

P5

HOW TO INTEGRATE  
SOFT ROBOTICS  
INTO BUILT ENVIRONMENT?

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5103908

GOAL ●

DEVELOPING A COMPUTATIONAL DESIGN APPROACH FOR INTEGRATING SPATIAL EXPERIENCE INTO DESIGN ●

WAYS TO INTEGRATE SOFT ROBOTICS INTO AN ARCHITECTURAL DESIGN APPROACH ●



***“The future of architecture will be soft and hairy.” - Salvador Dalí***

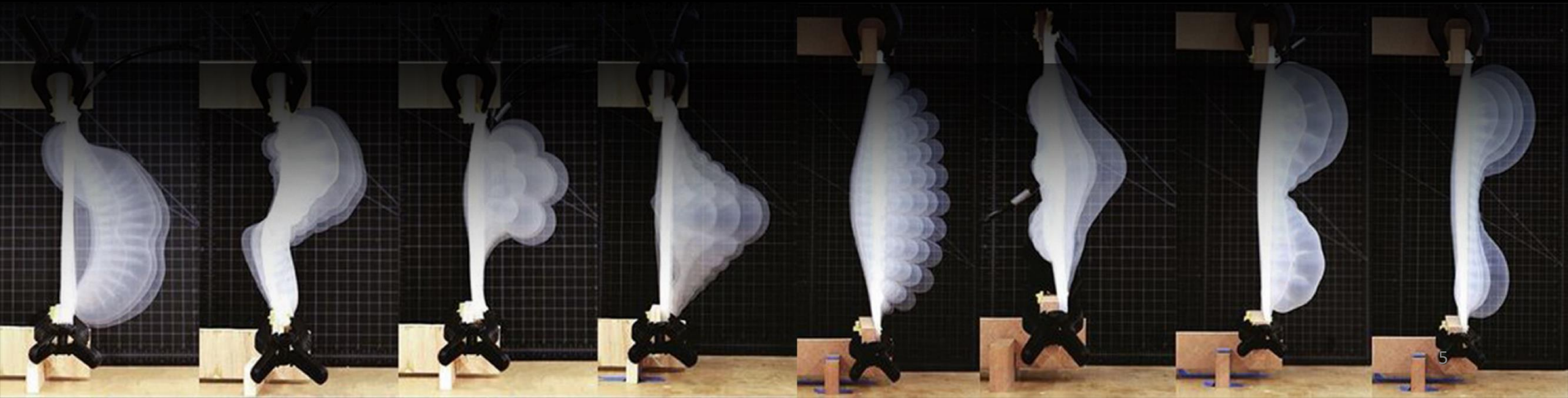
***“In listening to me, Le Corbusier had the look of one who had swallowed gall.”***

***The occasion was a self-reported conversation that the ubiquitous surrealist artist had with that other unavoidable figure, Le Corbusier, in 1922.***

# SOFTSCAPE



*“Soft robotics is a general term that covers all types of active and reactive compliant systems ranging from soft actuators, soft stretchable sensors, soft energy harvesting, and even soft electronics. These machines are largely constructed from soft materials (e.g. silicone) and most commonly powered by flow of fluids (e.g. air and liquid).”*





ROBOTICS IN ARCHITECTURE

INFLATABLE ARCHITECTURE

BOLD

PLAYFUL

INTERACTIVE

ATION

CIRCULATION

EXPERIENCES

FUNCTIONAL

FIGURABLE

SENSOR CONTROL

PHYSICAL + TEMPORAL

CIRCULATION

STATIC + DYNAMIC

HARD + SOFT

COMPUTATION

MOVEMENTS

FUNCT

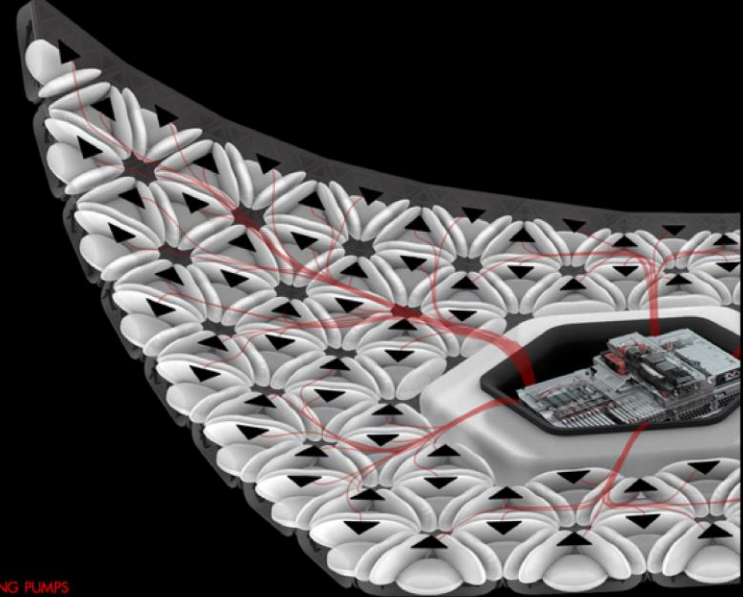
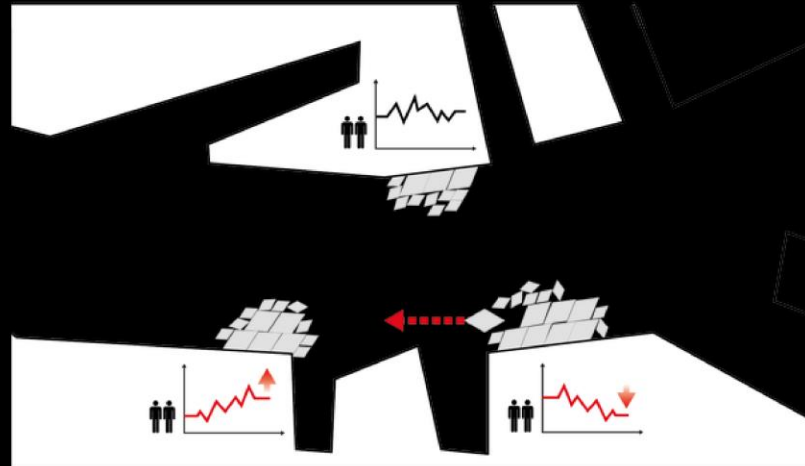
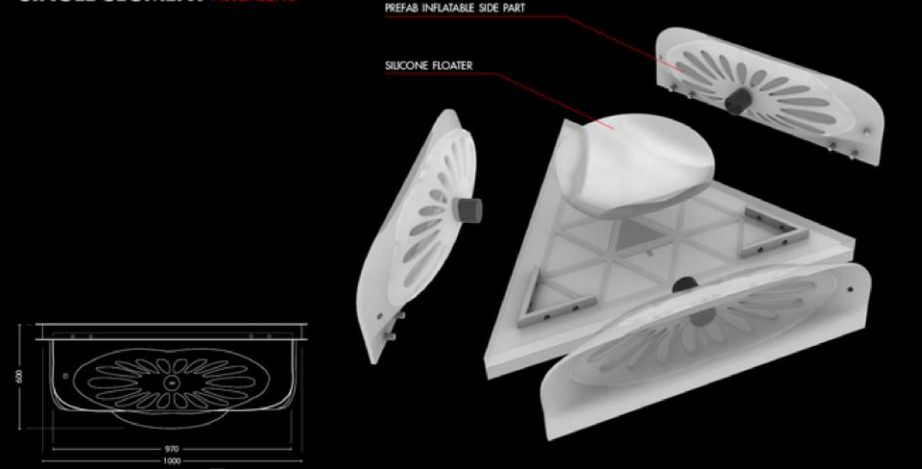
ENCES

