

AFDR

ARCHITECTURE
FOR DISASTER RELIEF

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WWW.EMOL.CL



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ARCHITECTUREFORDISASTERRELIEF

DESIGN TO ROBOTIC PRODUCTION SYSTEM FOR DISASTER MANAGMENTCENTRE

explores the possibility of developing robotic building system and long-duration architecture solutions with the aim to re-settle post disaster environments, through digital driven design parameters, material and numeric controlled technology research and experimentation through scale models and prototypes

01

NATURAL DISASTERS

—

+ SUDDEN & CALAMITOUS EVENT
+ SERIOUSLY DISRUPTS FUNCTIONING OF A COMMUNITY OR SOCIETY CAUSES HUMAN, MATERIAL, ECONOMIC OR ENVIRONMENTAL LOSSES THAT EXCEED THE COMMUNITY'S OR SOCIETY'S ABILITY TO COPE USING ITS OWN RESOURCES.
+ THOUGH OFTEN CAUSED BY NATURE, DISASTERS CAN HAVE HUMAN ORIGINS.

—

A disaster occurs when a hazard impacts on vulnerable people.

$$\frac{\text{VULNERABILITY} + \text{HAZARD}}{\text{CAPACITY}} = \textbf{DISASTER}$$



Source: http://reliefweb.int/countries

02

CHILE COUNTRY OF DISASTERS

BASED ON ITS UNIQUE GEOGRAPHY AND MULTIPLE CLIMATES, CHILE IS ONE OF THE COUNTRIES THAT IS MORE VULNERABLE TO HAZARD.



(...)Históricamente, terremotos y tsunamis asociados han sido los desastres de mayor impacto tanto en términos de número de afectados, víctimas fatales e impacto económico en chile. No existe actualmente un sistema de manejo estadístico nacional que haya compilado información a lo largo del tiempo respecto de estas variables, pero centros internacionales especializados en el monitoreo de desastres nos otorgan una panorámica respecto de la tendencia (...)

Según el informe: Análisis de Riesgos de Desastres en Chile, VII Plan de Acción dipecho en Sudamérica 2011 - 2012, pág. 39.

El país, figura noveno entre los países que más dinero perdieron por daños producto de desastres naturales desembolsando, desde 1992, 31.000 millones de dólares producto de los siniestros(...)

Según el informe de la oficina de las naciones unidas para la reducción del riesgo de desastres. (UNISDR) , extraído de www.tercera.com

En los últimos 20 años, 4.400 millones de personas se han visto afectadas por algún desastre natural o algún accidente relacionado con el medioambiente(...)

Según el informe de la oficina de las naciones unidas para la reducción del riesgo de desastres. (UNISDR) , extraído de www.tercera.com

A lo largo de la cordillera de los andes existen, sólo en nuestro territorio, cerca de 3.000 volcanes , desde pequeños conos de ceniza, hasta enormes calderas de varias decenas de kilómetros de diámetro.

Según www.emol.com._especial volcanes.

Según especialistas, se estima probable que del total de 80 volcanes activos, 42 pueden entrar en erupción en el futuro inmediato; es decir, a partir de ahora y hasta 200 años más; otros 16 en los próximos nueve mil años y otros 20 en varias decenas de miles de años más..

Según www.emol.com._especial volcanes.

Chile ostenta ser el país más sísmico a nivel mundial, así como también el que ha registrado el evento sísmico (terremoto) de mayor liberación de energía, que tuvo lugar en mayo de 1960.

Según el informe: Análisis de Riesgos de Desastres en Chile, VII Plan de Acción dipecho en Sudamérica 2011 - 2012, pág. 39.

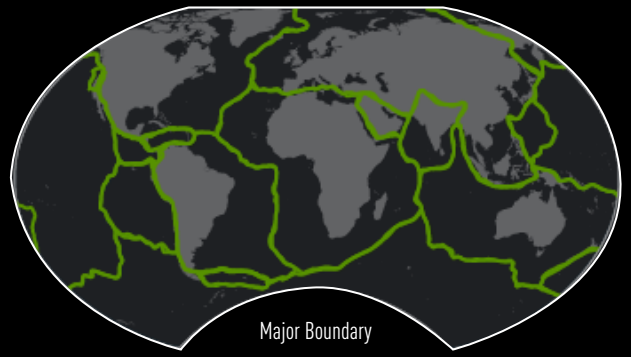
DATE	PLACE	INTENSITY	DEATHS	EVENT
1822	Valparaíso	_	200	Tsunami
1835	Concepción	_	120	Tsunami
1868	Arica	_	300	Tsunami
1877	Arica	_	5	Tsunami
1906	Valparaíso	8.39	3.000	Tsunami
1922	Vallenar	8.5	800	Tsunami
1928	Talca	8.3	300	_
1939	Chillán	8.3	30.000	_
1943	Ovalle	8.3	12	_
1949	Angol	IX-X Mercalli	35	_
1960	Sur de Chile (9 terremotos ocurridos)	Entre 6.75 y 8.75	_	_
1960	Valdivia	9.5	6.000	Tsunami
1971	Coquimbo	7.0	100	_
1985	Santiago	7.5	177	_
1995	Antofagasta	_	3	_
2005	Iquique	7.9	12	_
2007	Tocopilla	7.7	2	_

Source: El terremoto y Tsunami del 27 de Febrero en Chile, OPS.

03

EARTHQUAKES

The Plate Boundaries | Where plates collide



Major Boundary



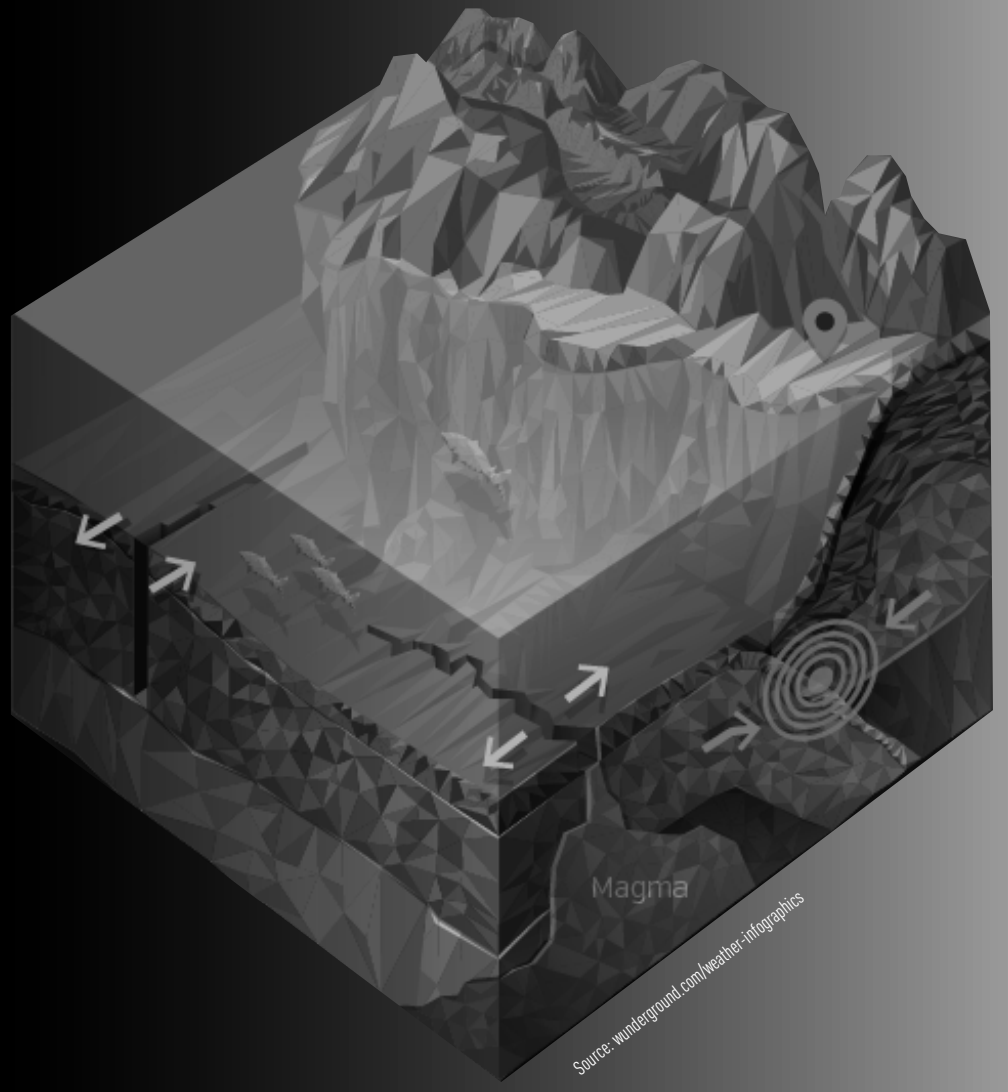
Ring of fire

452

The amount of volcanoes along the Ring of Fire

90%

Most of the world's earthquakes happen along the Ring of Fire



Fault Types

Convergent Fault

Plates move in to one another

Divergent Fault

Magma rises & pushes plates apart

Transform Fault

Plates move sideways against one another

Hypocenter

Location of quake below the surface

Epicenter

Location of quake above the surface

#ARCHITECTUREFORDISASTERRELIEF_EARTHQUAKES

[PNG_ 03]

04

THE PROBLEM !

27F CASE STUDY

00 DAYS

05 DAYS

90 DAYS



1825 DAYS

PREVENTION

CATASTROPHE

NO SOLUTION !

EMERGENCY SOLUTION ?


13 APR 2010

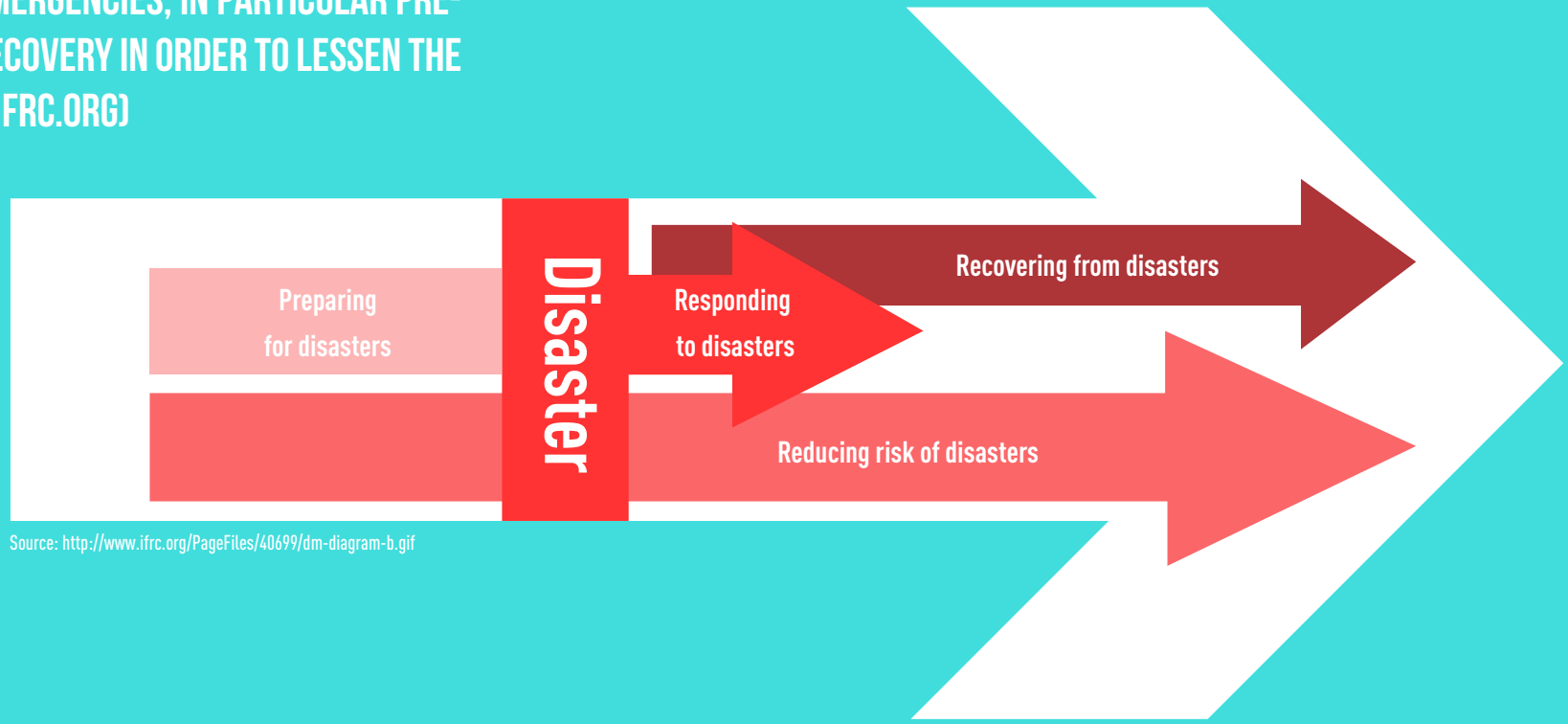

22 JUN 2013
Llico 22 de junio del 2013


RECONSTRUCTION ?
Castrol

05

DISASTERS MANAGEMENT

CAN BE DEFINED AS THE ORGANIZATION AND MANAGEMENT OF RESOURCES AND RESPONSIBILITIES FOR DEALING WITH ALL HUMANITARIAN ASPECTS OF EMERGENCIES, IN PARTICULAR PRE-PAREDNESS, RESPONSE AND RECOVERY IN ORDER TO LESSEN THE IMPACT OF DISASTERS. (WWW.IFRC.ORG)



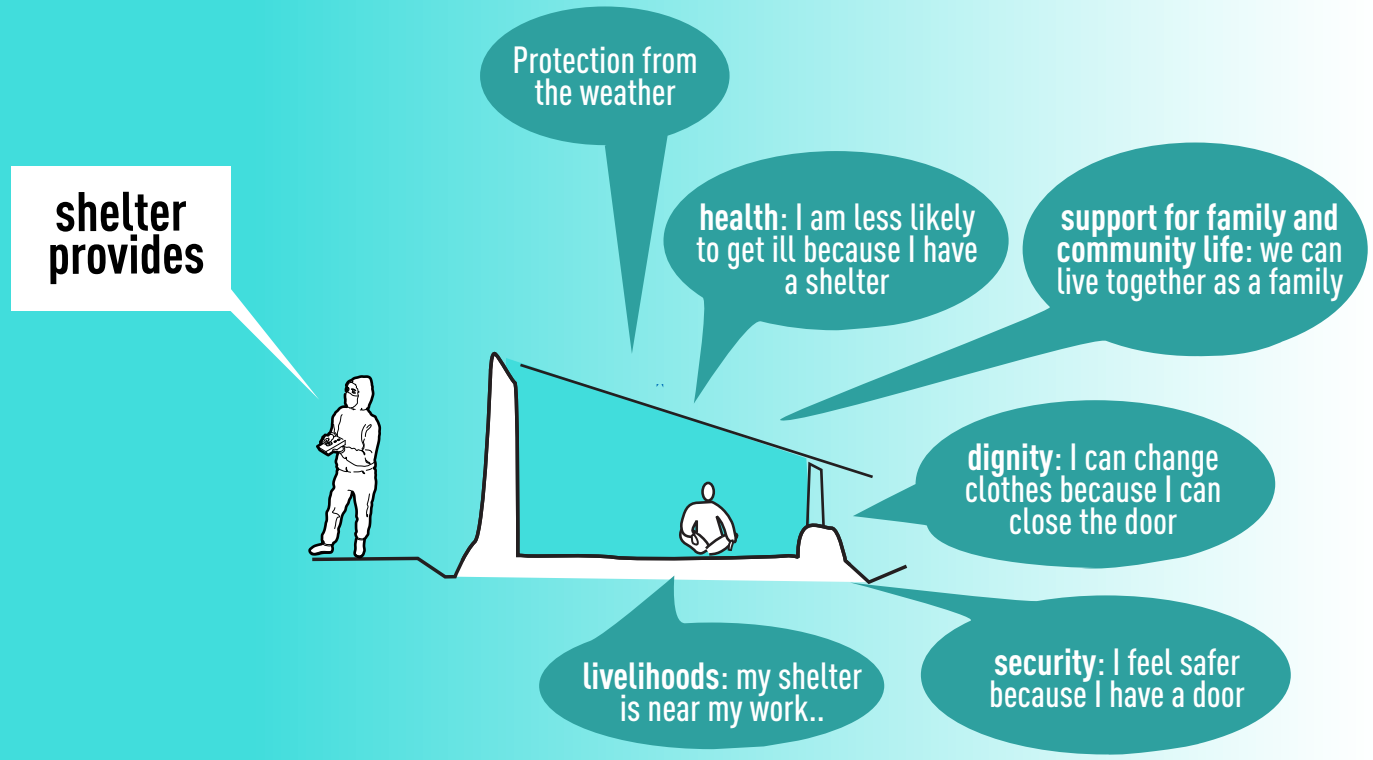
Source: http://www.ifrc.org/PageFiles/40699/dm-diagram-b.gif

SHELTER RELIEF

focuses on saving lives. This is particularly urgent where the affected people are exposed to harsh climatic conditions such as extreme cold or heat.

Rapid shelter solutions include tents and shelter kits, or materials to build or repair homes. Beyond survival, the key considerations are:

1) providing protection from the climate
2) ensuring privacy and dignity
3) providing personal safety and security

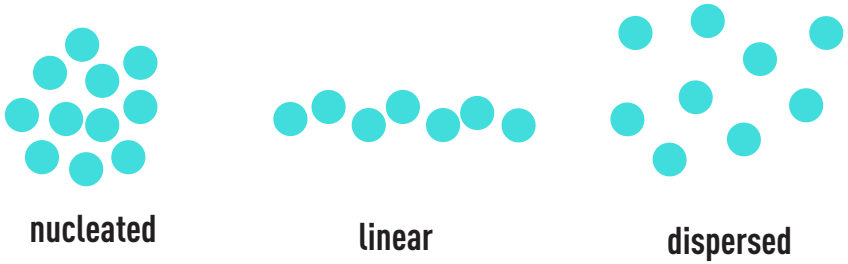


Source: IFRC Shelter Guidelines

WHAT IS SETTLEMENT?

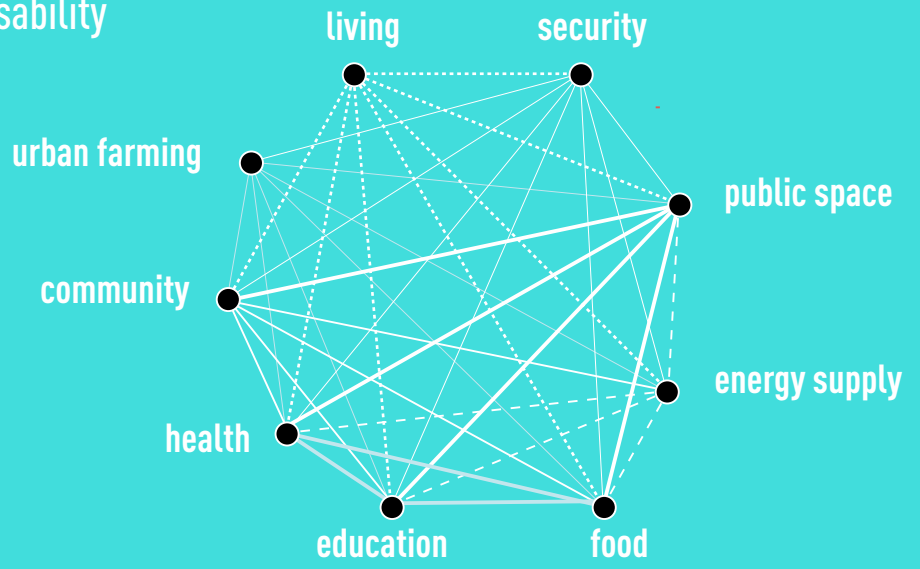
"In the aftermath of a disaster, civil unrest, confict or as a result of rapid urbanization it may be necessary to assist in the process of settling populations to a safer location.

(...) Moving the affected population away from their original settlement is the least preferred sheltering option, on occasions it may be the only solution to minimize the population at risk's vulnerability to future hazards"



MAIN REQUIREMENTS

The aim of a new settlement is to provide:
> a home
> security
> adequate protection from climate related events
> community environment
> livelihood opportunities
> access to services such as electricity and water
> accessability

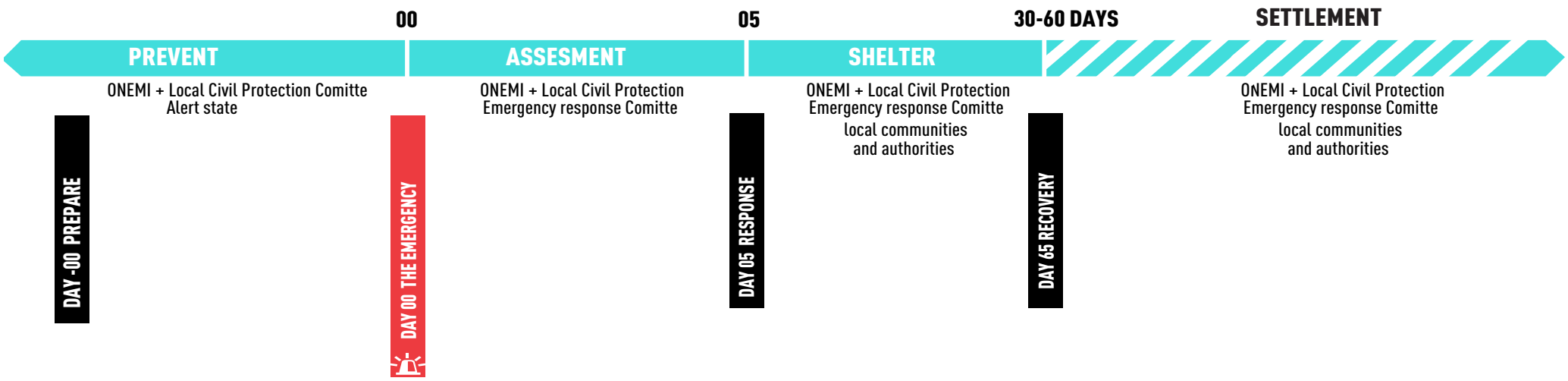


ARCHITECTURE FOR DISASTER RELIEF

DISASTER MANAGEMENT ARCHITECTURAL SYSTEM FOR AIDING AND REDUCING EARTHQUAKE RISK IN LATIN AMERICA

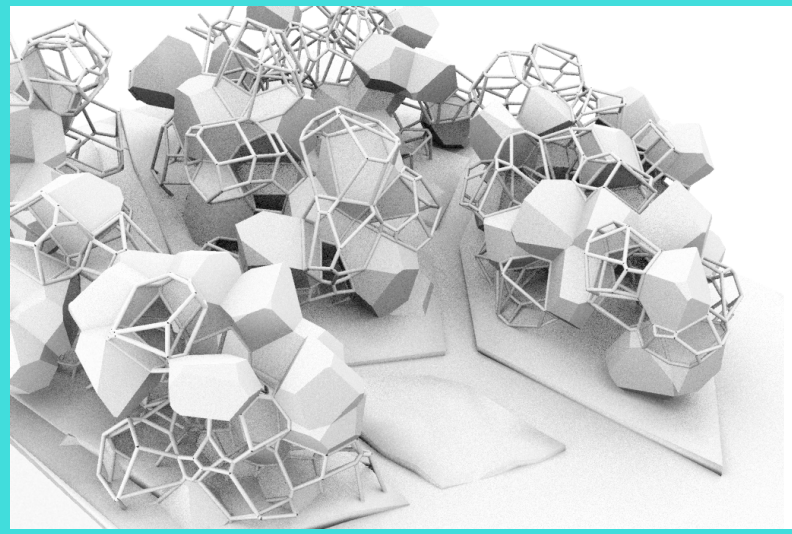
¿ HOW CAN WE PREPARE, RESPOND AND RECOVER FOR A NATURAL DISASTER ?

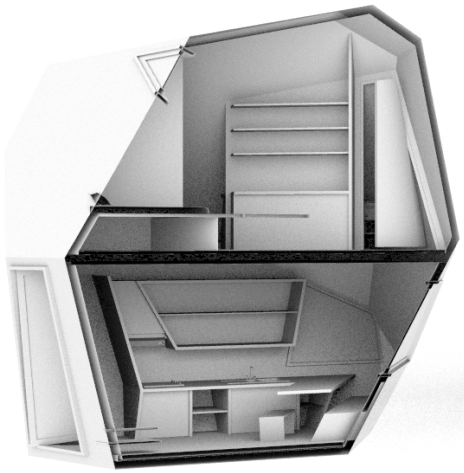
Risk management > Disaster risk reduction oriented settlement > Sustainable projects

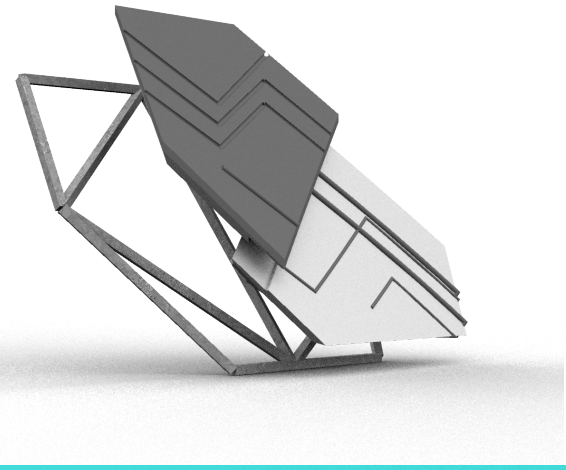


06

A MULTI SCALE DESIGN TO PRODUCTION SYSTEM





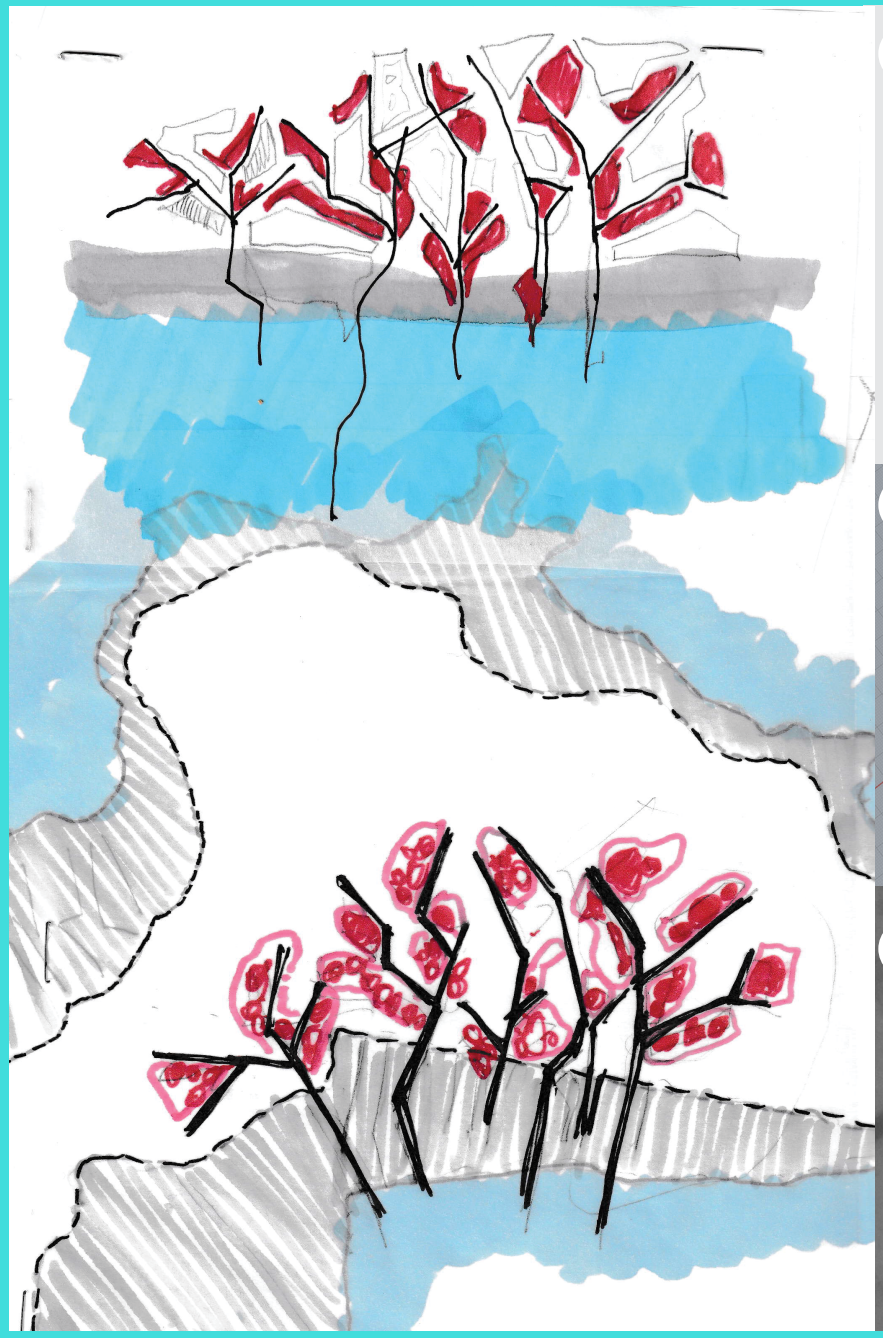


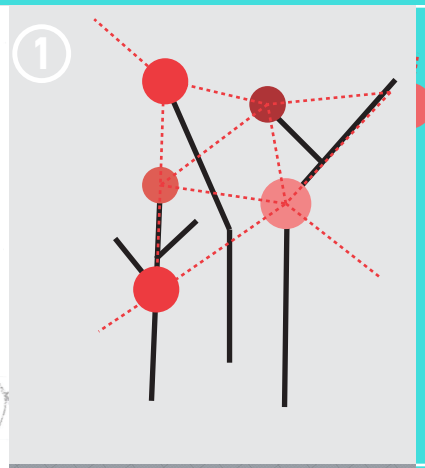
MACRO ⟷ **MESSO** ⟷ **MICRO**

Urban intervention that will address the design system on the urban scale. The assignment at this scale is to visualise the system growth-adaption and transformation on a time-base.

