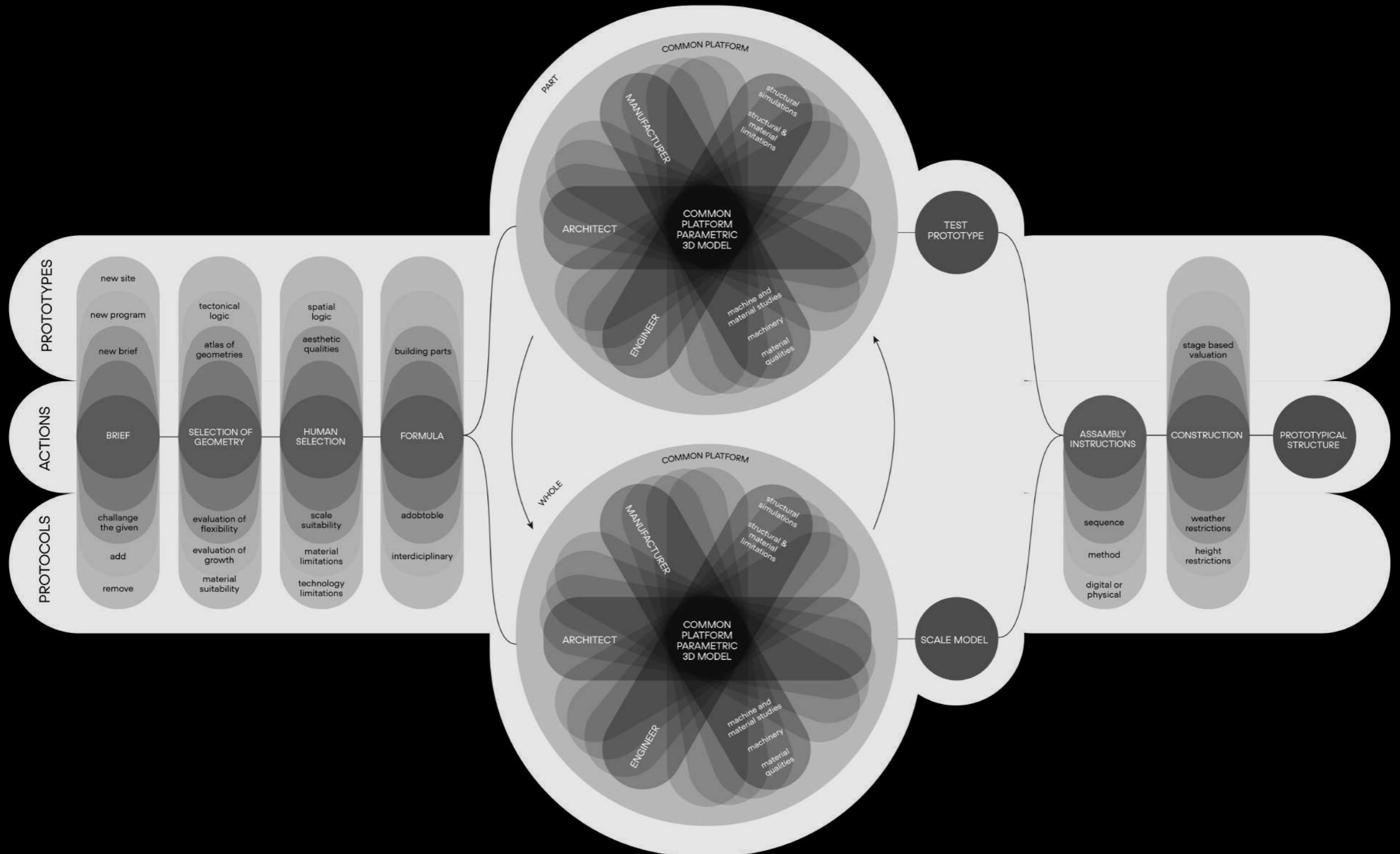


Bespoke Timber Architecture

exhibition at  
Palazzo Bembo, Venice  
Opening reception  
24 May 6 p.m.



PART.icular - bespoke timber architecture  
Time.Space.Existence exhibition  
Venice Architecture Biennale 2018



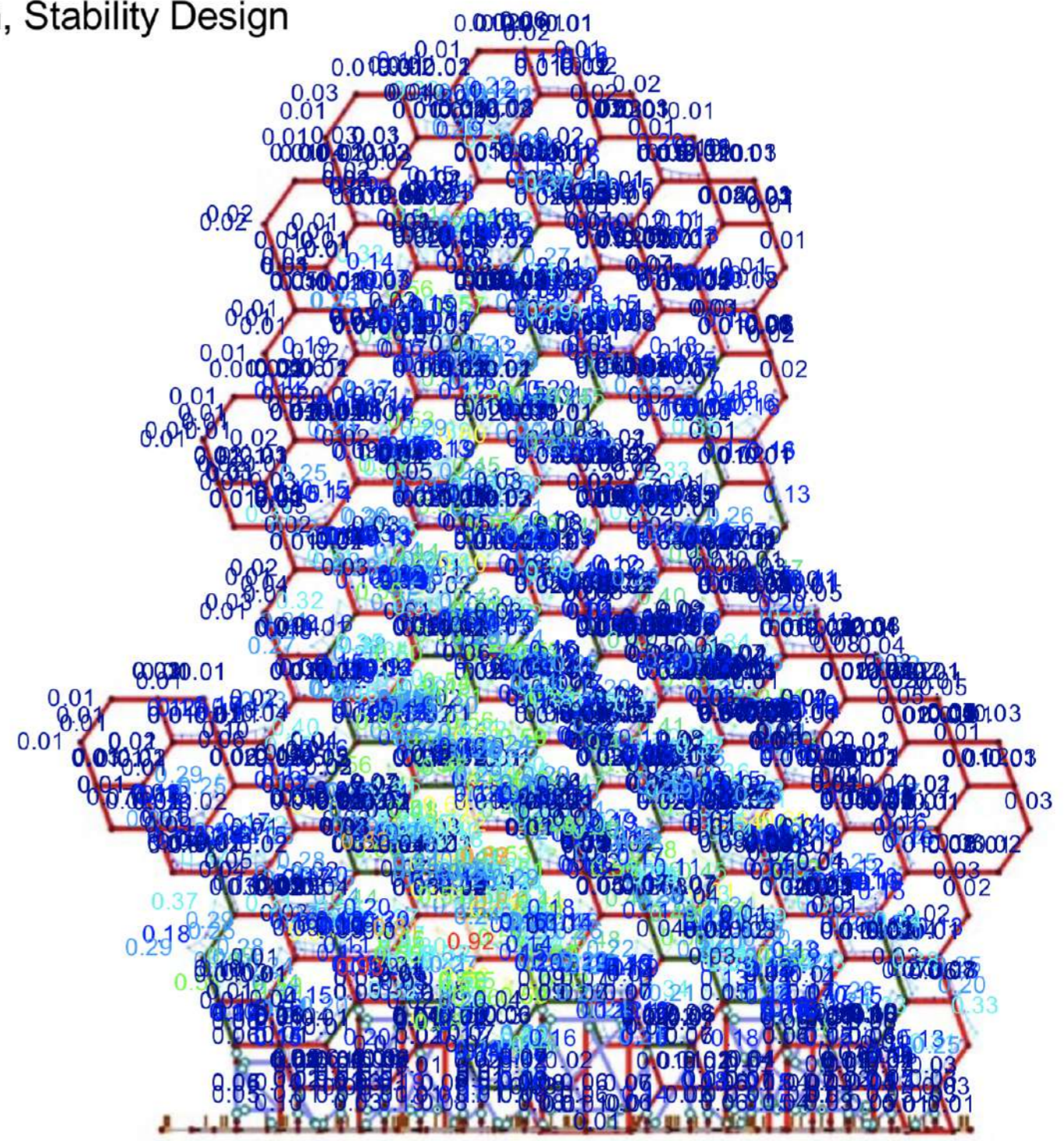
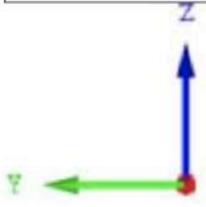
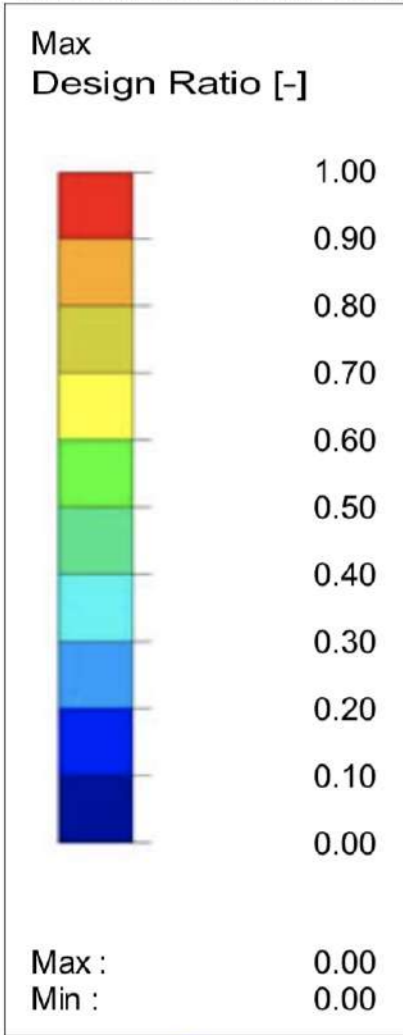
Workflow diagram  
Aggregational structures