RECONFIGURABLE

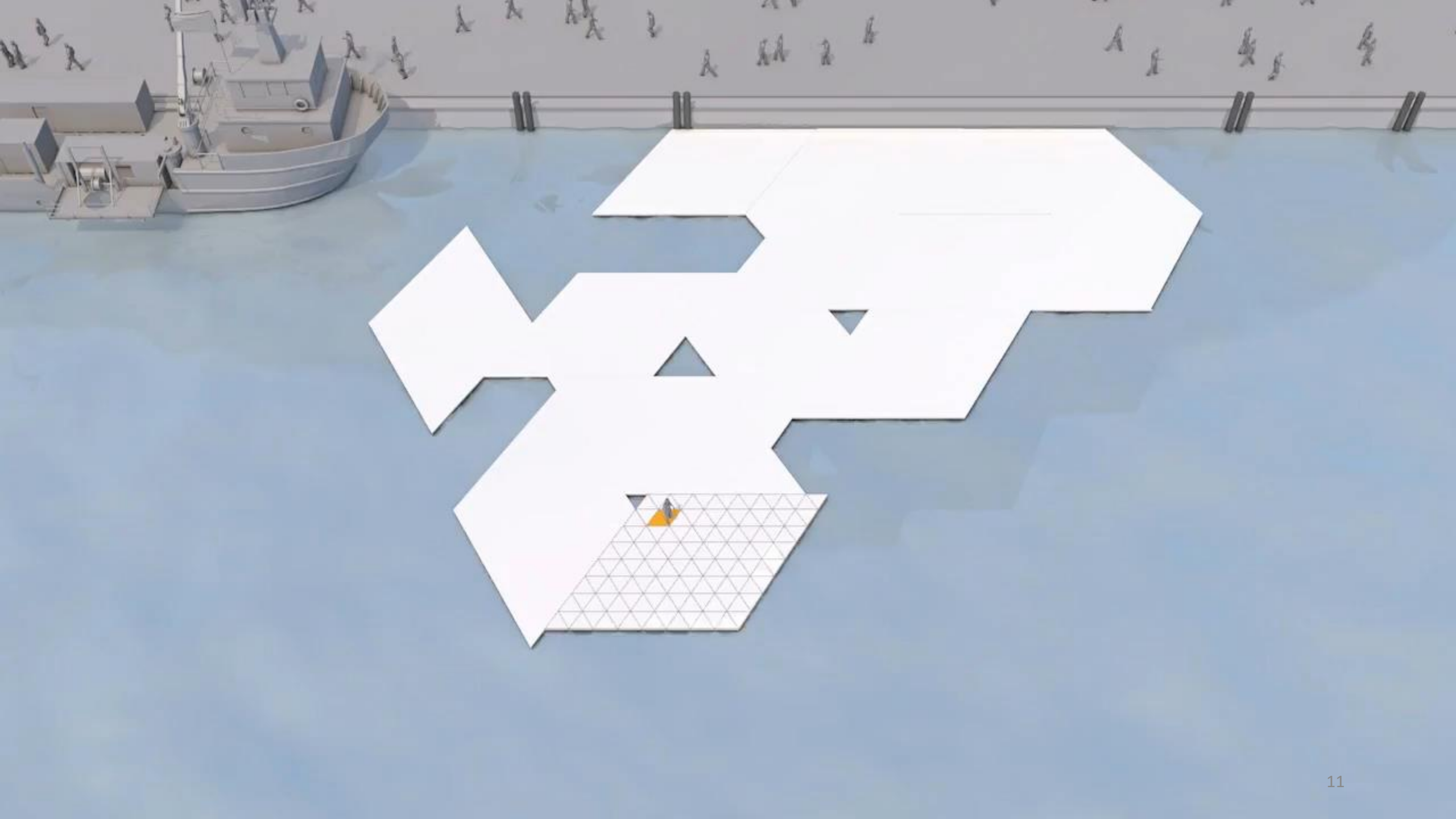


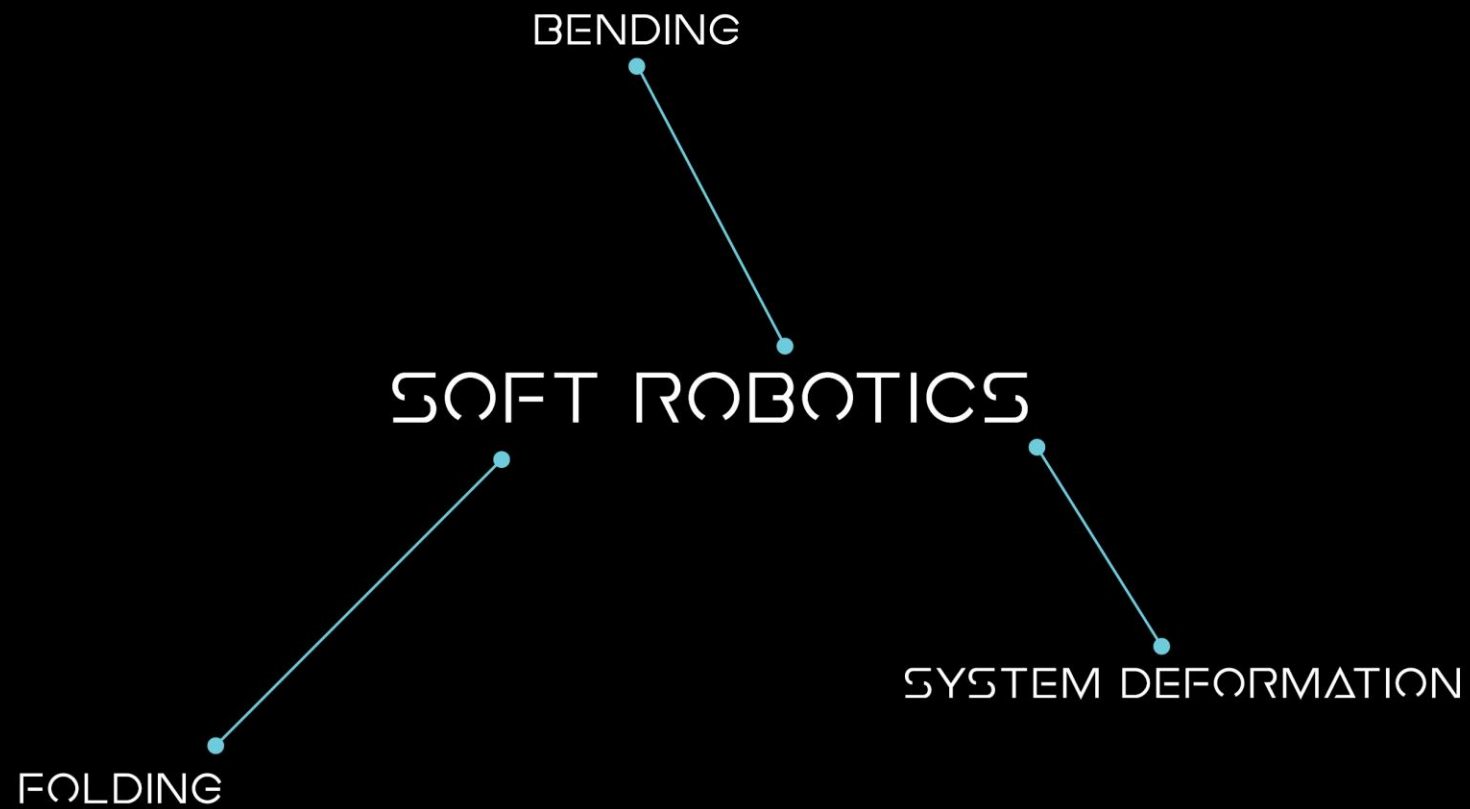


## SINGLE SEGMENT ASSEMBLY

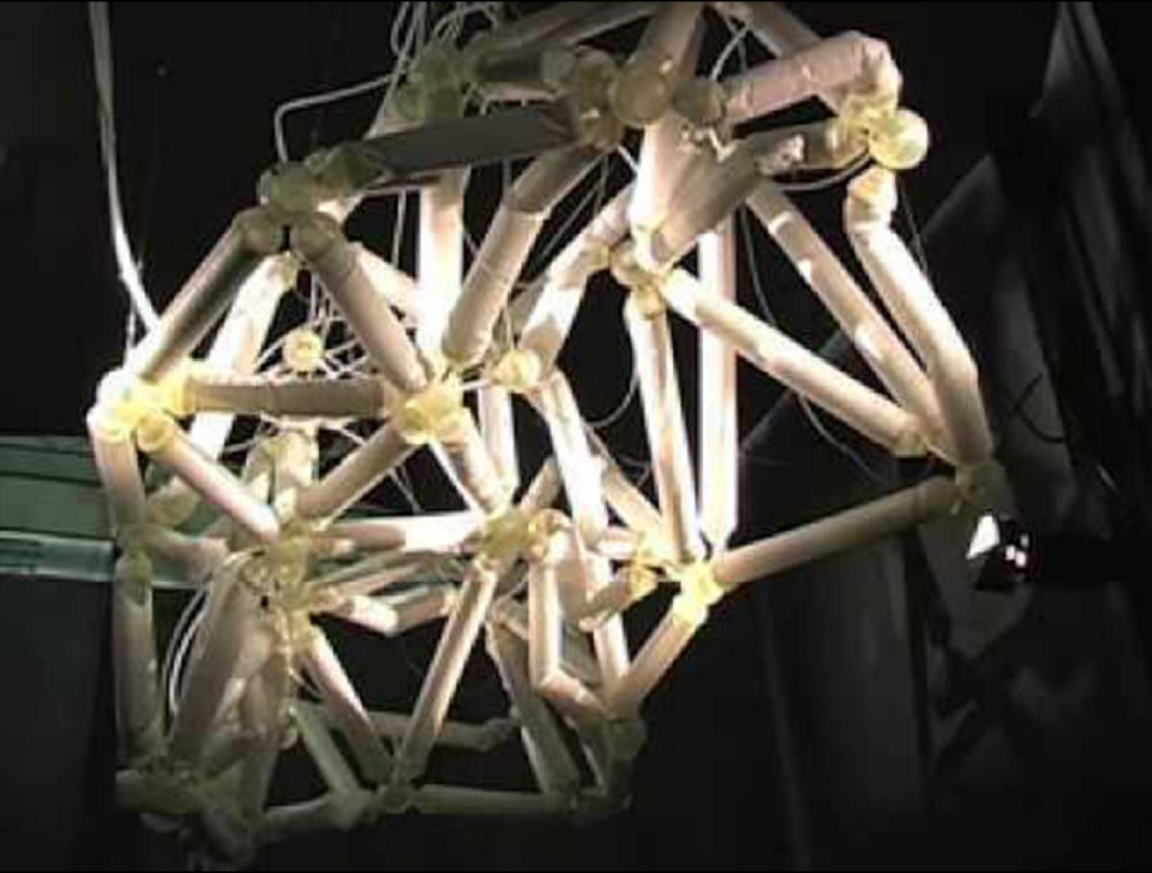


OLLING PUMPS



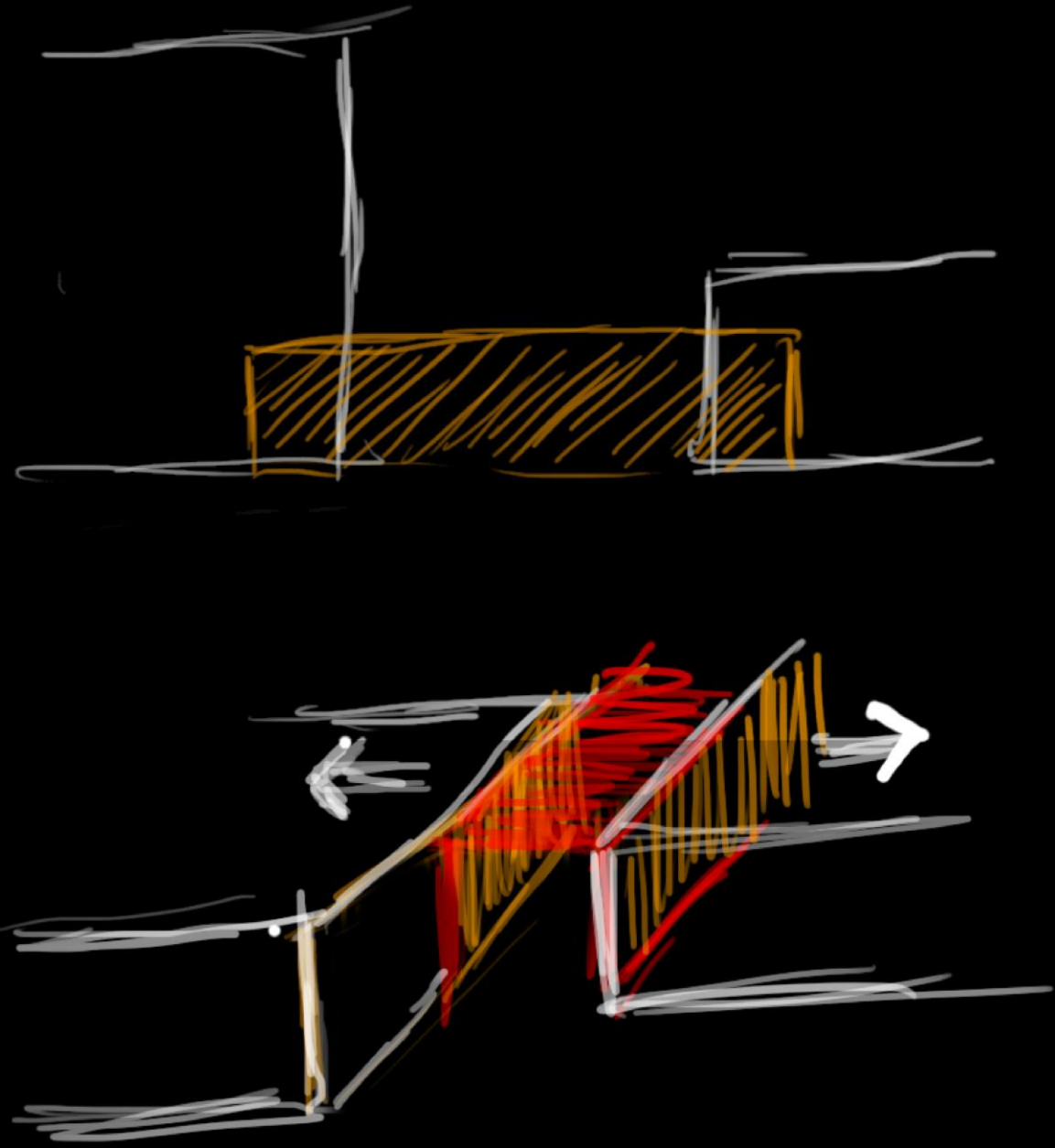


# SOFT ROBOTIC SYSTEM FOR SPATIAL DEFORMATION

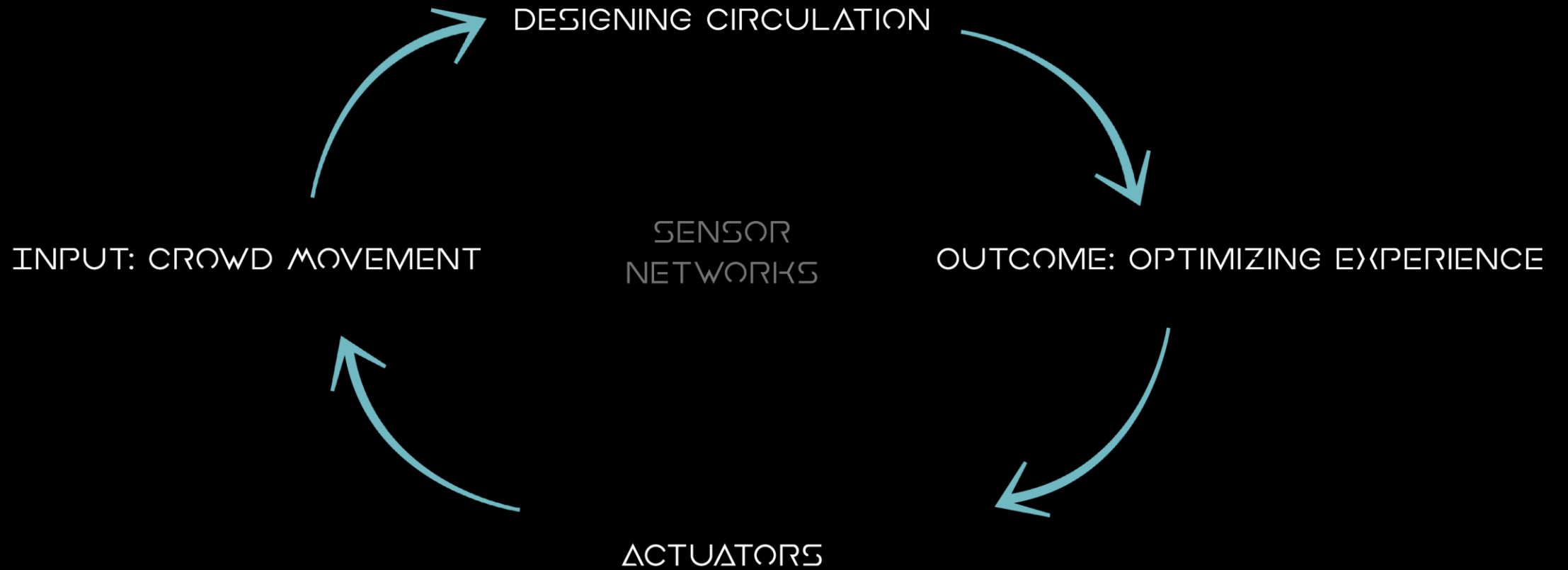




# LATTICE DEFORMATION



# ESTABLISHING A FEEDBACK LOOP



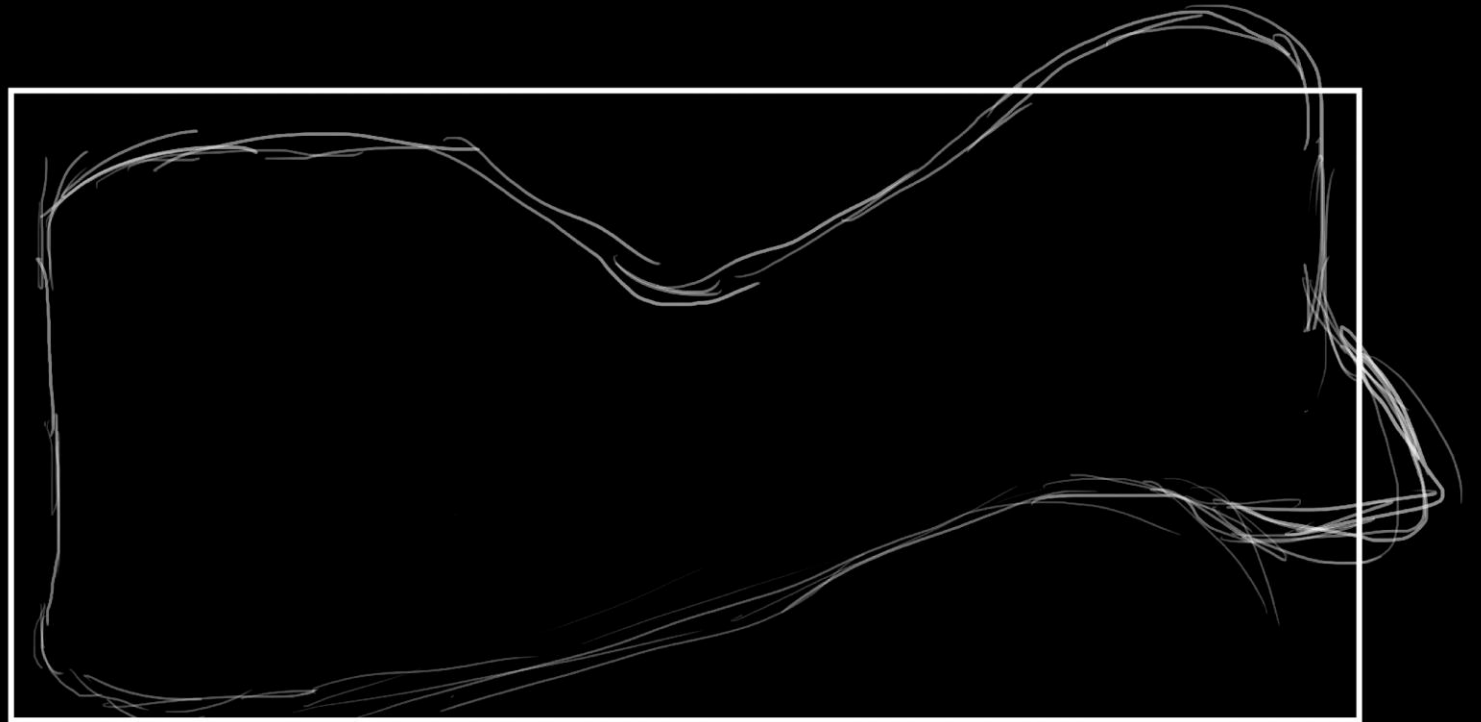
# LAYERS OF SPATIAL HYBRIDITY

1. MATERIAL INTELLIGENCE

2. RESPONSIVE

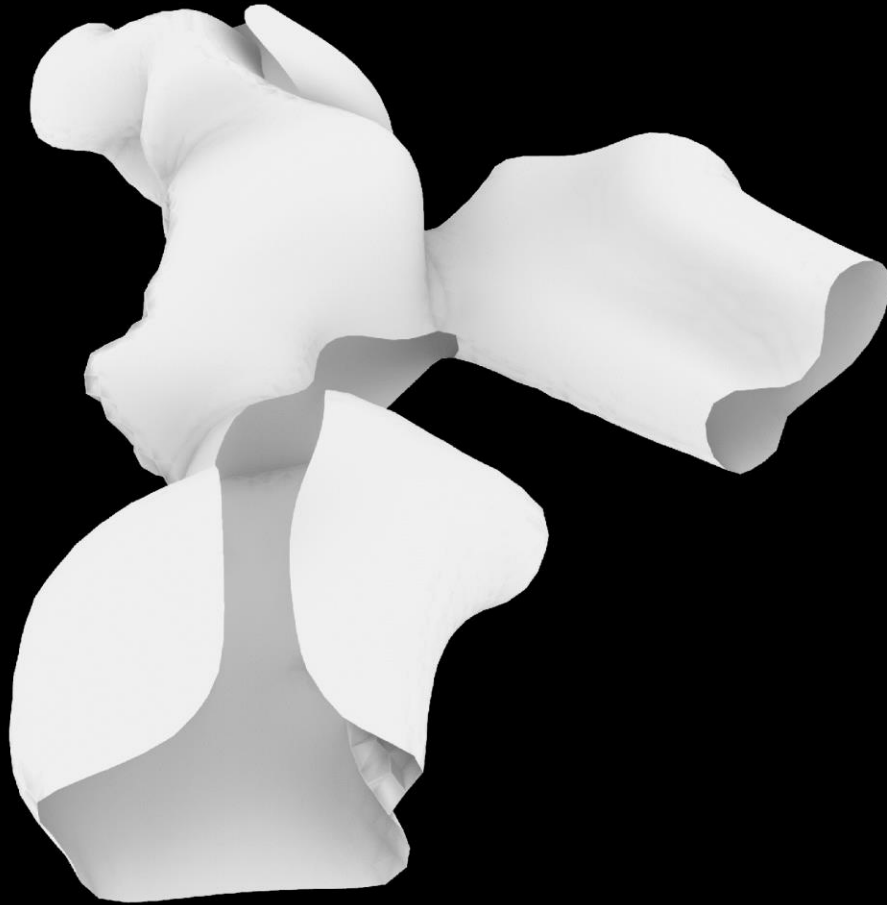
3. IMMERSIVE

4. INTERACTIVE

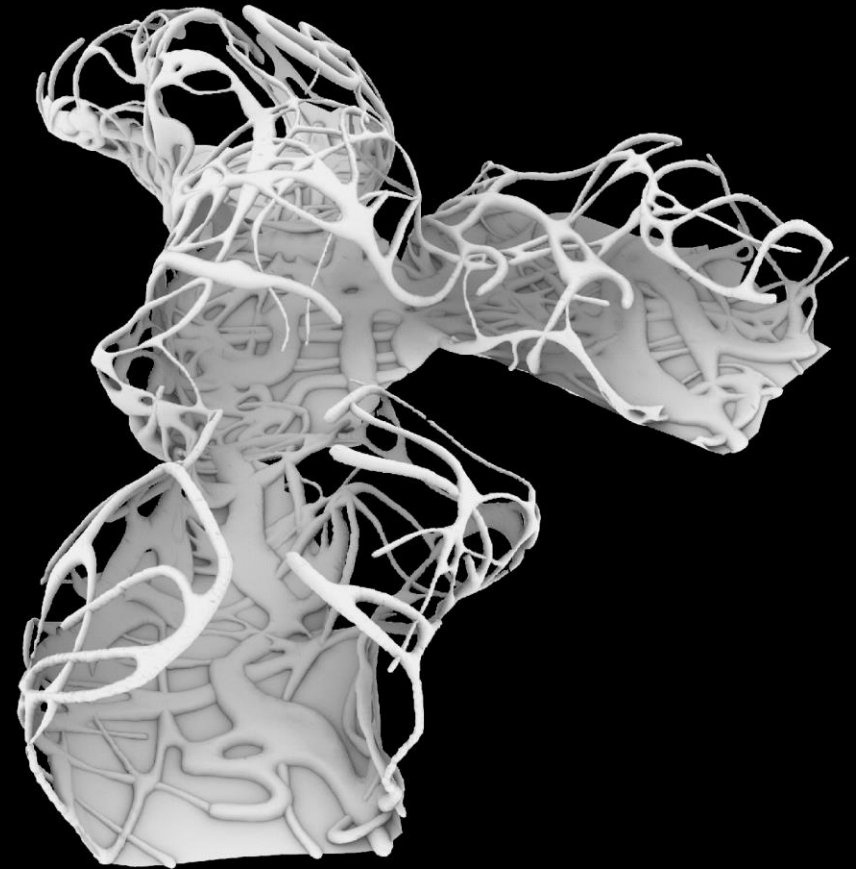


# WORKSHOP

# WORKSHOP - CIRCULAR WOOD PAVILION

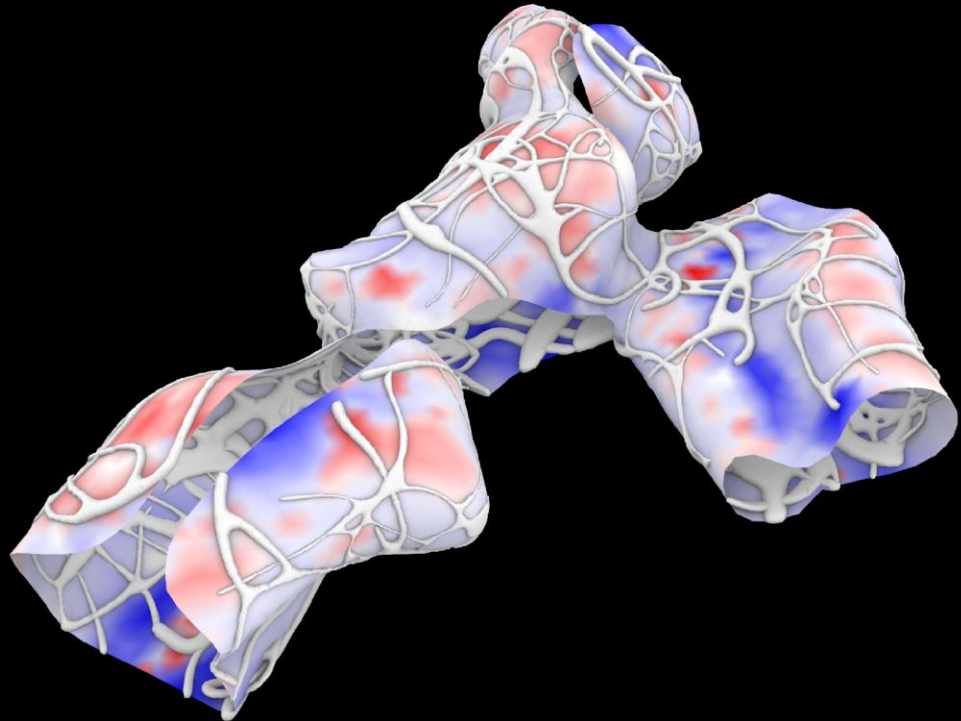
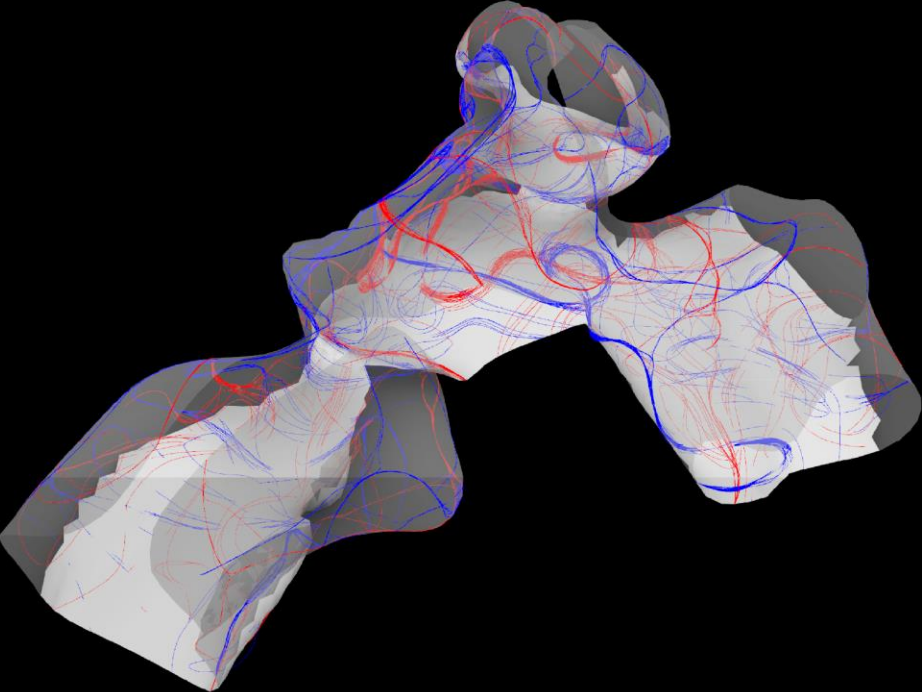