Architectural Unit based on ergonomic and programmatic functions. At this scale the assignment is to design a living unit which integrates energetic, environmental, structural and climatic conditions. This unit will be fully robotically produced.

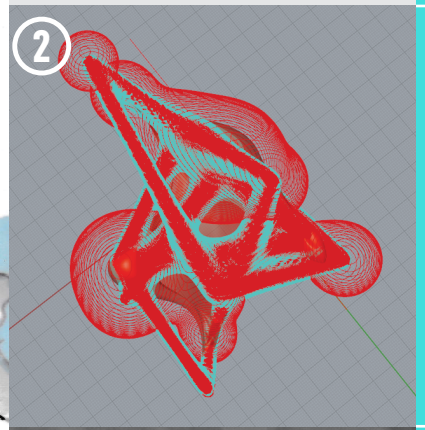
Multi robotic production system. “Pack” of robots with specific building and fabrication tasks. Here the assignment is to define a prefababrication and on site framework focused on the robotic production process.





Hazard analysis & Main programme

- Safety and existing damage
- Evacuation routes as starting point
- Allocation of main programme



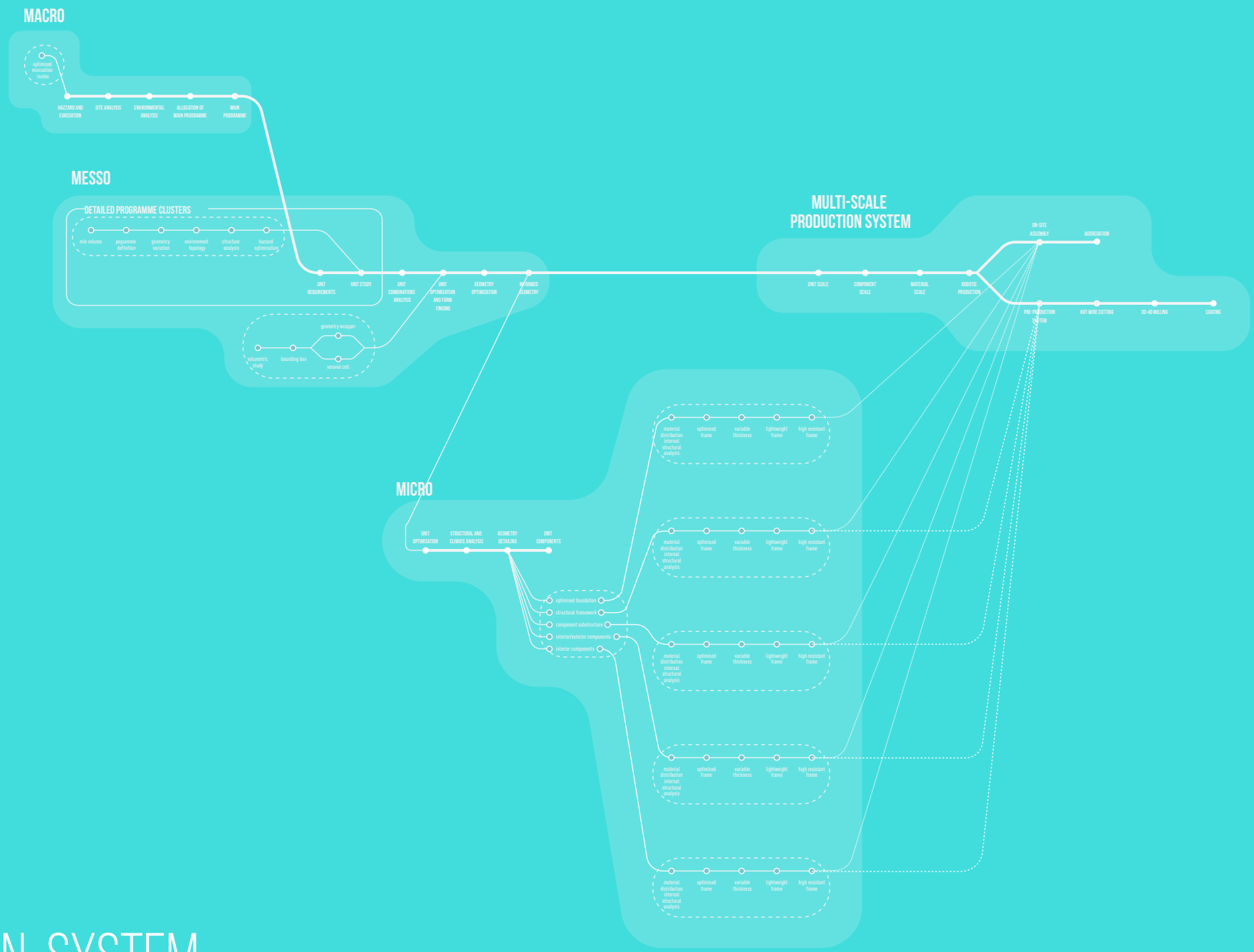
Specific programme & Environment

- Detailed programme clusters
- Environmental analysis
- Initial geometry



Optimisation & Production

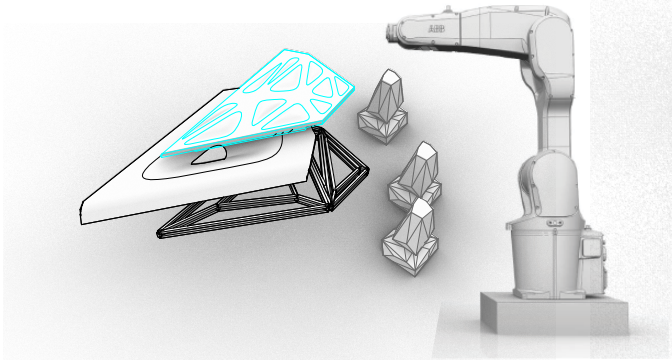
- Geometry detailing and optimisation
- Structural and climate analysis
- D2RP & O

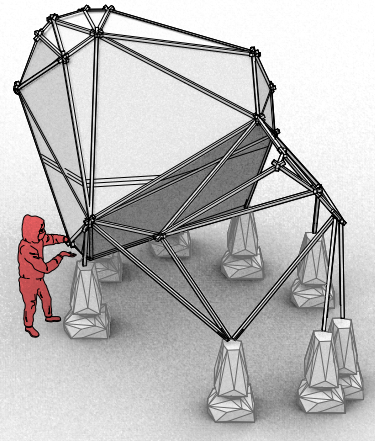


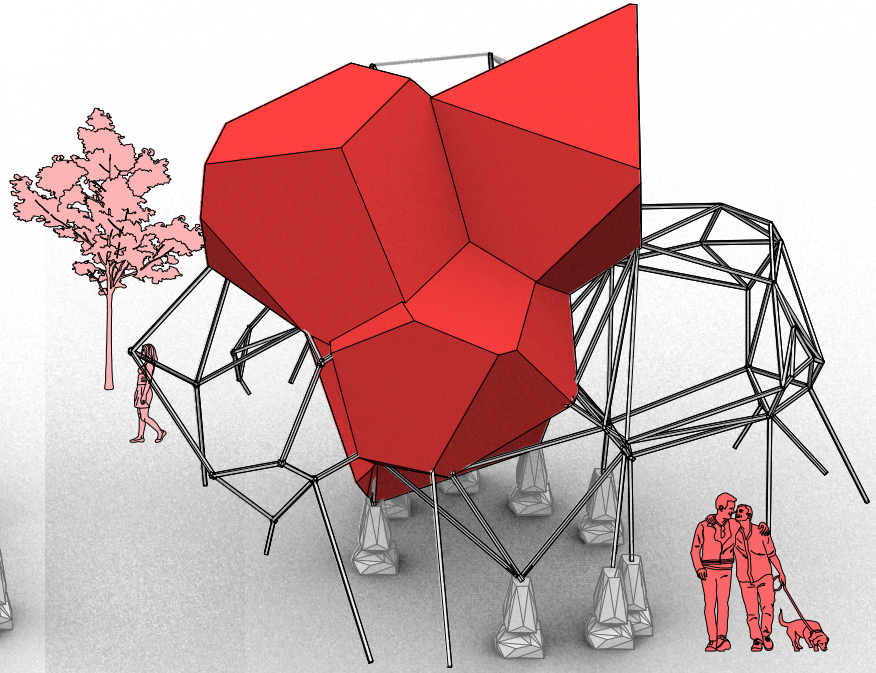
DESIGN SYSTEM

#ARCHITECTUREFORDISASTERRELIEF_MULTI SCALE DESIGN TO PRODUCTION SYSTEM

[PNG_ 012]





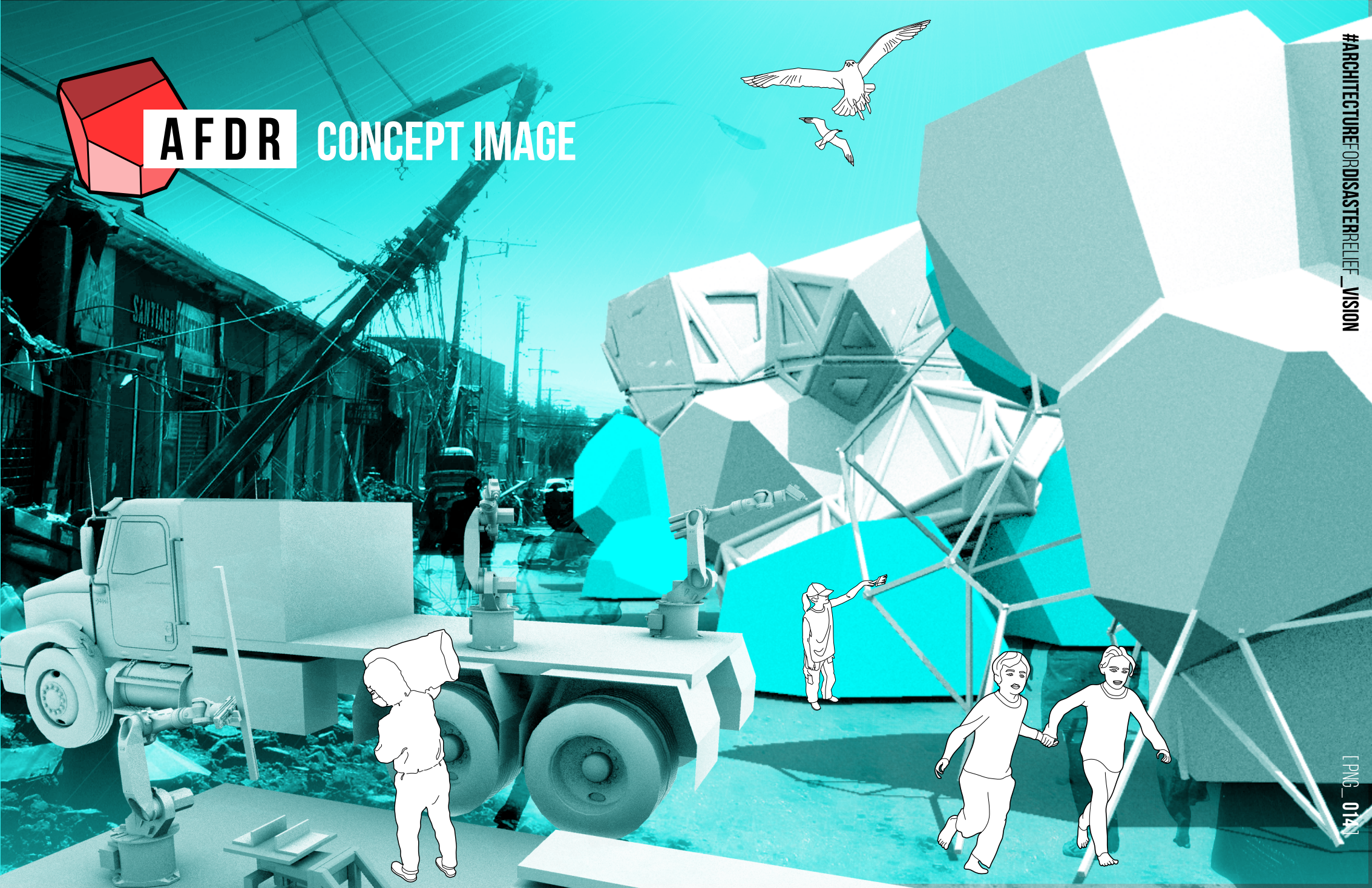


PREPARE - RESPOND - RECOVER

PRE-PRODUCTION

ON-SITE ASSEMBLY AND PRODUCTION

SOCIAL/LOCAL CUSTOMISATION


AFDR
CONCEPT IMAGE
#ARCHITECTUREFORDISASTERRELIEF_VISION
[PNG_ 014]

07

MESSO SCALE

—

ARCHITECTURAL UNIT BASED ON ERGONOMIC AND PROGRAMMATIC FUNCTIONS. AT THIS SCALE THE ASSIGNMENT IS TO DESIGN A LIVING UNIT WHICH INTEGRATES ENERGY PRODUCTION, ENVIRONMENTAL, STRUCTURAL AND CLIMATIC CONDITIONS.

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	UNIT TYPE	FUNCTION	DETAILED PROGRAMME	MIN AREA M^2		MIN VOLUME M^3	
				2-4 IHA	4-6 IHA	2-4 IHA	4-6 IHA
L1	LIVING	BASIC	bathroom	40	60	120	180
			kitchen				
			common space				
L2	LIVING	EXTENDED	common space	20	40	60	120
			toilett				
			bedroom1				
			bedroom2				
L3	LIVING	PRODUCTIVE/LEISURE	workshop	10	20	30	60
			commercial				
			balcony				
				70	**120**	**210**	**360**
P1	POWER/ENERGY	SOLAR	energy storage and productio	30	60	60	120
P2	POWER/ENERGY	WATER	water collection and use	10	20	20	40
G1	PUBLIC SPACE	GREEN AREA	commom shared space	60		300	
G2	URBAN FARMING*	GREEN FOOD	meat/dairy	10	20	20	40
G2.1	URBAN FARMING*	GREEN FARMING	vertical garden	20	40	20	40
G2.2	URBAN FARMING*	GREEN PRODUCTION	green house	10	20	20	40



2 TO 4 IHA

UNIT STUDY

MIN VOLUME

PROGRAMME DEFINITION

GEOMETRY VARIATION

ENVIROMENT TOPOLOGY

STRUCTURE ANALYSIS

HAZZARD OPTIMISATION

L1 | **L2** | **L3** | **P1** | **P2** | **G1** | **G2** | **G2.1** | **G2.2**

iteration 06
Living Unit 1
Basic Shelter programme

iteration 14
Living Unit 2
Programatic Variation and spatial upgrade

iteration 22
Living Unit 3
Extra programme and functions

iteration 36
Power Unit 1
Solar and/or wind power generation and storage

iteration 2
Power Unit 2
Water storage and and purification system

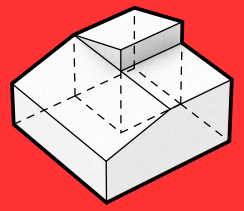
iteration 8
Green Unit 1
Social/Community shared areas

iteration 31
Green Unit 2
Urban Farming

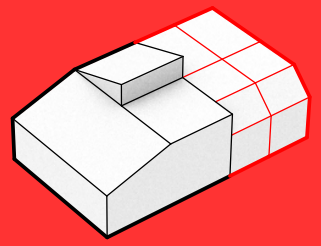
iteration 18
Green Unit 2.1
Vertical Farming

iteration 4
Green Unit 2.2
Green House or Interior Farming

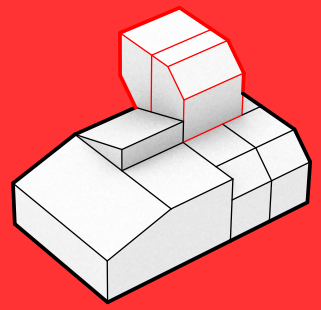
UNIT COMBINATIONS ANALYSIS



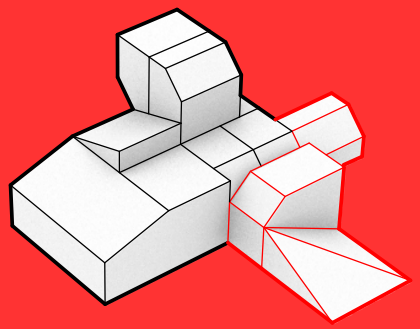
L1
120 m³
05-30 days



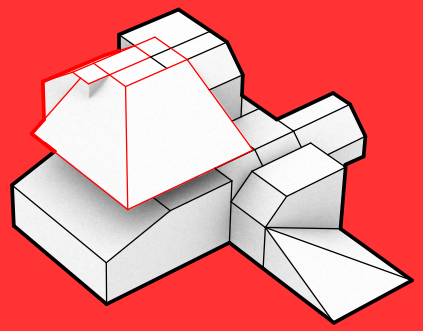
L1+L2
180 m³
60-120 days



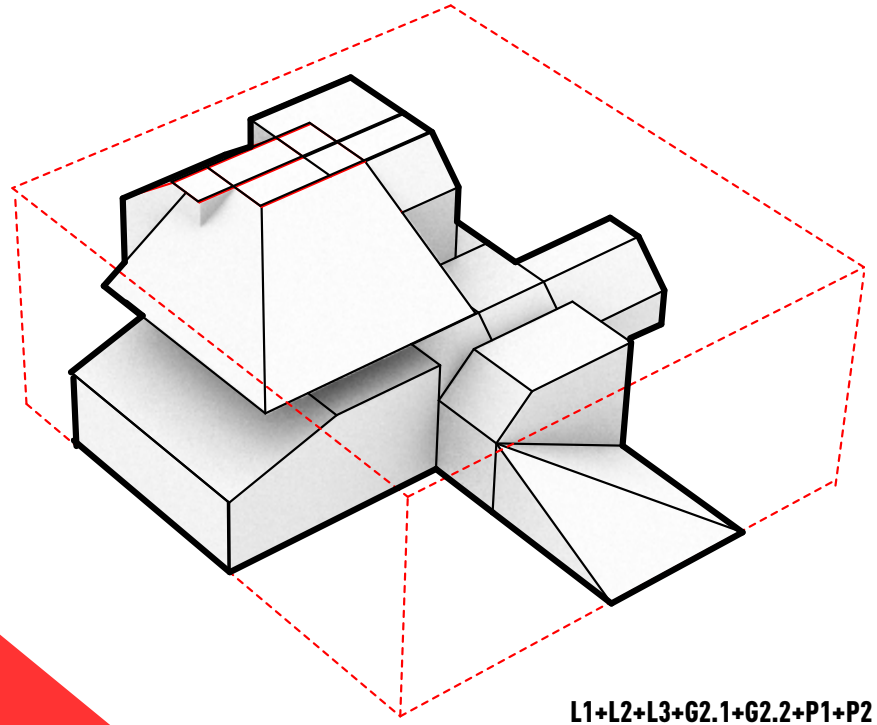
L1+L2+L3
210 m³
120- 360 days



L1+L2+L3+G2.1+G2.2
250 m³
60- 360 days



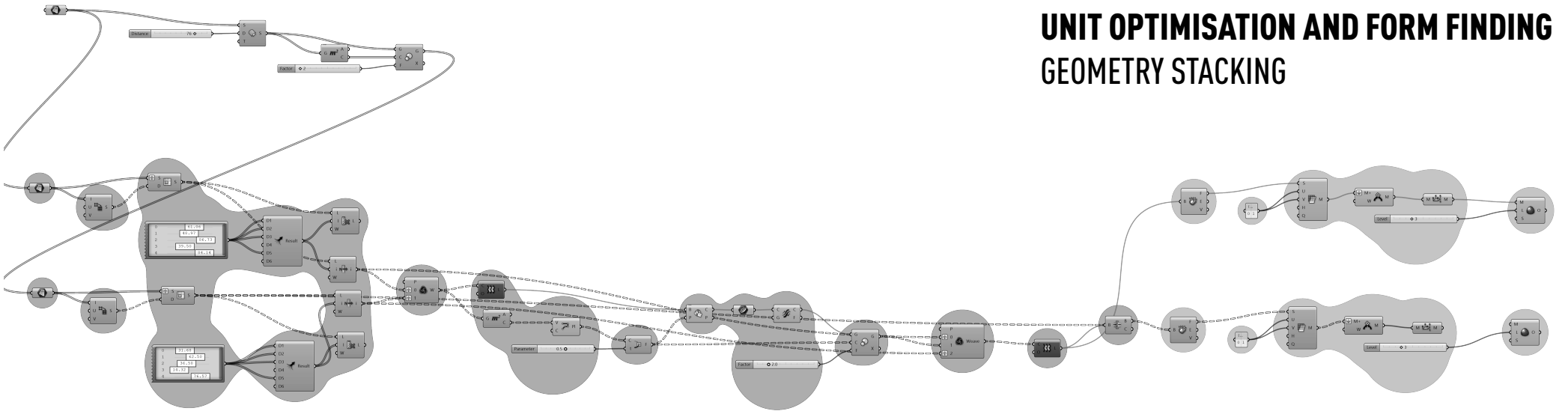
L1+L2+L3+G2.1+G2.2+P1+P2
330 m³
60- 360 days



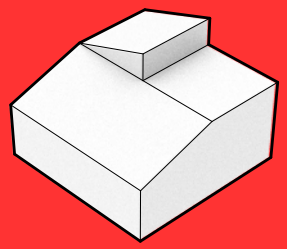
L1+L2+L3+G2.1+G2.2+P1+P2
330 m³
60- 360 days
iteration 16

UNIT OPTIMISATION AND FORM FINDING

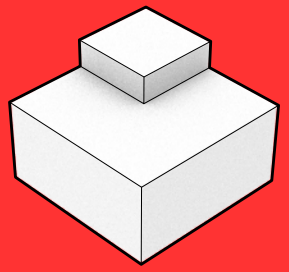
GEOMETRY STACKING



volumetric study



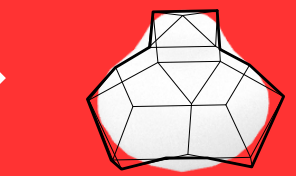
bounding box

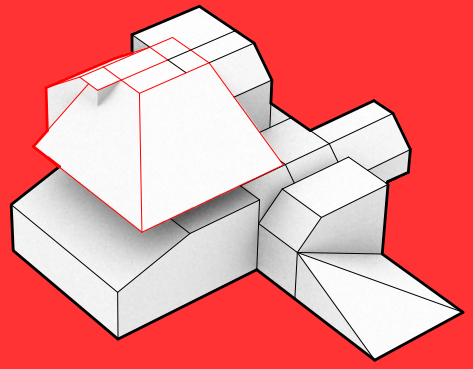


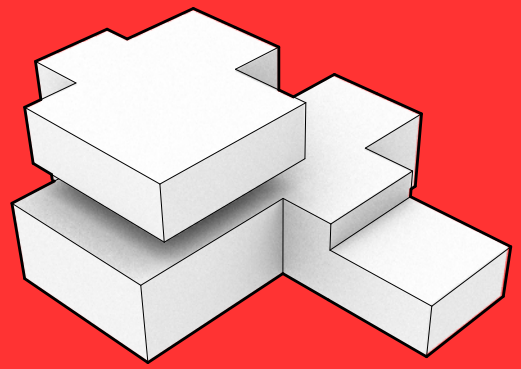
geometry wrapper

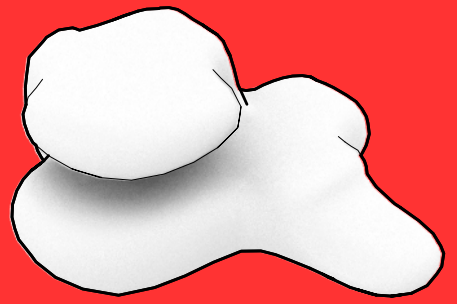


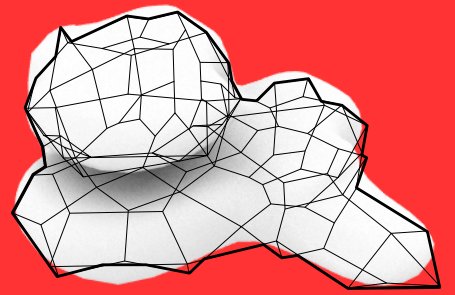
geometry structural frame











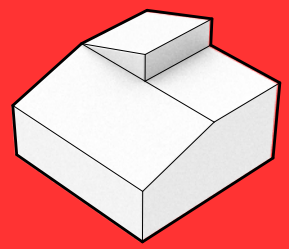
UNIT OPTIMISATION AND FORM FINDING

GEOMETRY PACKING

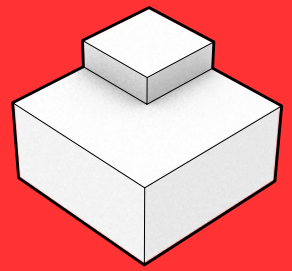
programme: stacking v/s packing

stacking elements uses less space but reduces number of programmatic connections: packimg uses less space and maintains or increases number of connections

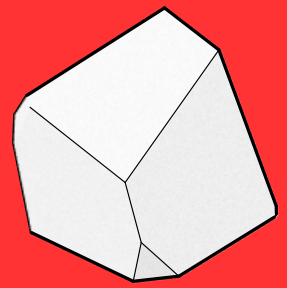
volumetric study

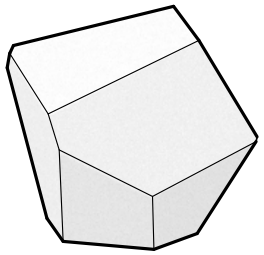


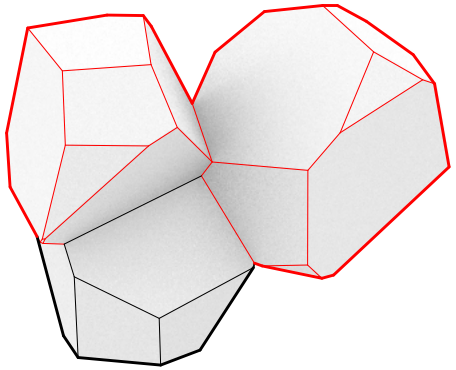
bounding box

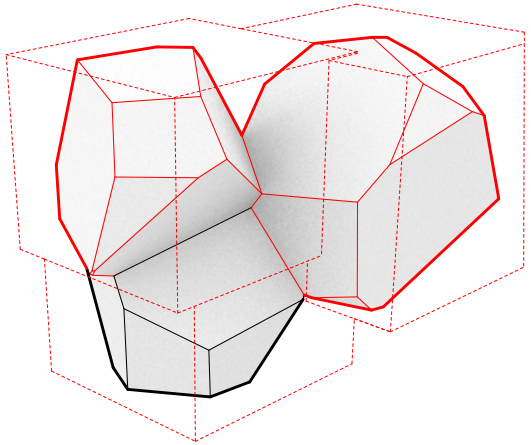


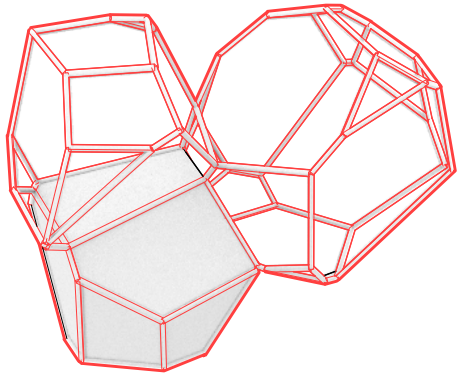
voronoi tesselation











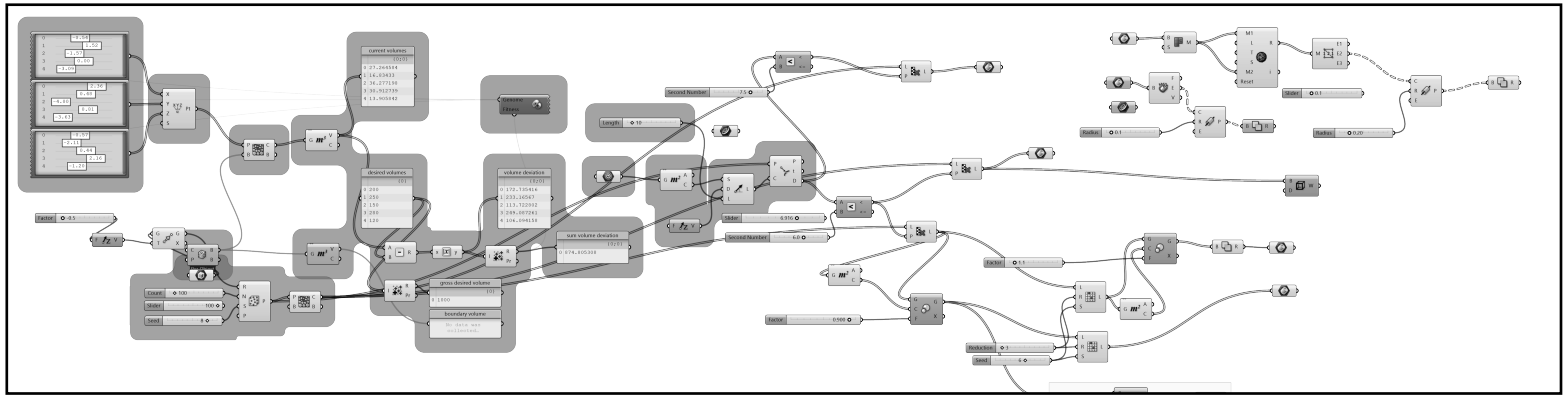
minimal surface, minimal materials:

voronoi tessellations utilize less material than their equal volumne orthogonal or geometry wrapped counterpart

Cellular growth

Volume optimisation

Angular Structure



#ARCHITECTUREFORDISASTERRELIEF_MESSO SCALE DESIGN

[PNG_ 020]