Urban Jungle vertical park  
T1 shoppingmall, Tallinn  
2018

# RF-STEEL EC3 CA1

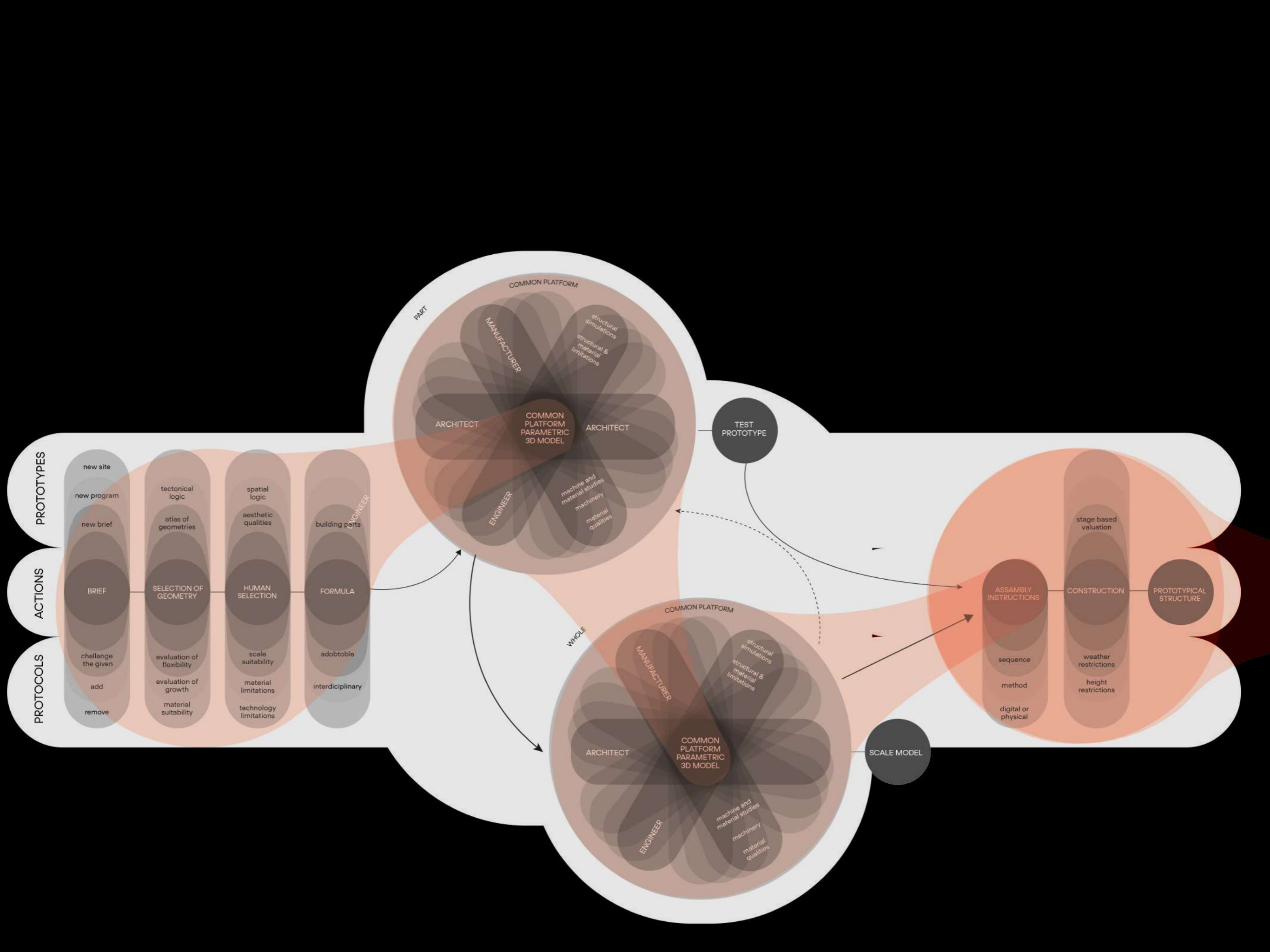
## Ultimate Limit State: Cross-Section Design, Stability Design