3D MODEL



BEAMS GENERATED

# STRUCTURAL ANALYSIS



# PROTOTYPING



# CURVILINEAR WOODEN BEAMS



# SITE STUDY

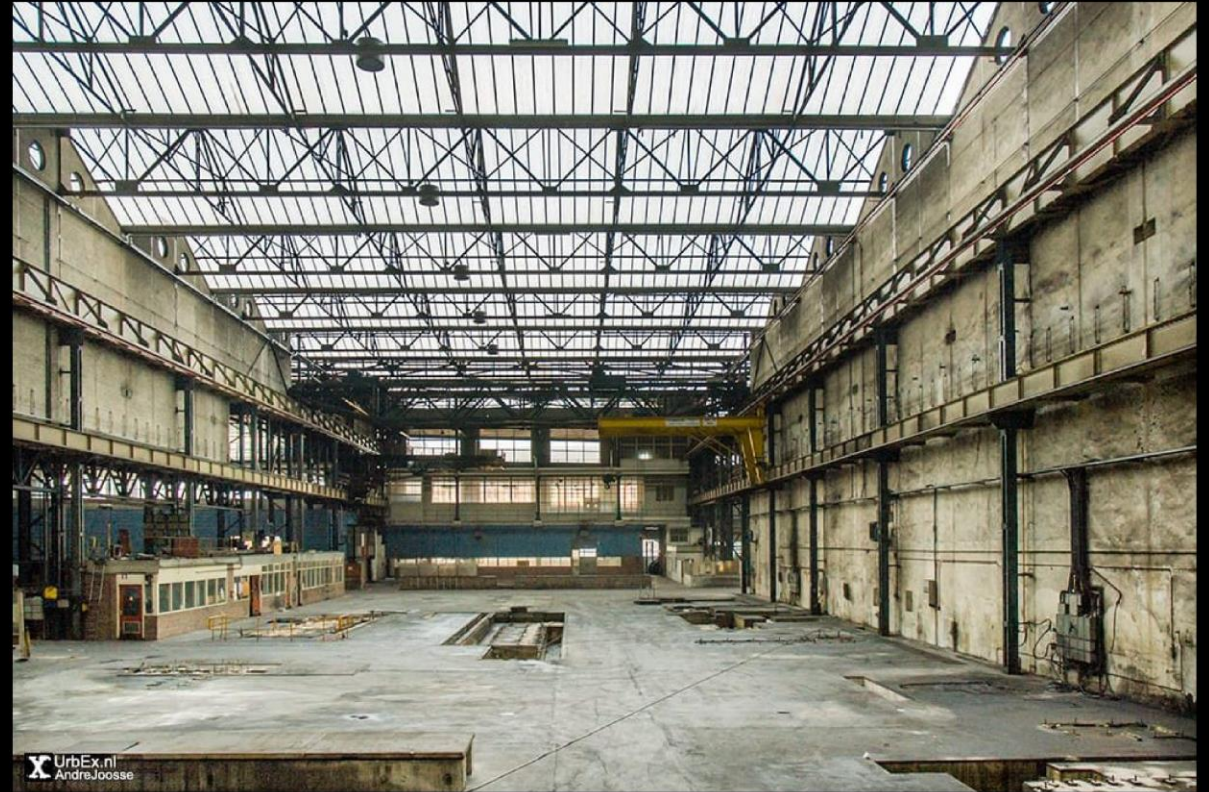
# URBAN CONTEXT



MACHINEFABRIEK VAN DE SCHELDE  
GLACISSTRAAT 102  
4381 NK VLISSINGEN

SITE





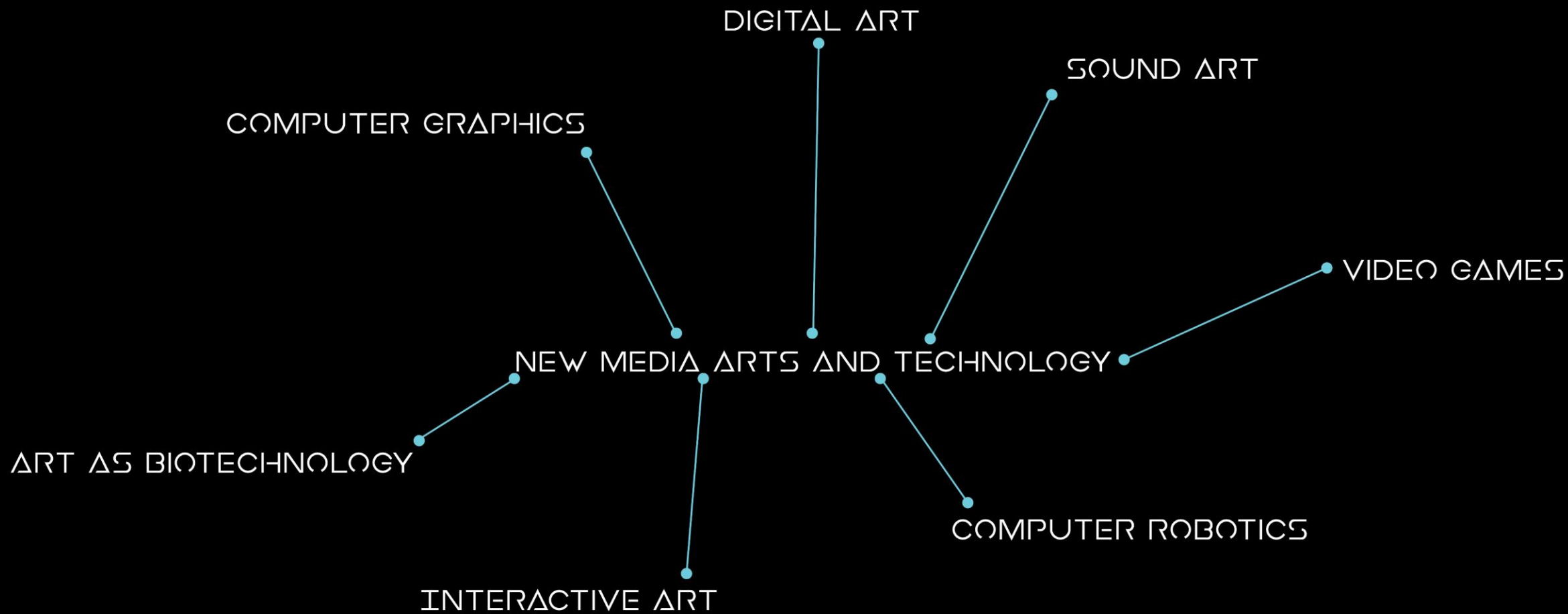
# SITE PLAN

A site plan of an industrial complex. The plan shows various buildings, roads, and a central water body. A large rectangular area in the center-right is highlighted with a red dashed border. The text 'MACHINEFABRIEK VAN DE SCHELDE' is placed to the right of this highlighted area. The overall style is minimalist with white lines on a dark background.

MACHINEFABRIEK VAN DE SCHELDE

INTERVENTION

NEW MEDIA ART AND TECHNOLOGY  
EXHIBITION SPACE



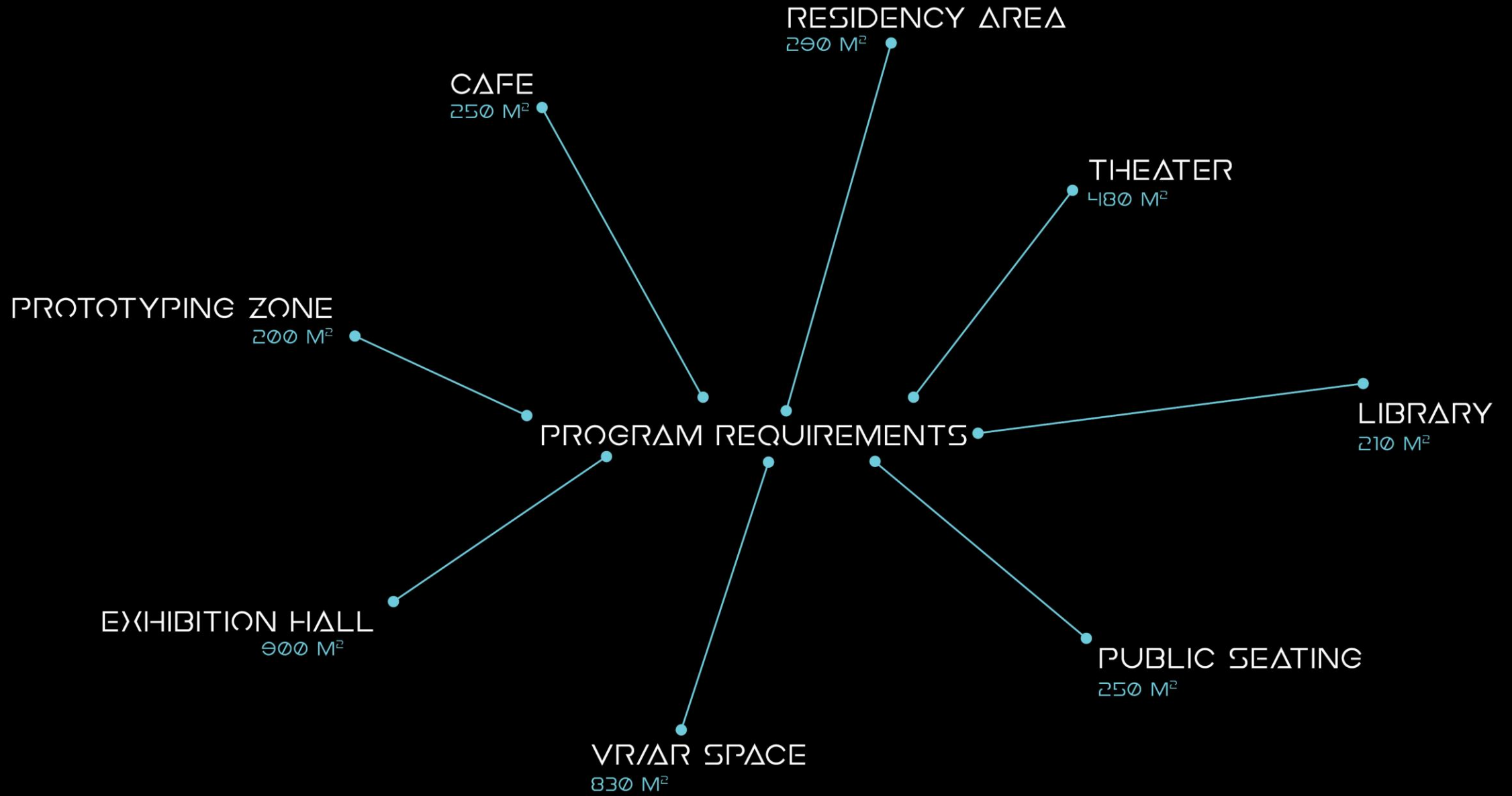






NXT MUSEUM





# FUNCTION REQUIREMENTS

## CAFE

OPEN  
VISUAL CONNECTIVITY  
END

## WORKSHOP

BRIGHT  
NOISY

## EXHIBITION

CLOSE  
BACK

## VR/AR AREA

DARK  
TALL  
BASIC SHAPE  
MULTIPLE ROOMS

## PROTOTYPING

ENTRANCE  
LARGE

## PUBLIC SEATING

OPEN  
NOISY  
BACK  
VISUAL CONNECTIVITY

## AUDITORIUM

CLOSE  
ACOUSTICS  
INSULATED

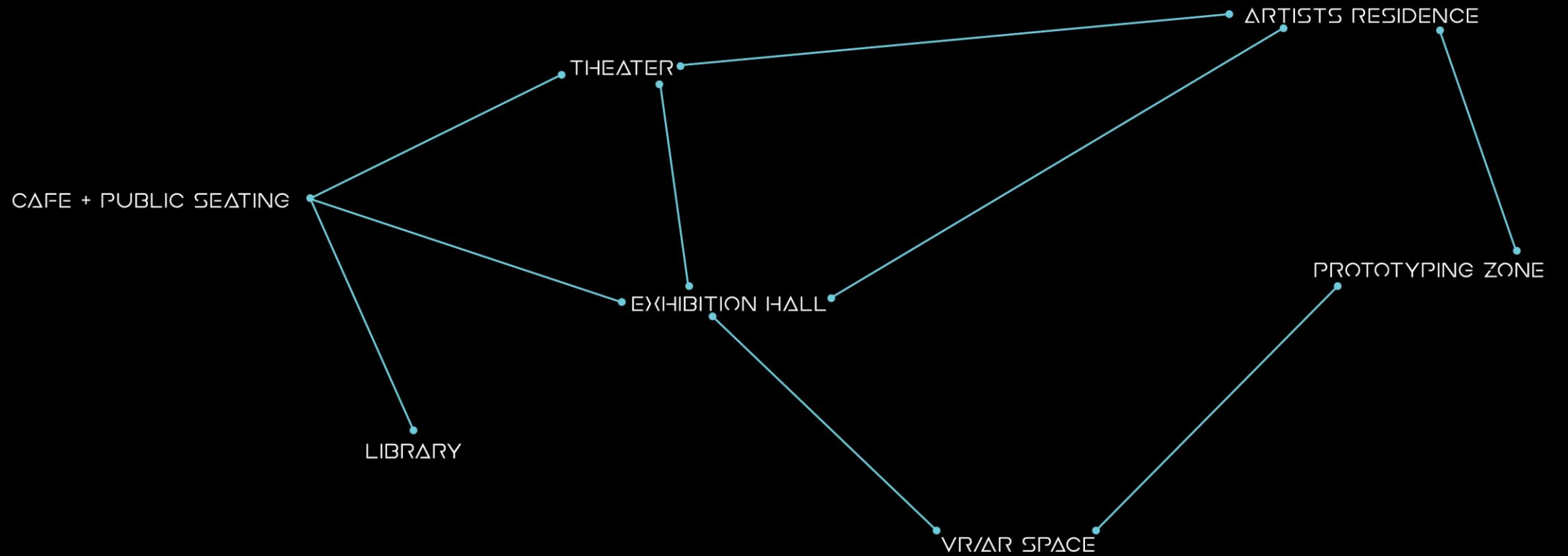
## LIBRARY

QUIET  
DARK  
CLOSE

## EXHIBITION

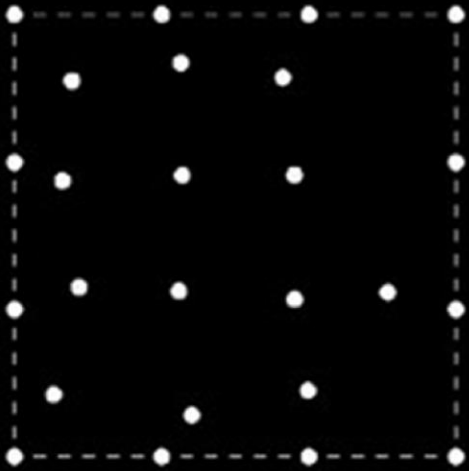
OPEN  
ENTRANCE  
VISUAL CONNECTIVITY

# ADJACENCY DIAGRAM

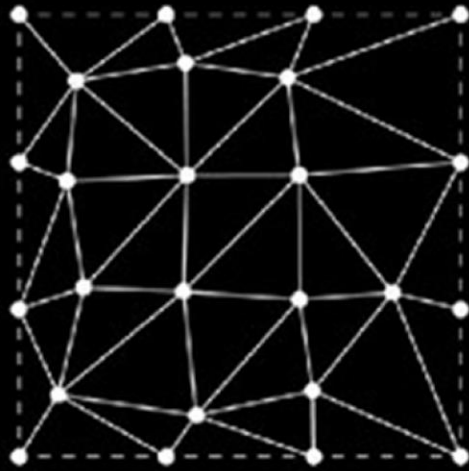


# FORM DEVELOPMENT

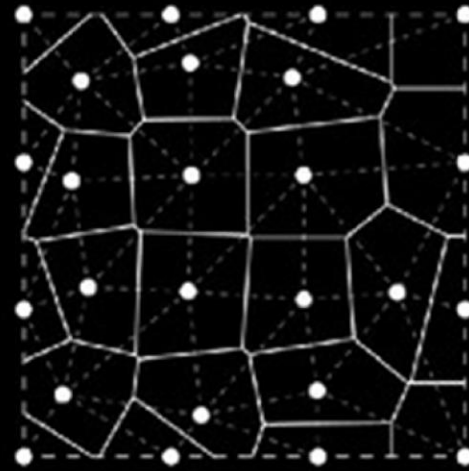
# VORONOI



*set of given points*



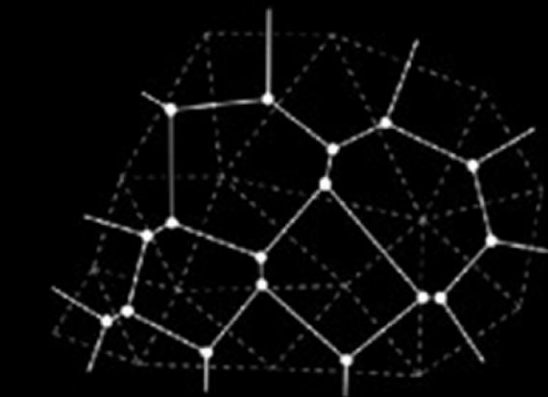
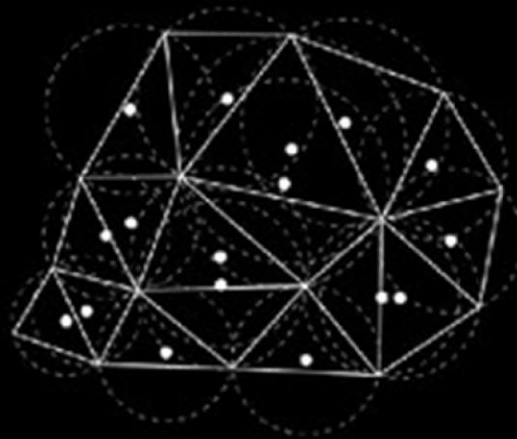
*Delaunay triangulation  
for given points*



*Voronoi diagrams  
for given points*



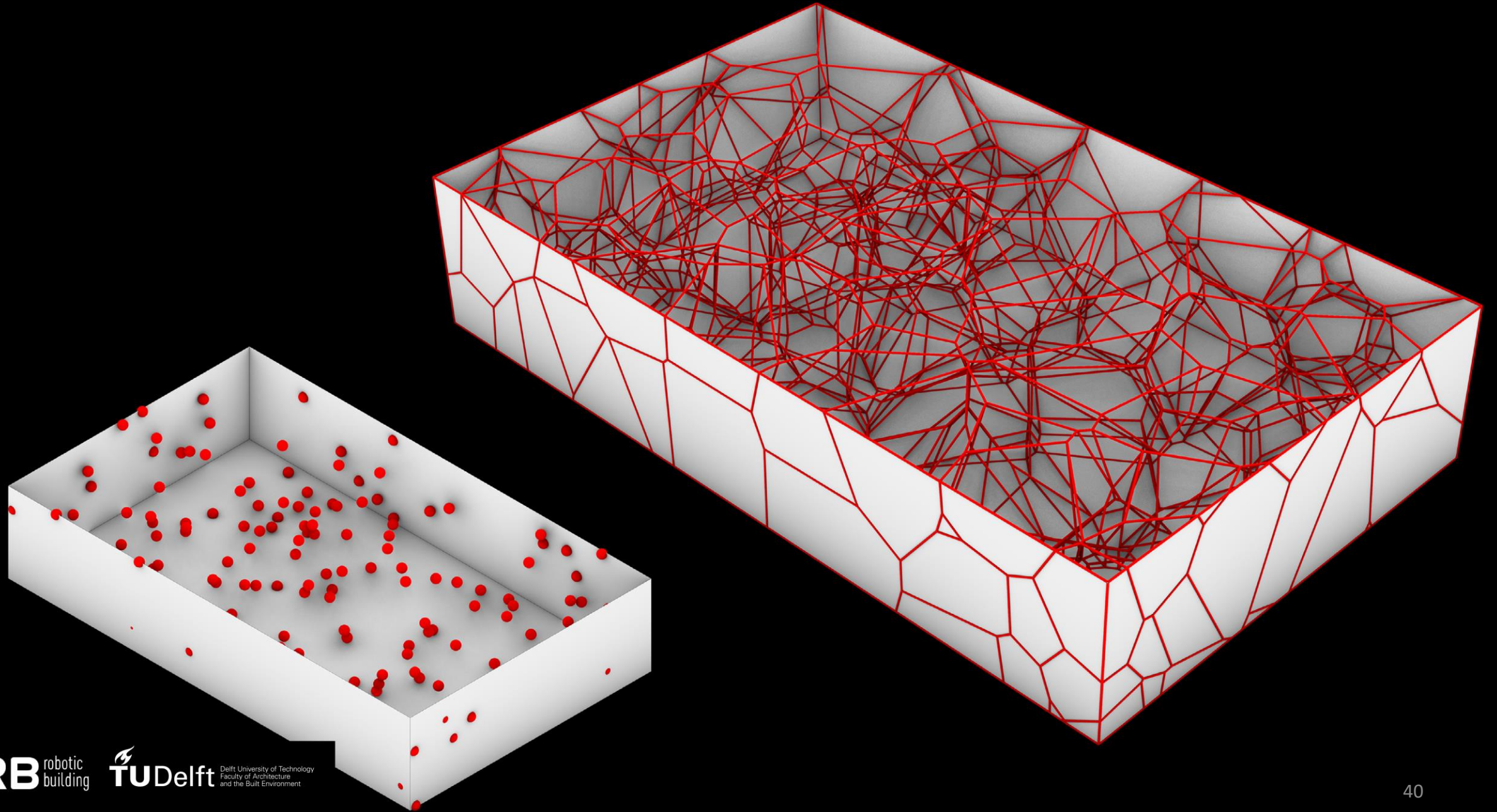
*determination of the center of the circle of the triangle*