Climate & Priorities

Priority 1. **Clothing & Bedding**



Clothes, blankets

Priority 2. **Waterproofing**



Water-proofing

Priority 3. **Bedding**



Bedding

Priority 4. **Wind proofing / Thermal buffer**



Wind proofing

Priority 5. **Heating & Ventilation**



Stove and fuel

Priority 6. **Insulation of Floor**



Insulated floor

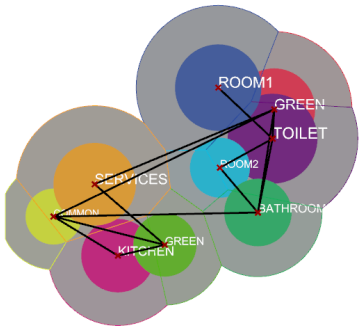
Priority 7. **Insulation of Walls**



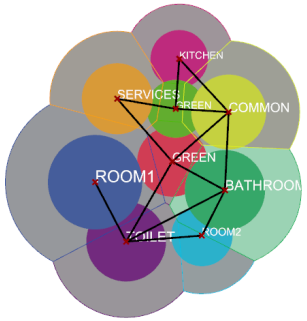
Insulated roof

Higher priority

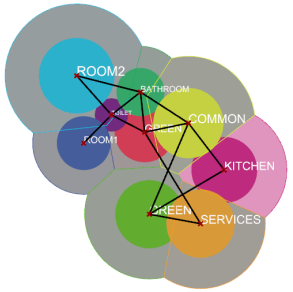
Initial programme , connections and growth system



iteration 1



iteration 4



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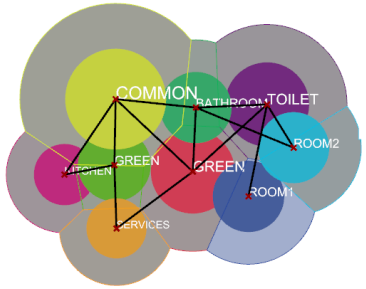

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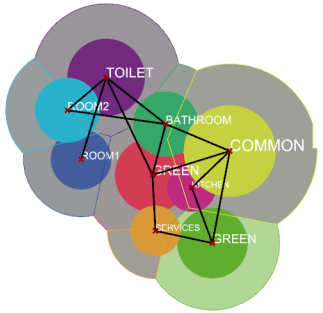
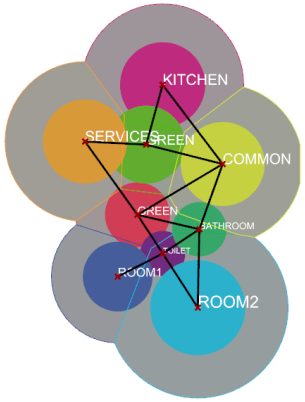


iteration 24



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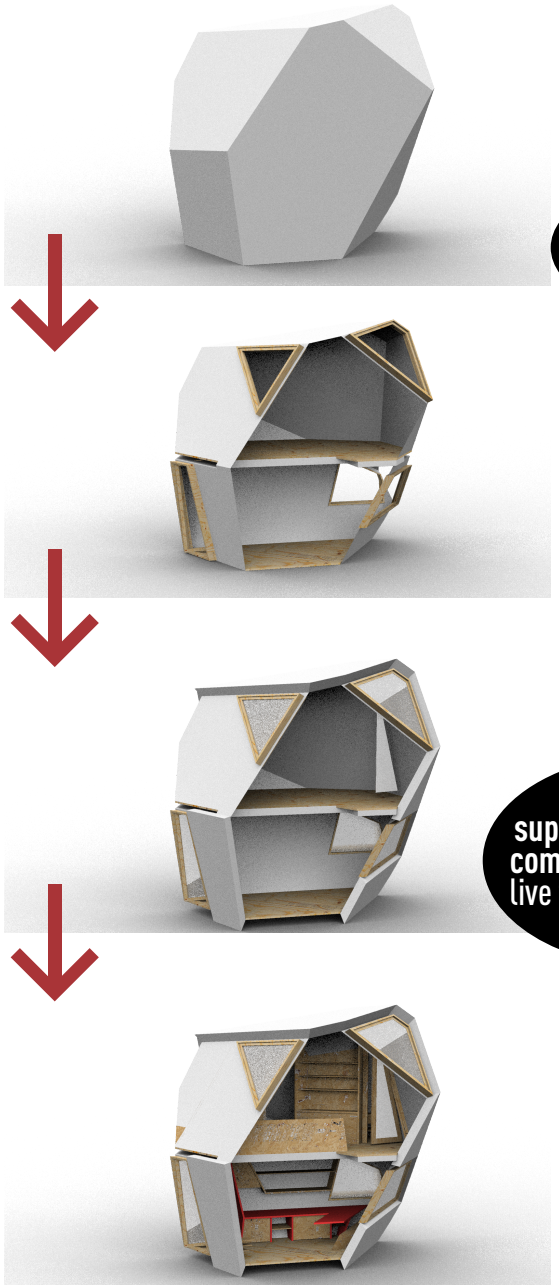
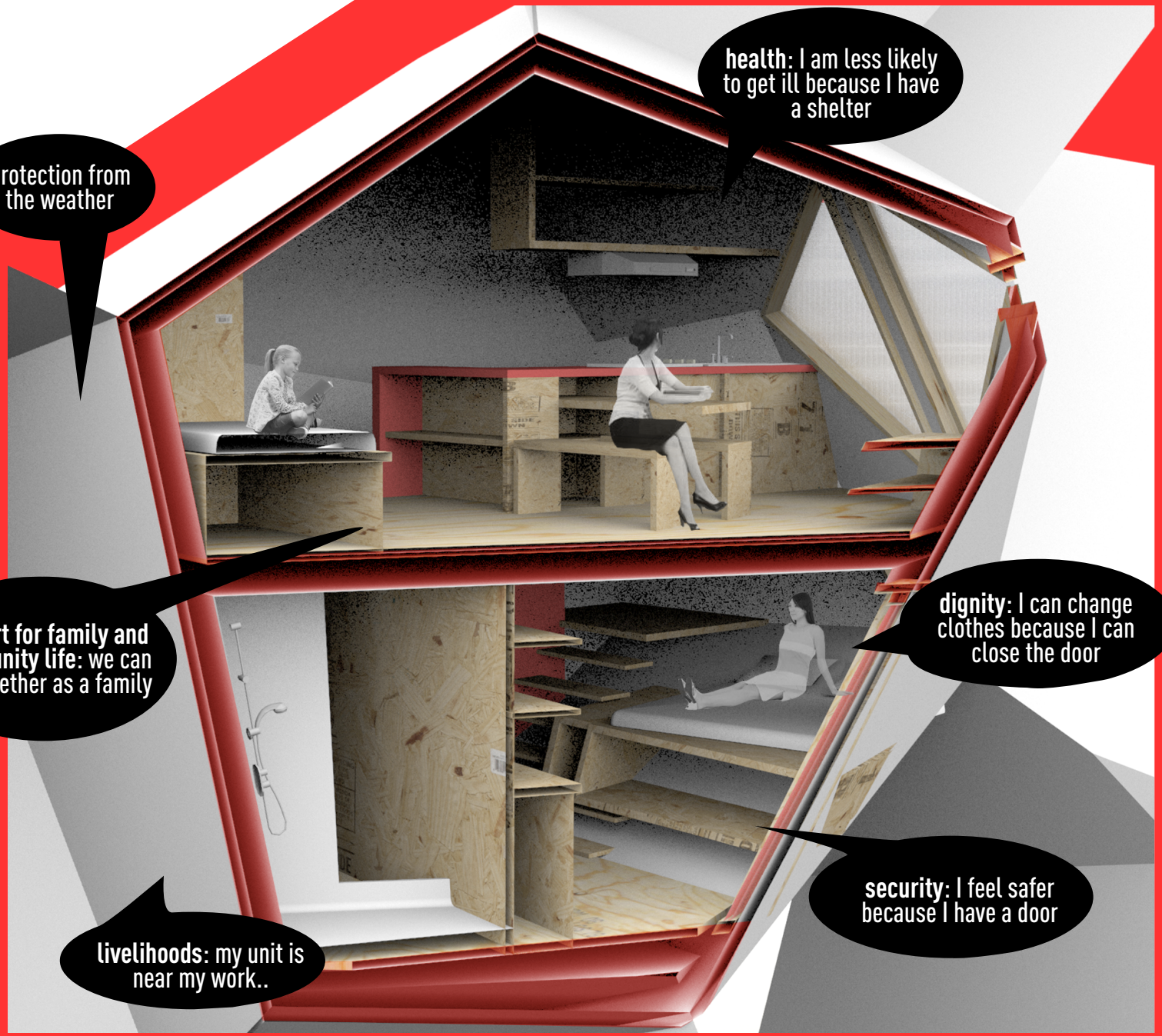
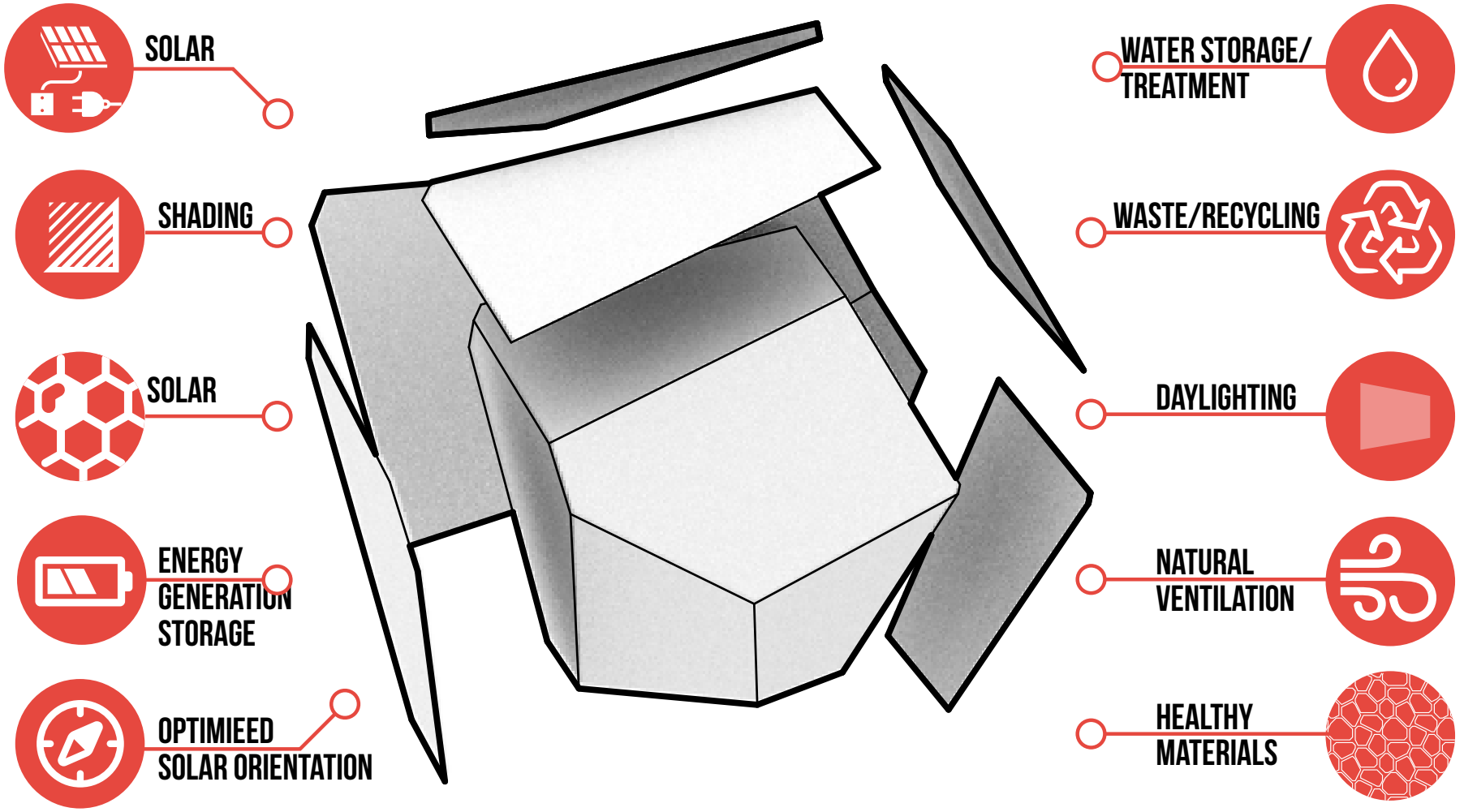



health: I am less likely to get ill because I have a shelter
Protection from the weather
support for family and community life: we can live together as a family
dignity: I can change clothes because I can close the door
security: I feel safer because I have a door
livelihoods: my unit is near my work..

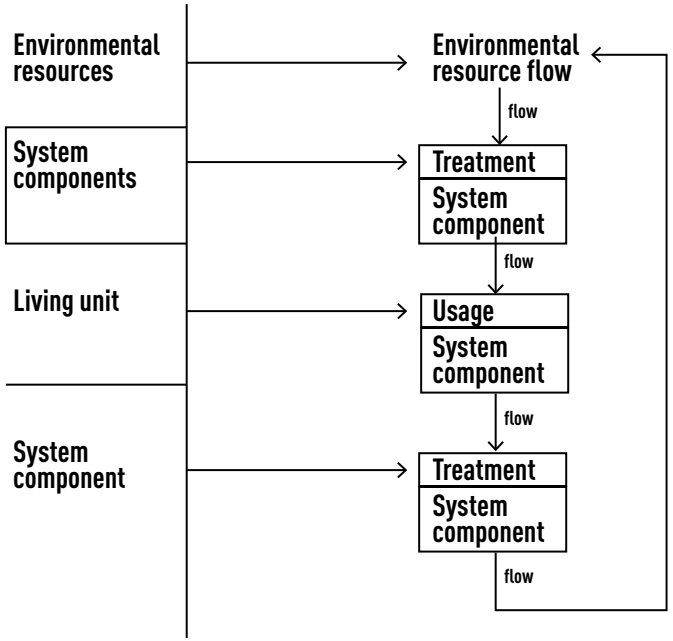
GREEN UNIT | COMMUNITY AND SAFETY



POWER UNIT | SELF SUFFICIENT ENERGY AND POWER SYSTEM



How it works
(the scheme)



Scheme unit/
districts

Sustainable unit

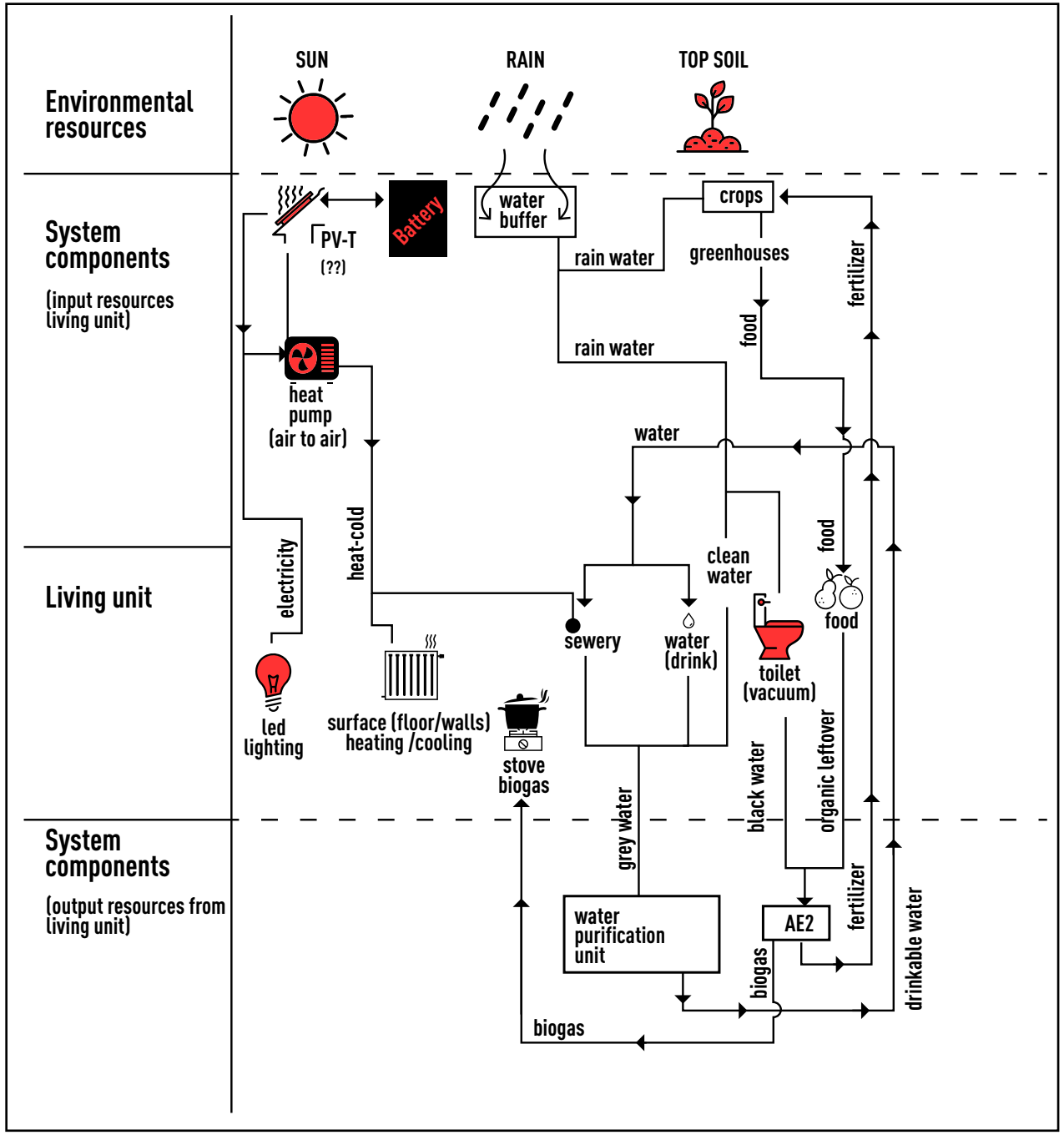
Sustainable district

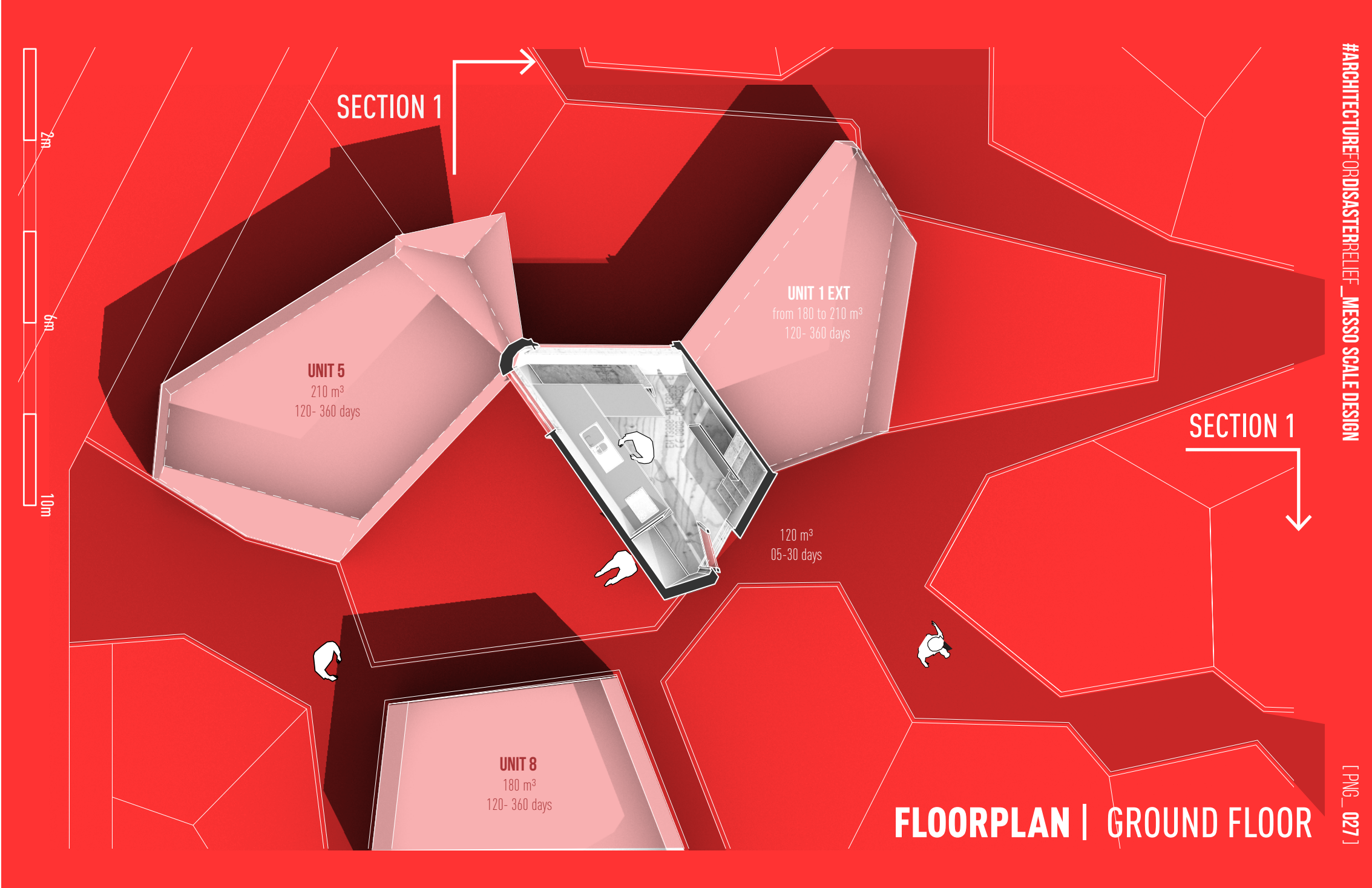
(when it grows)

transport ⟷

Battery for all ???

Li-on/H2

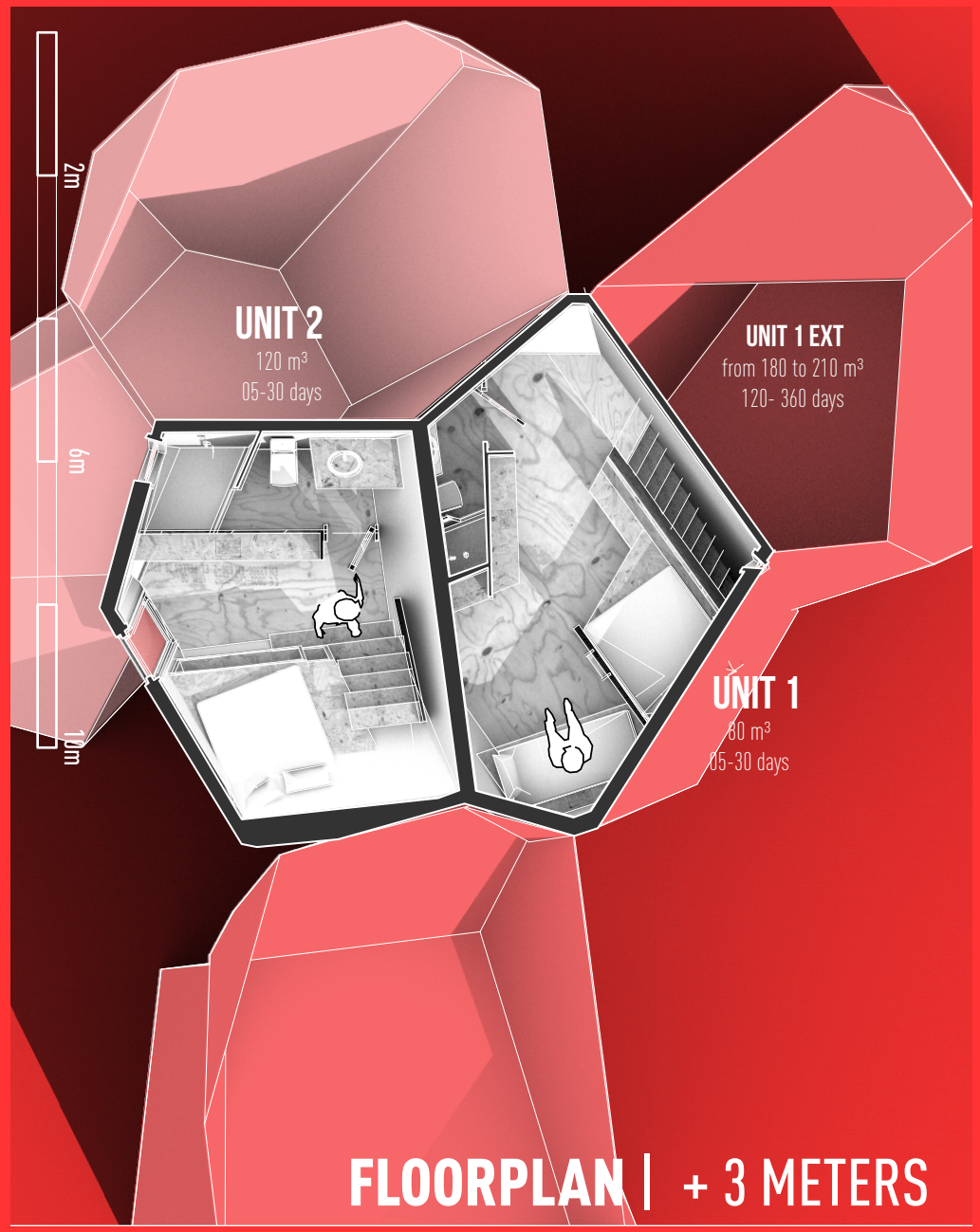




FLOORPLAN | GROUND FLOOR

#ARCHITECTUREFORDISASTERRELIEF_MESSO SCALE DESIGN

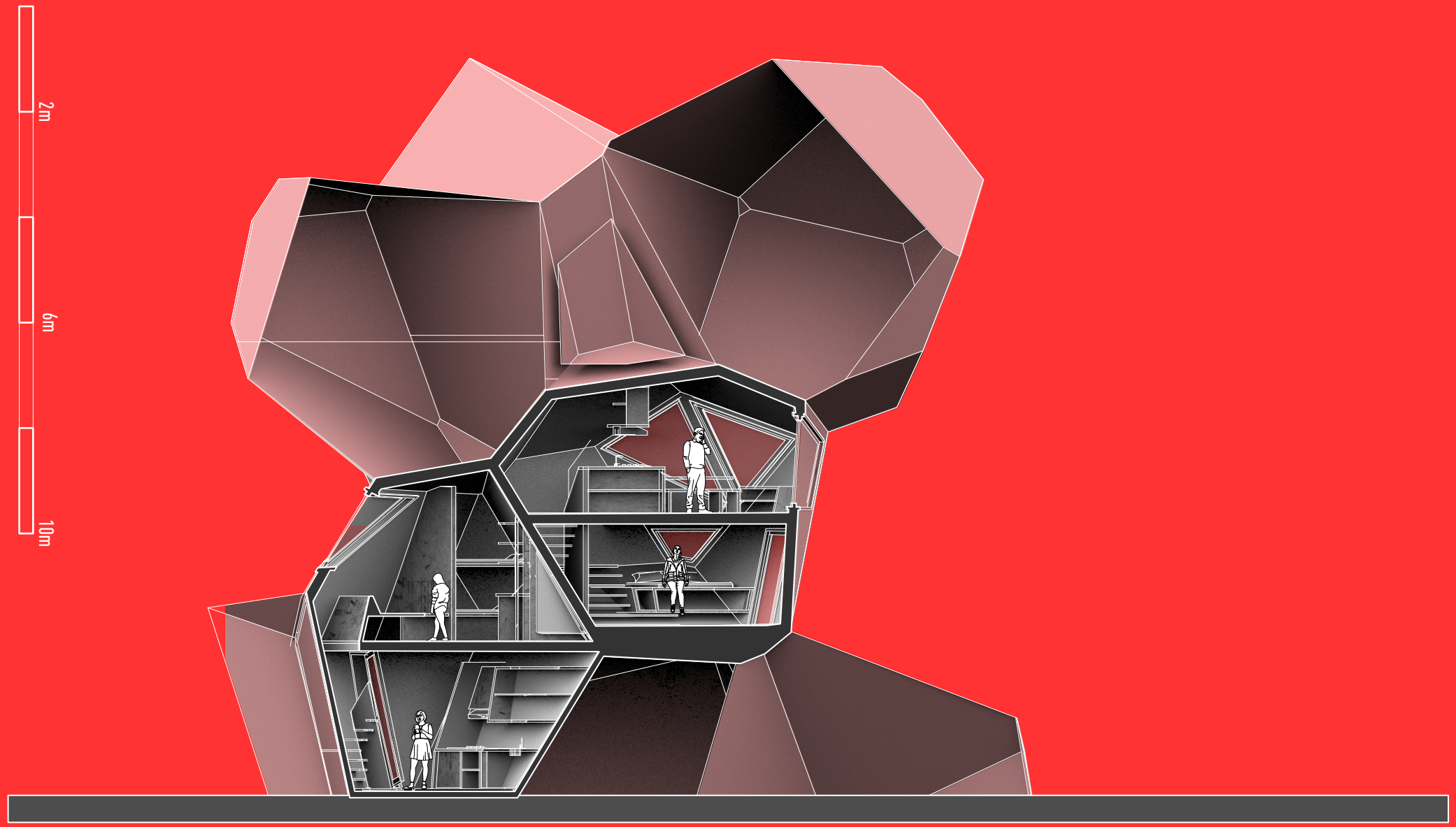
[PNG_ 027]