Members Max Design Ratio: 0.93







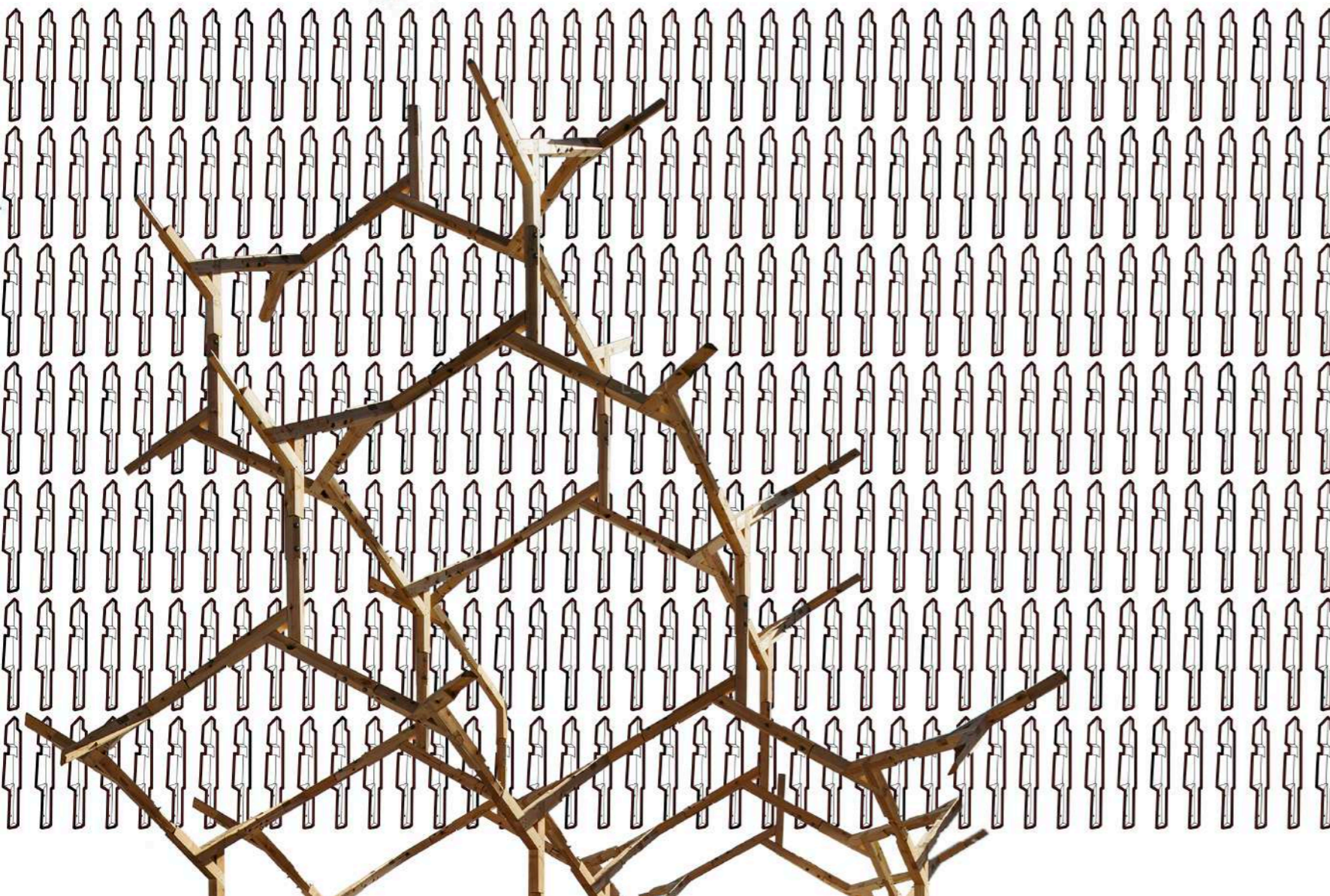
## Aggregated systems

+

- standardised elements reduce production time and cost
- intelligent connection detail reduces necessity of metal connections
- fast and effective way of creating space filling systems

-

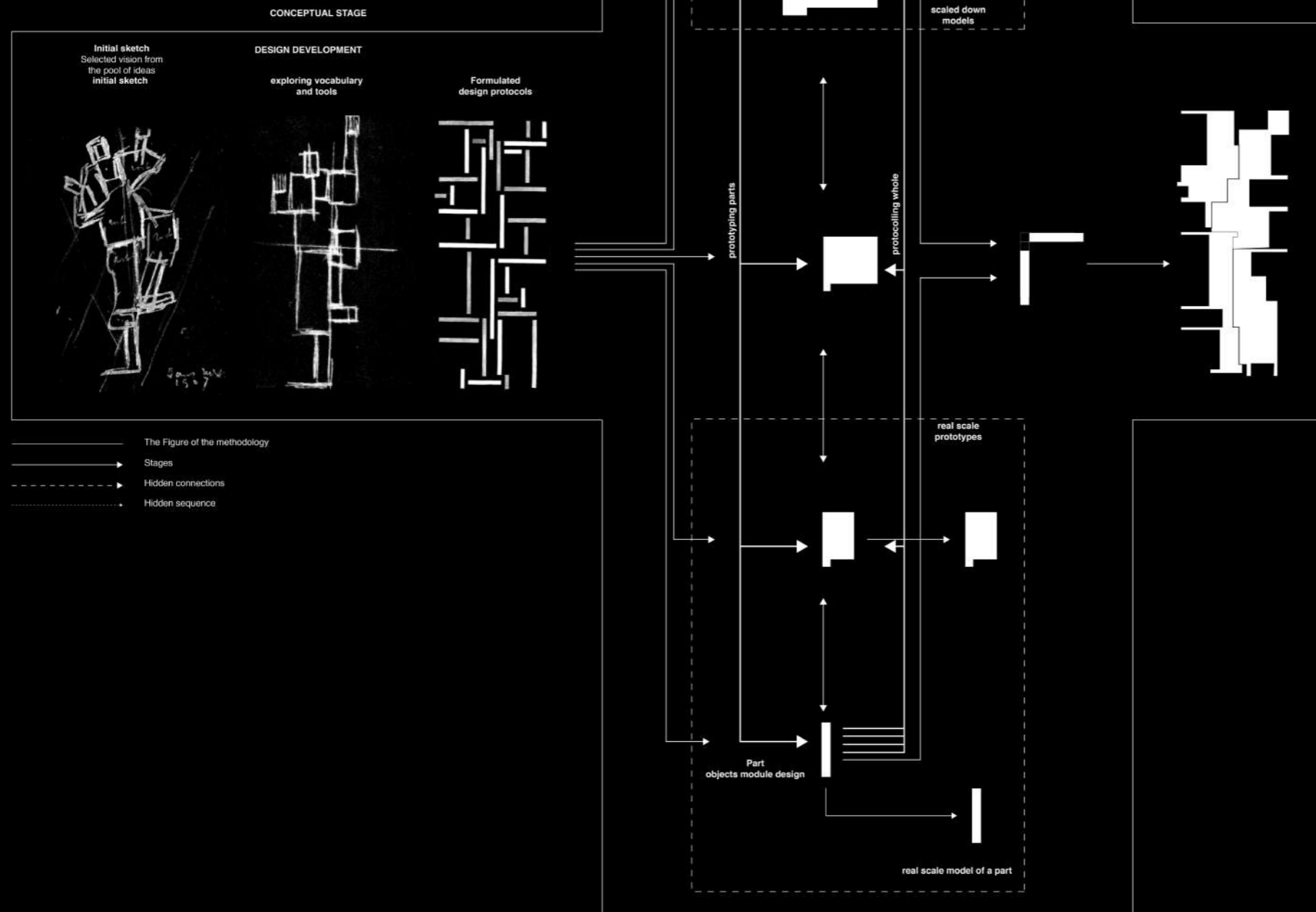
- the overall form is rigid and rather cullled out grid
- spacegrid rigity is not adobpting different functions it inhabits

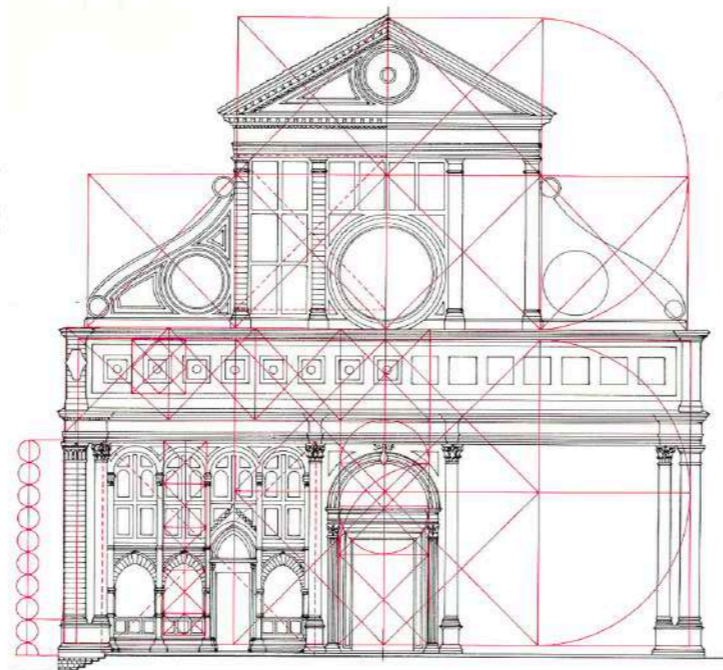
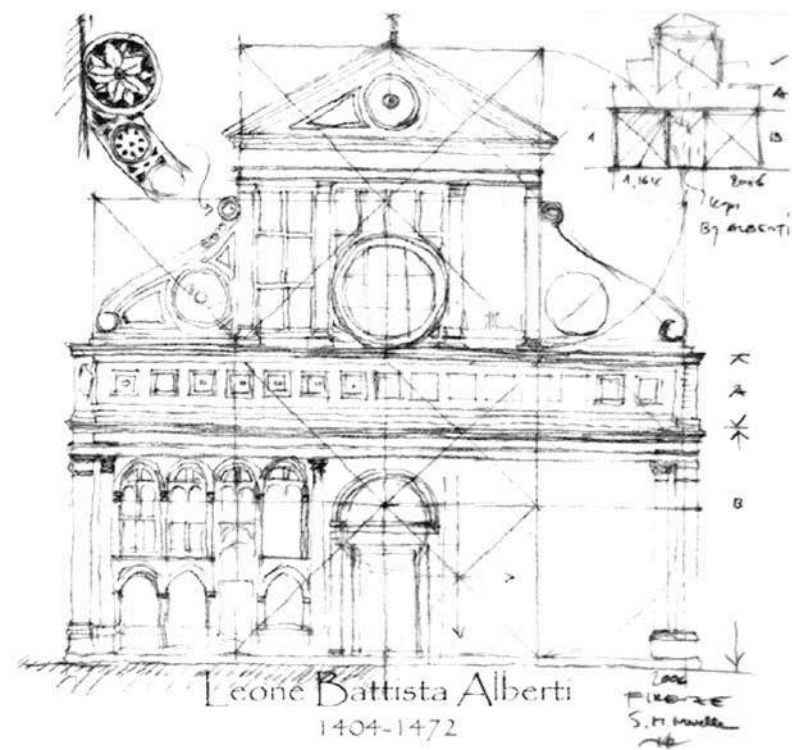