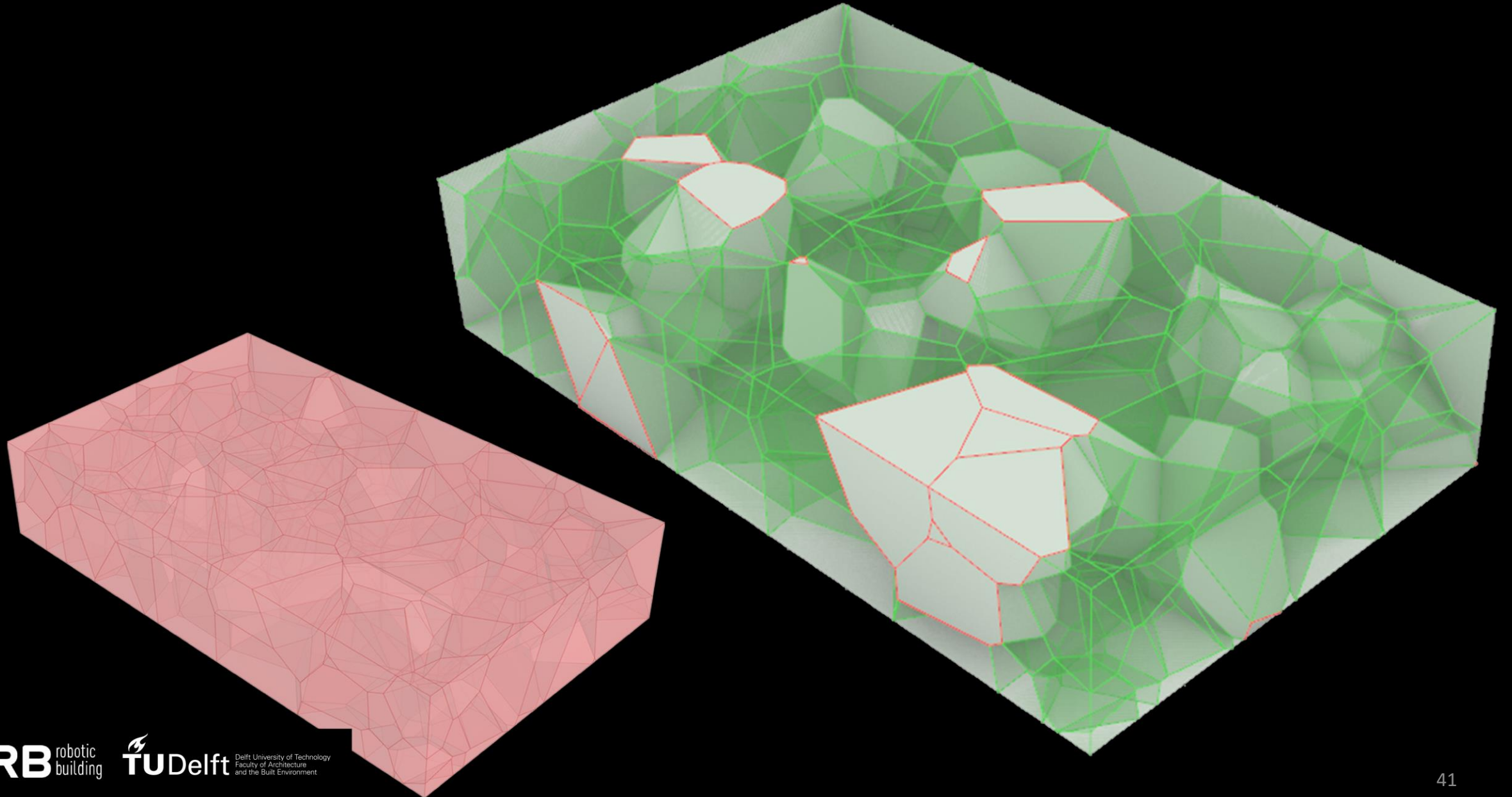
*centers of the circles determine  
the vertices of a convex polygon  
Voronoi diagram - dual graph*

*Rokicki, Wiesław & Gawell, Ewelina. (2016). Voronoi diagrams – architectural and structural rod structure research model optimization. MAZOWSZE Studia Regionalne. 2016. 155-164. 10.21858/msr.19.10.*