FLOORPLAN | + 3 METERS



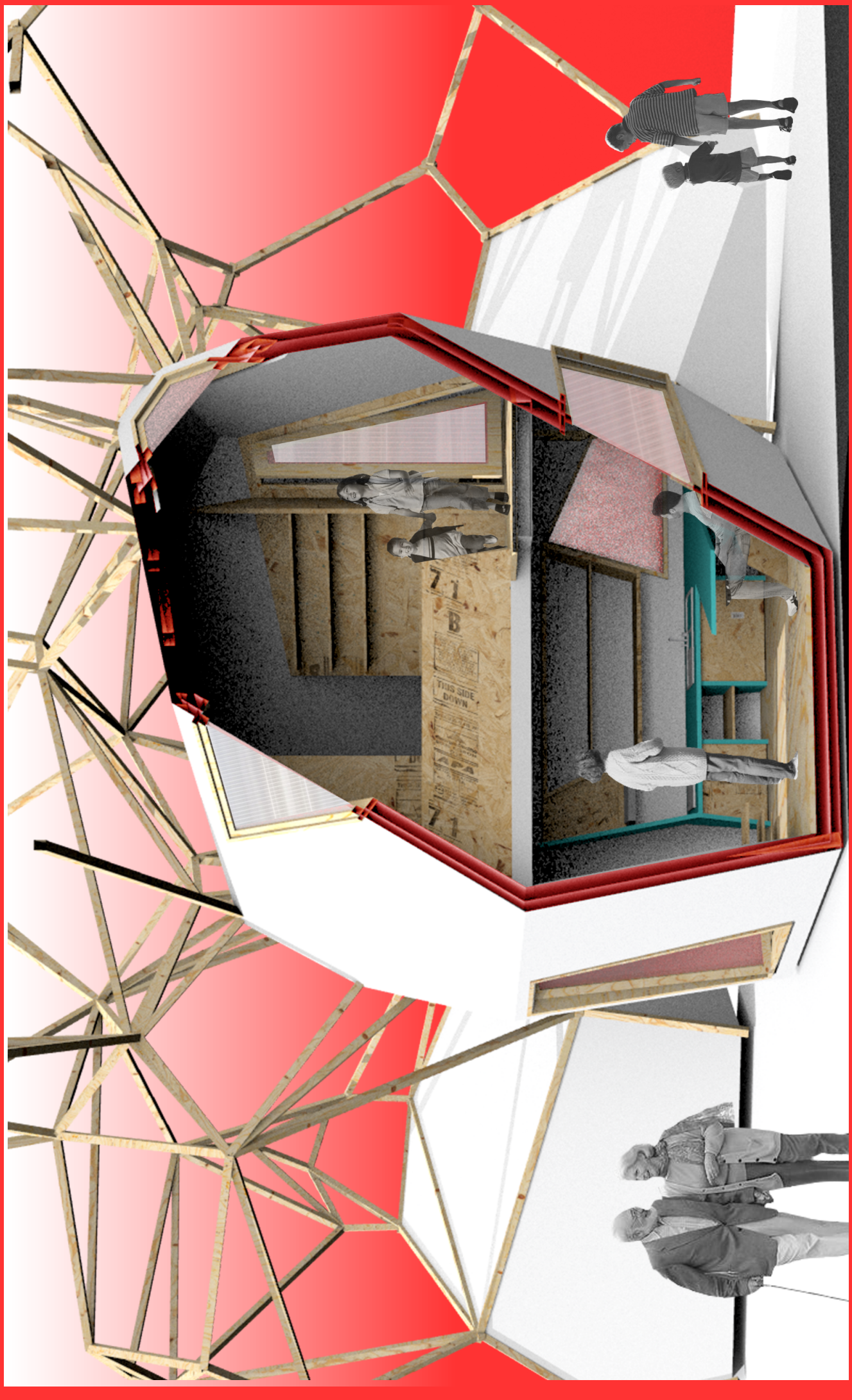
FLOORPLAN | + 6 METERS

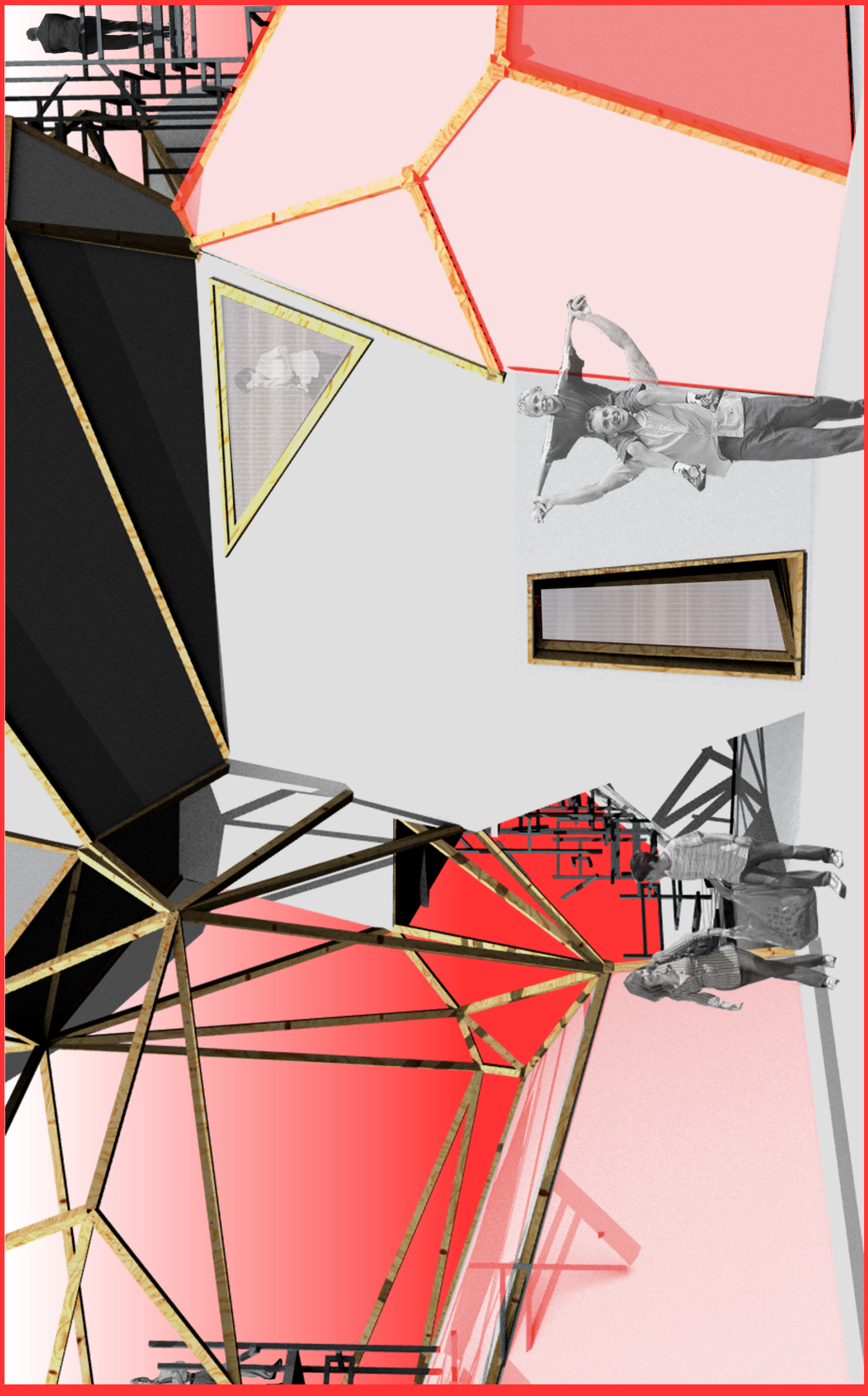


SECTION 1 | INITIAL UNITS AND EXTENSION



SECTION 2 | INITIAL UNIT AND EXTENSION

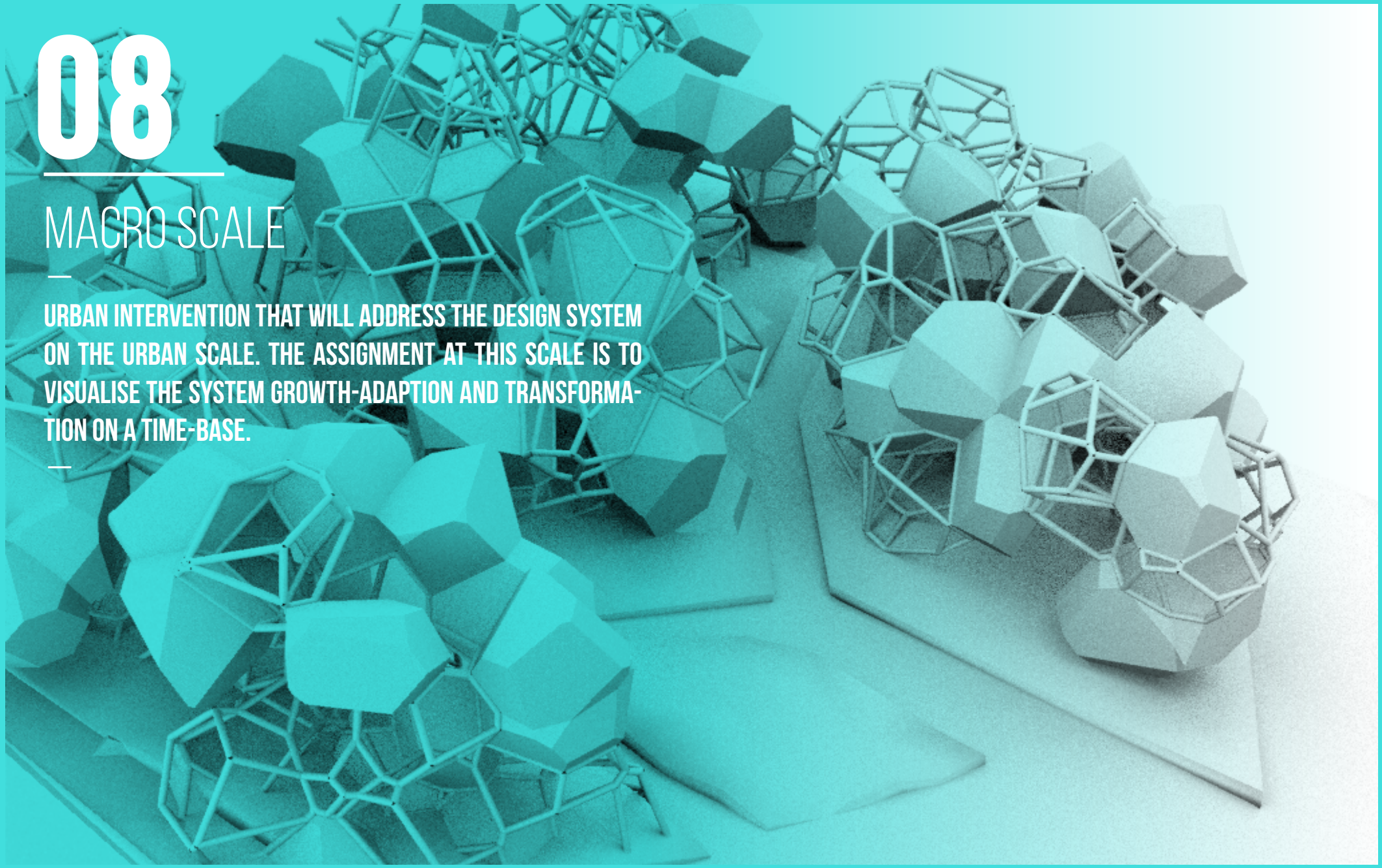

71
B
THIS SIDE DOWN
APA
71

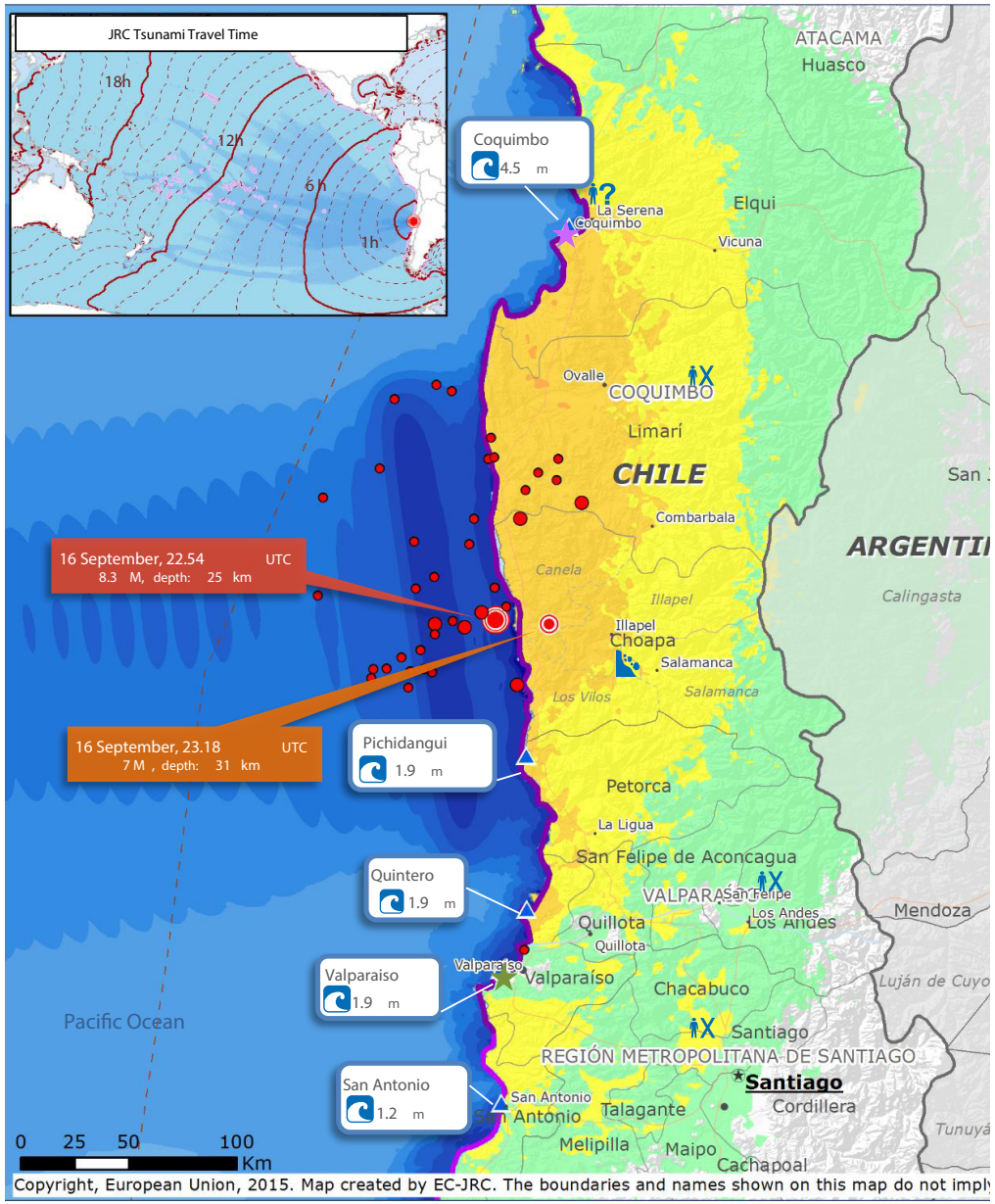


08

MACRO SCALE

URBAN INTERVENTION THAT WILL ADDRESS THE DESIGN SYSTEM ON THE URBAN SCALE. THE ASSIGNMENT AT THIS SCALE IS TO VISUALISE THE SYSTEM GROWTH-ADAPTION AND TRANSFORMATION ON A TIME-BASE.







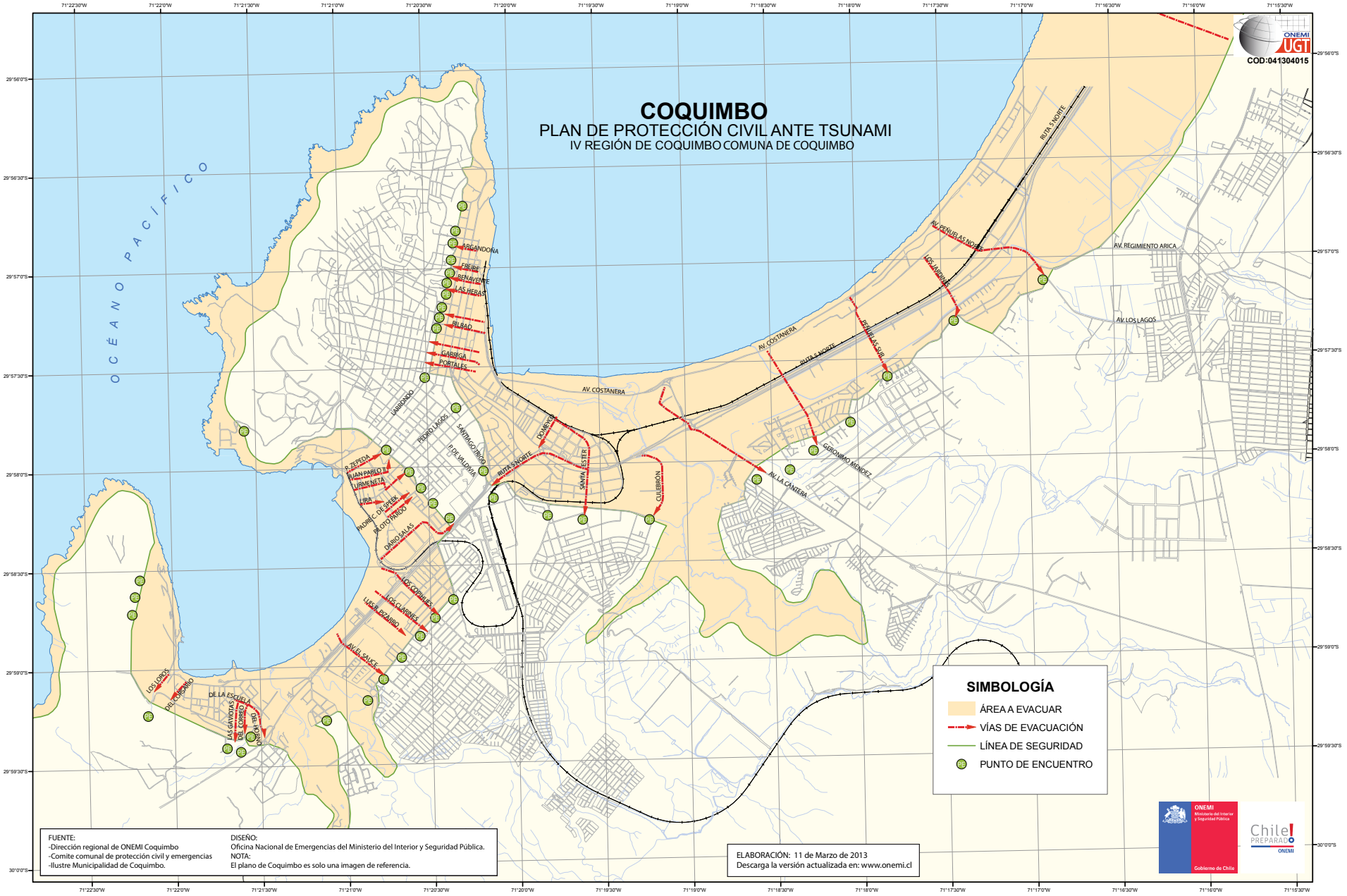




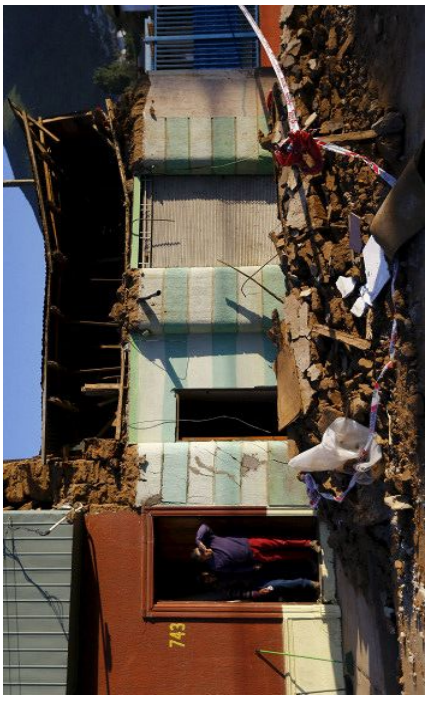


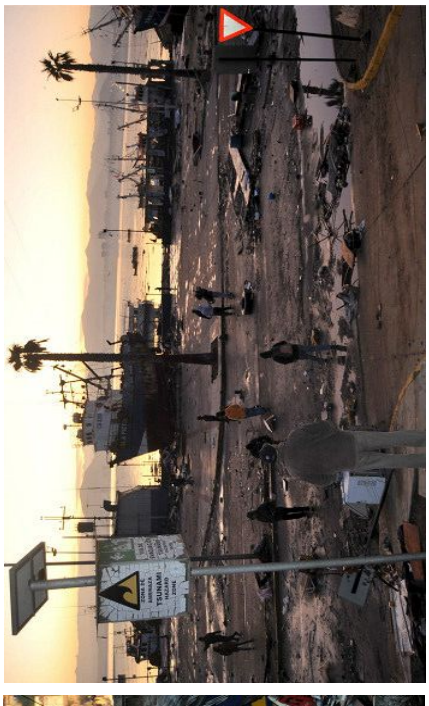
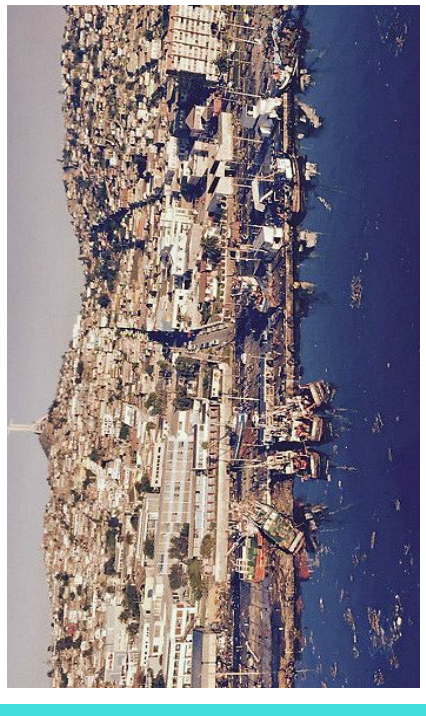
ZONES OF POSSIBLE DISASTER AND LAST EPICENTRE OF EARTHQUAKE

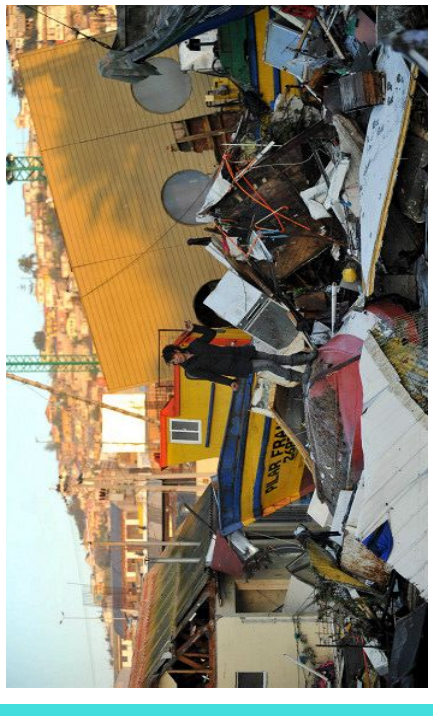
COQUIMBO, CHILE

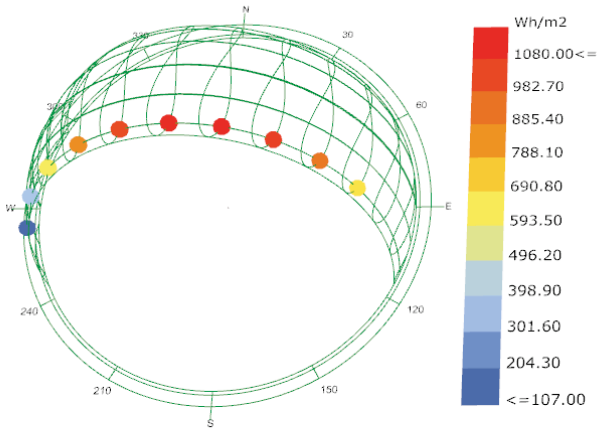




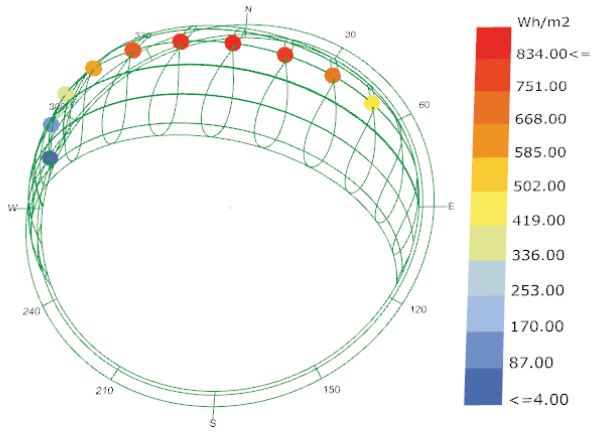


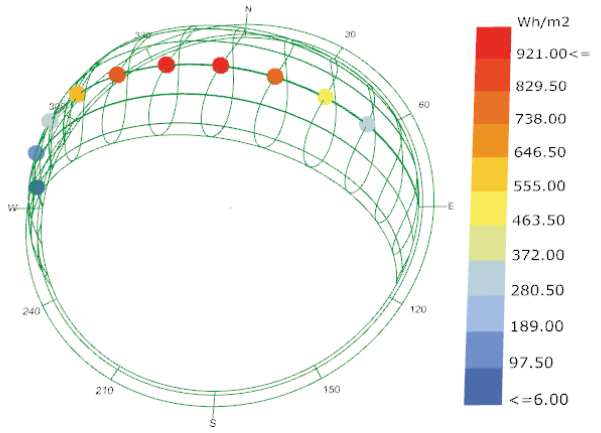




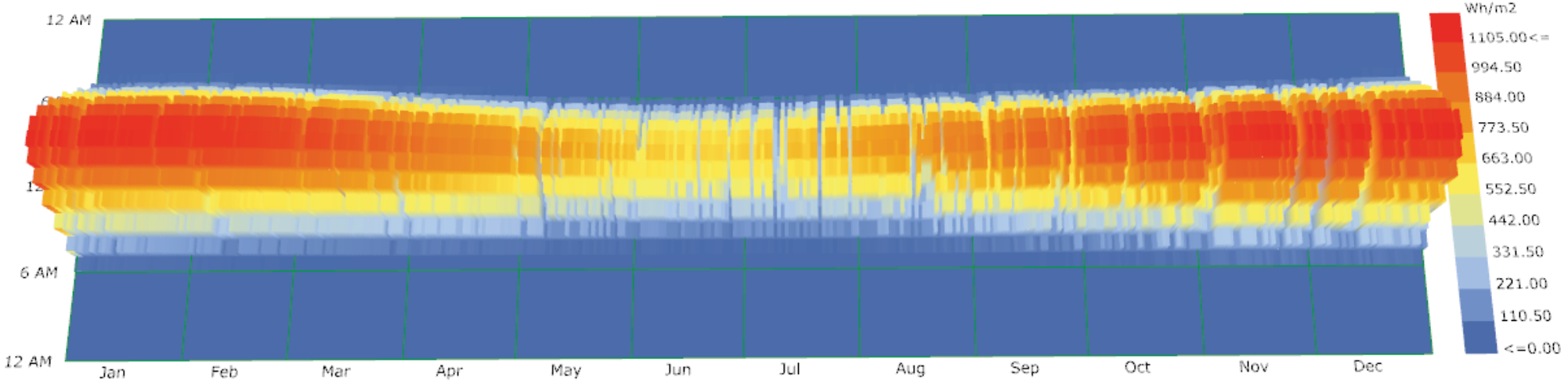
Sun-Path Diagram - Latitude: -23.43
21 JAN
Hourly Data: Global Horizontal Radiation (Wh/m2)
ANTOFAGASTA_CHL



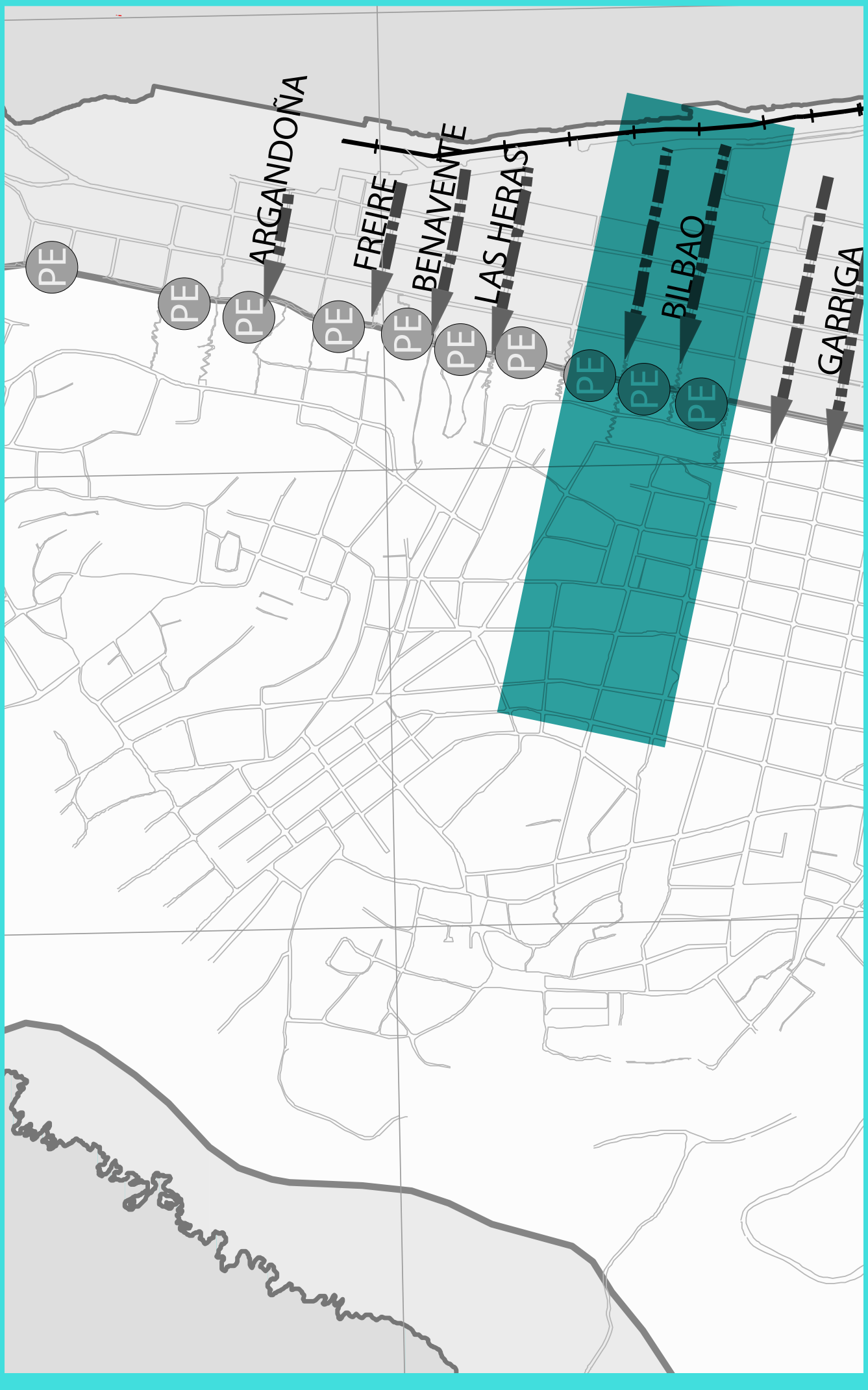
Sun-Path Diagram - Latitude: -23.43
21 APR
Hourly Data: Global Horizontal Radiation (Wh/m2)
ANTOFAGASTA_CHL