## Somaatile modulaarsus

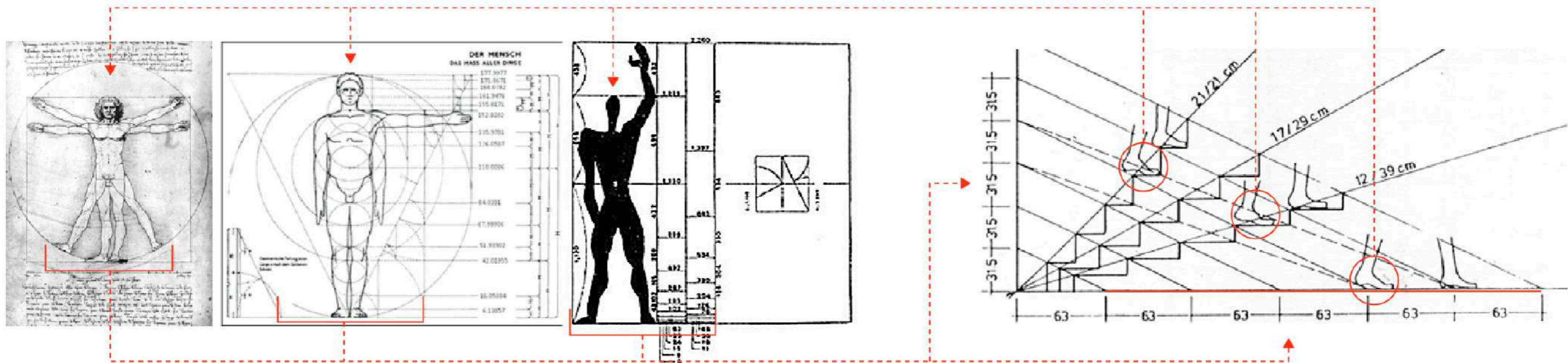
*Somatic modularity [somaatile modulaarsus, kehalik, lihaline]: variable modular system, where unified building components are based on discrete design system, guided by grid-based parameters and material based element details. Modular parts vary in size and shape, while keeping uniform connection logic. This approach also proposes a distinct theoretical understanding of the design process that is essential to somatic modularity, which enables all scales and homogenous connection systems for heterogenous whole, a corporeal system for architecture.*

**Aggregated Thinking Methodology:**  
from conceptual to built object

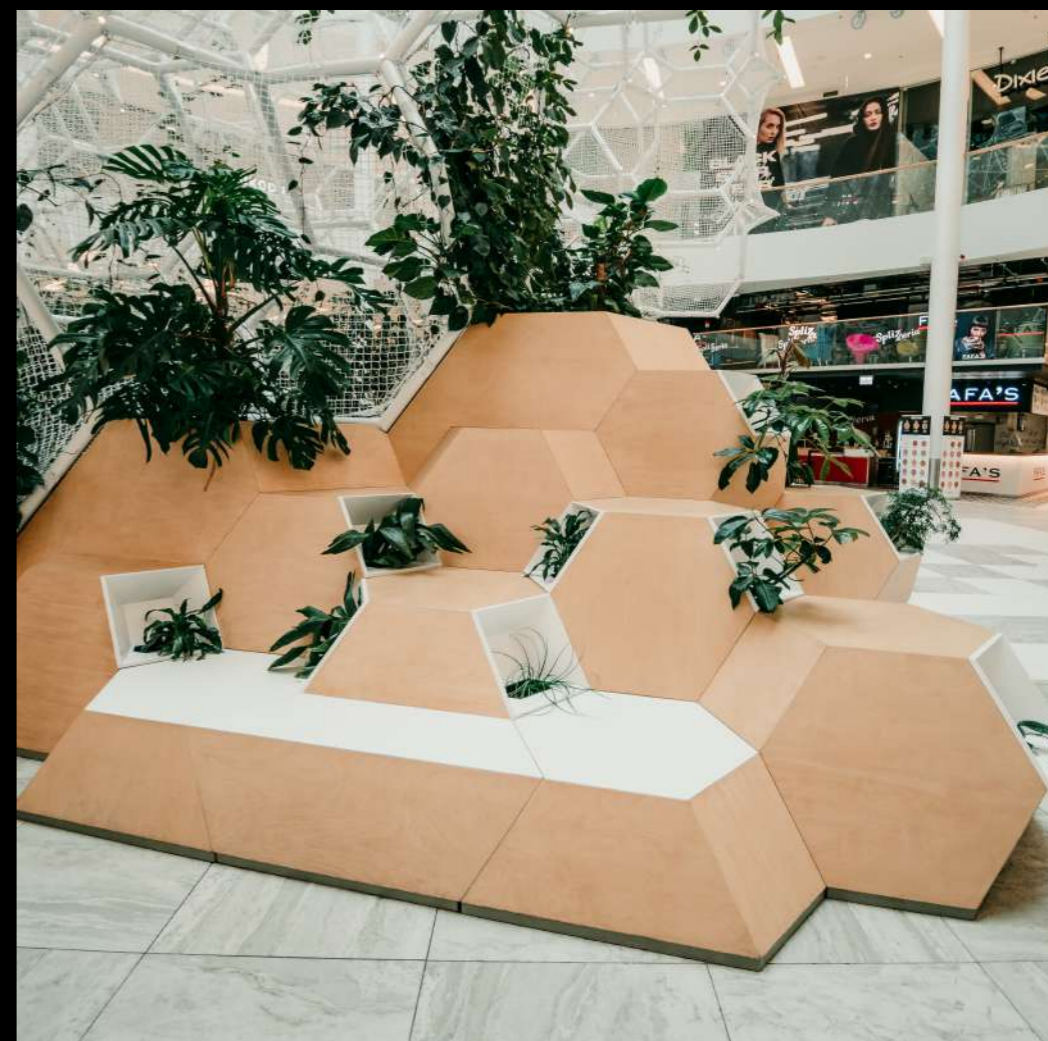




The façade of Santa Maria Novella, completed by Leon Battista Alberti in 1470.  
2D parametric drawings define the relations between elements, but also between the detail (like pillar subdivisions) and thus guiding the overall composition.



Geometric parameters in the human body that define elements in a physical and subconscious way, enabling an understanding of the scale of elements at the scale of building elements. Drawings by Leonardo da Vinci—Vitruvian man (1490), Ernst Neufert *Bauentwurfslehre* (1936), and Le Corbusier—*Modulor* (1948).