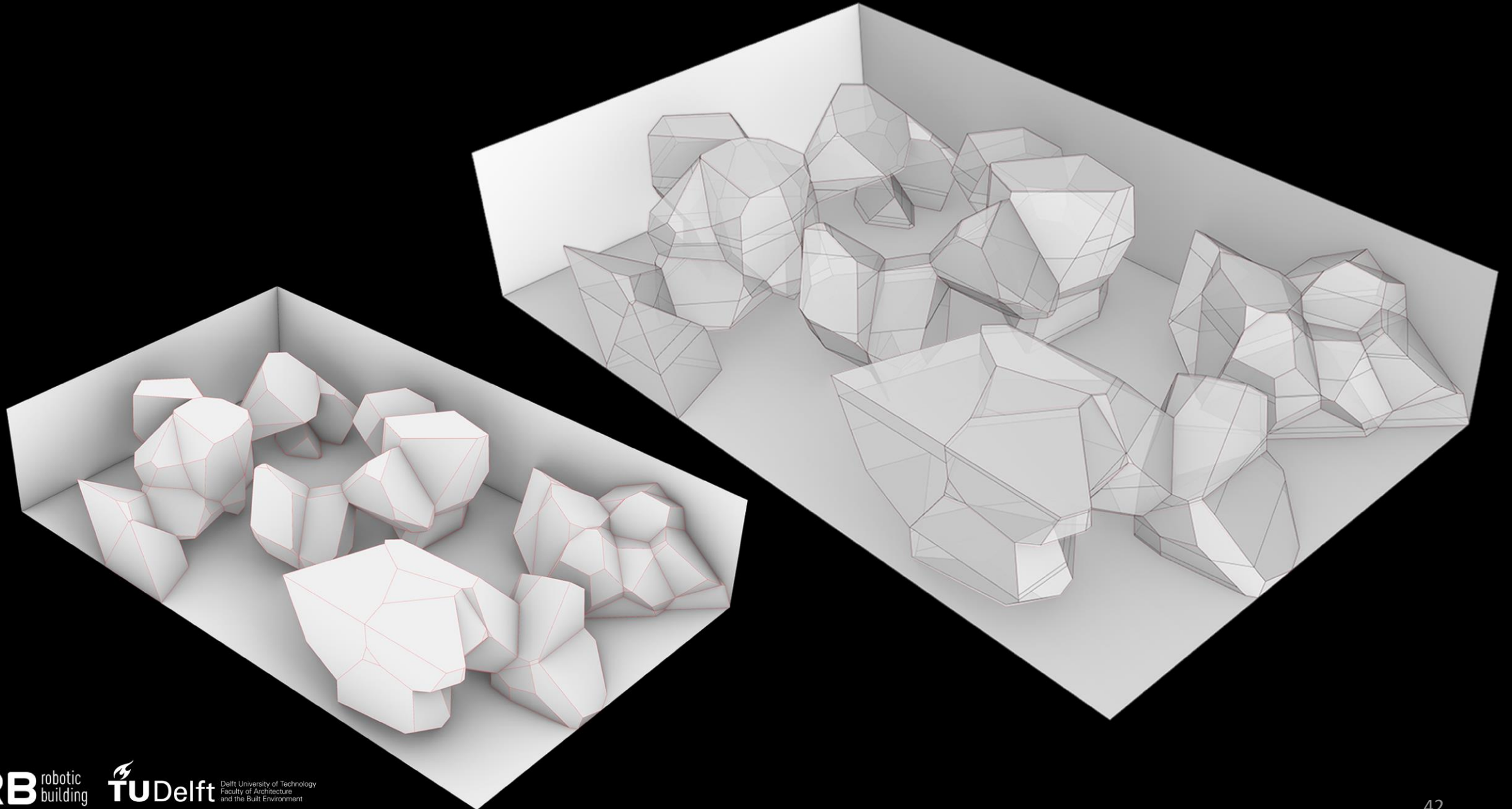
# STEP 1 : POINT DISTRIBUTION



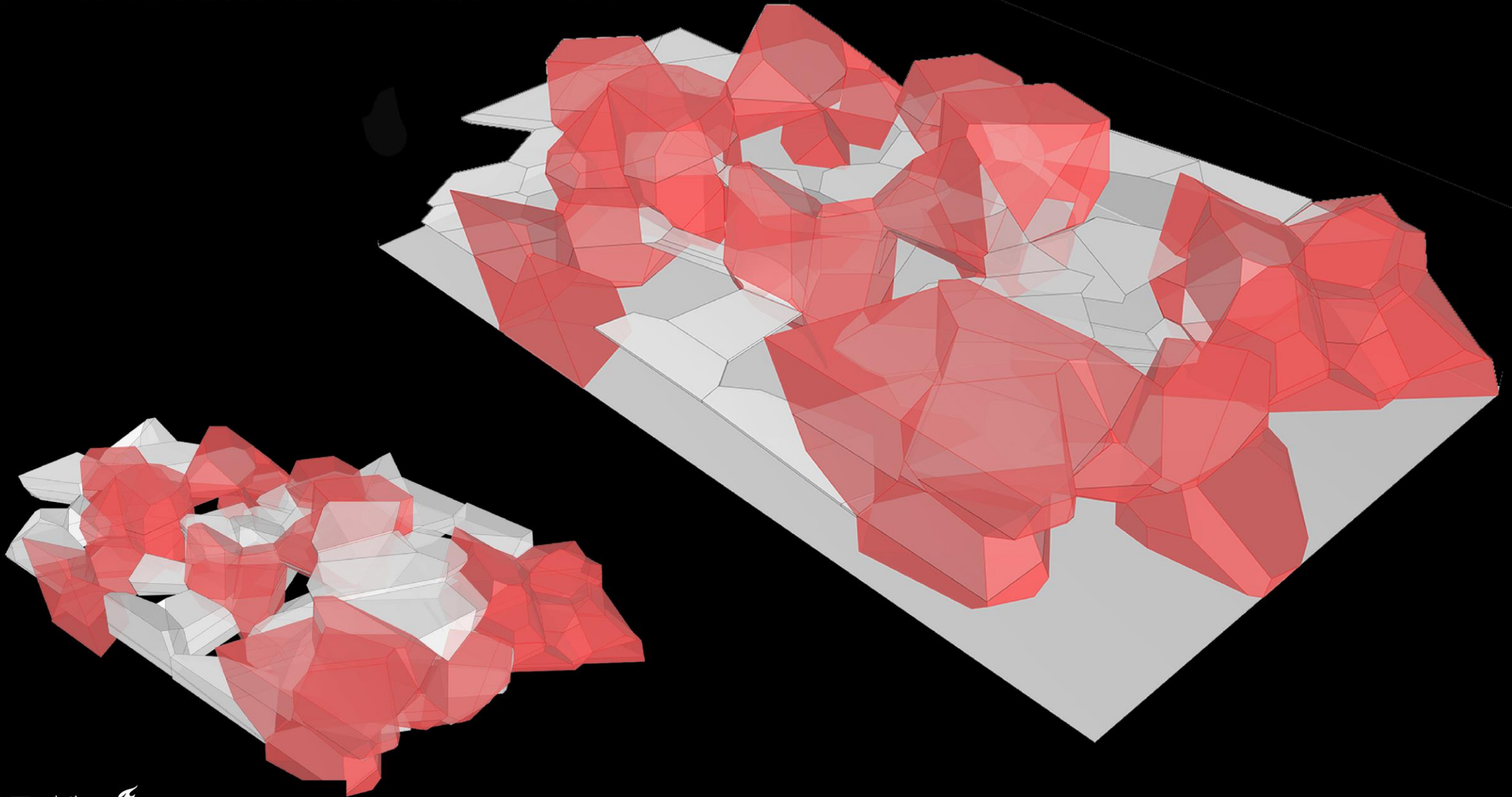
## STEP 2 : CREATING VORONOI CELLS



## STEP 3 : CREATING VORONOI CELL CLUSTERS



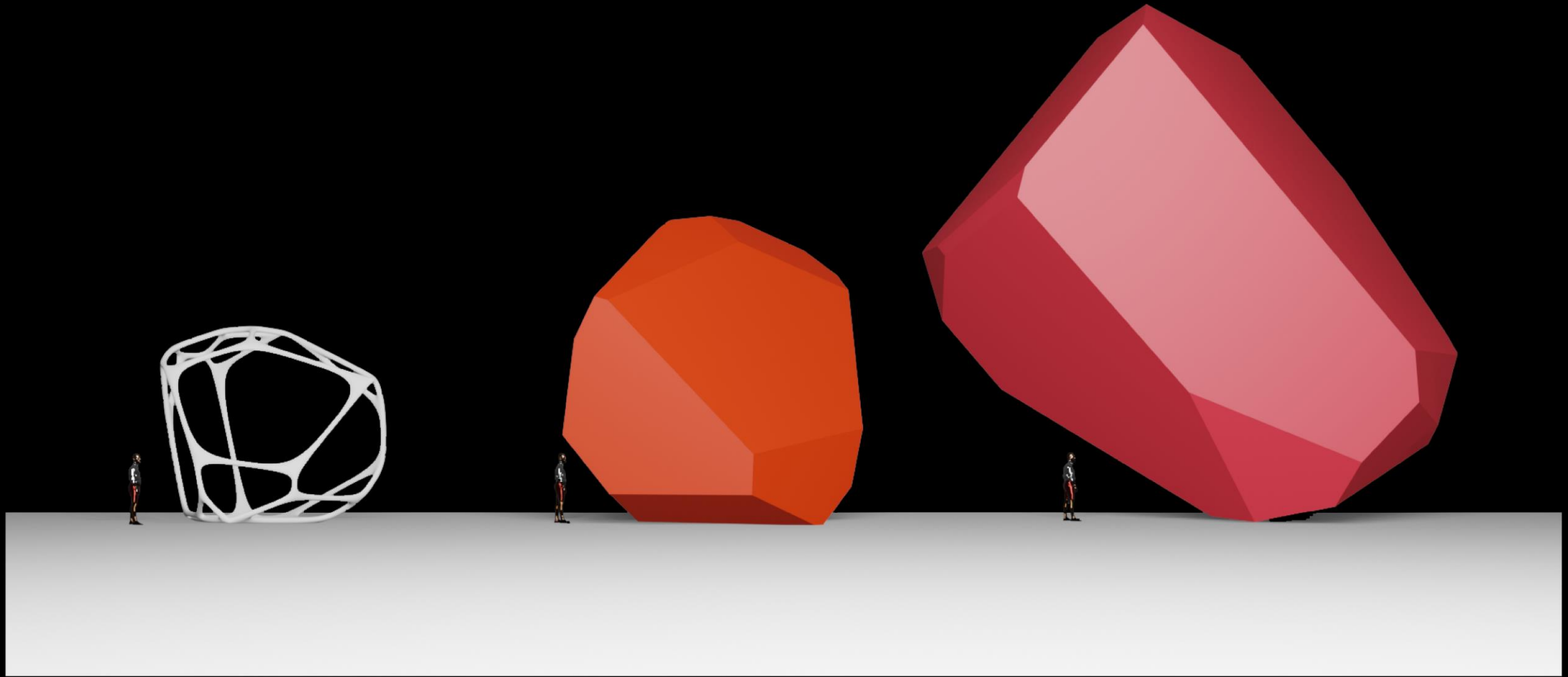
## STEP 4 : CREATING RAMP CONNECTIONS

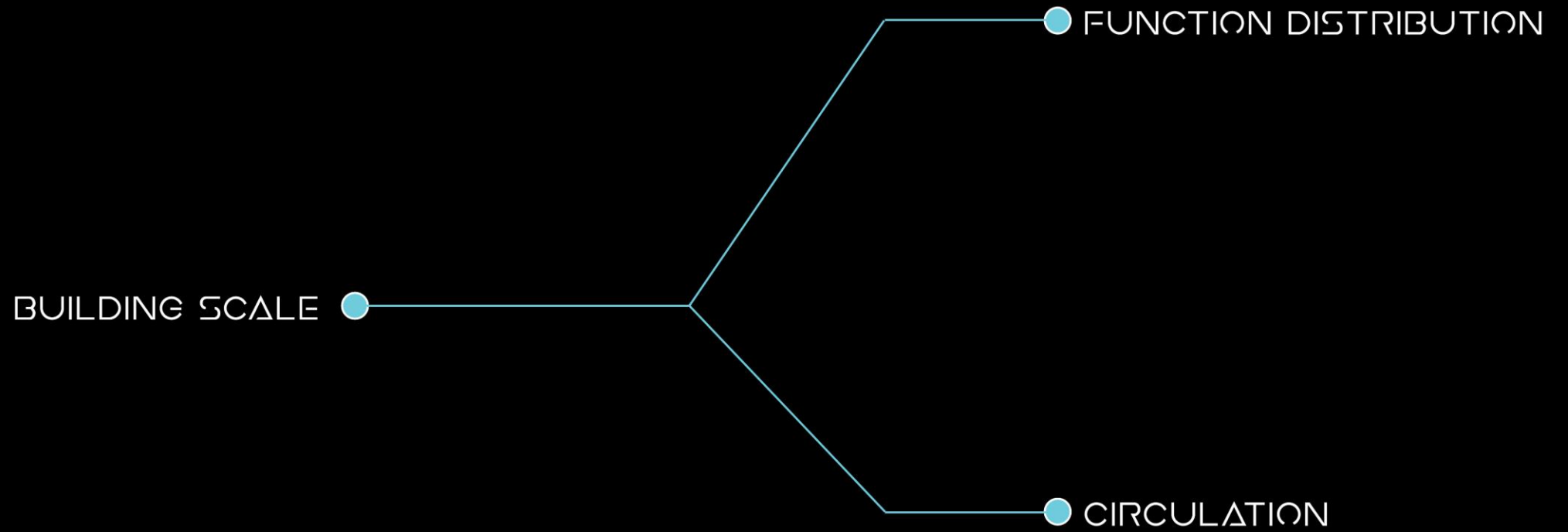




# HEIRARCHY

# VORONOI SCALE DIFFERENTIATION

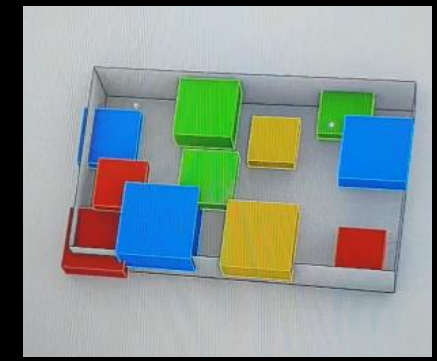
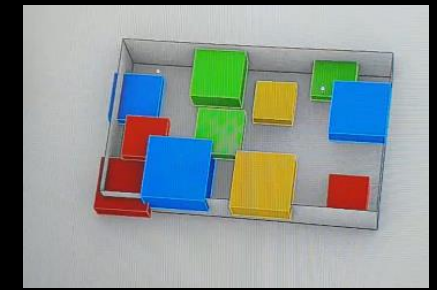
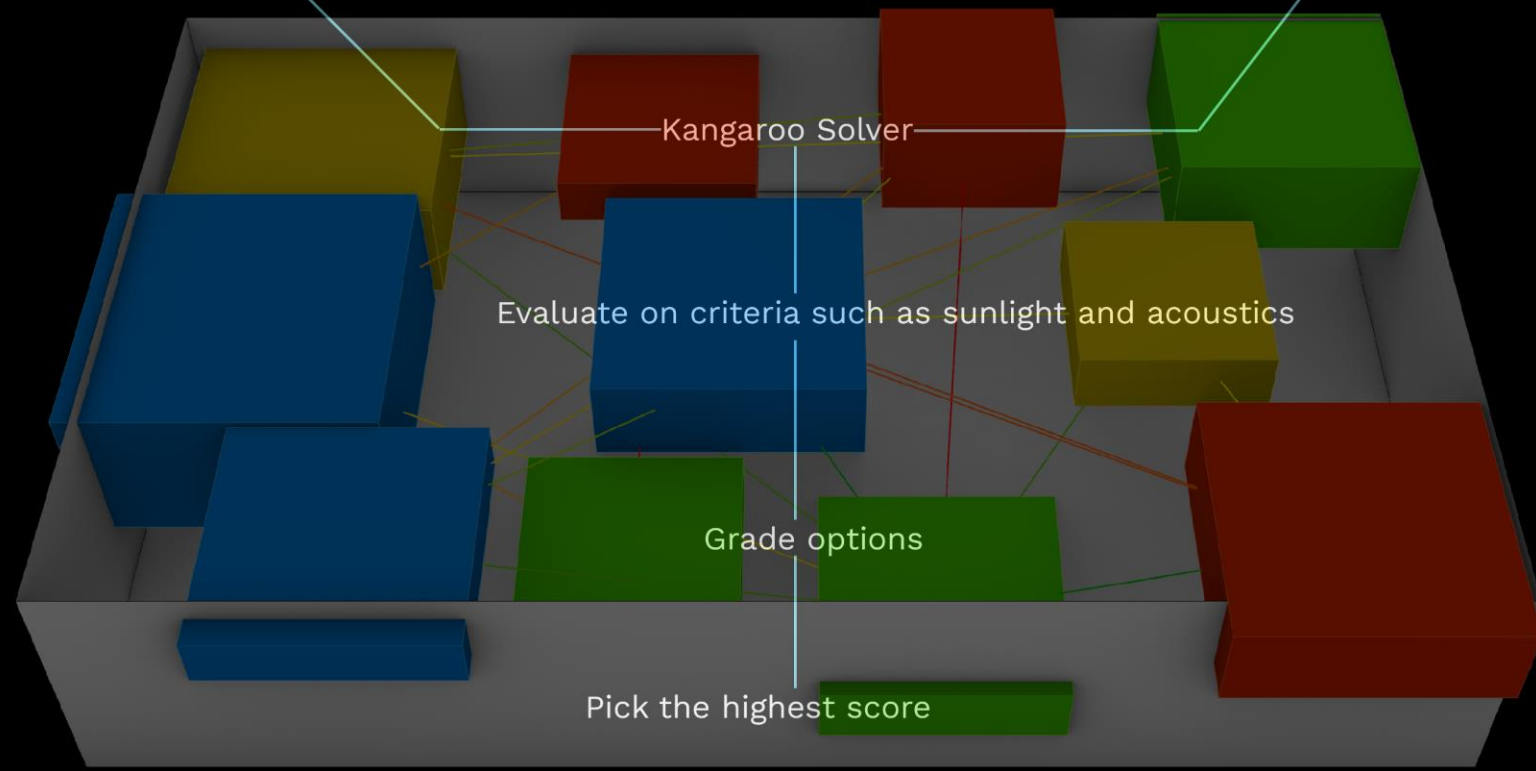