Sun-Path Diagram - Latitude: -23.43
21 SEP
Hourly Data: Global Horizontal Radiation (Wh/m2)
ANTOFAGASTA_CHL



Global Horizontal Radiation (Wh/m2) - Hourly
ANTOFAGASTA_CHL
1 JAN 1:00 - 31 DEC 24:00

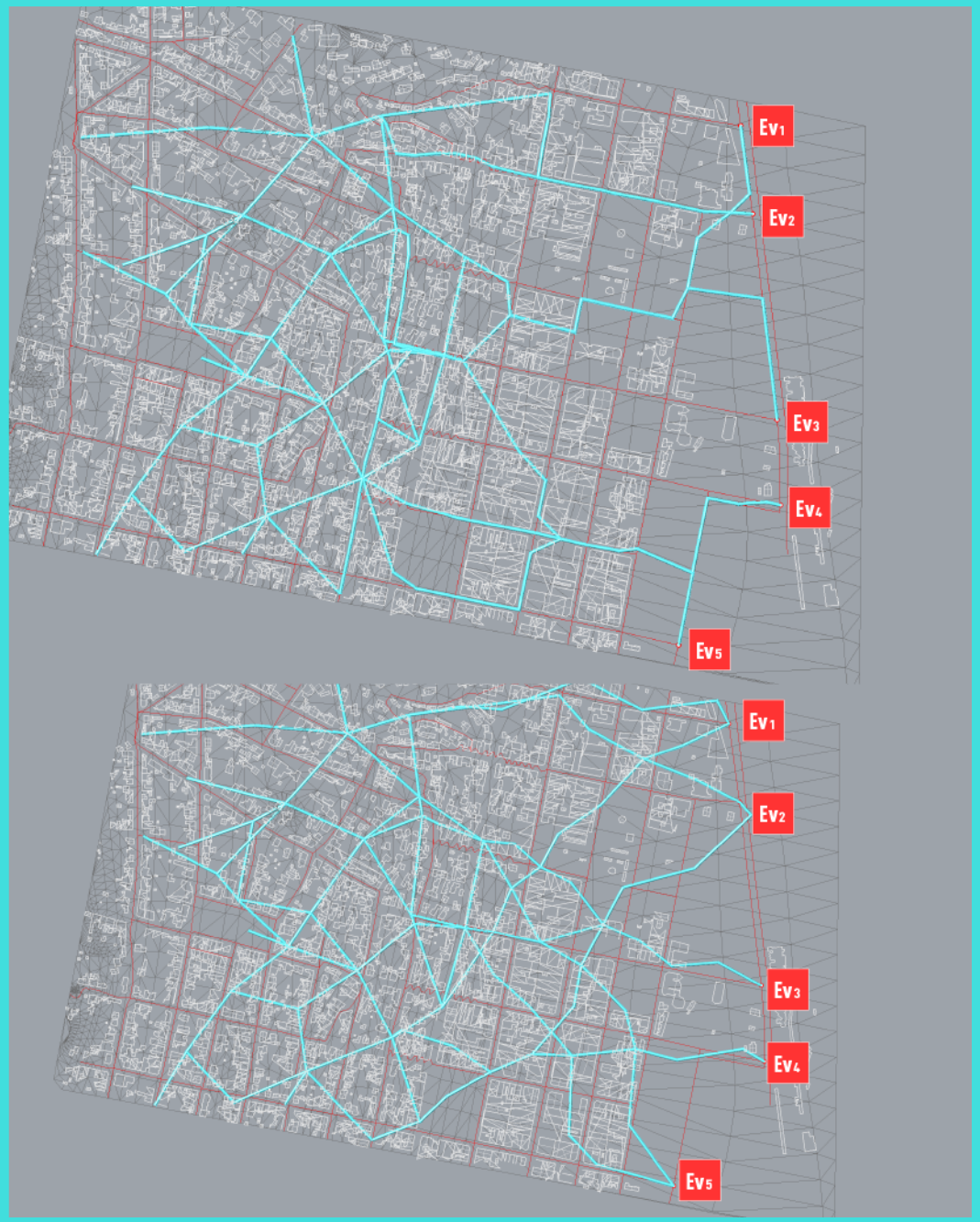

ARGANDOÑA
FREIRE
BENAVENTE
LAS HERAS
BILBAO
GARRIGA
PE
PE
PE
PE
PE
PE
PE
PE
PE

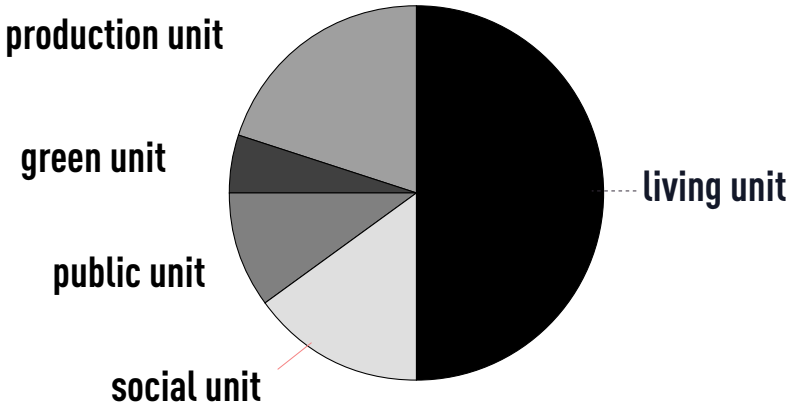
Hazard & Evacuation



Accessibility

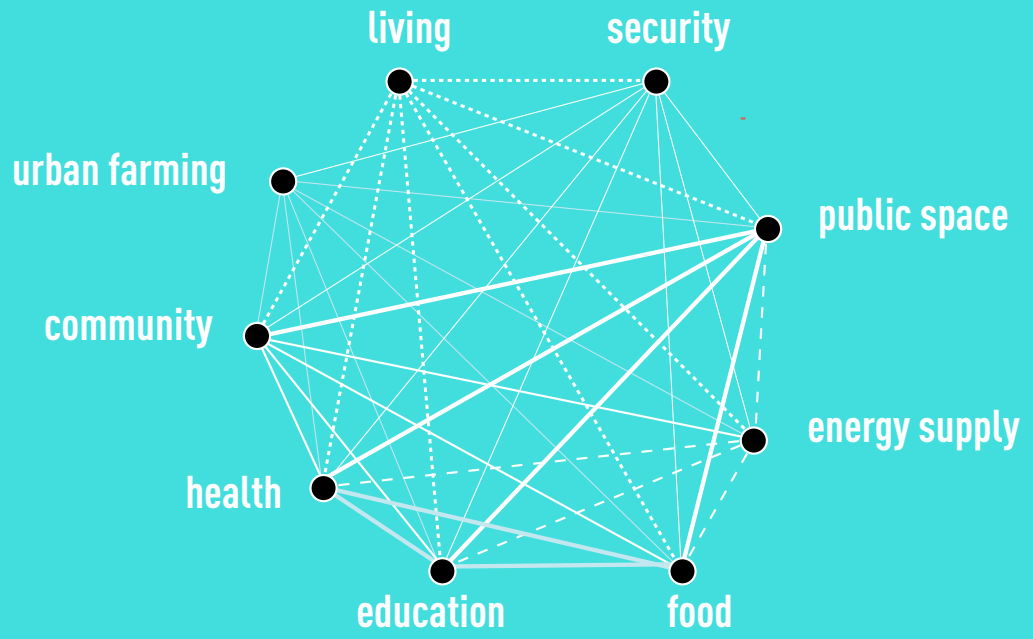
an adaptive production system is able to respond to real-time contingencies and respond through design variations decided in real-time





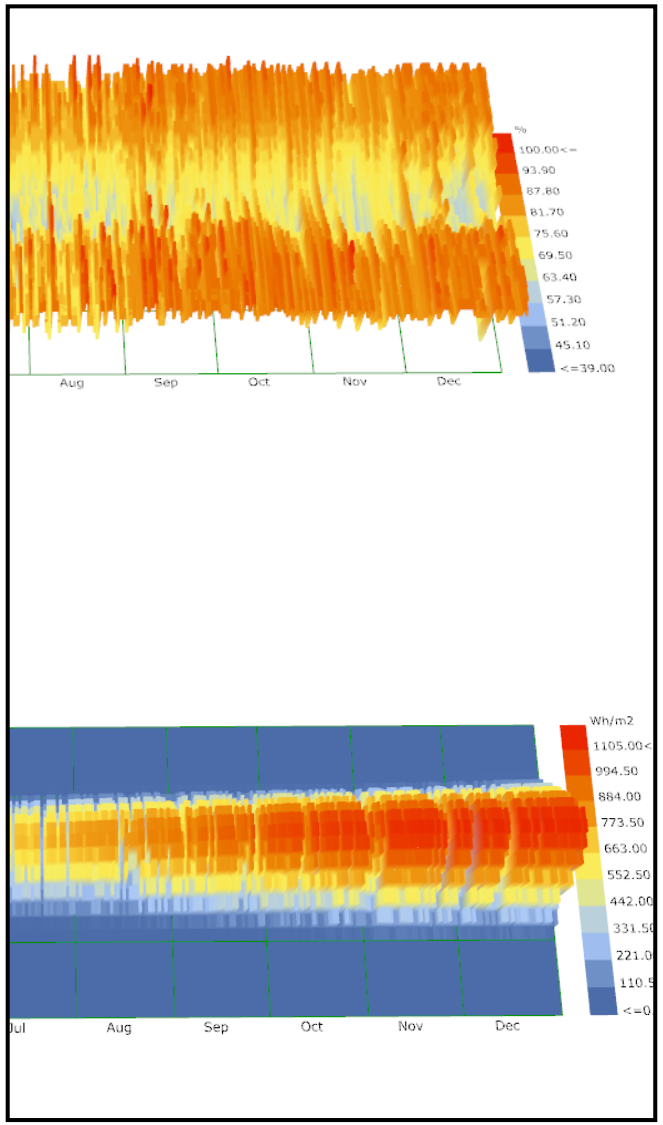
program parameters

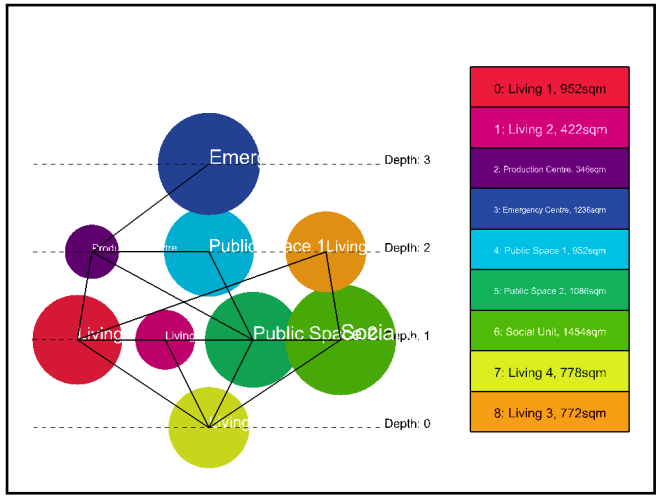
proportion of activities / program per area and volume



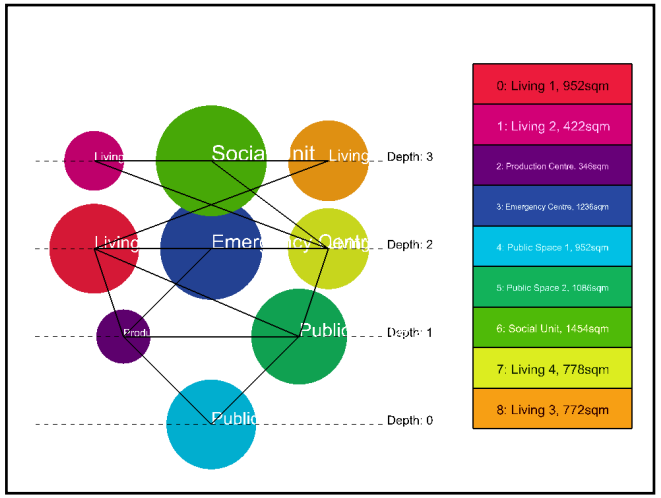
programatic strategy

Dimentions (units)	Living Unit	Social Unit	Public Unit	Green Unit	Production Unit	TOTAL
Area (m2)	U	30% * U = V	0% * V = 0.11*U = X	40% * X = 0.5*U = W	50% * U+V+X = Y	2,41* U
Height (m2)	3	4	6	5	8	5,2
Volume (m3)	3 * U	4*V	6*X	5*W	8*Y	7,56 * U

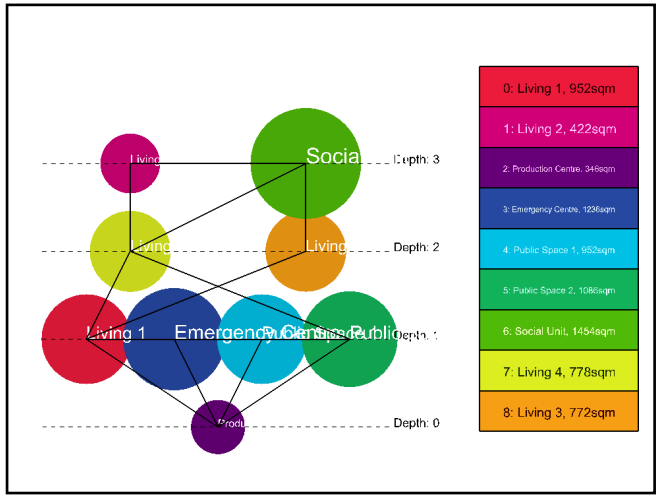




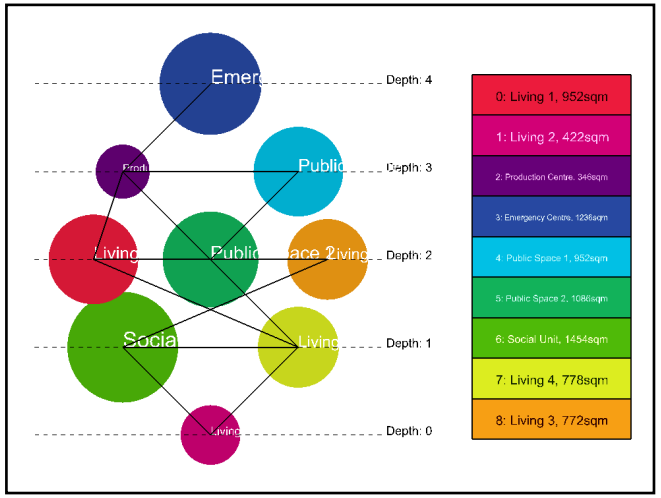
iteration 1



iteration 4



iteration 8



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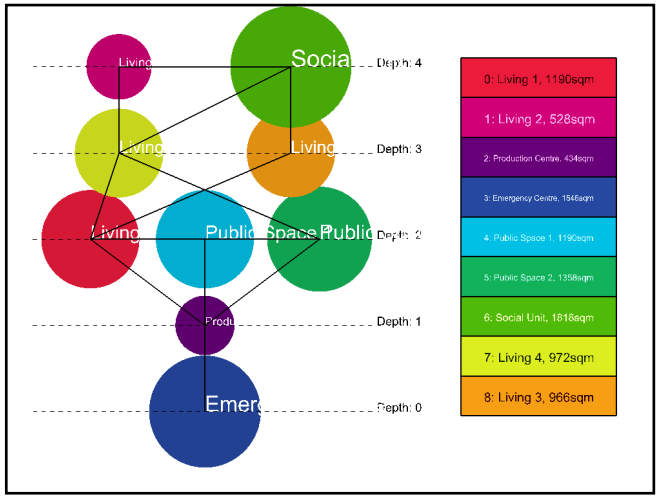
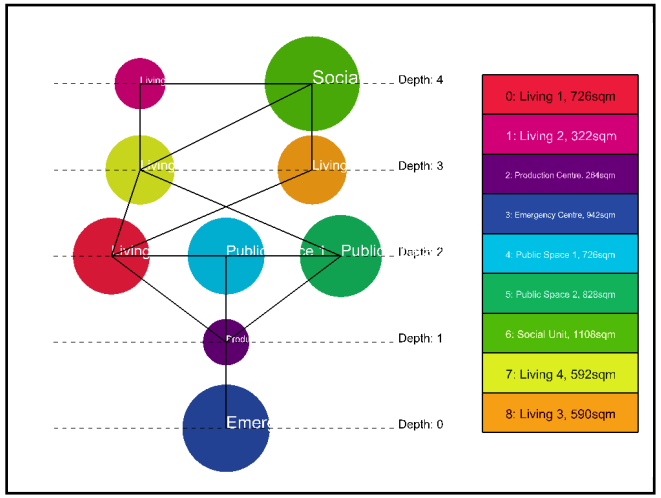


iteration 1



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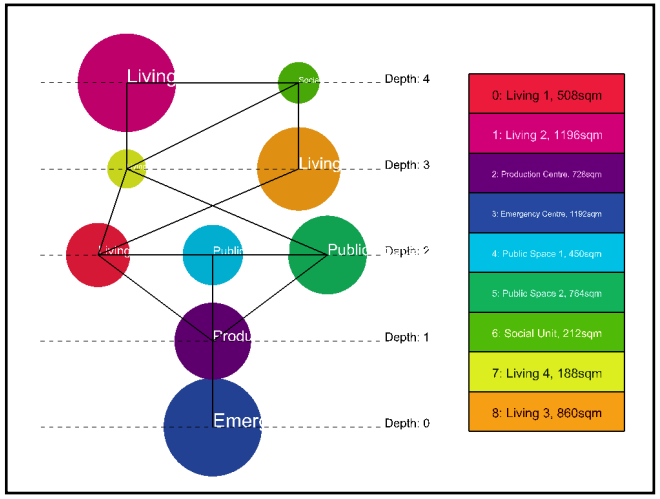

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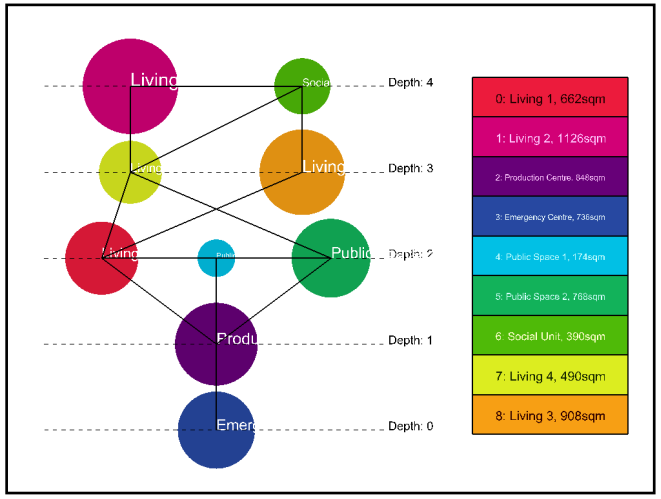

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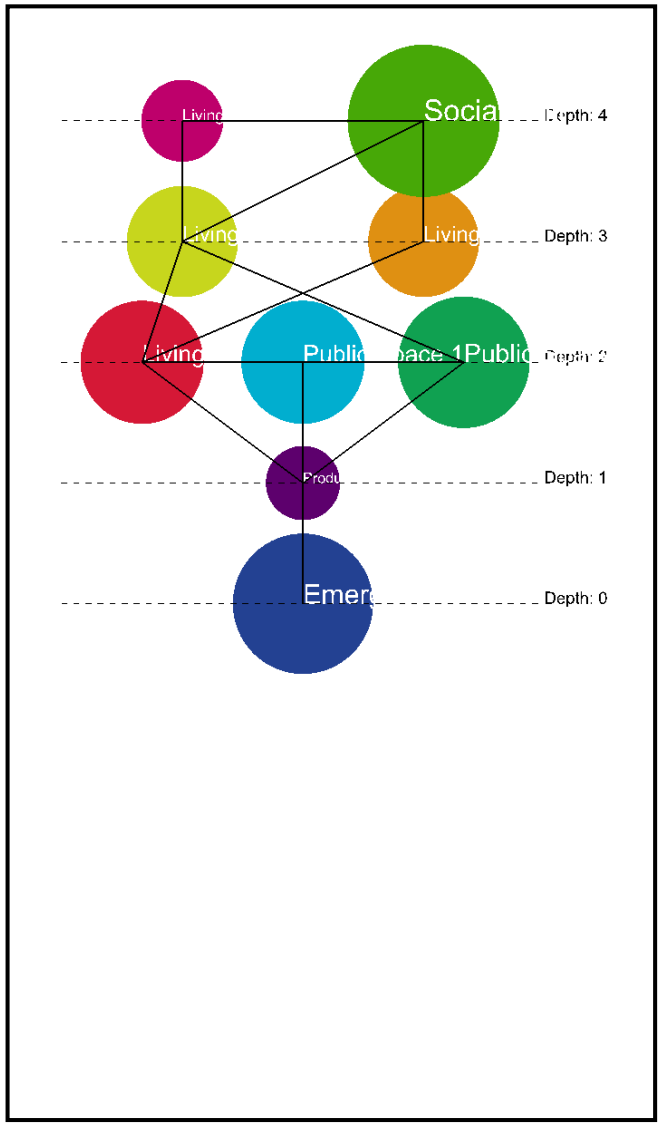