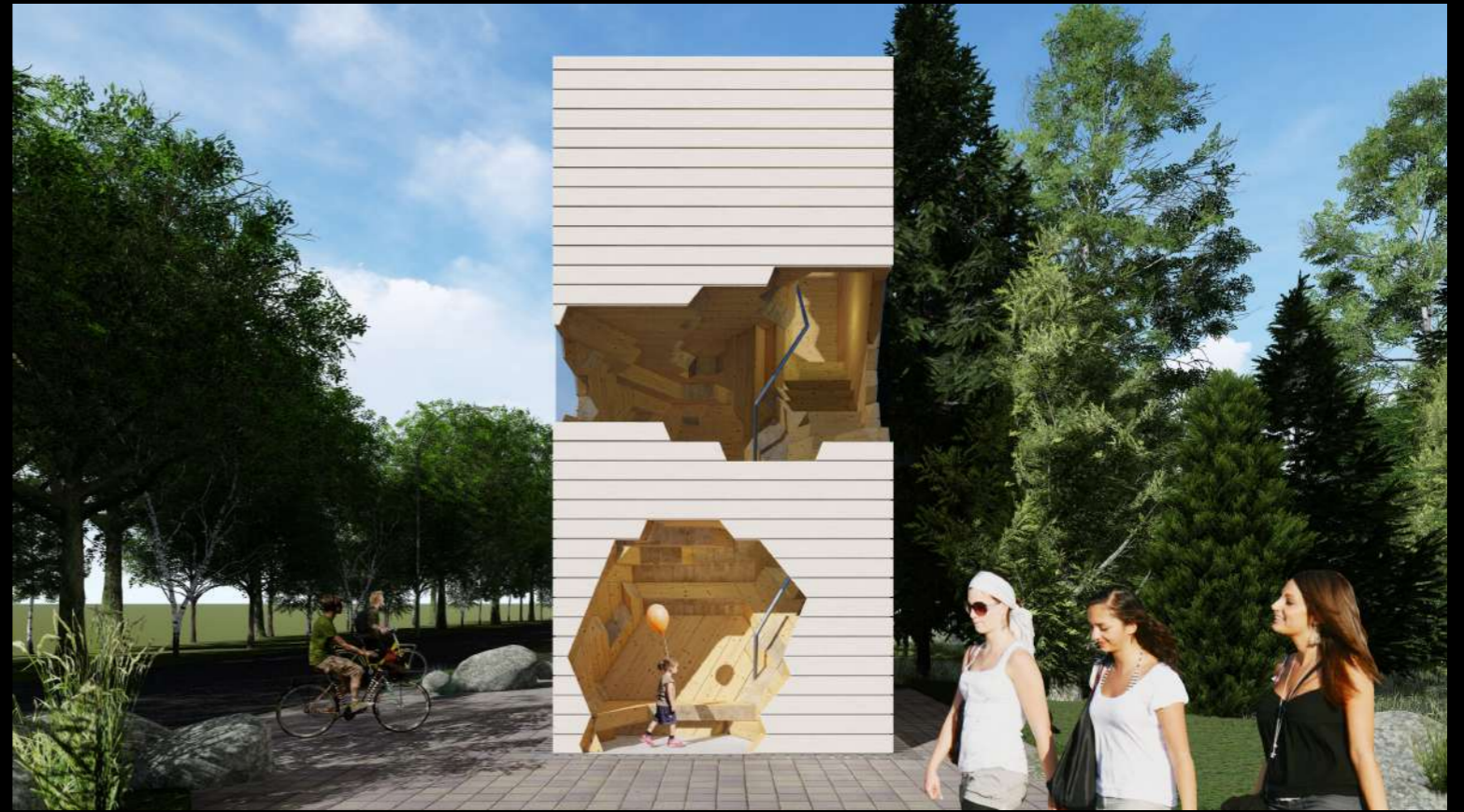
Urban Jungle vertical park  
T1 shoppingmall, Tallinn  
2018



Urban Jungle vertical park  
T1 shoppingmall, Tallinn  
2018



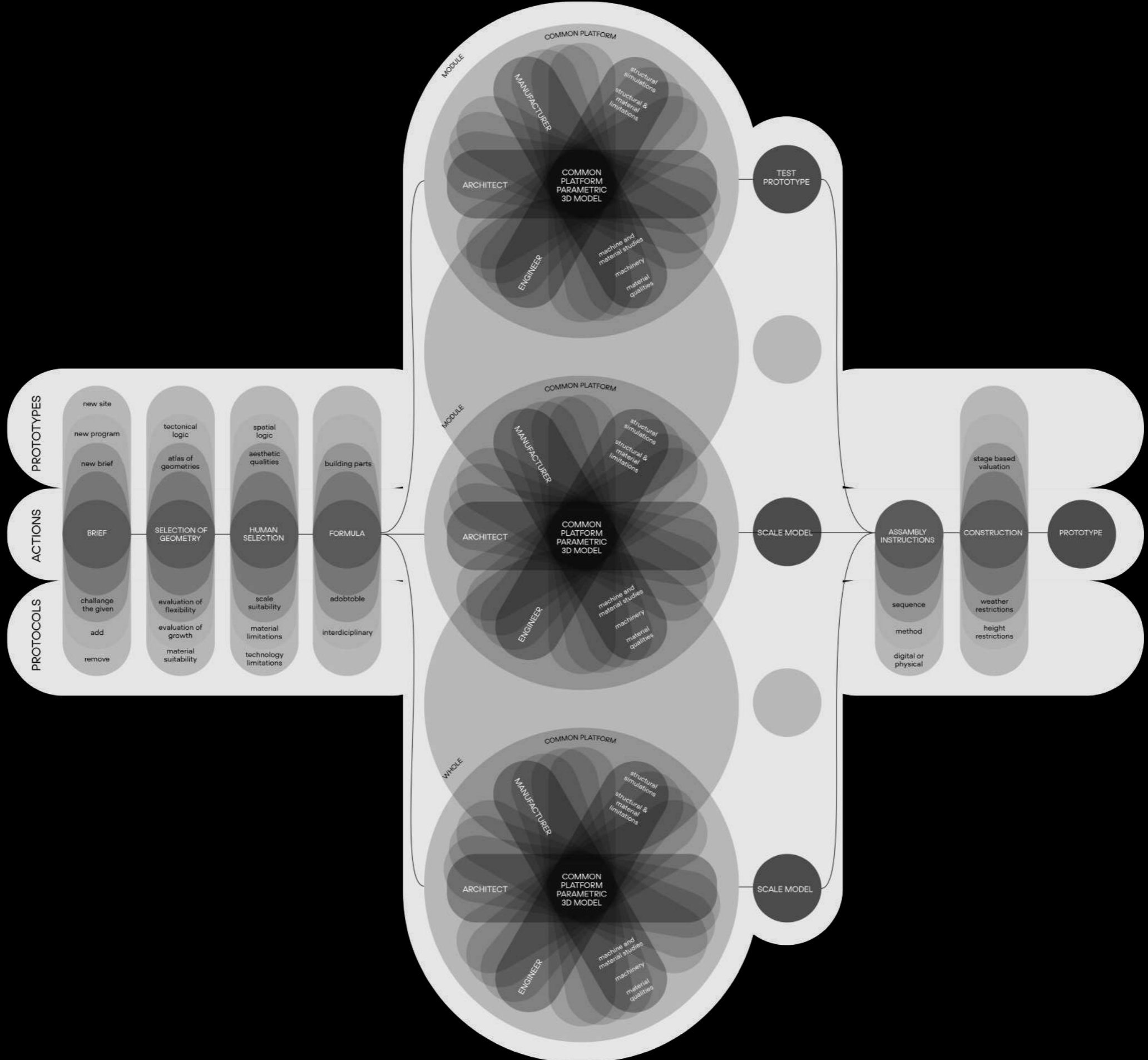
Urban Jungle vertical park  
T1 shoppingmall, Tallinn  
2018