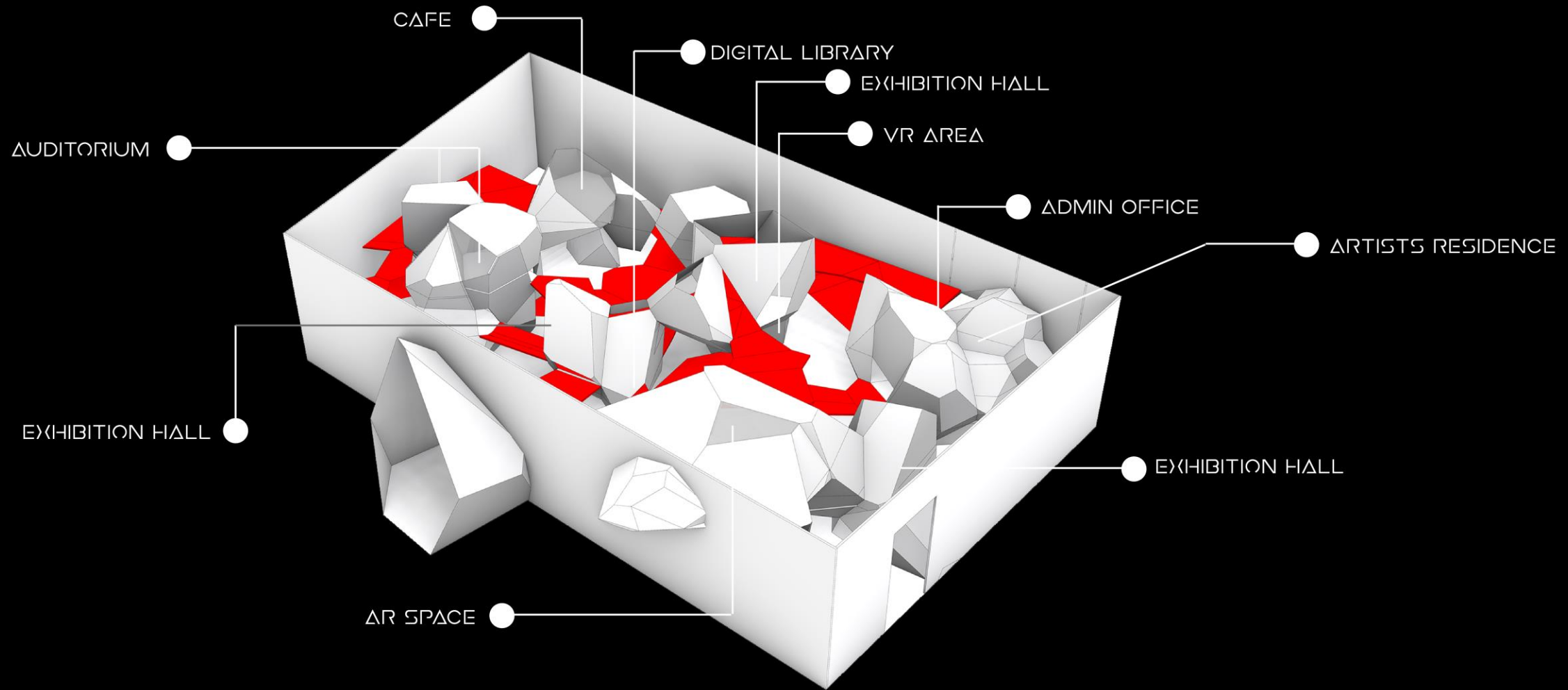


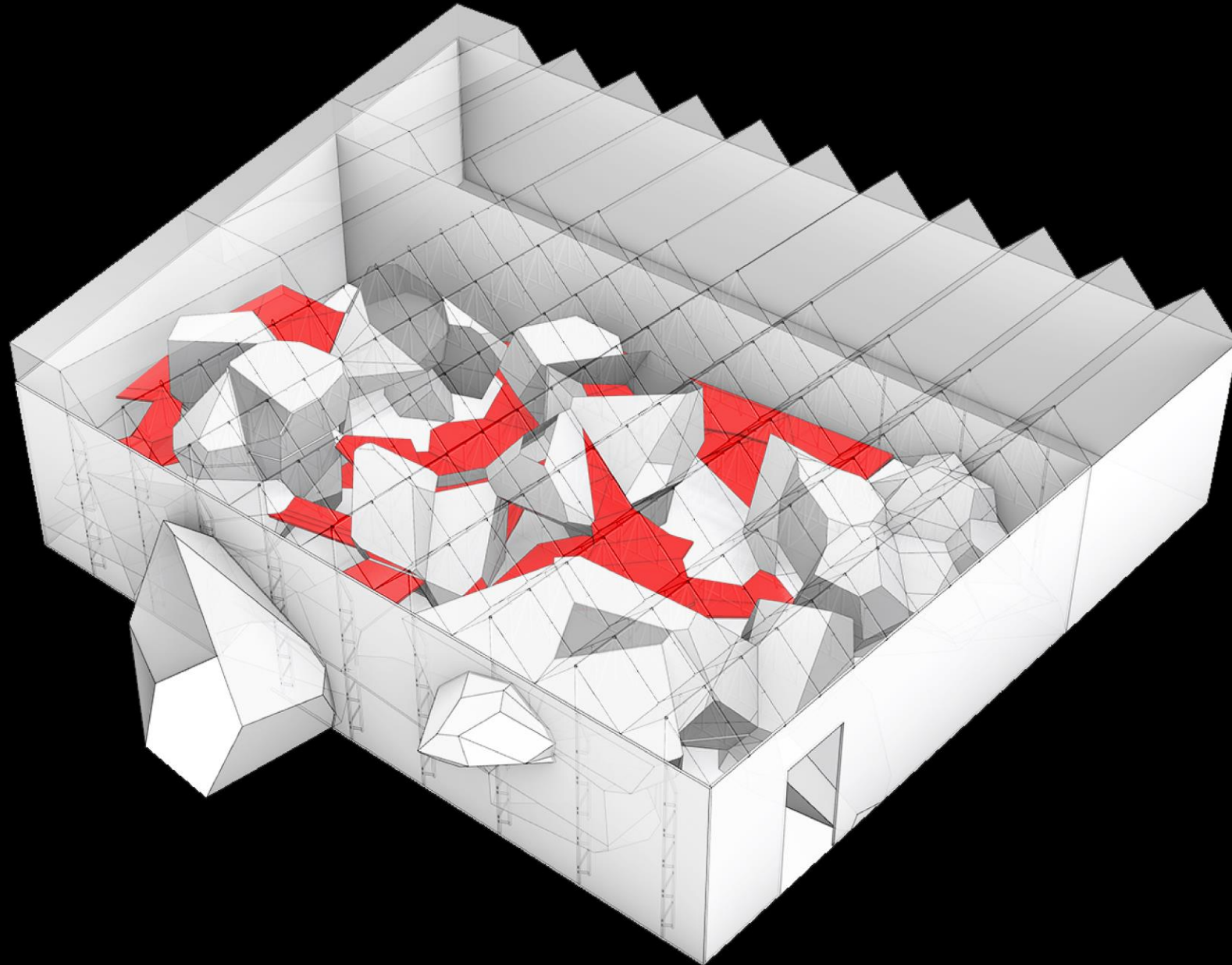
# COMPUTATIONAL FRAMEWORK

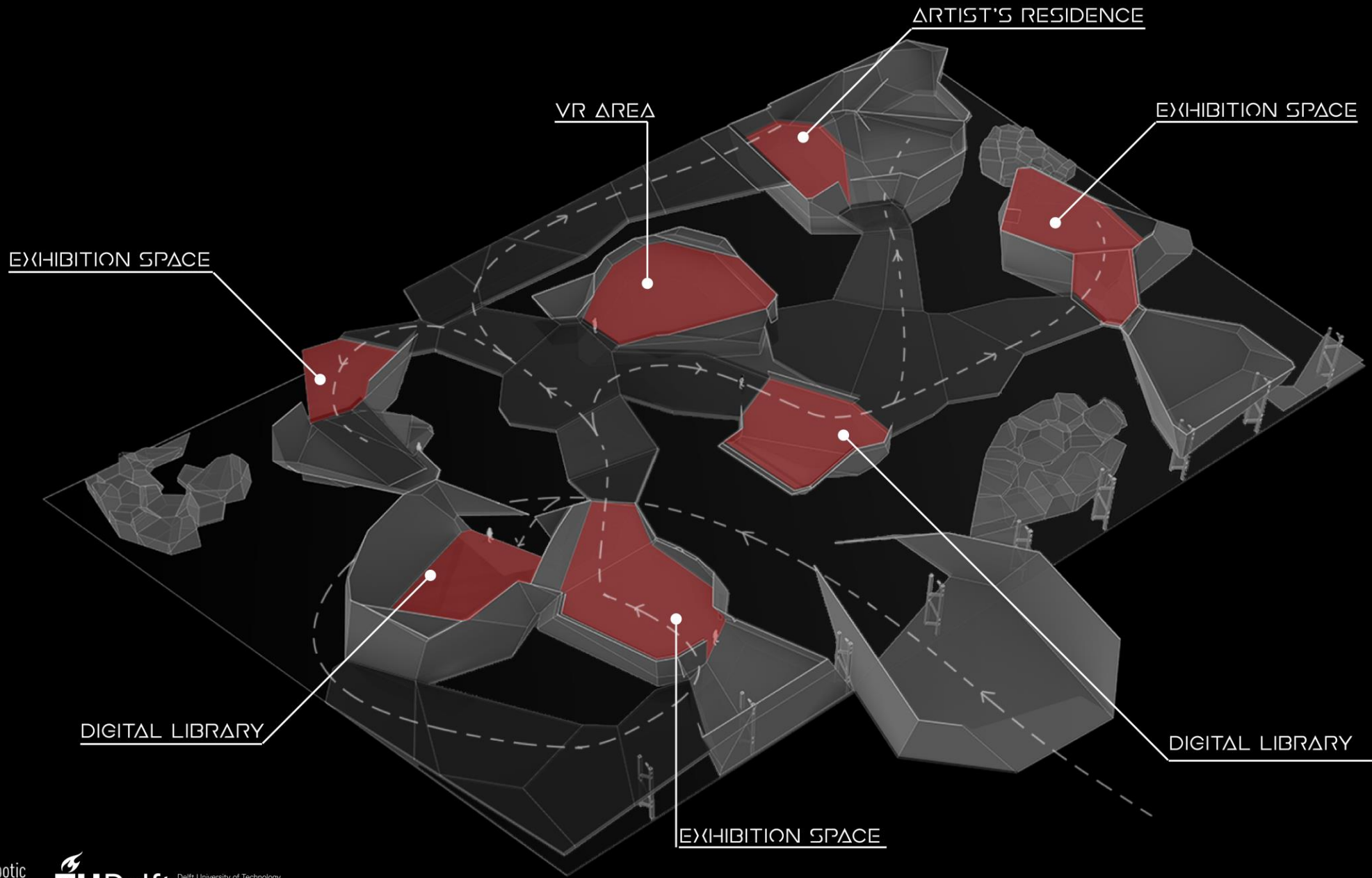
Functional areas and heights

Rate all proximity situations

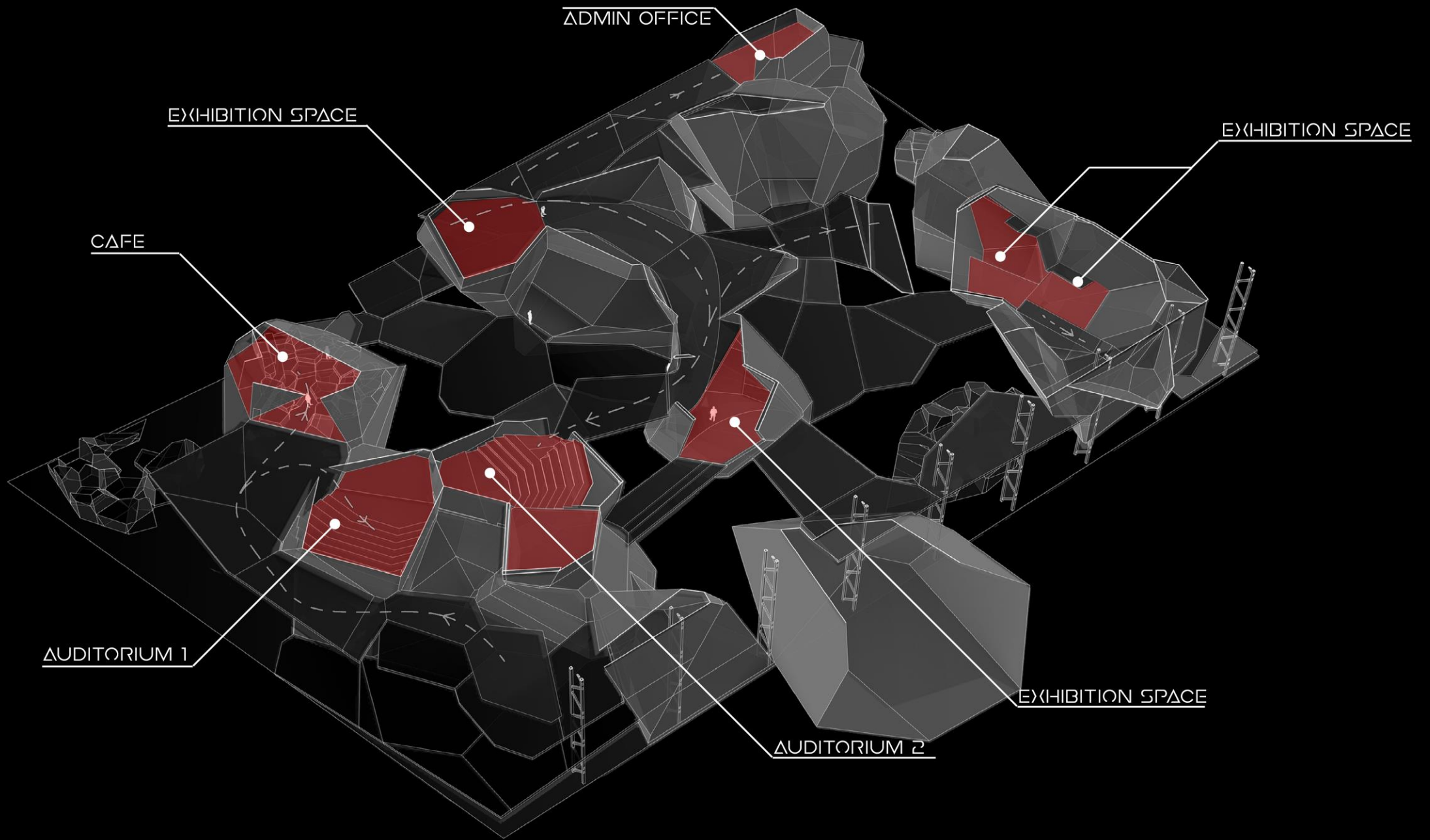


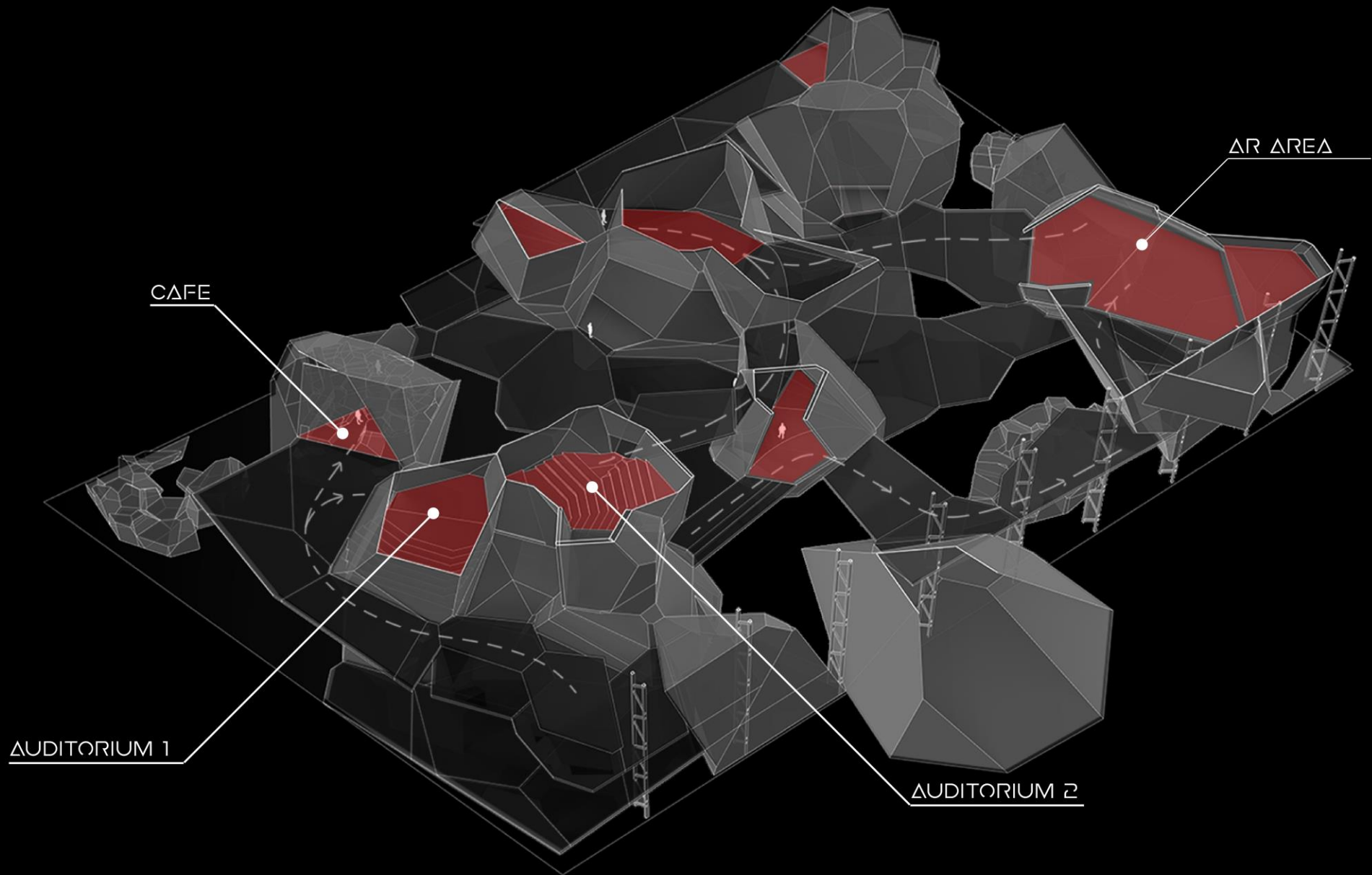


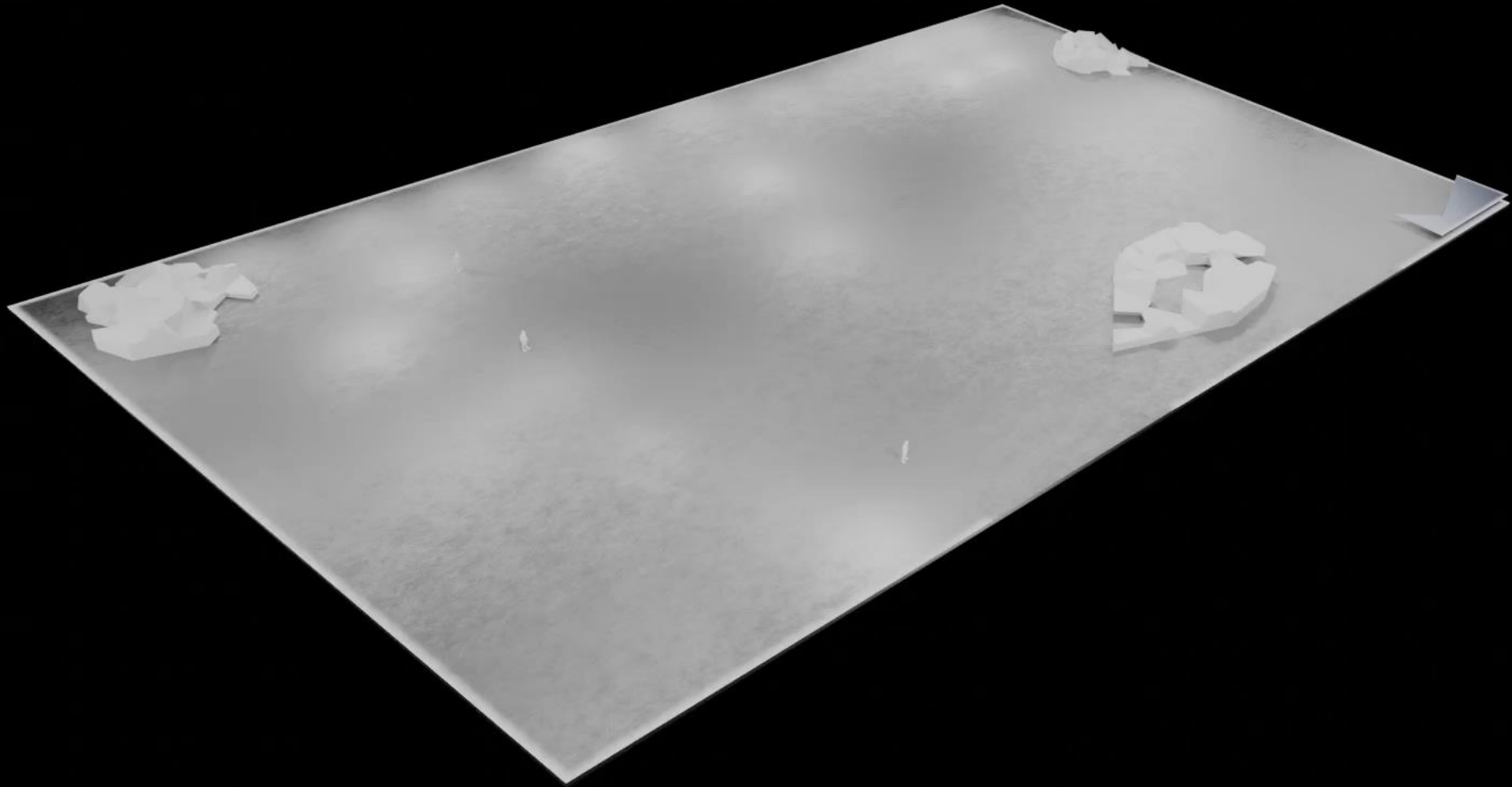


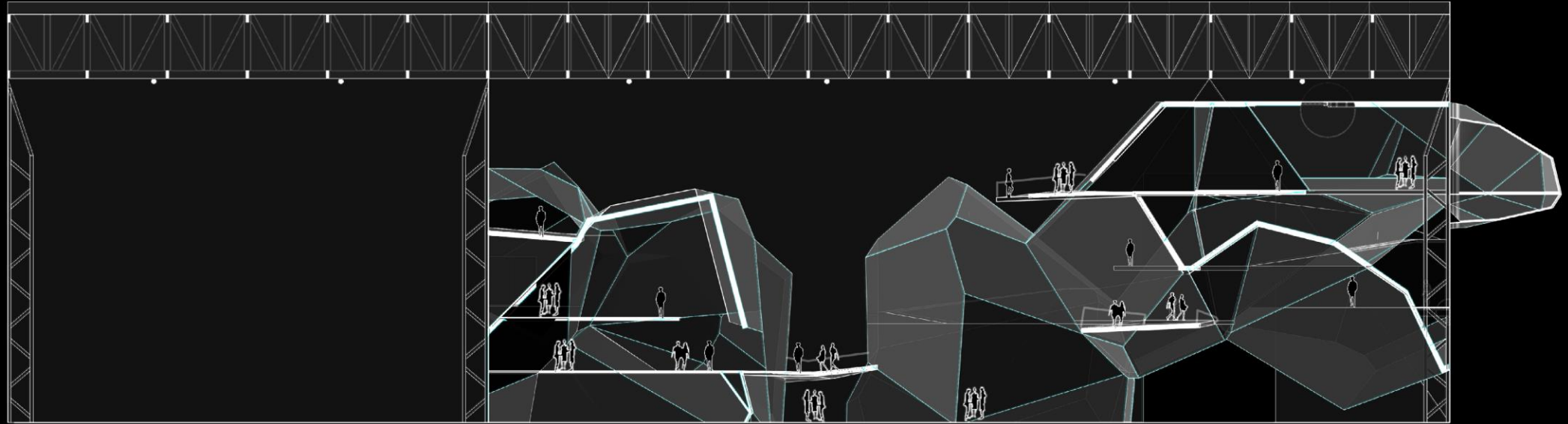


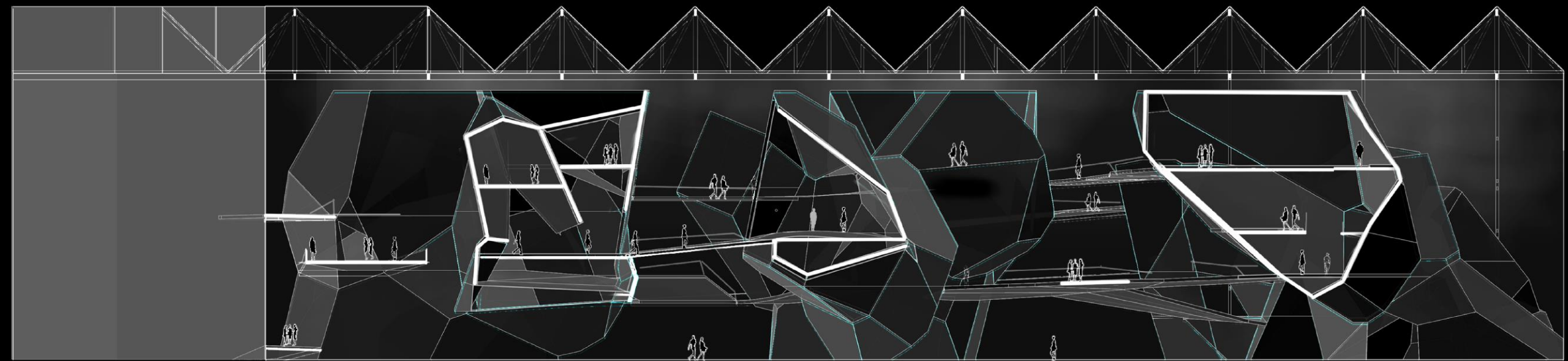