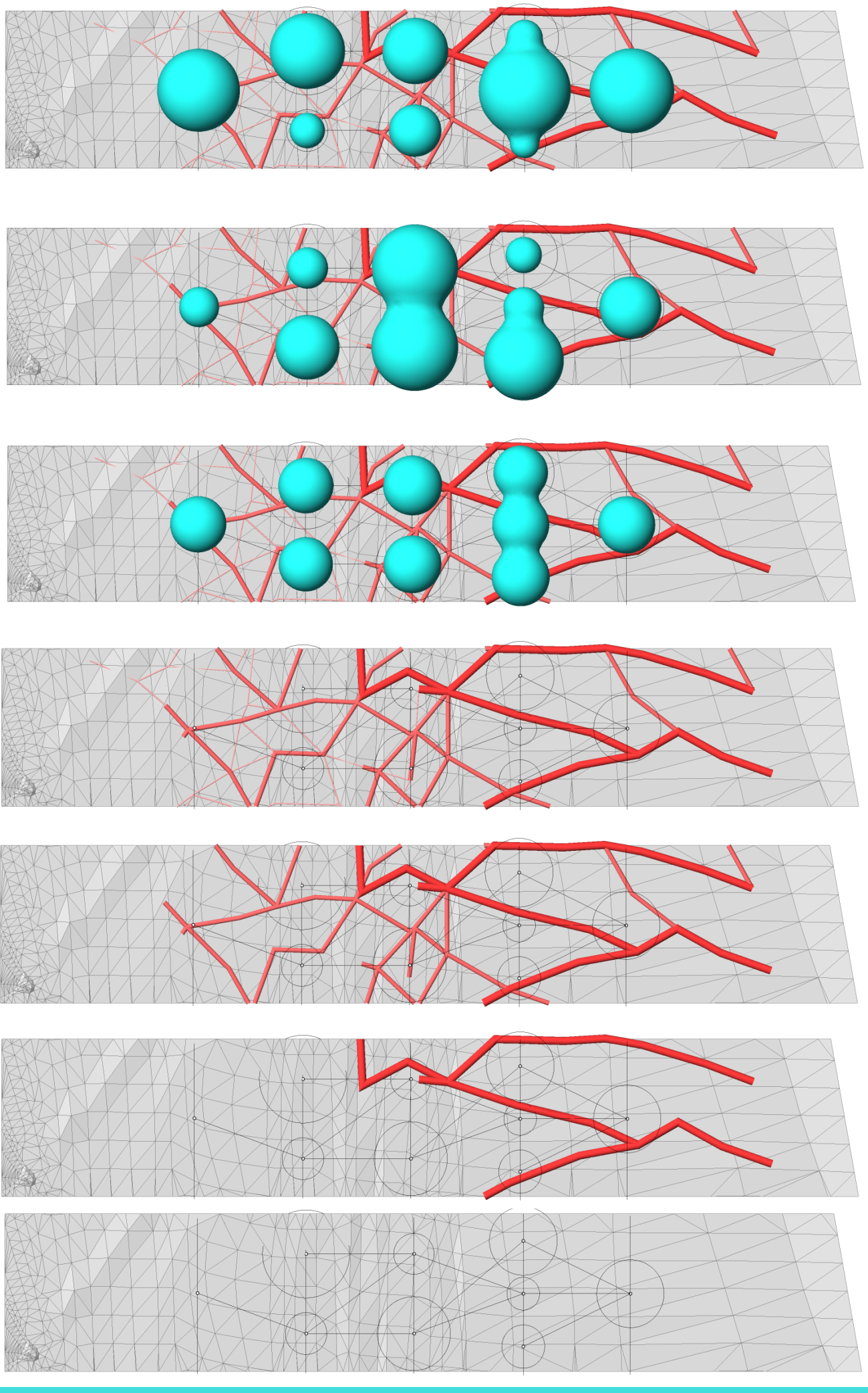

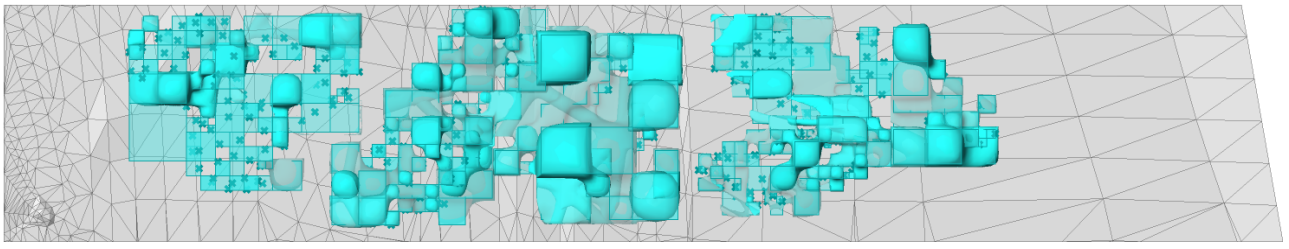

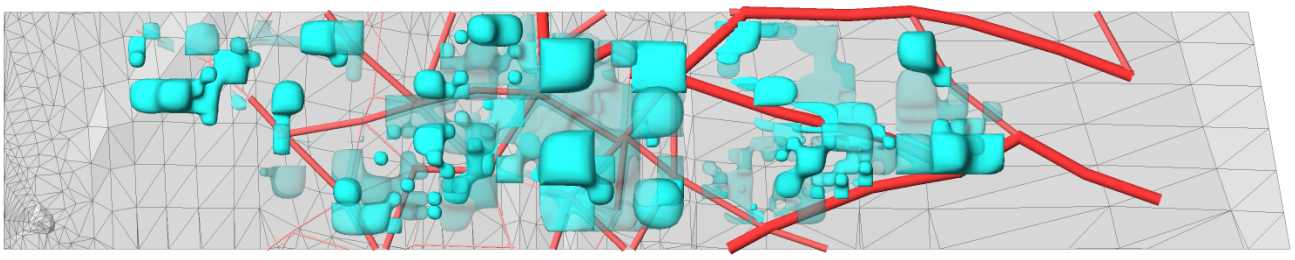

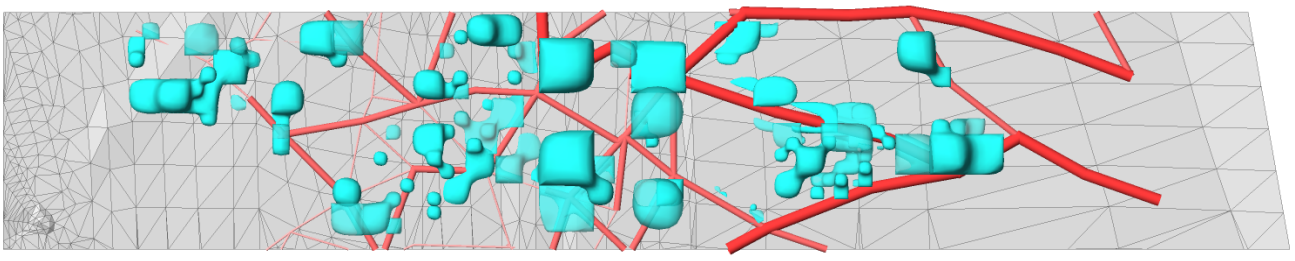

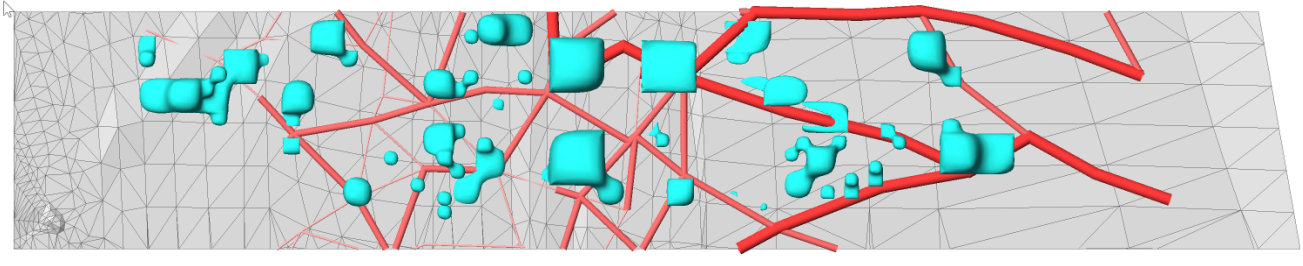

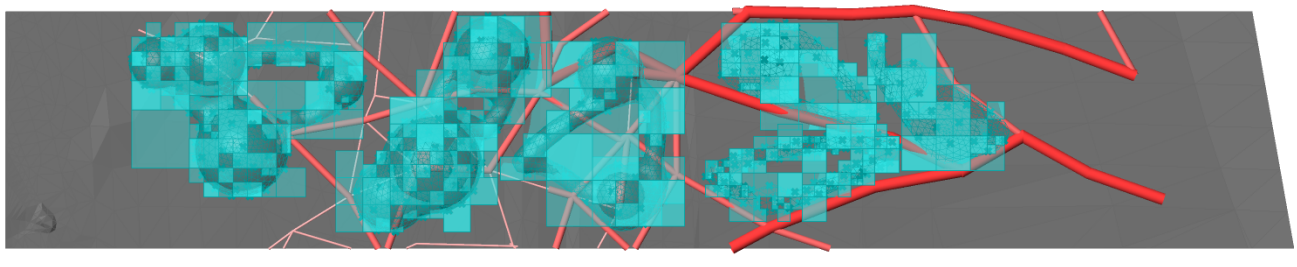

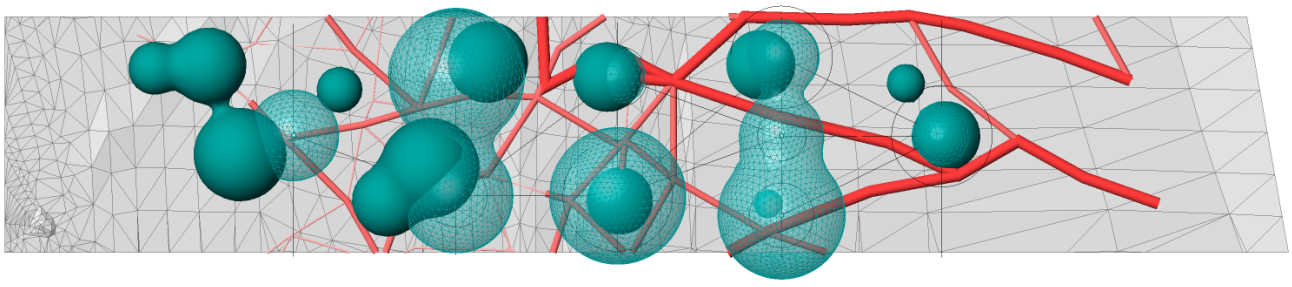

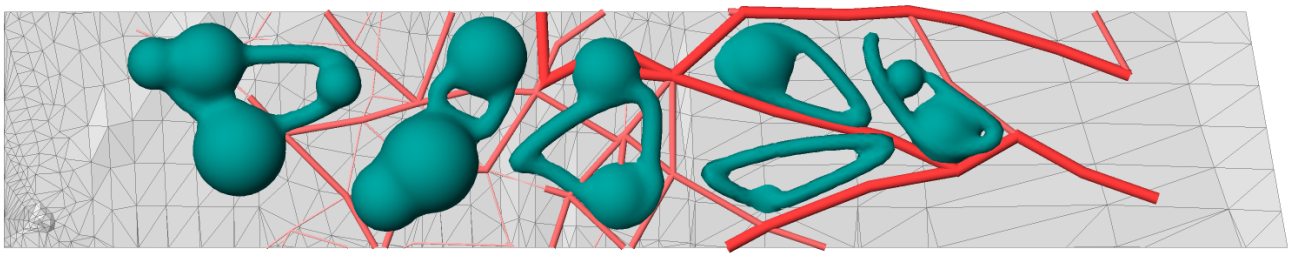

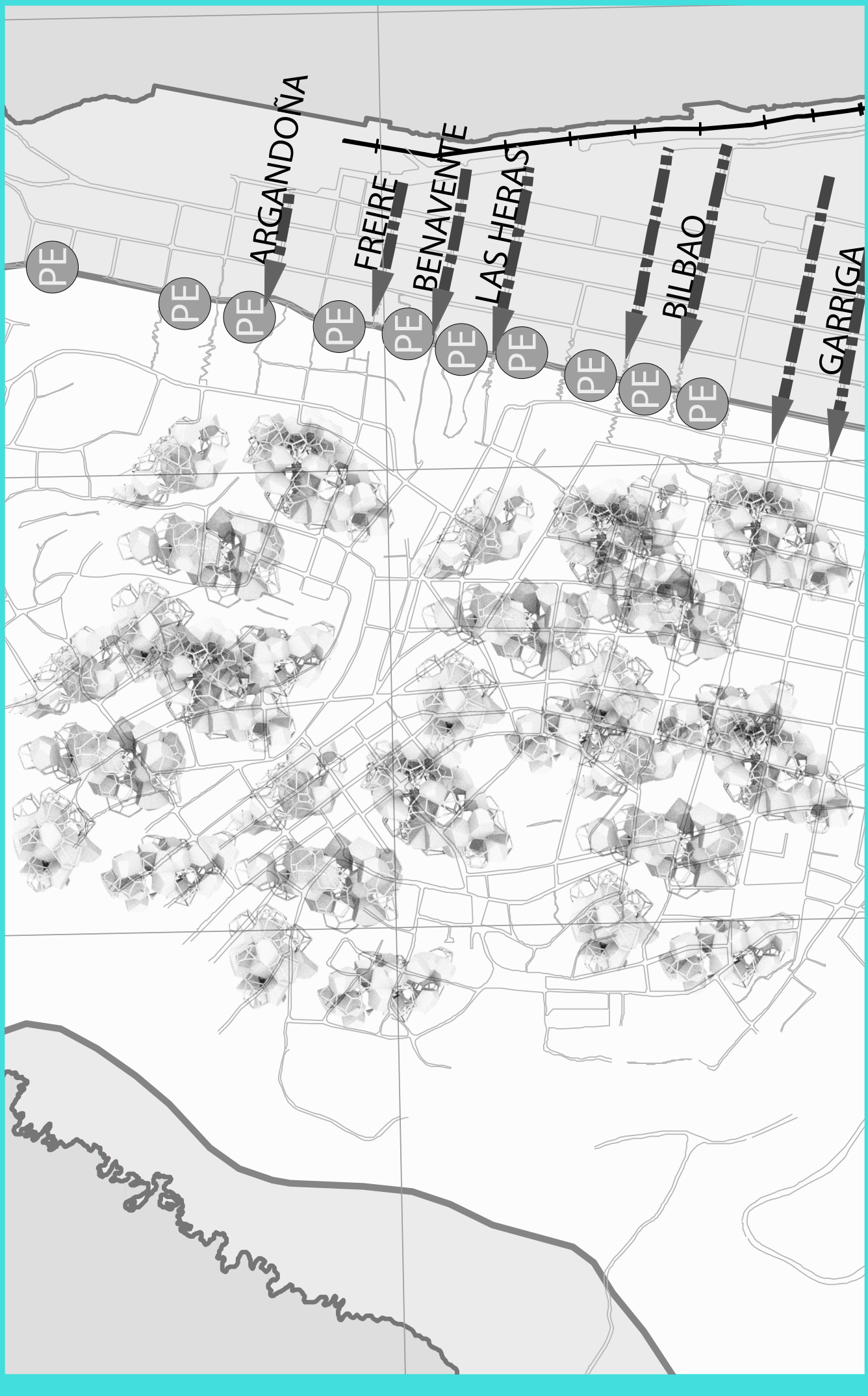
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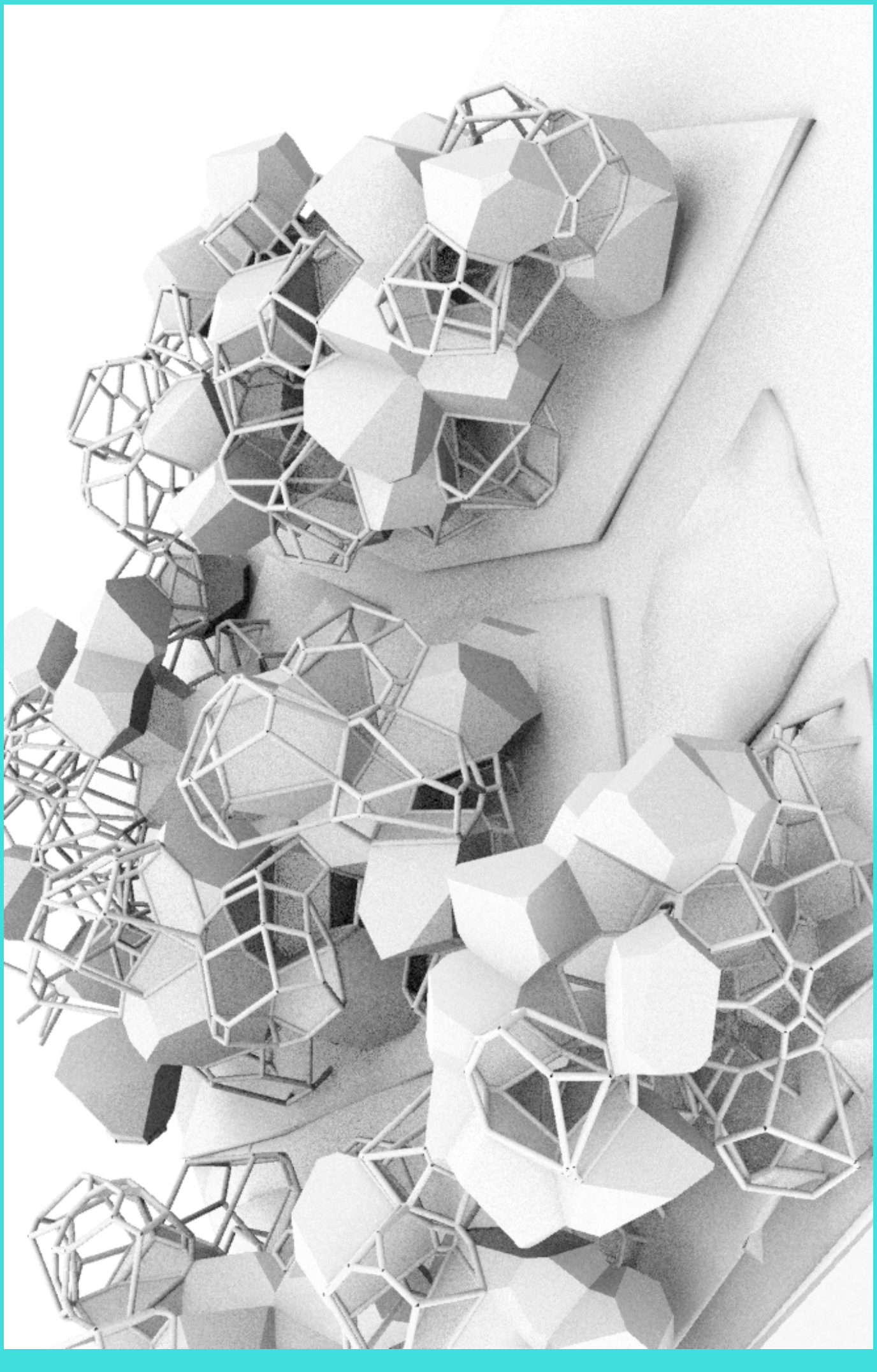


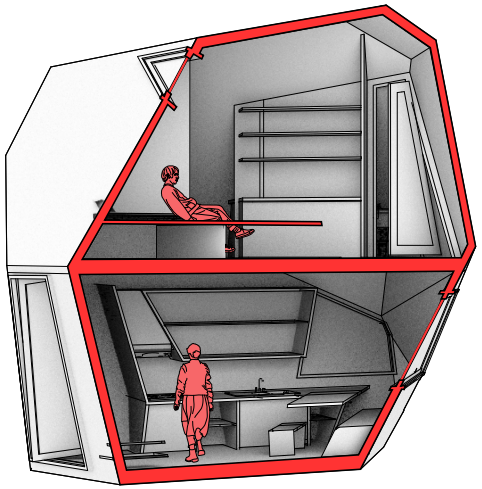
09

MICRO SCALE

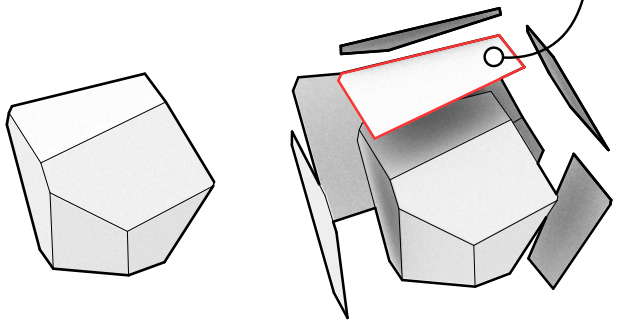
MULTI ROBOTIC PRODUCTION SYSTEM. “PACK” OF ROBOTS WITH SPECIFIC BUILDING AND FABRICATION TASKS. HERE THE ASSIGNMENT IS TO DEFINE AN PREFAB AND ON SITE FRAMEWORK FOCUSED ON THE ROBOTIC PRODUCTION PROCESS.



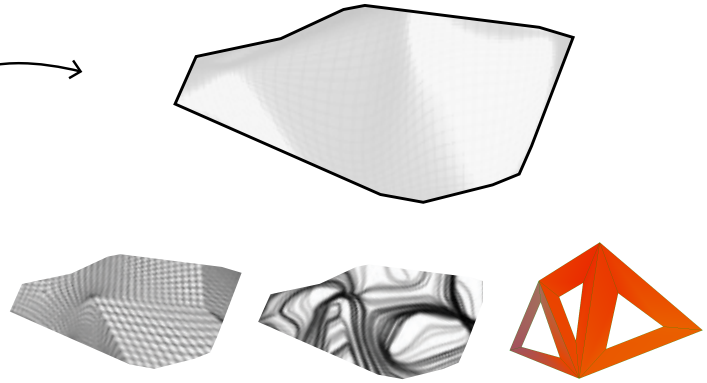
MULTI-SCALE PRODUCTION SYSTEM



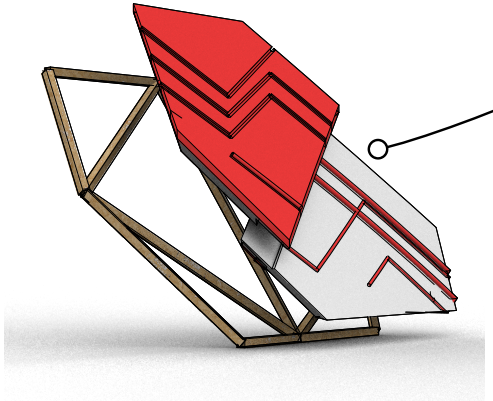
UNIT SCALE
Living Unit



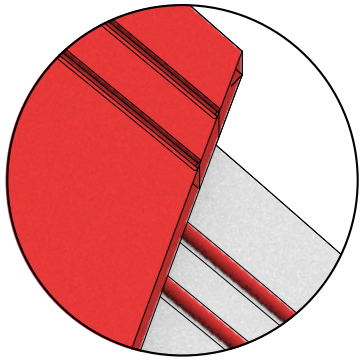
Unit Design iteration based on architectural and geo-location parameters



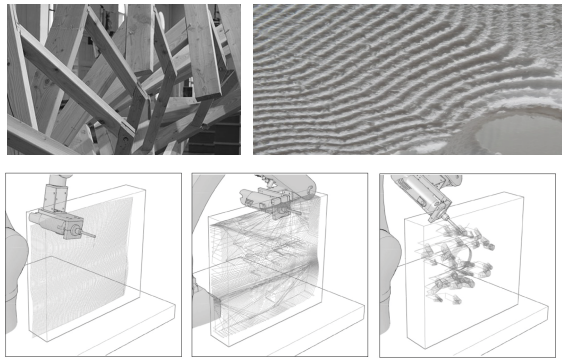
COMPONENT SCALE
Building Component



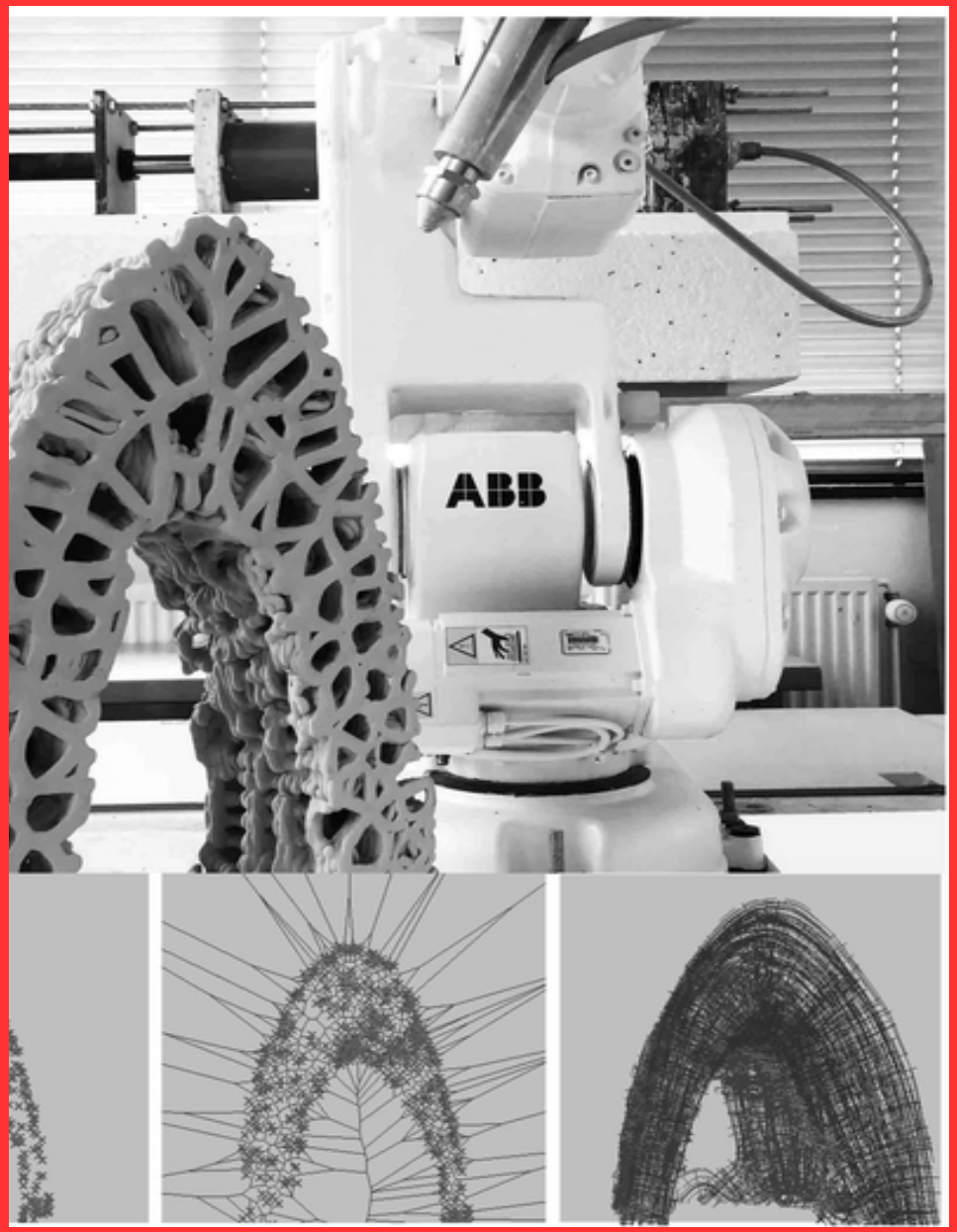
Component optimisation based on geometry analysis, structural optimisation, enviromental requierments and climate control



MATERIAL SCALE
Material & Performance

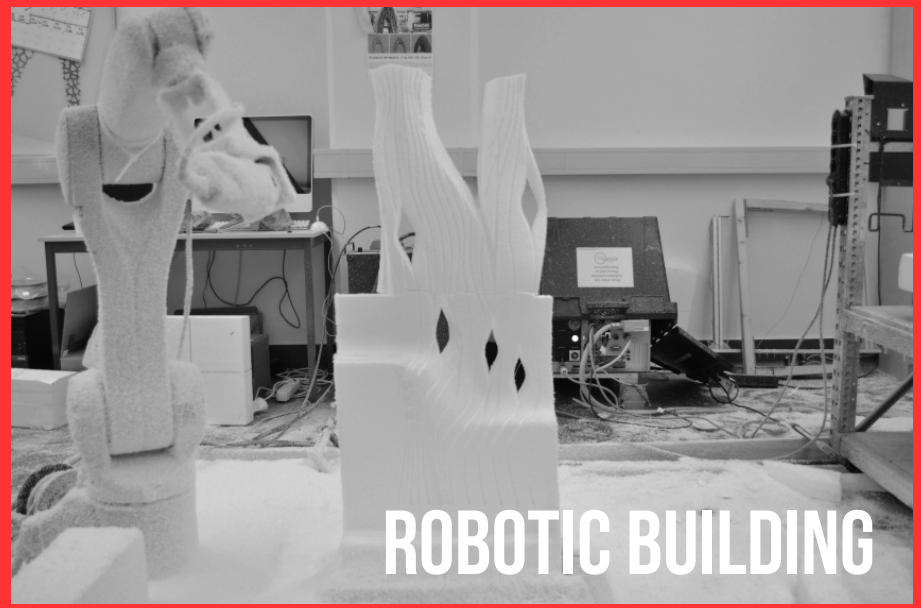


Multi Material Production System difined by hybrid porosity, assembly and component performance



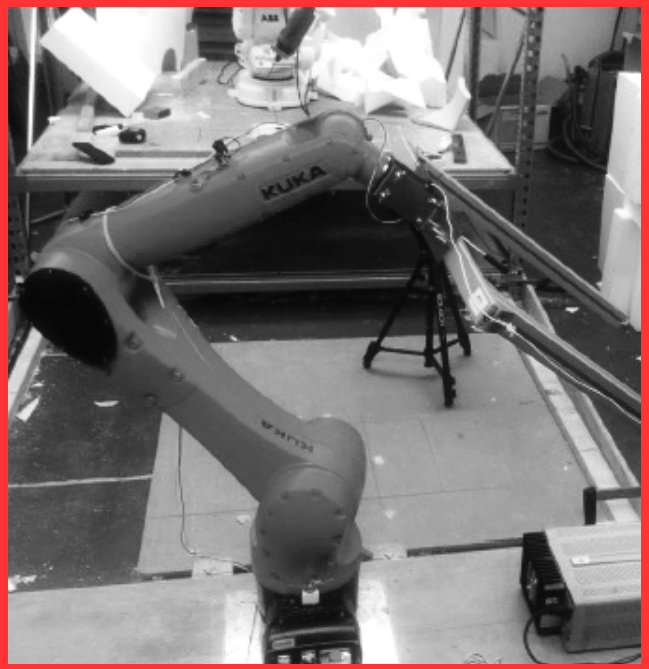




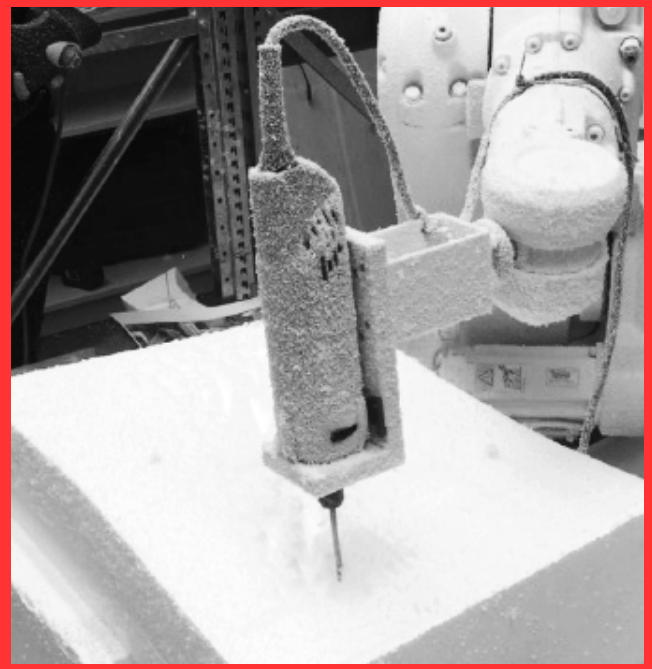


ROBOTIC BUILDING

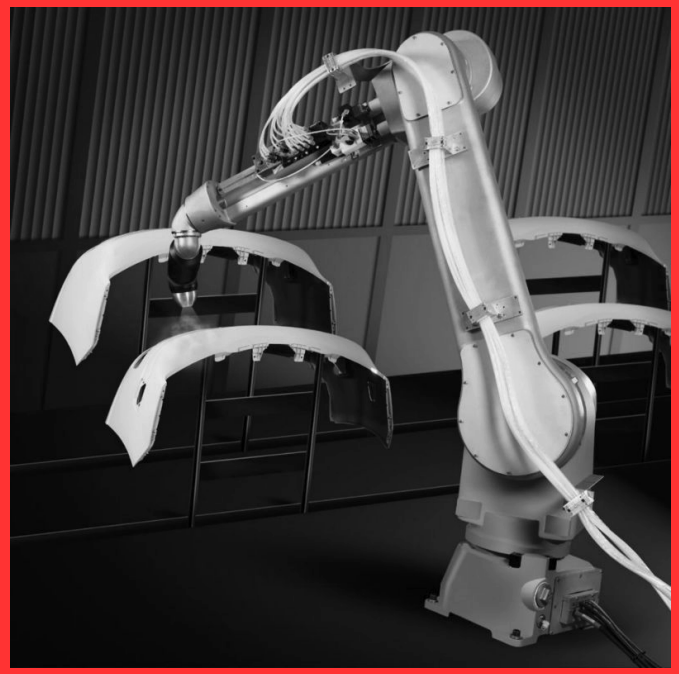




HOT WIRE CUTTING
Component primitive structure



3D-4D Milling
Structure Porosity and Surface Tech-tonics

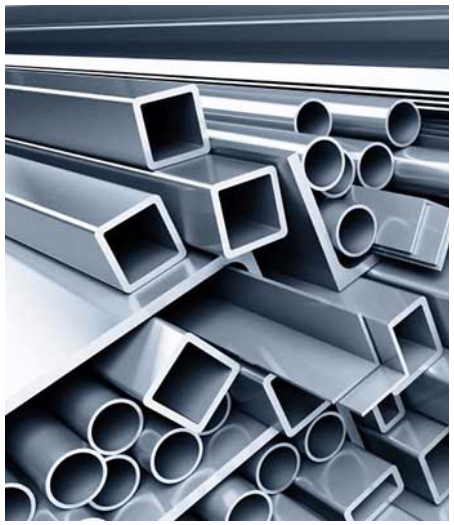


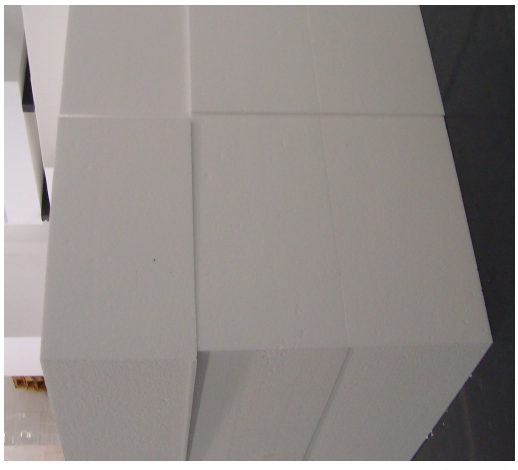
COATING
Performance and finishing techtonics