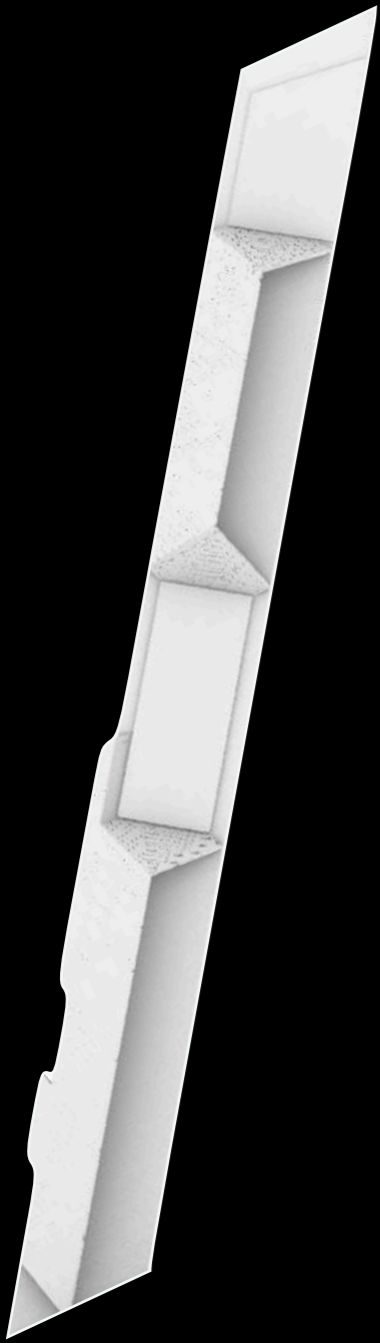


Käsmu Bus Stop  
Design development

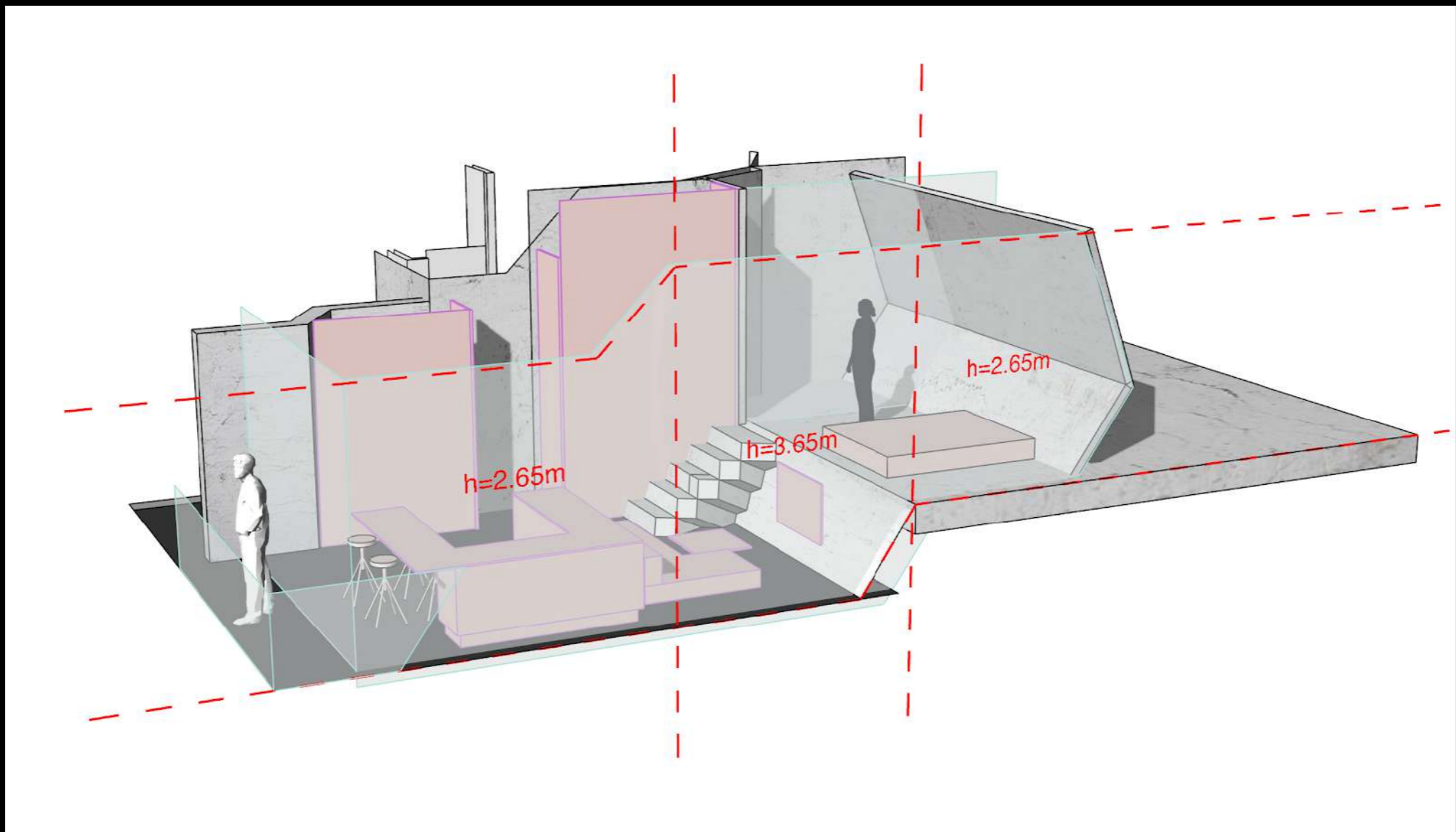


Pärnu Art Center  
Honourable mention  
2019





Voistluse 7 apartment building. Schematic design. 2018



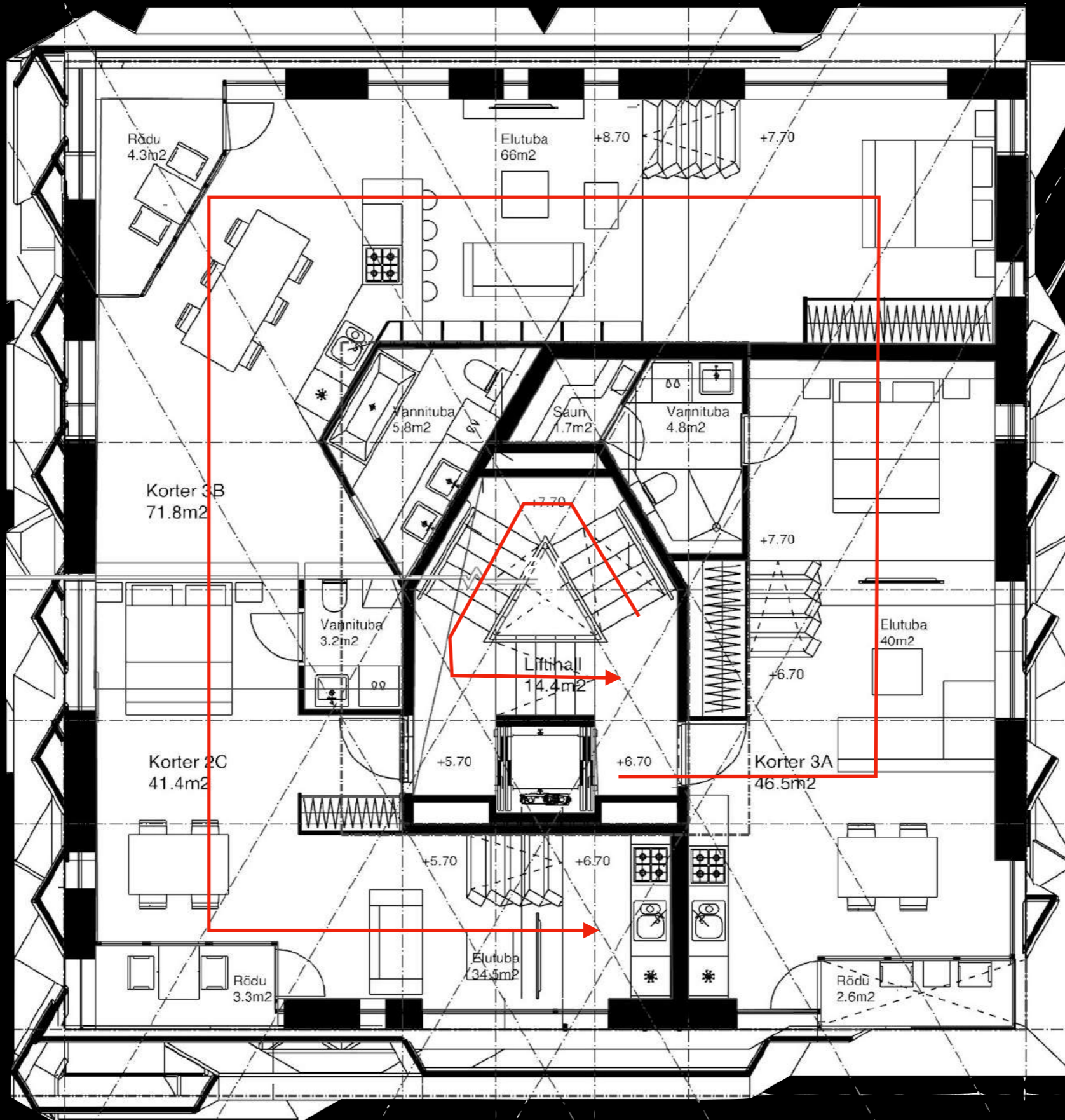