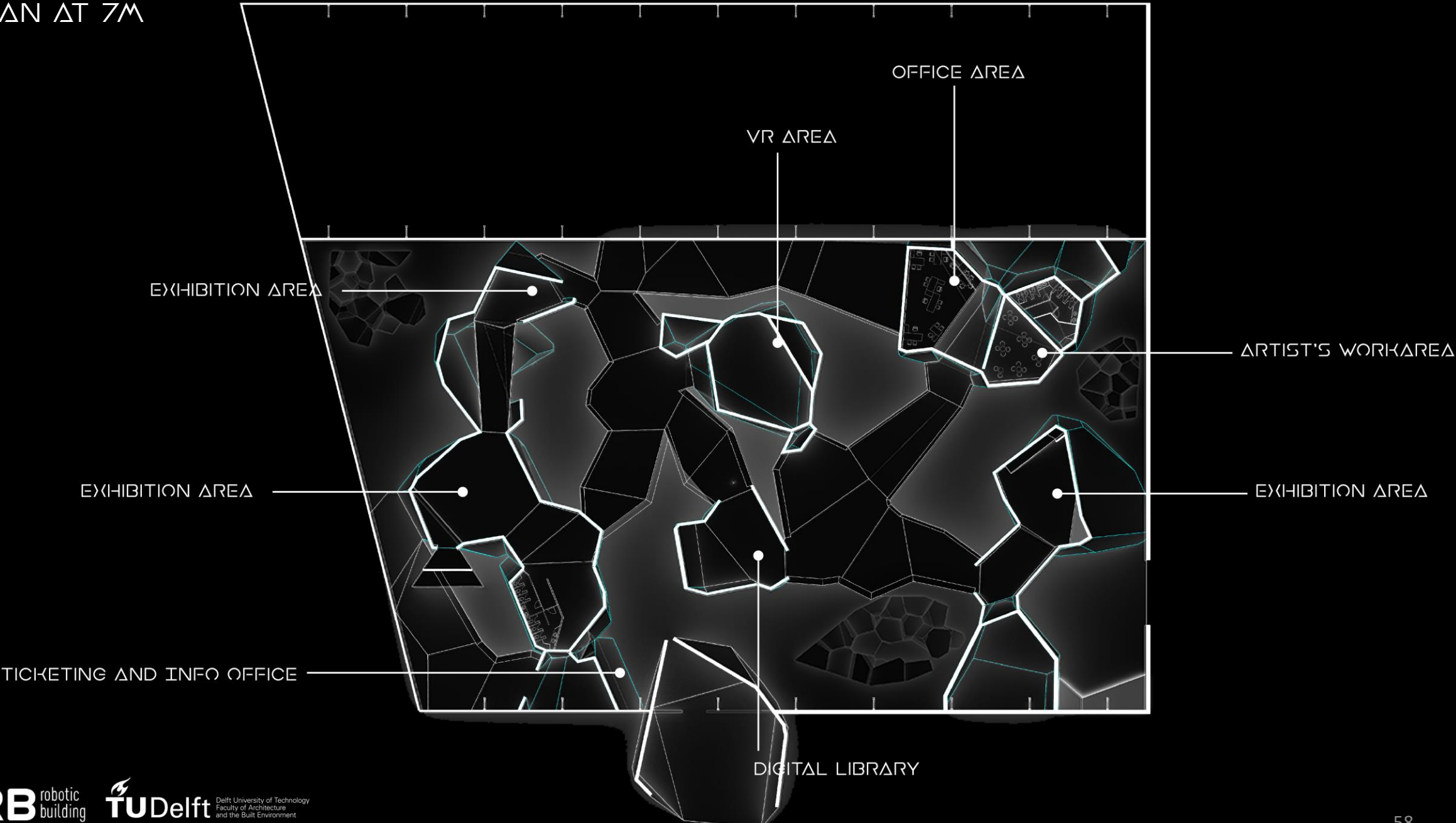




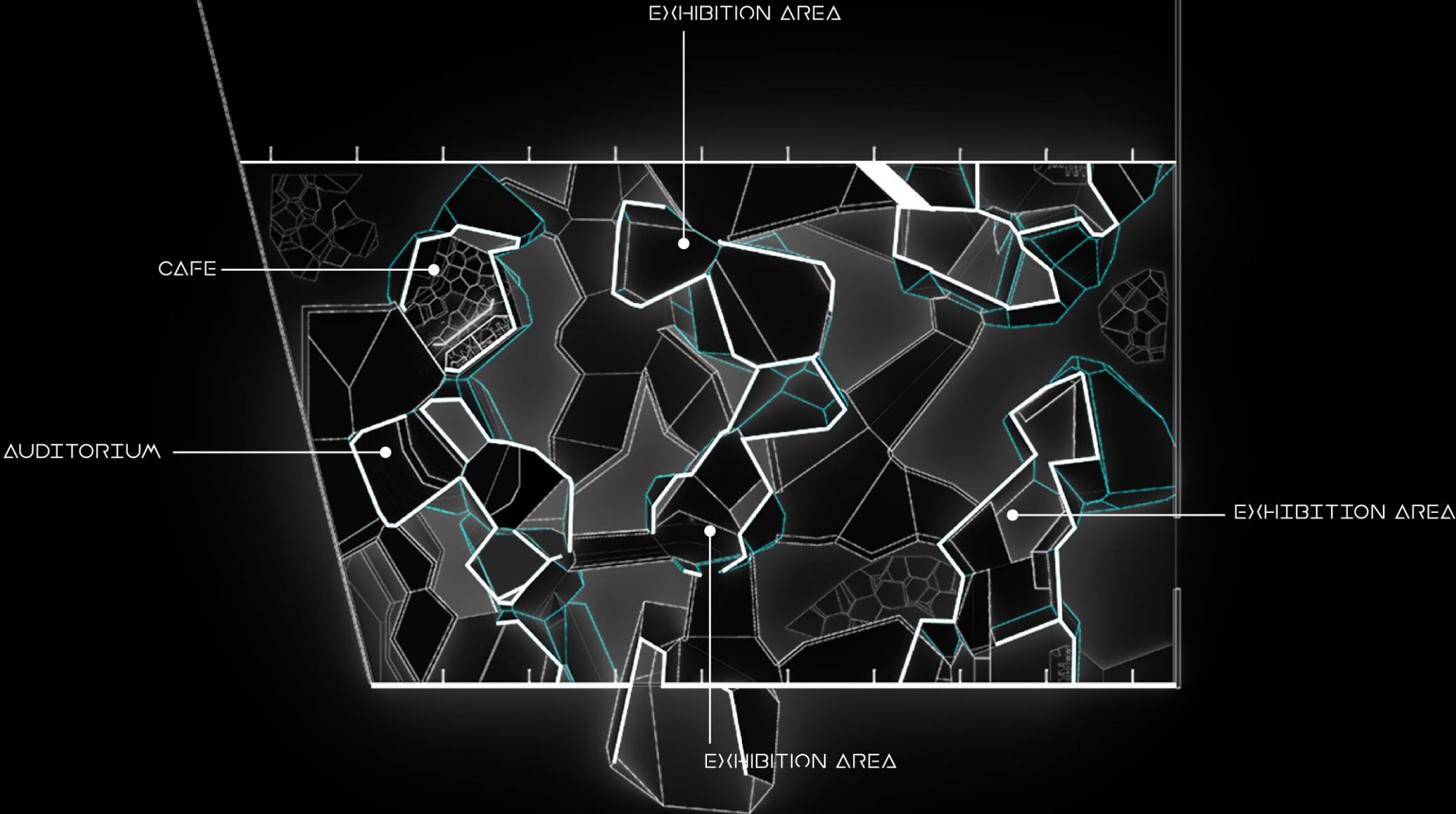




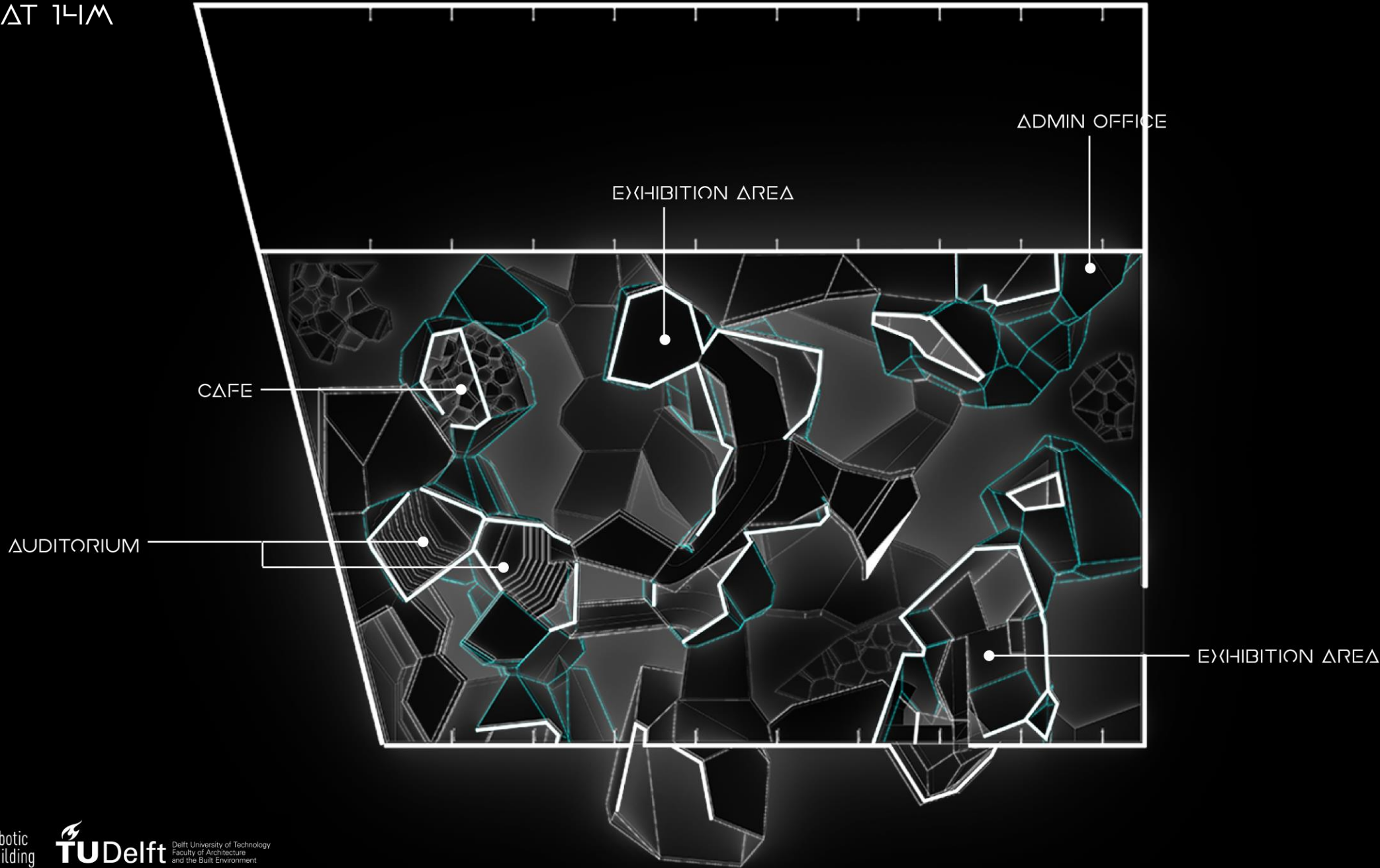
PLAN AT 7M



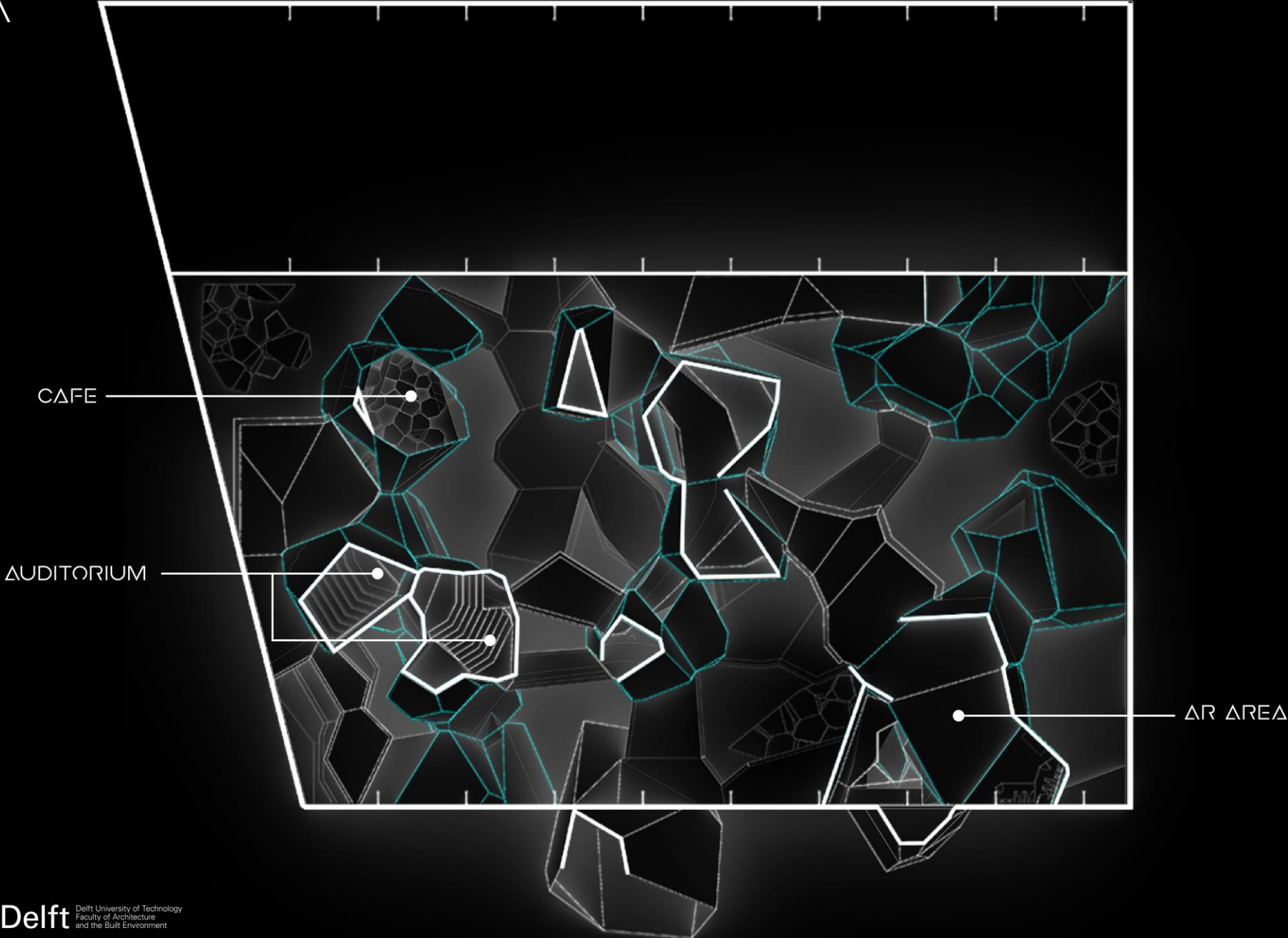
PLAN AT 11M

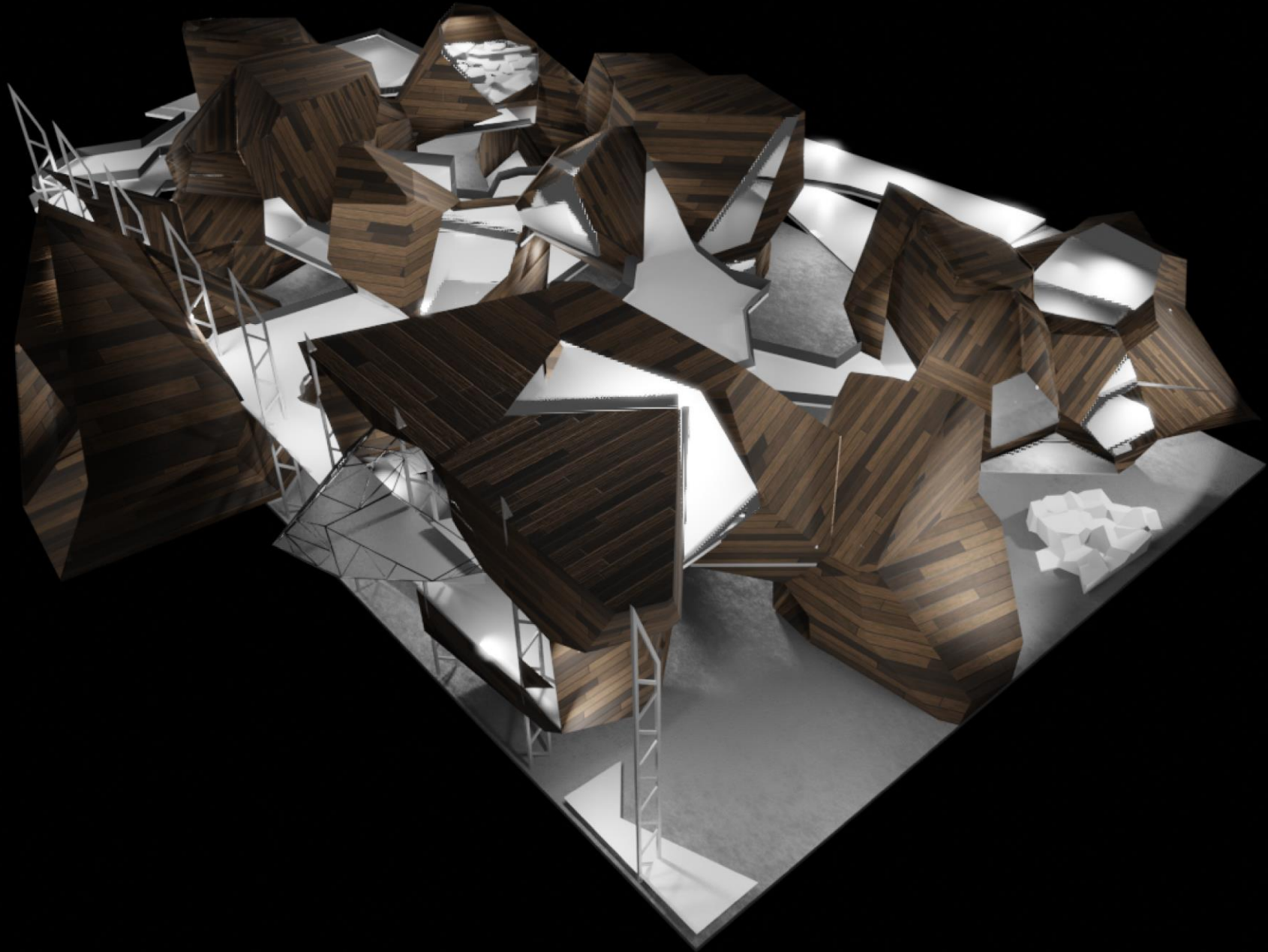


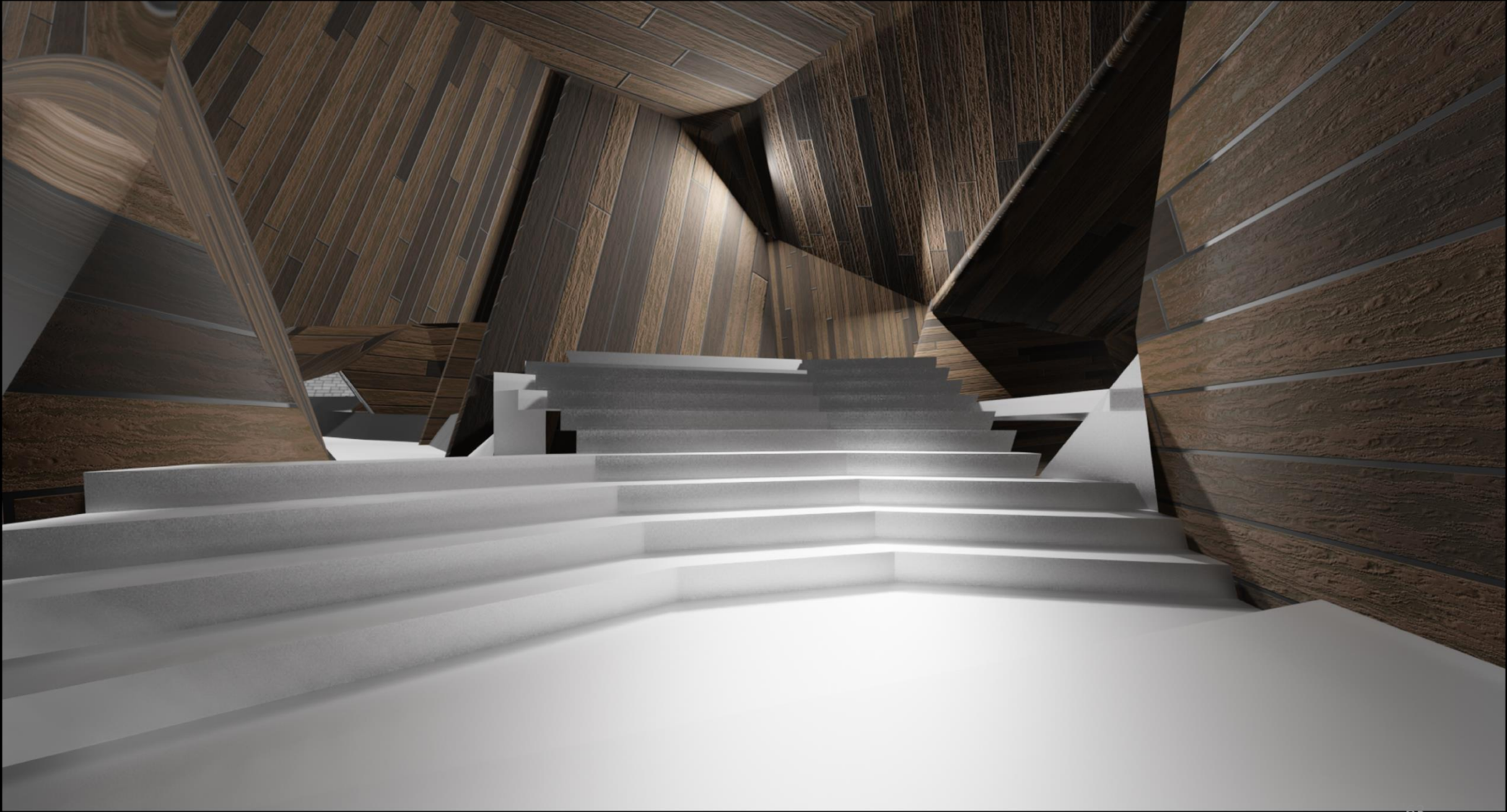
PLAN AT 14M

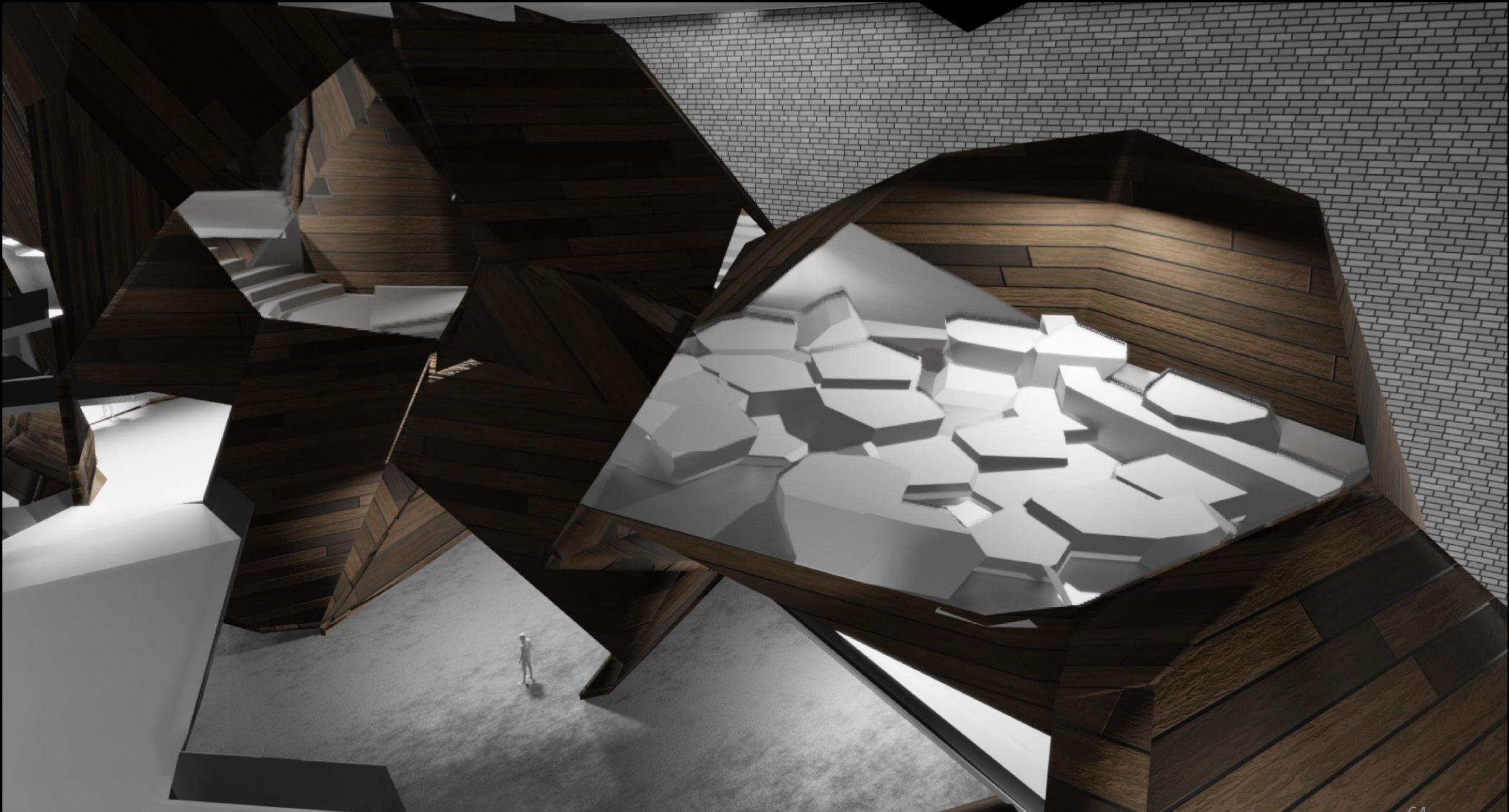


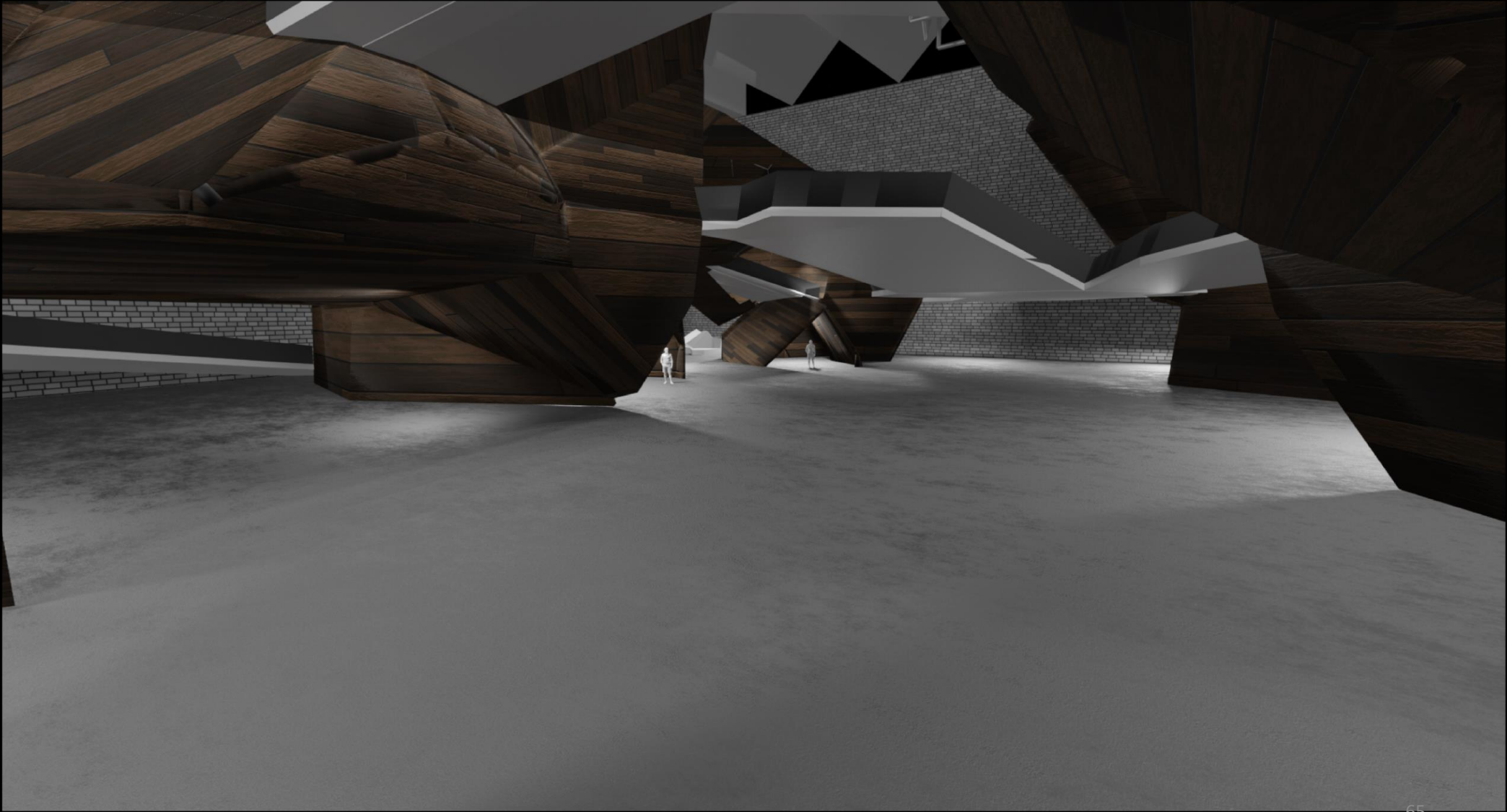
PLAN AT 10M