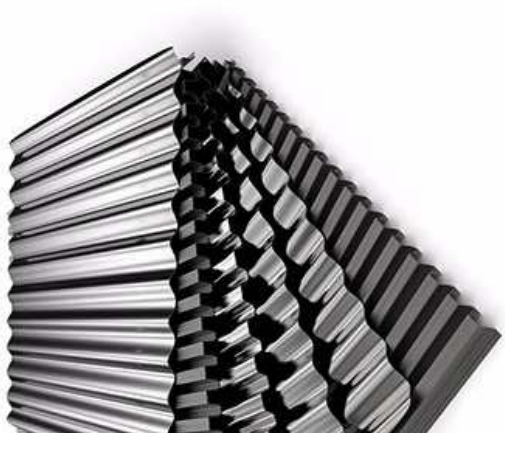


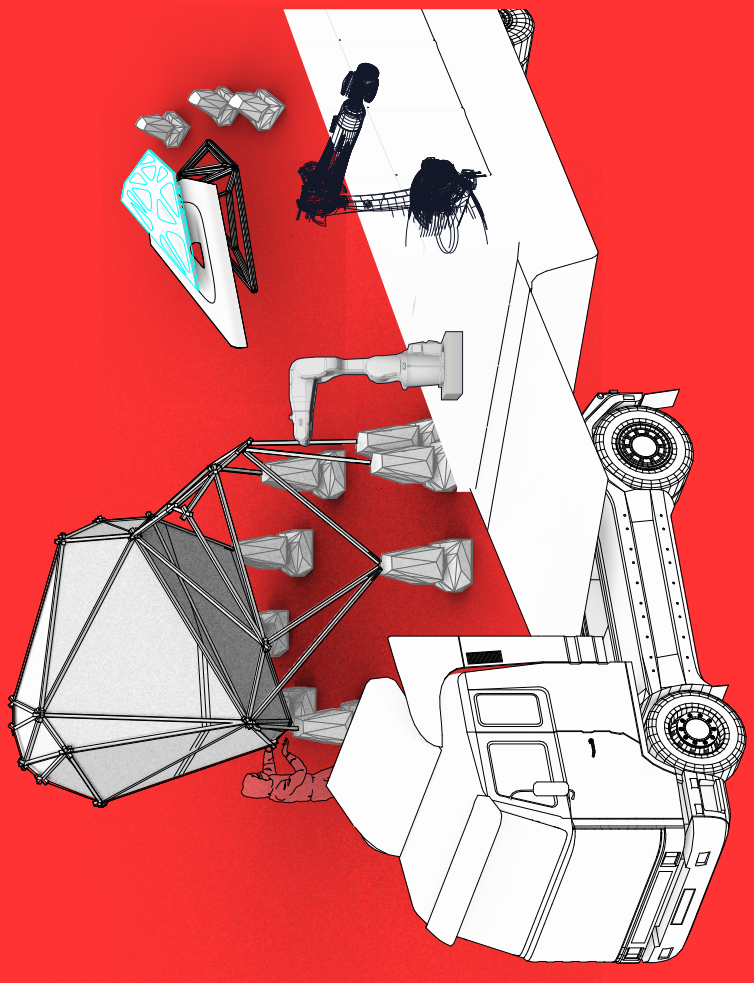














ON-SITE ASSEMBLY

UNIT COMPONENTS

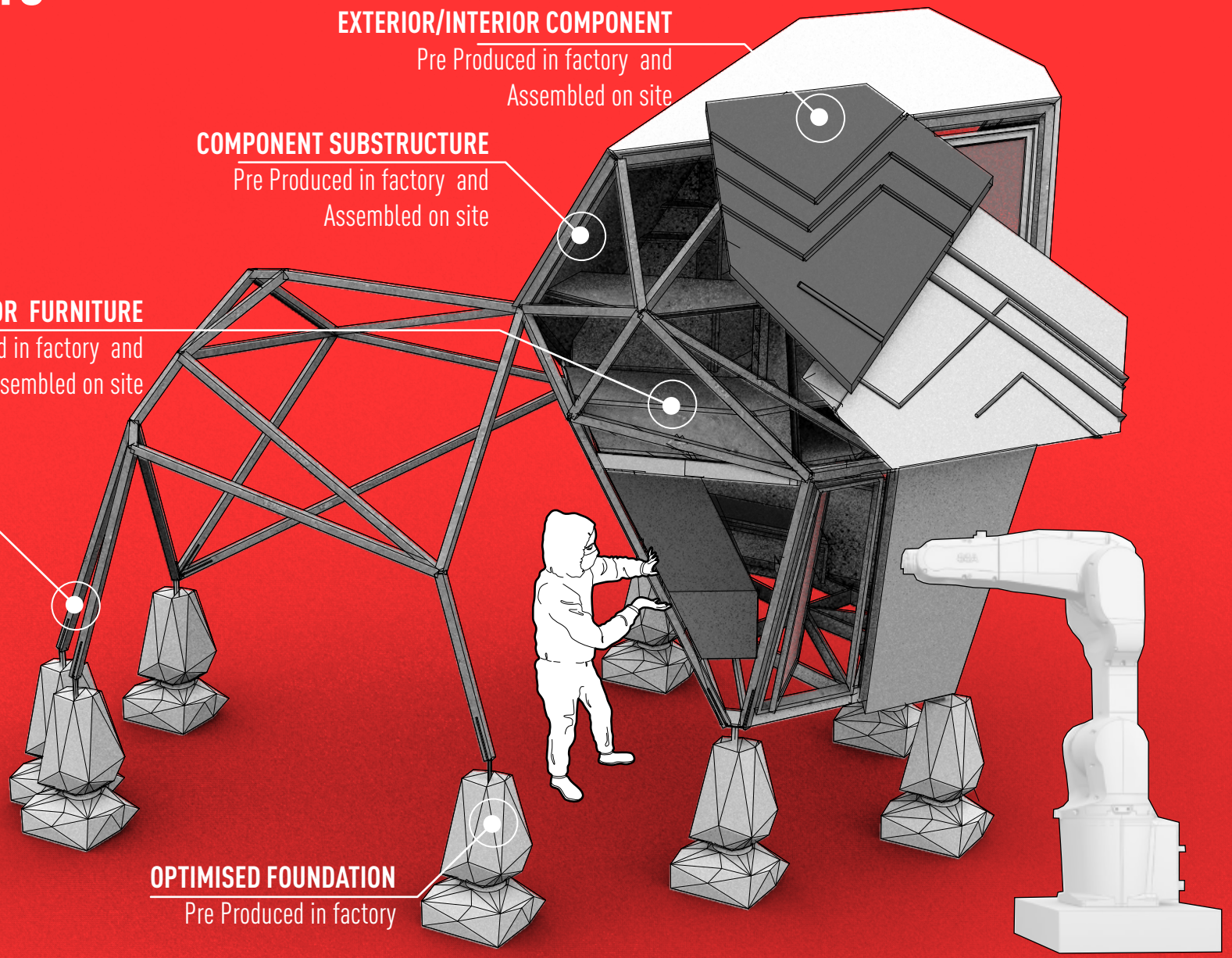
EXTERIOR/INTERIOR COMPONENT
Pre Produced in factory and
Assembled on site

COMPONENT SUBSTRUCTURE
Pre Produced in factory and
Assembled on site

INTERIOR FURNITURE
Pre Produced in factory and
Assembled on site

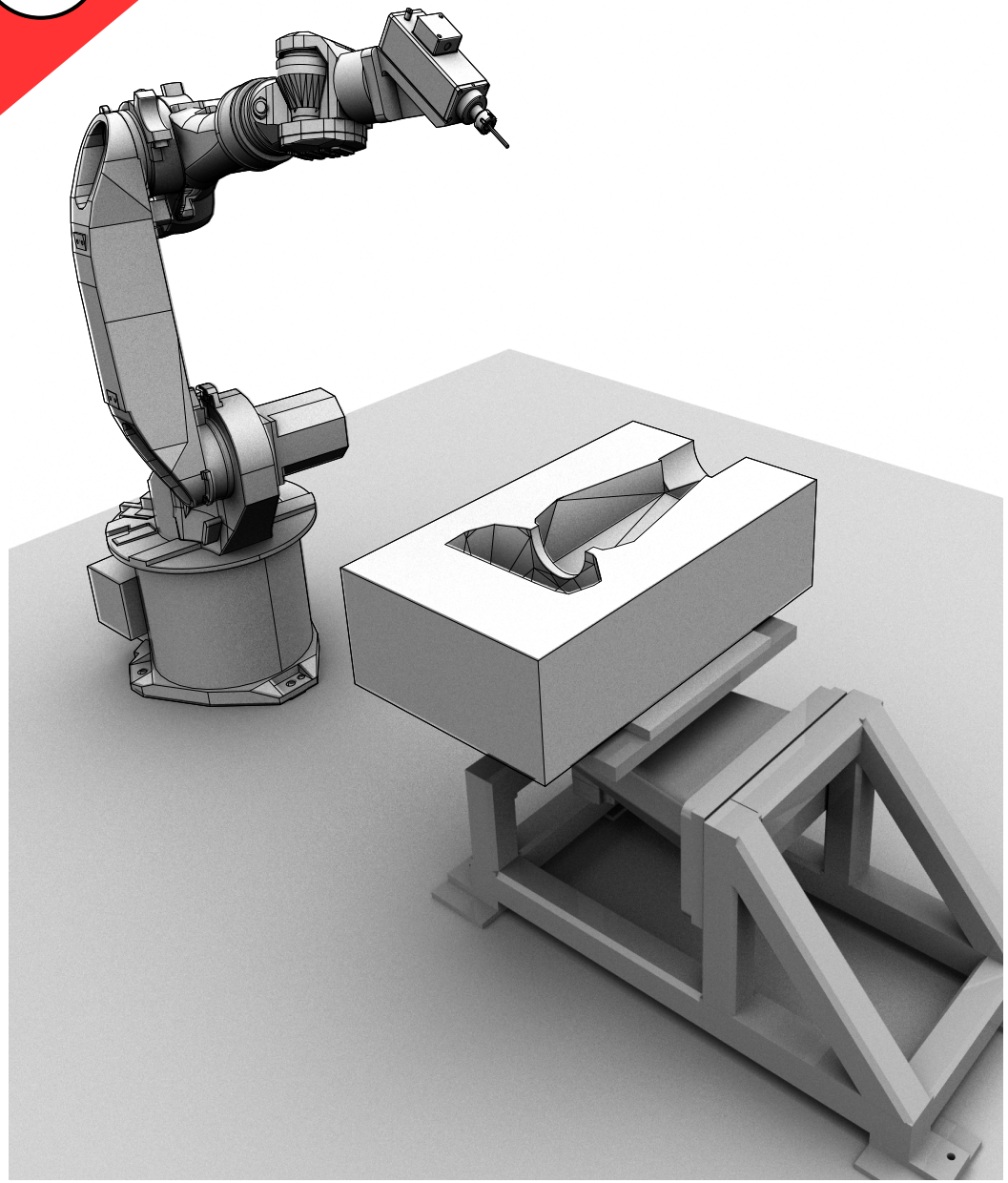
STRUCTURAL FRAMEWORK
On Site Robotic Assembly

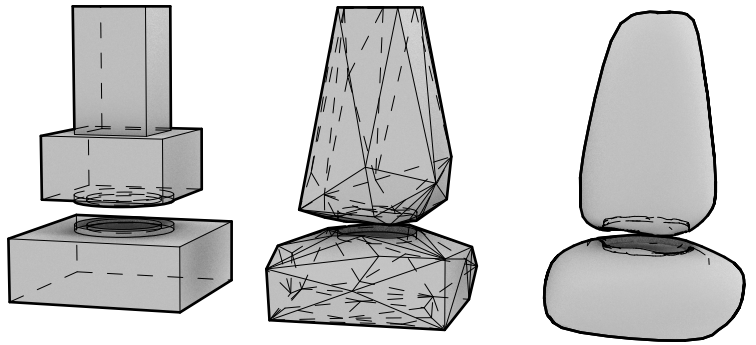
OPTIMISED FOUNDATION
Pre Produced in factory



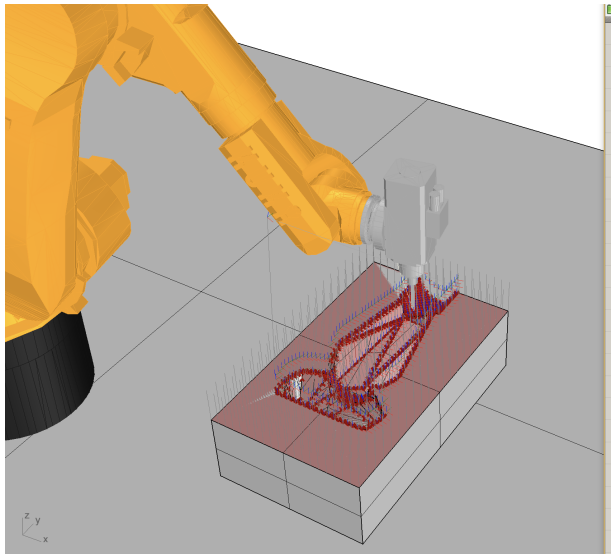
F01

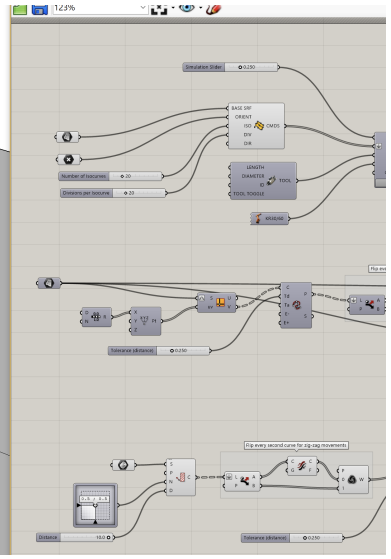
OPTIMISED FOUNDATION
PRE PRODUCED IN FACTORY

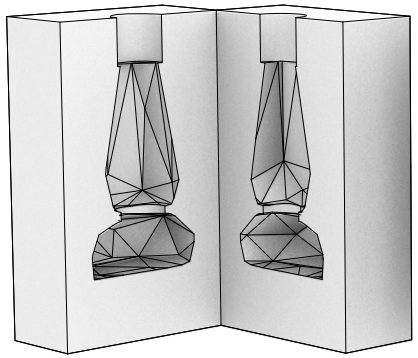




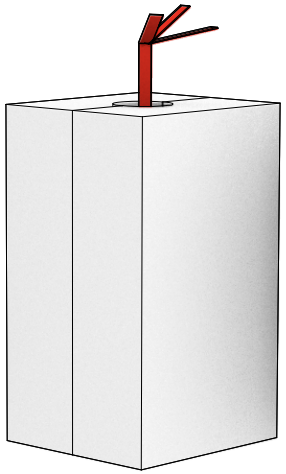
Foundation Optimisation
Topology Variation



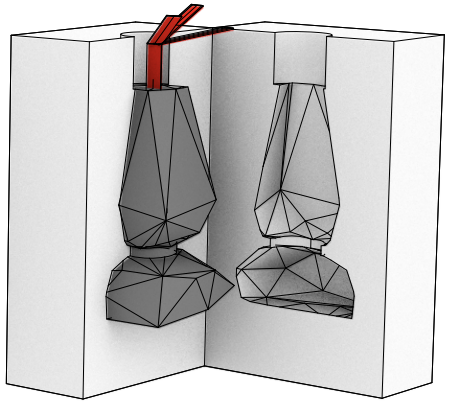




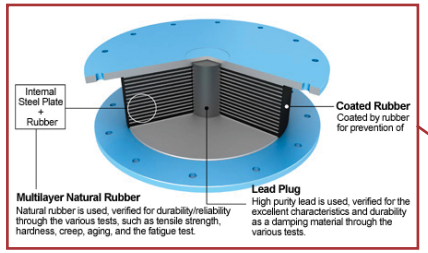
EPS Milling
Concrete Cast Molds



Concrete Casting
Insert of steel joint



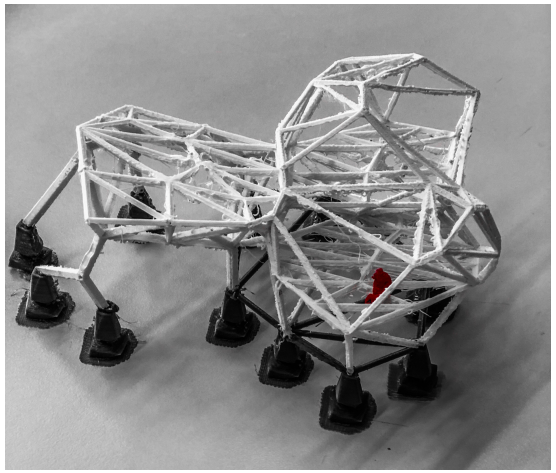
Optimised Foundation
Extraction of casting molds

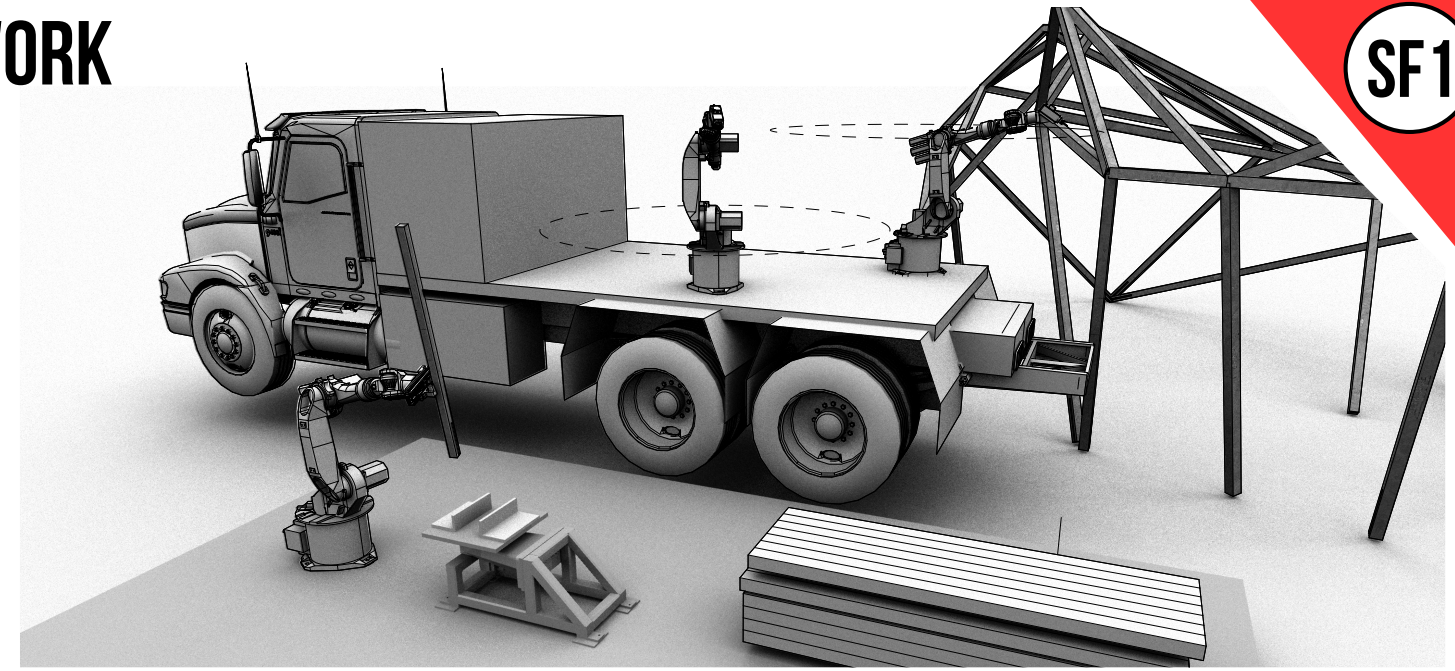


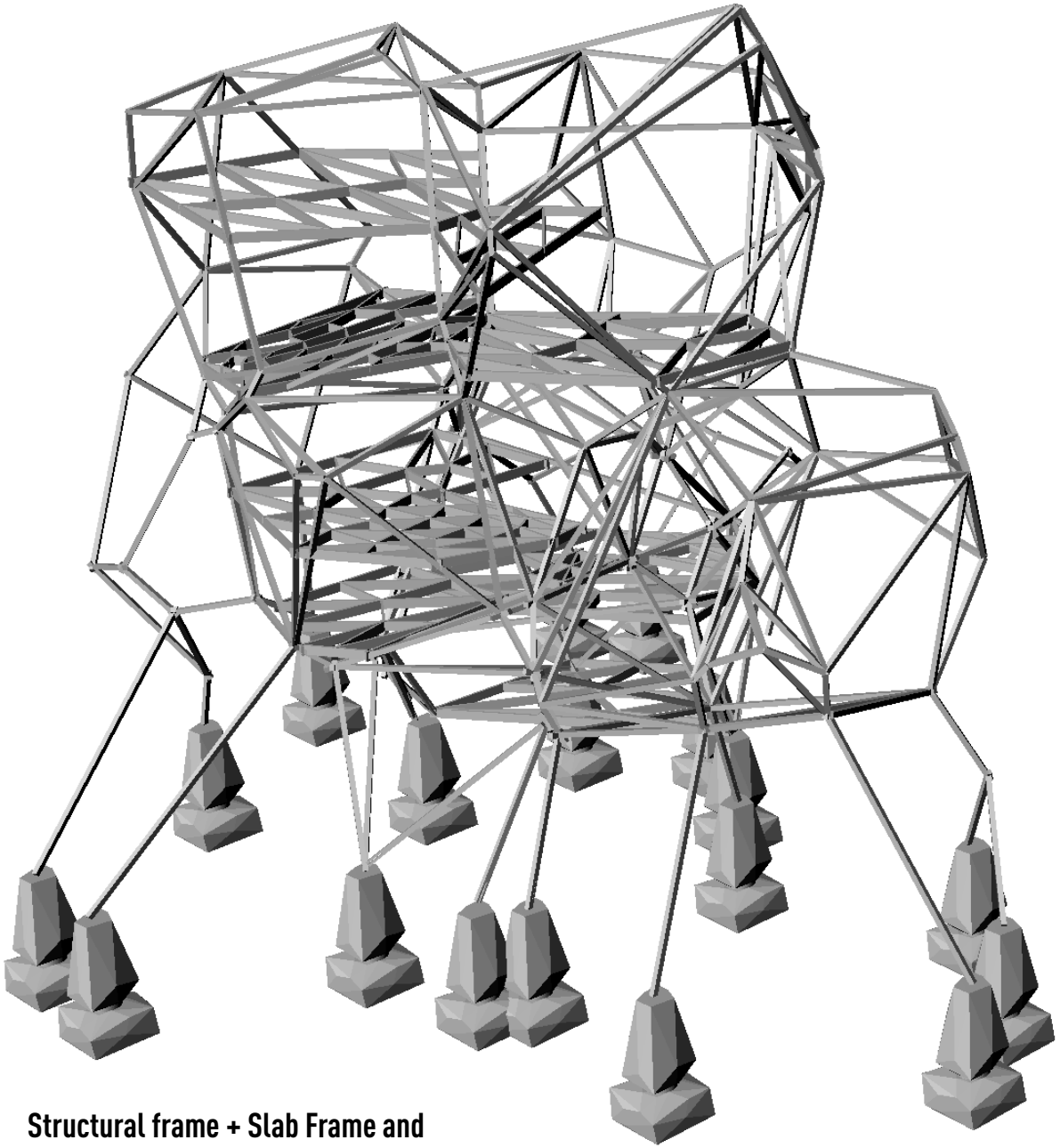
Vibration Damper Detail

STRUCTURAL FRAMEWORK
ON SITE PRODUCTION

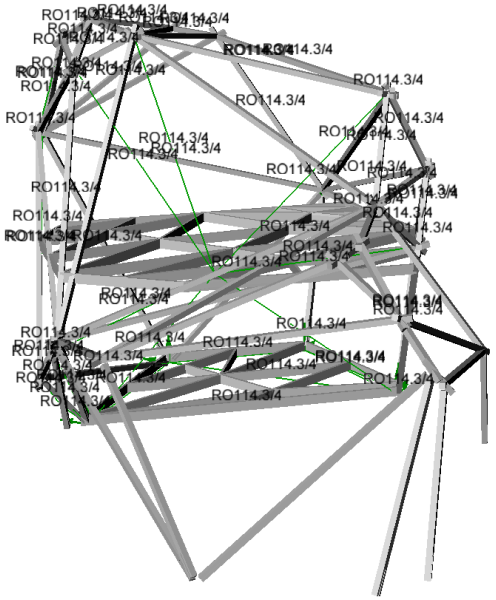
SF 1



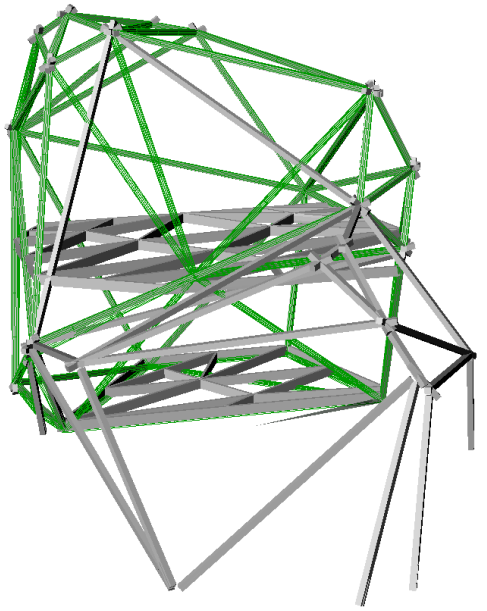




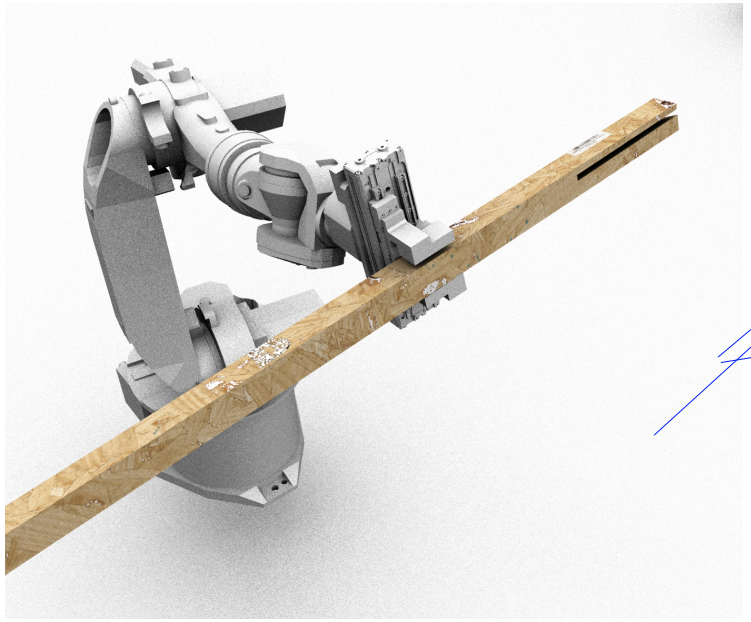
Structural frame + Slab Frame and
connection with foundation

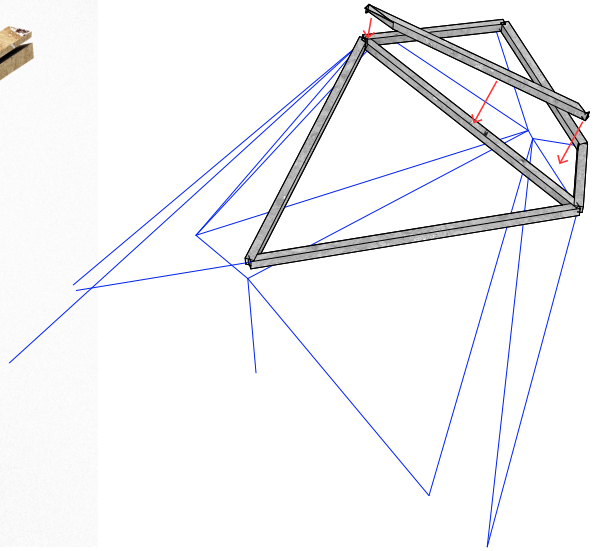


Element Tagging



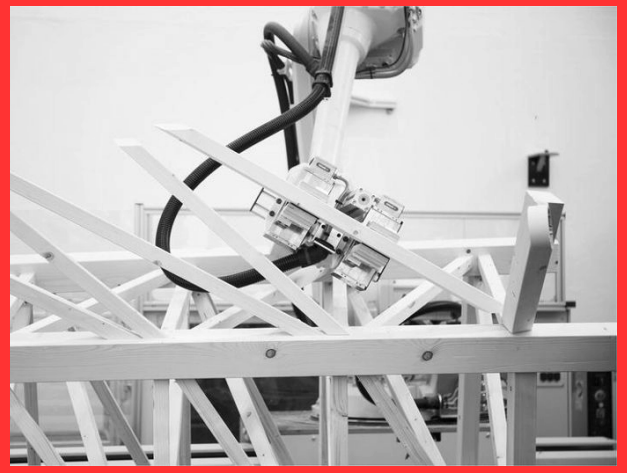
Element Optimisation

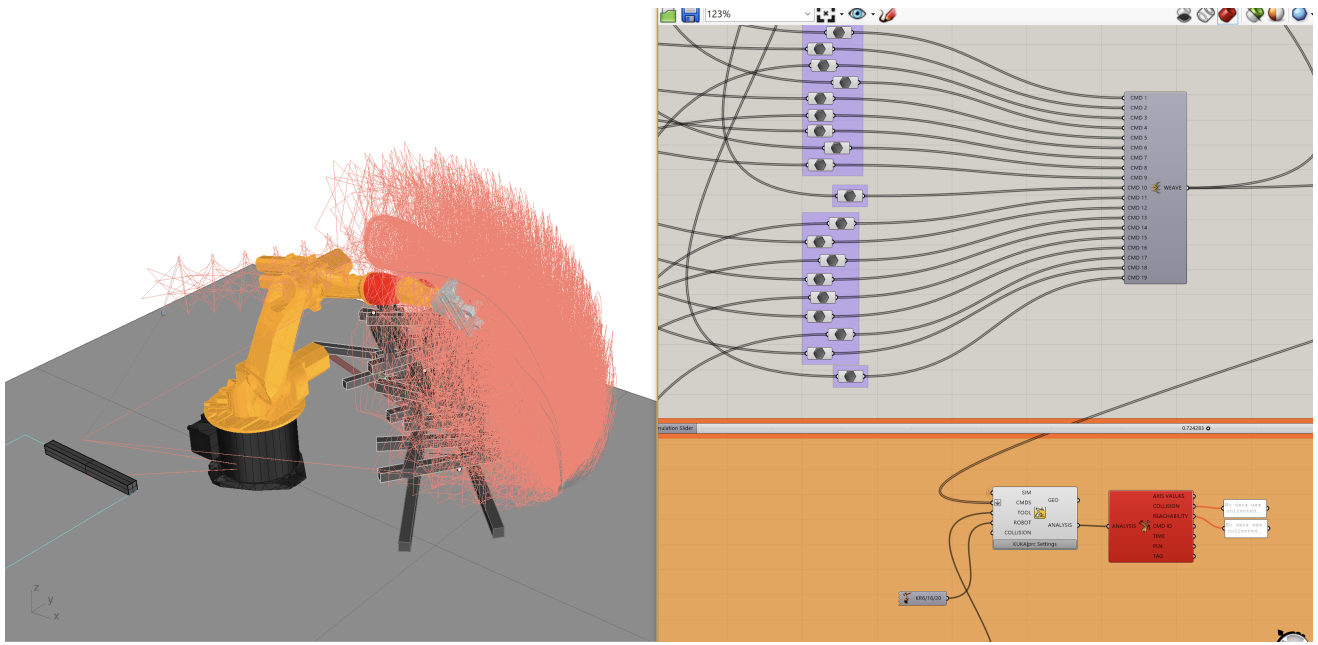






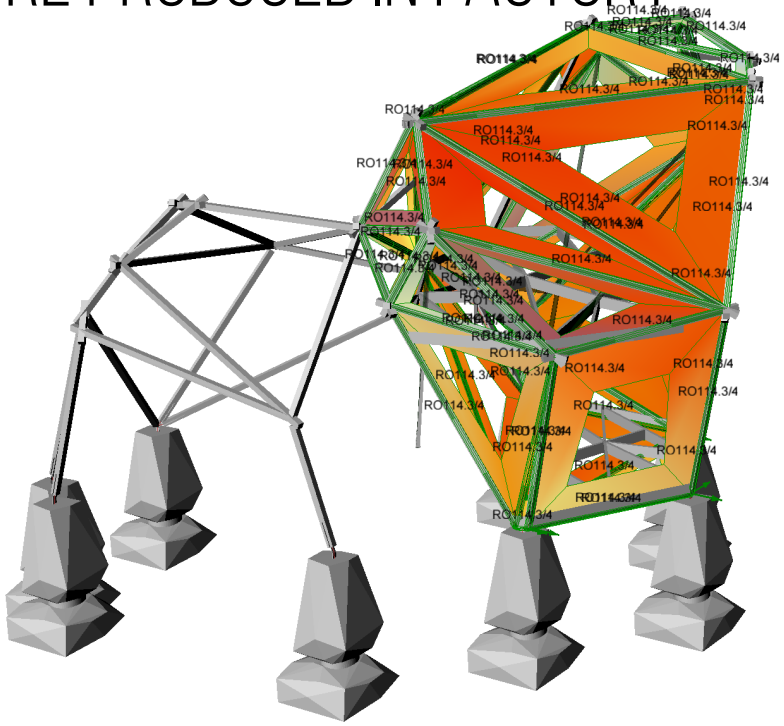


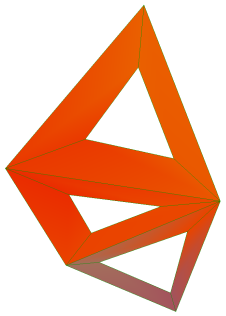




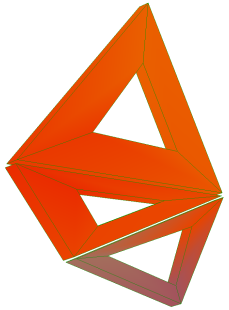
Robotic timber fabrication reference project