multi-height apartment



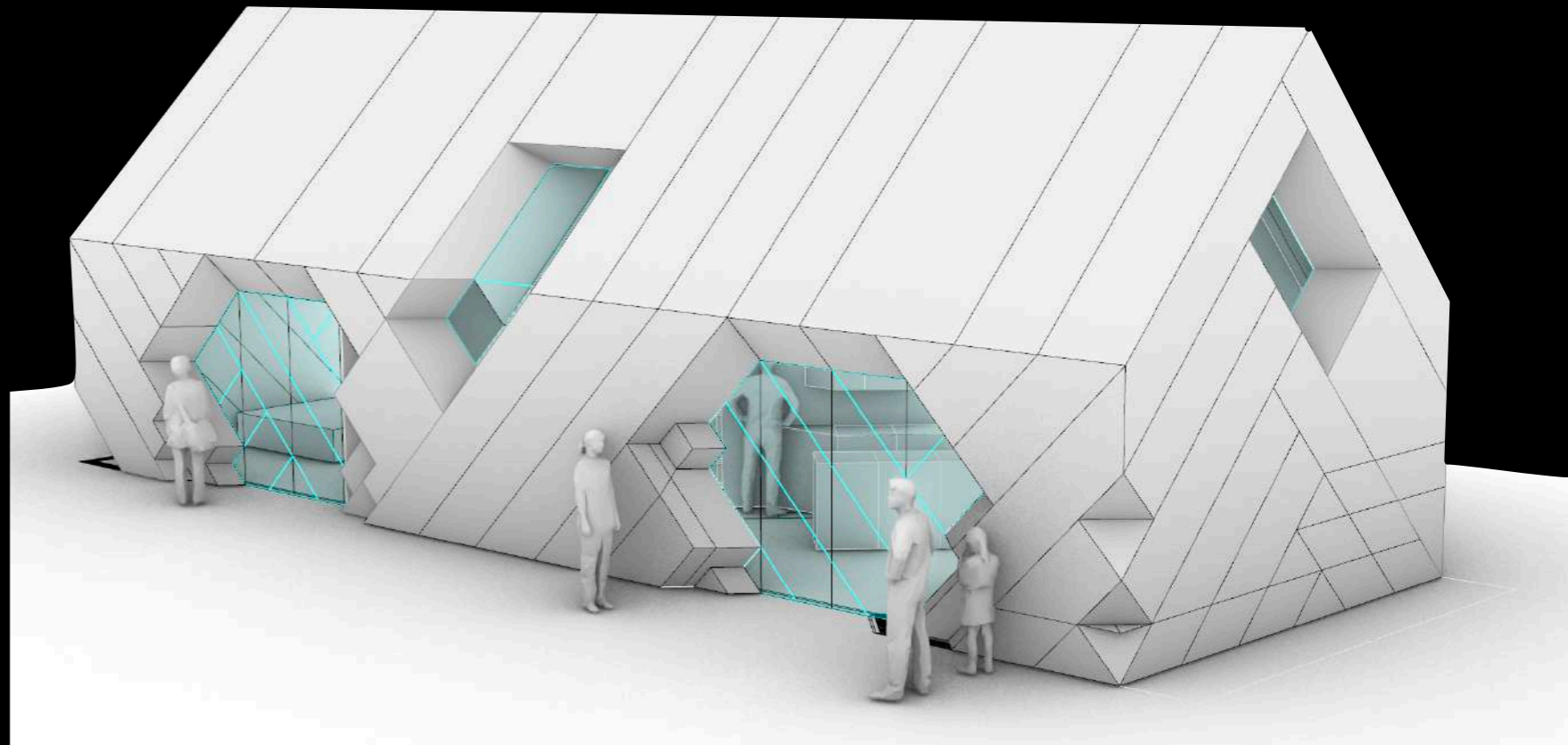
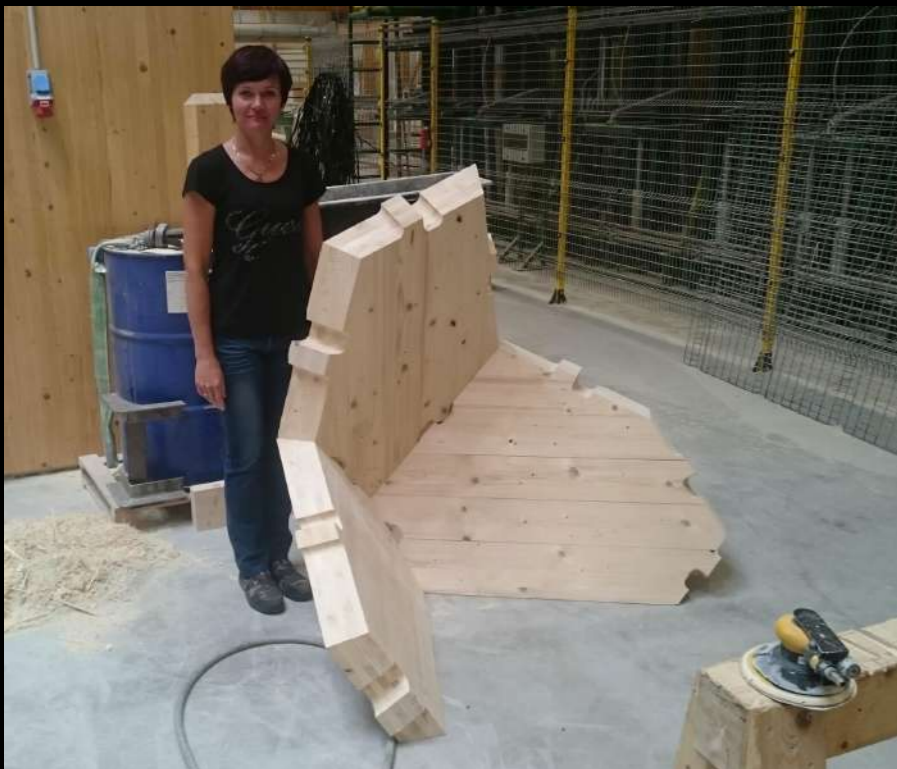
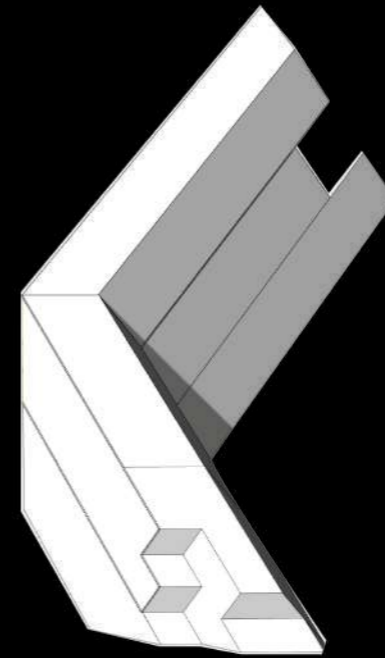
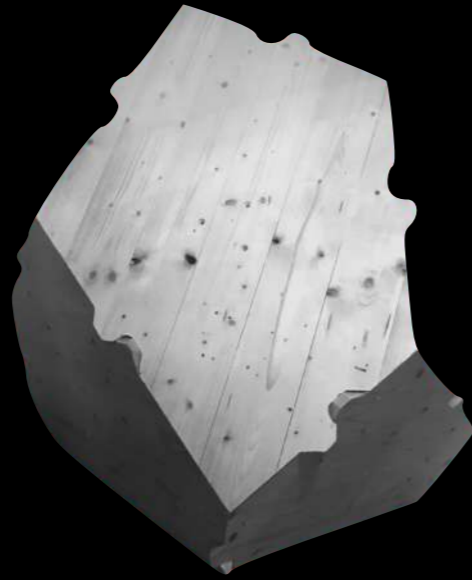
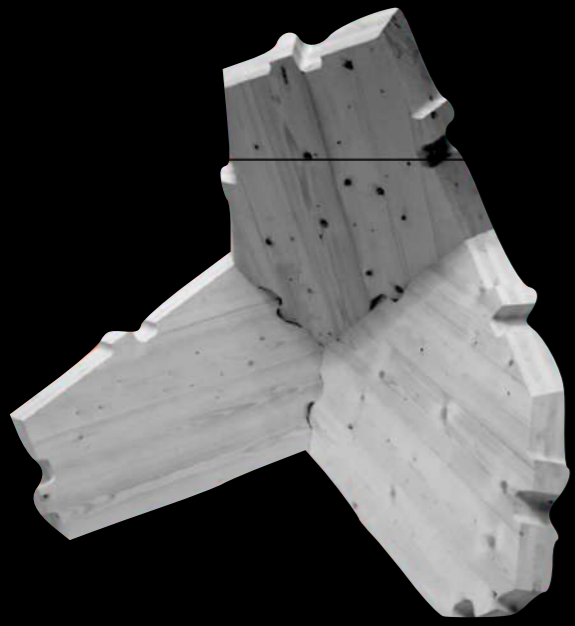
Interior views