COMPONENT SUB-STRUCTURE
PRE PRODUCED IN FACTORY

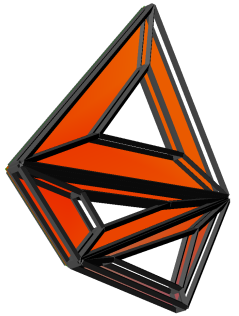




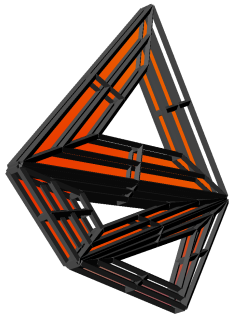
Uptimised Frame



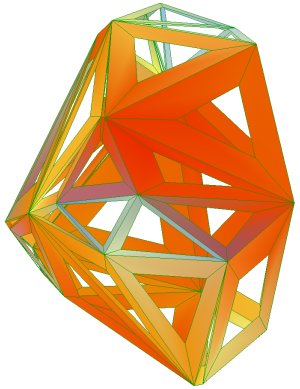
Variable Thickness

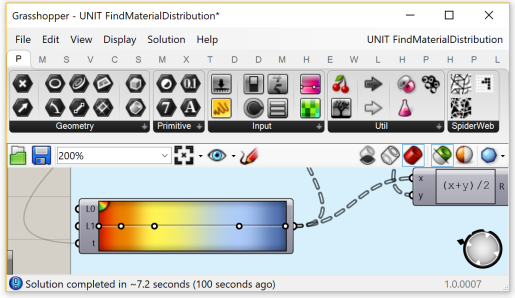


Lightweight Frame

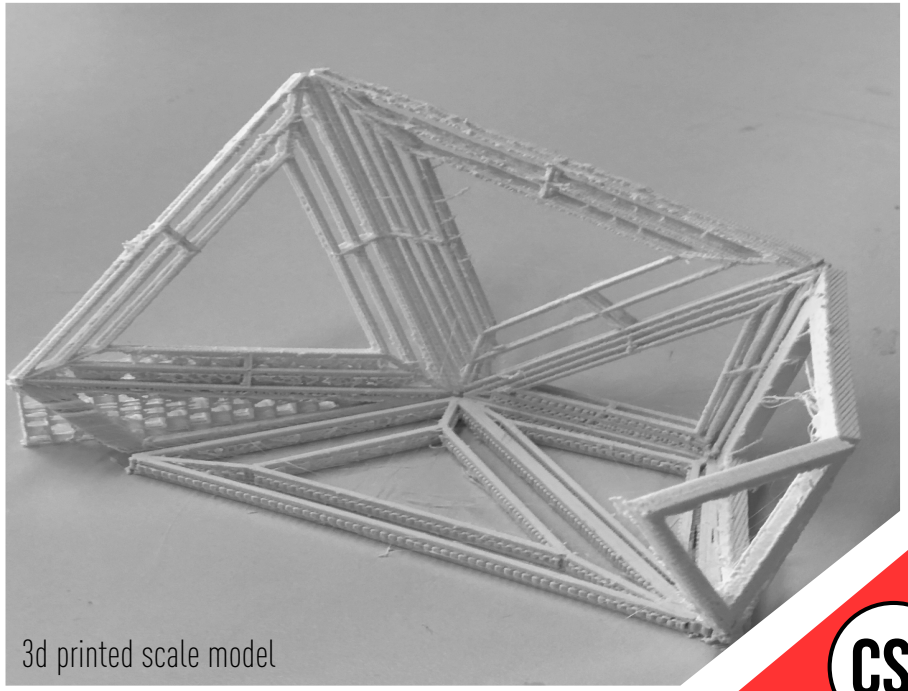


High Resistant Frame





Material distribution internal structural analysis



3d printed scale model

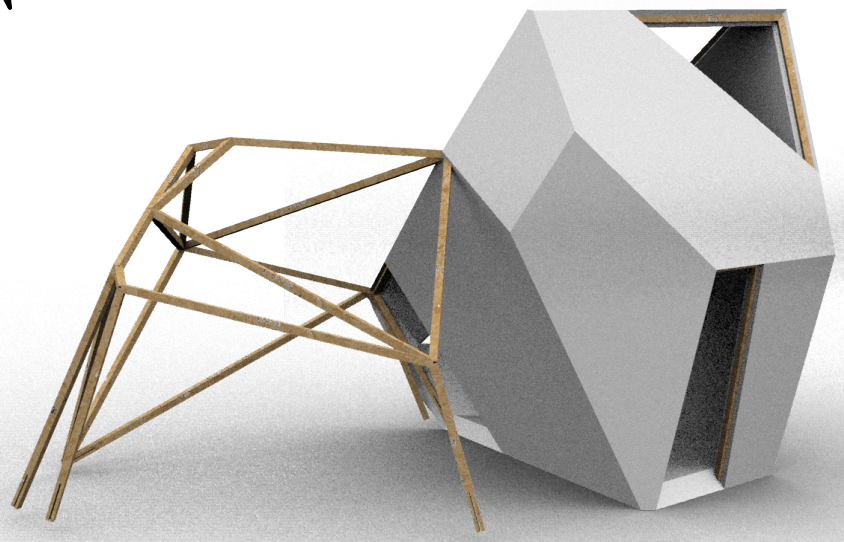
CS1

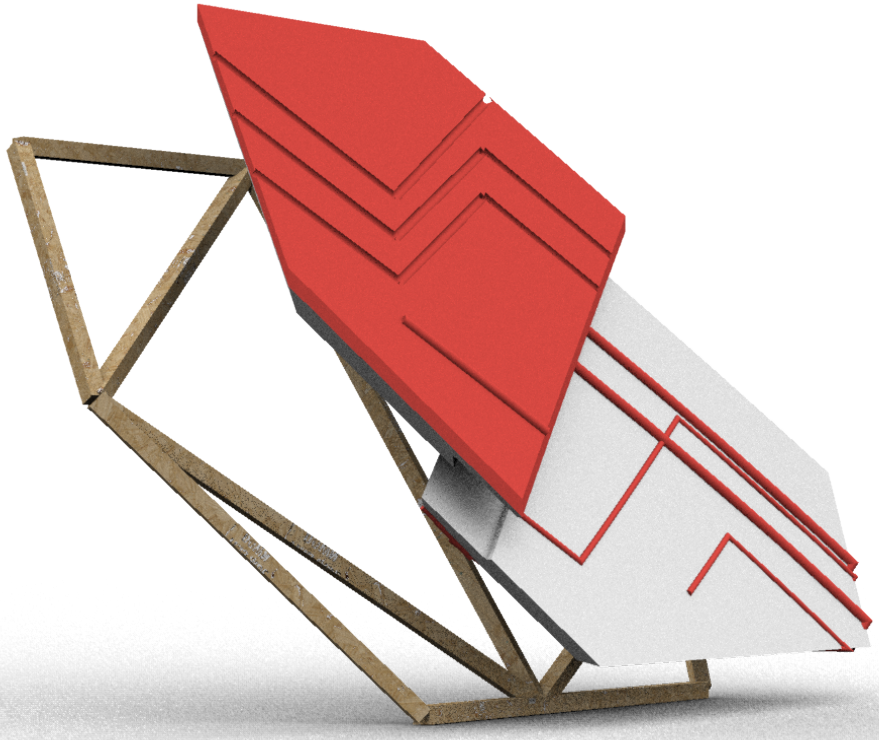
#ARCHITECTUREFORDISASTERRELIEF_MICRO SCALE DESIGN

EIC 1

INTERIOR/EXTERIOR COMPONENT
PRE PRODUCED IN FACTORY







INTERIOR FURNITURE
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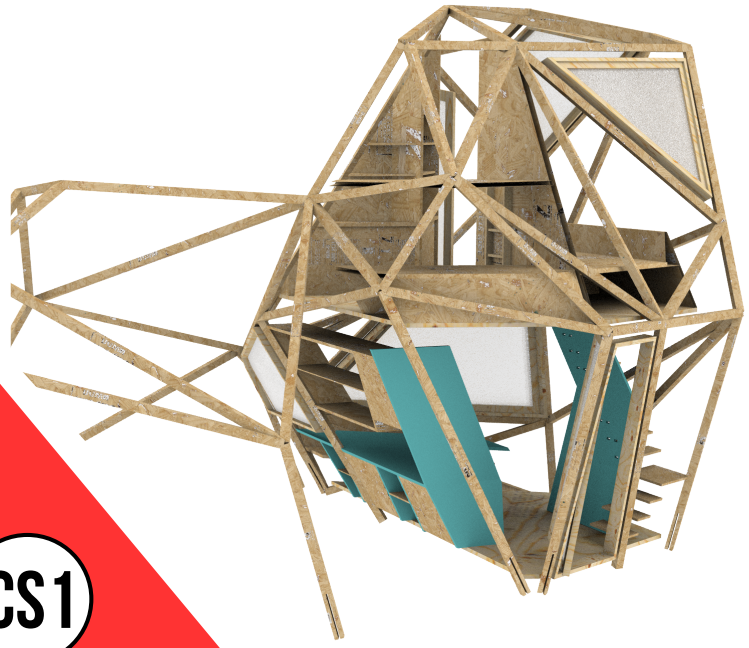
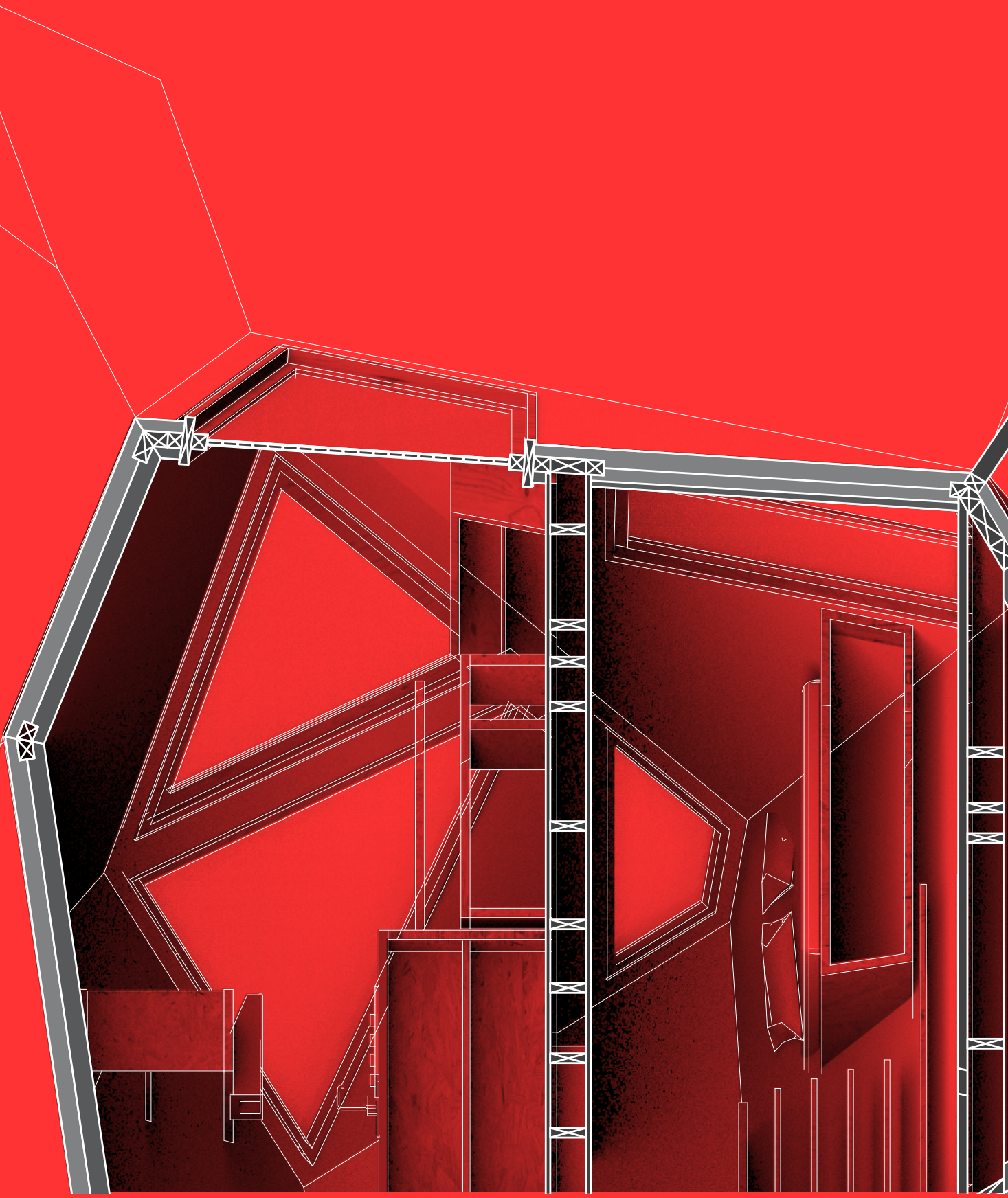
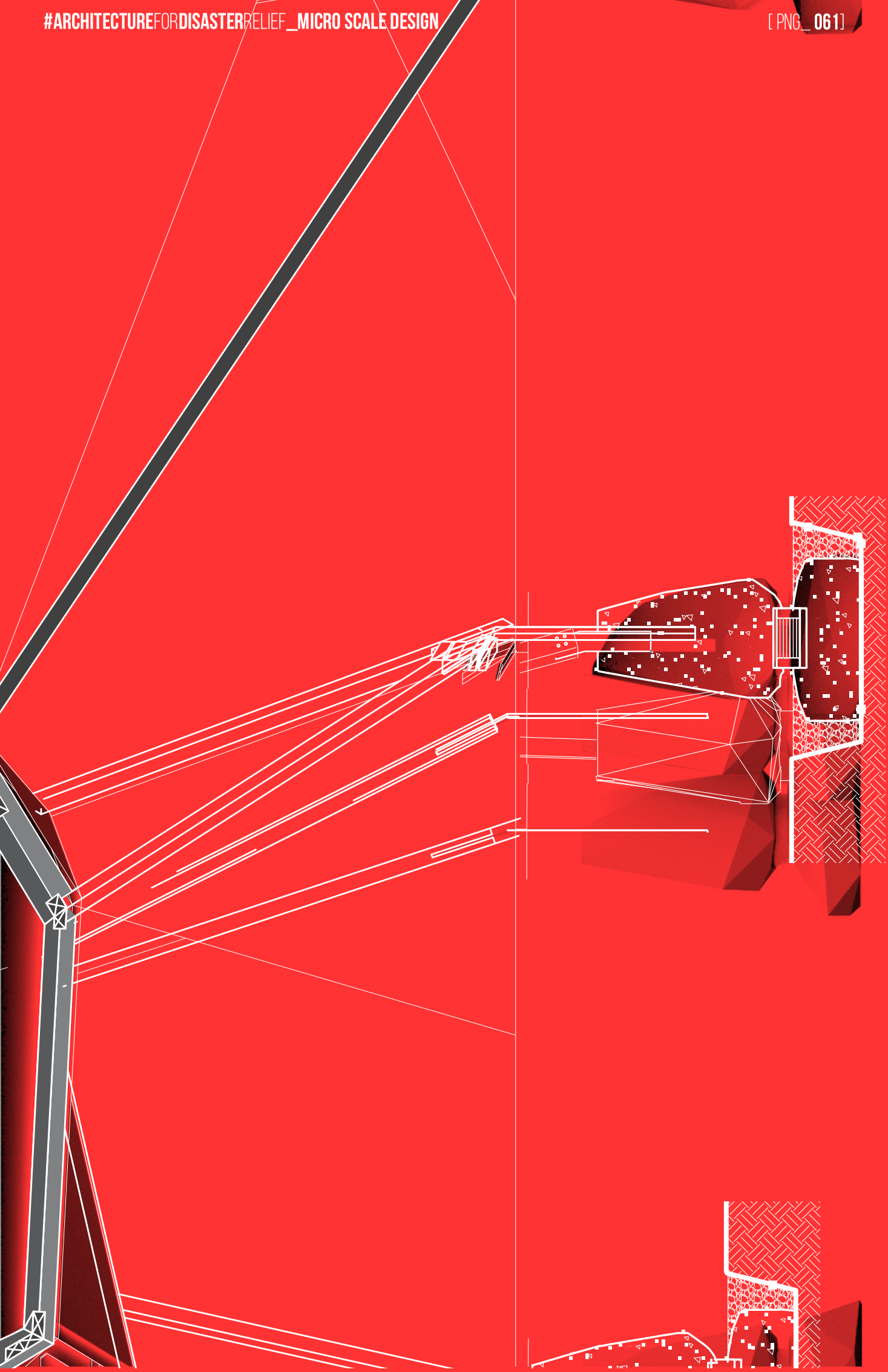


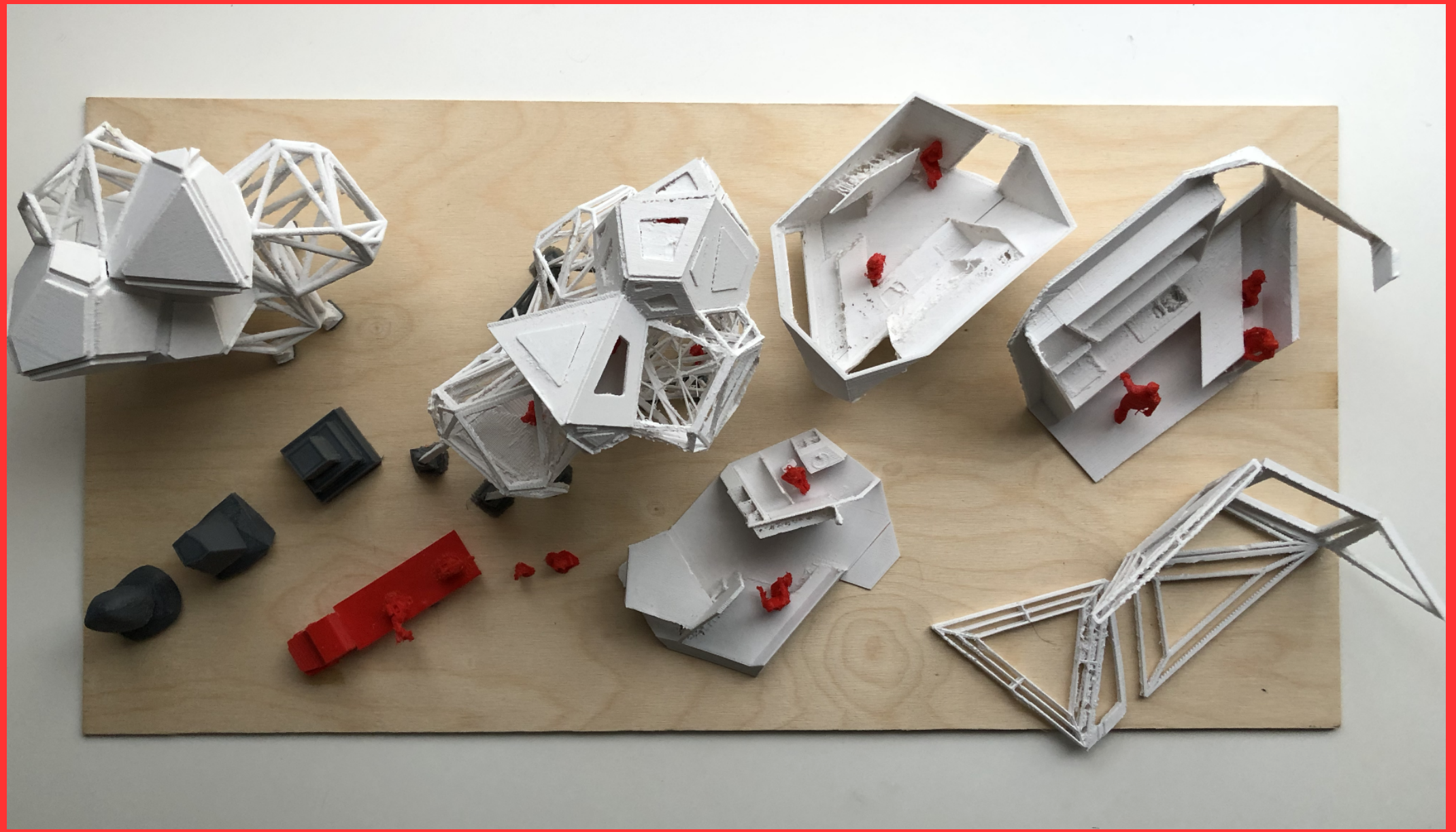


CS1





3D PRINTED PROTOTYPE STUDY



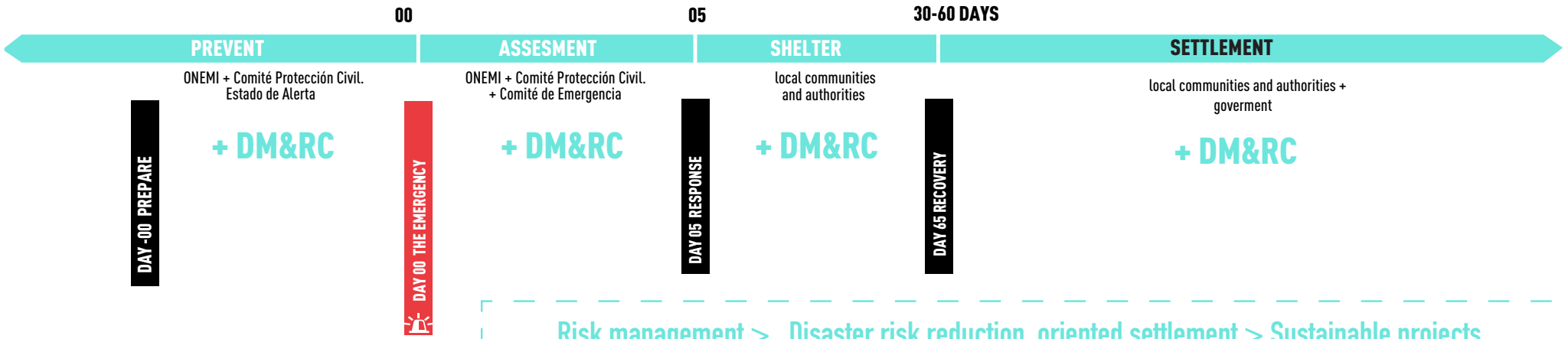
09

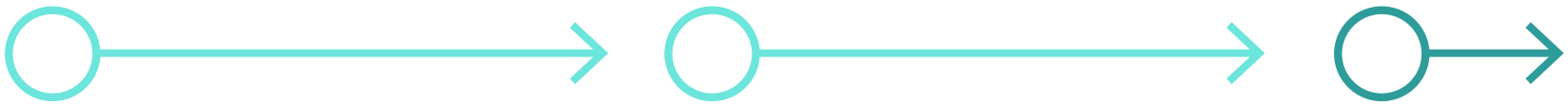
WHAT NEXT?

"The demands of crisis also represent unexpected possibilities, creating opportunities to work in extraordinary situations, as long as we are willing to inmerse ourselves. (...) looks forward to what's next." Ballesteros, M



PREPARE - RESPOND - RECOVER





PRE-PRODUCTION

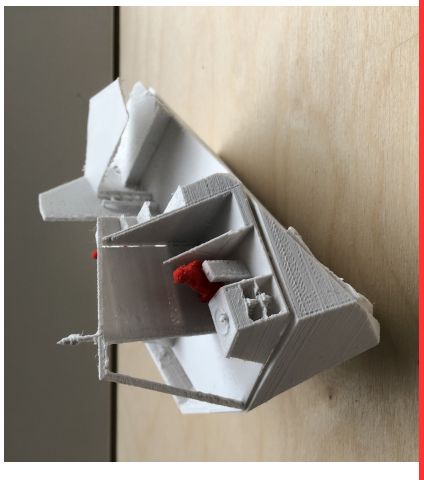
ON-SITE ASSEMBLY AND PRODUCTION

SOCIAL/LOCAL CUSTOMISATION





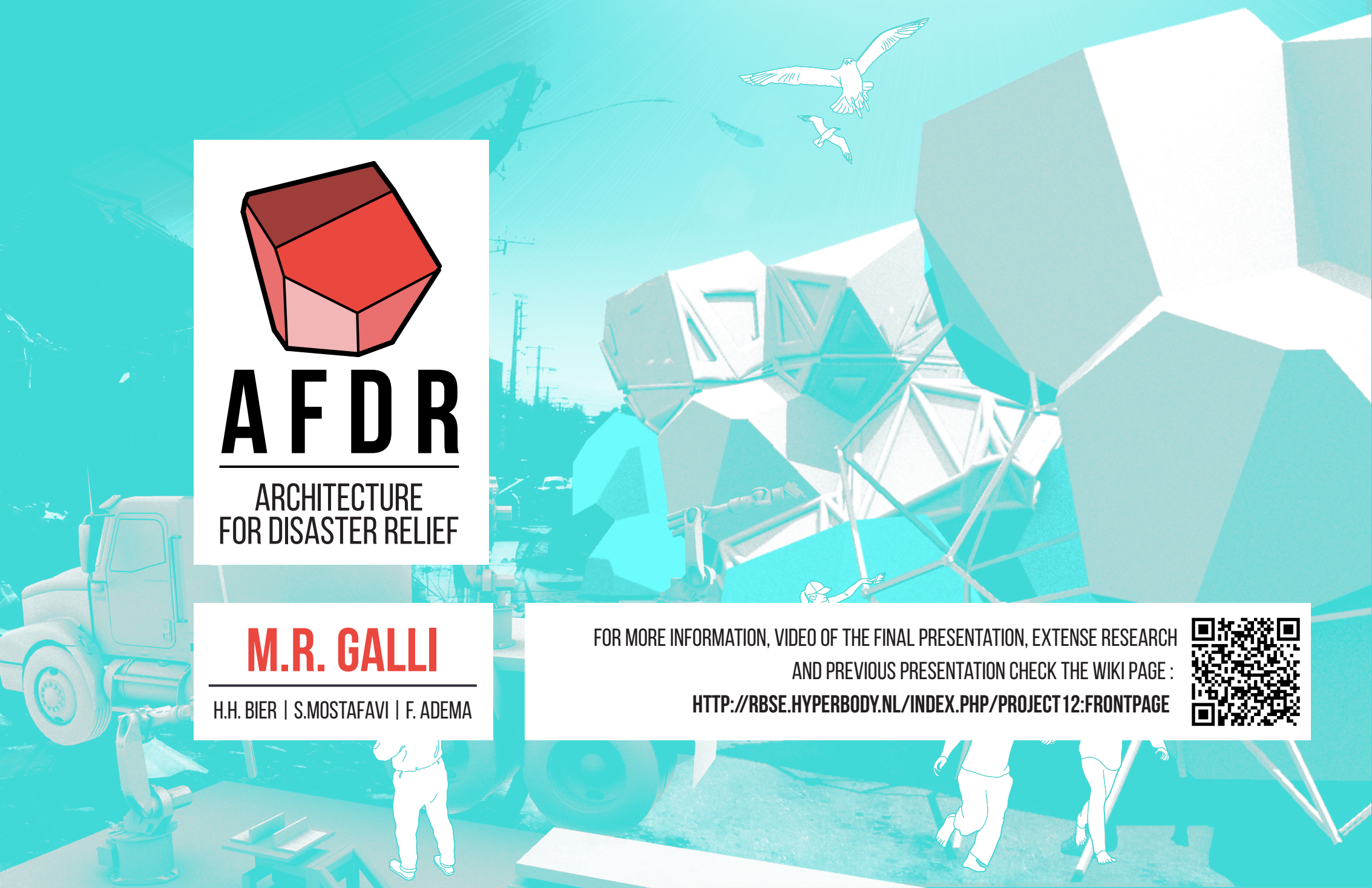












AFDR

ARCHITECTURE
FOR DISASTER RELIEF

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FOR MORE INFORMATION, VIDEO OF THE FINAL PRESENTATION, EXTENSE RESEARCH
AND PREVIOUS PRESENTATION CHECK THE WIKI PAGE :

HTTP://RBSE.HYPERBODY.NL/INDEX.PHP/PROJECT12:FRONTPAGE



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