Vöistluse 7  
Apartment building  
Exterior views



Võiõstluse 7 apartment building. 3rd floor plan



Private house  
Design development

# Somatic modularity

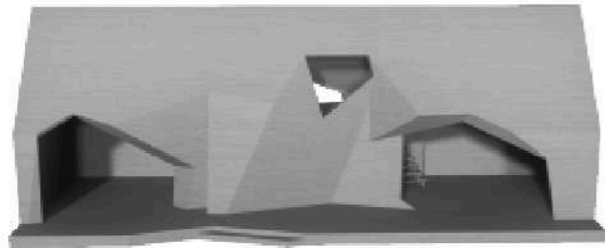
+

- reintroducing primitive geometries
- various resolutions and scales in one system
- perfect combination of quasi-automated industry and sustainable architecture

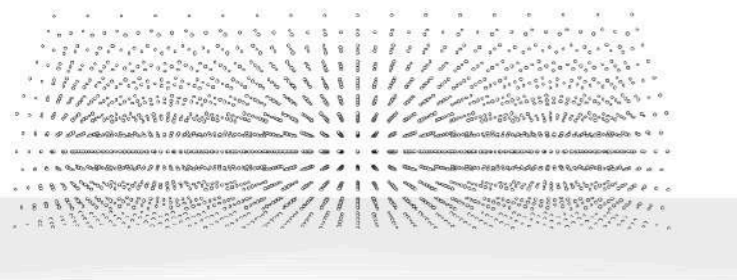
-

- no constructed case studies (yet)

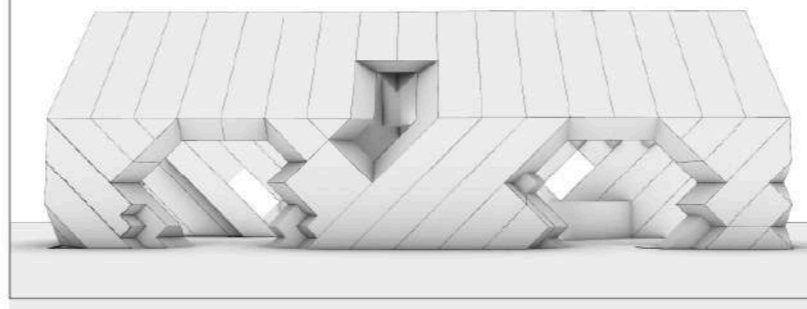
Primitive sketch-model with defined proportions, appatures, spatial organisation and divisions



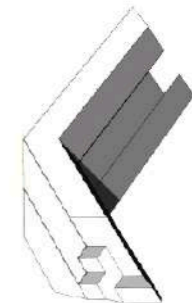
Primitive based grid



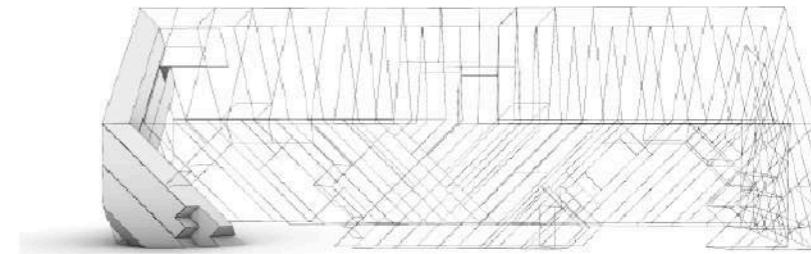
Somatically modulated pitched roof primitive



Corner-component



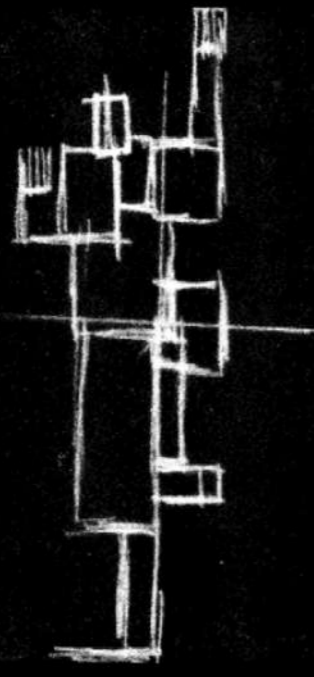
Primitive sketch-model with defined proportions, appatures, spatial organisation and divisions





Initial sketch

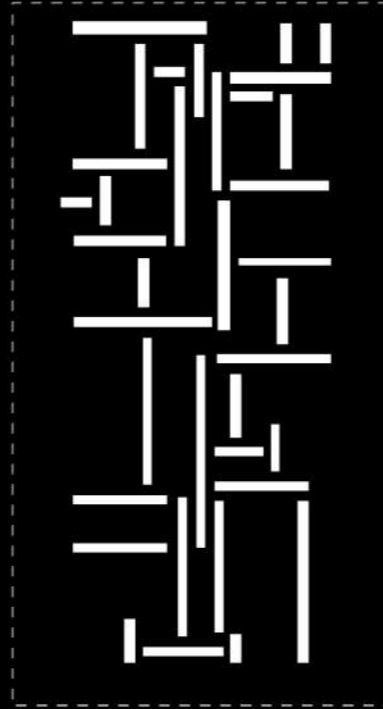
Jan 2007



Applied grid



### Somaatile modulaarsus



Somatic Modularity



Variable resolutions of components



Defined component logic

WHOLE

PART



THESE PROCESSES  
MUST BE SUSTAINABLE  
IN ARCHITECTURE

“What is design thinking, designing,  
materials, workflows, manufacturing,  
transportation,  
pre-assembly, site assembly,  
construction, maintenance and  
dismantling.”