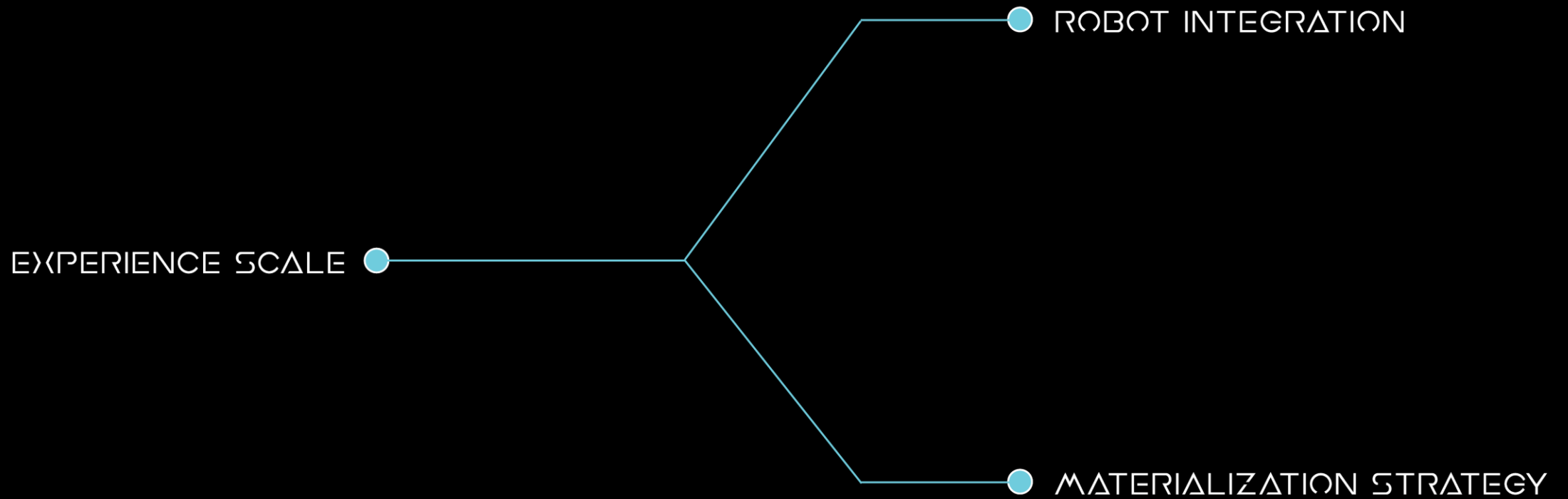












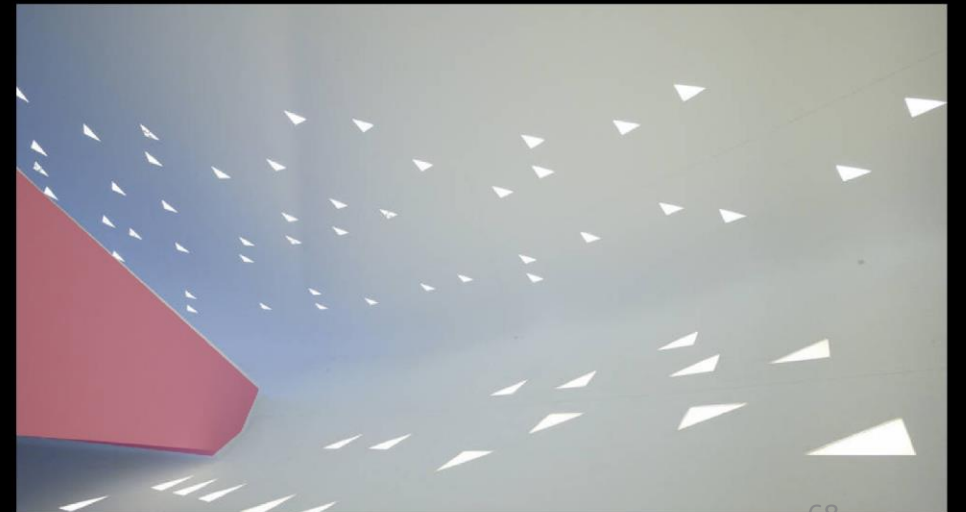
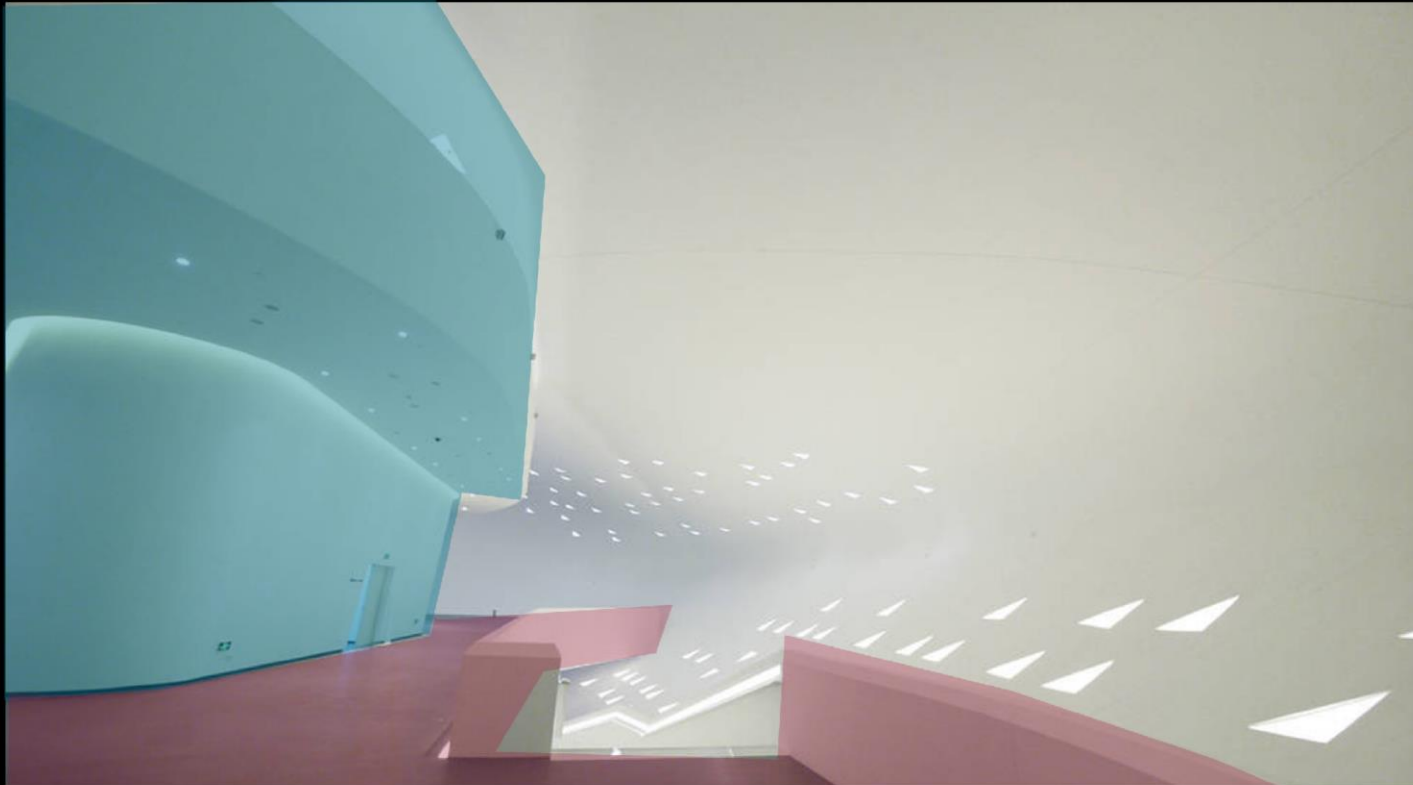
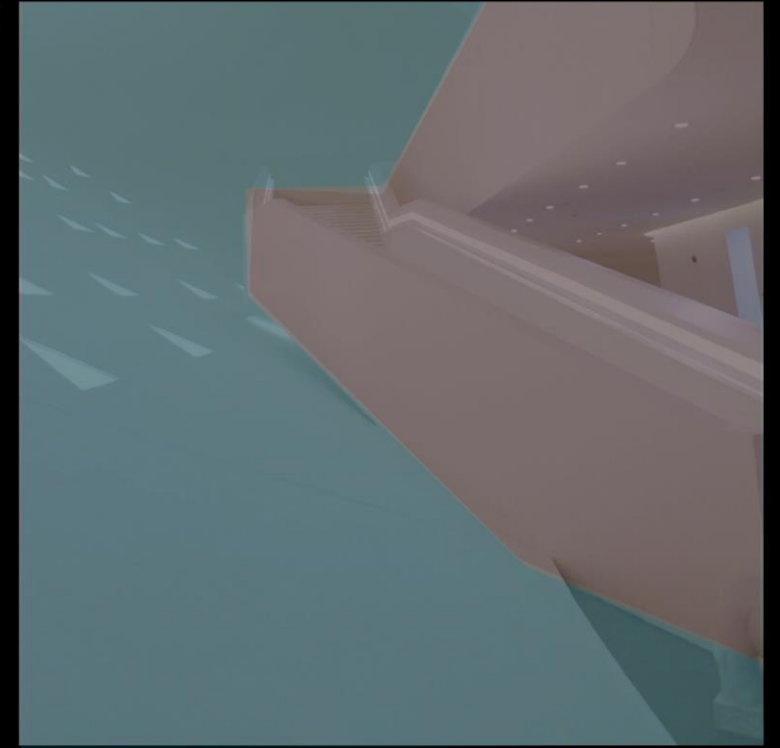
# EXPERIENCE CATALOGUE

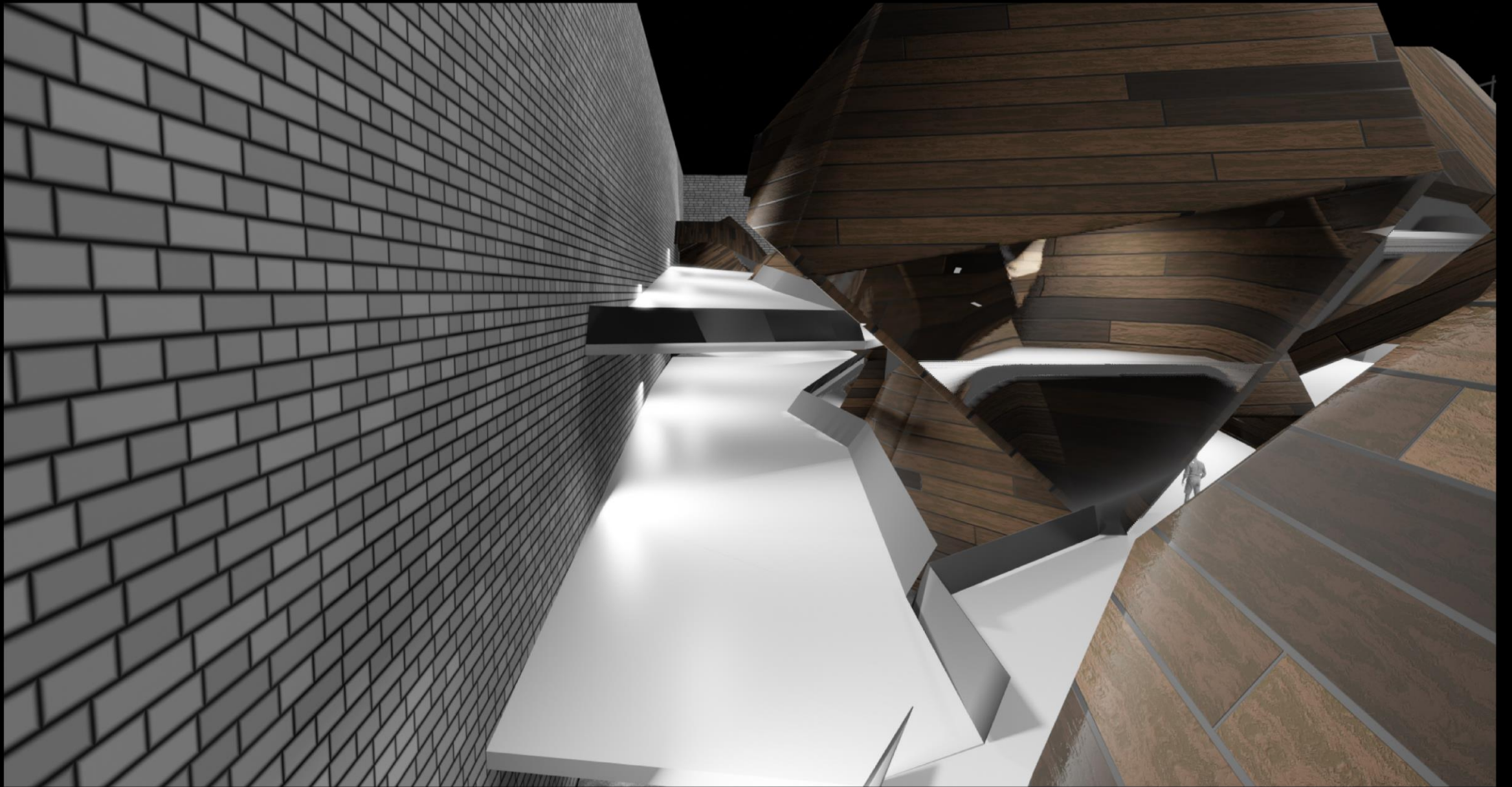
# OCT DESIGN MUSEUM

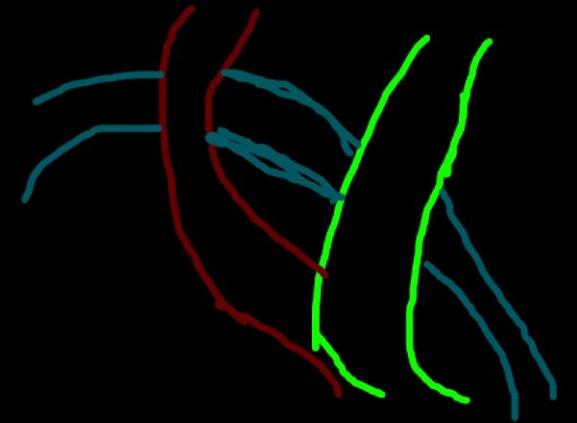
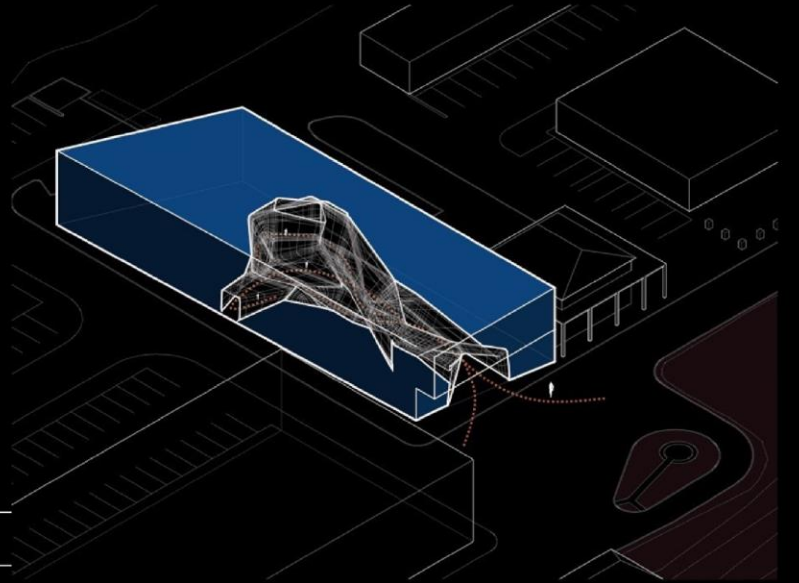
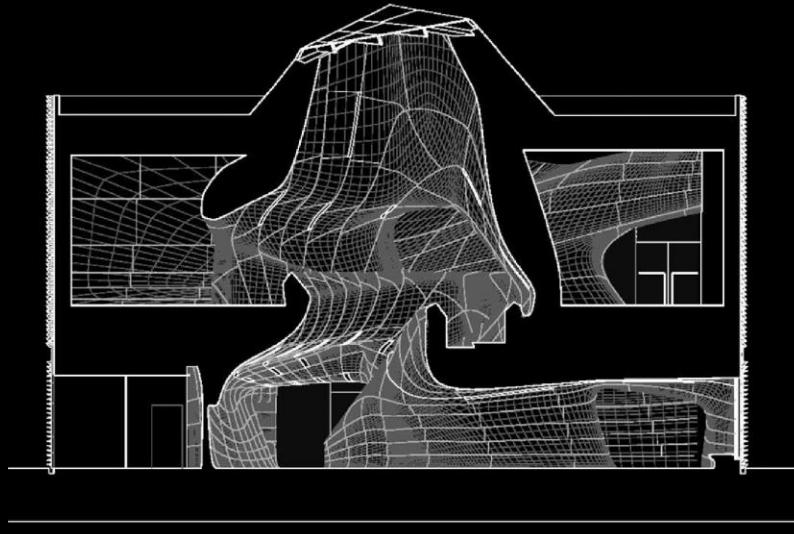
STUDIO PEI-ZHU

## Goal:

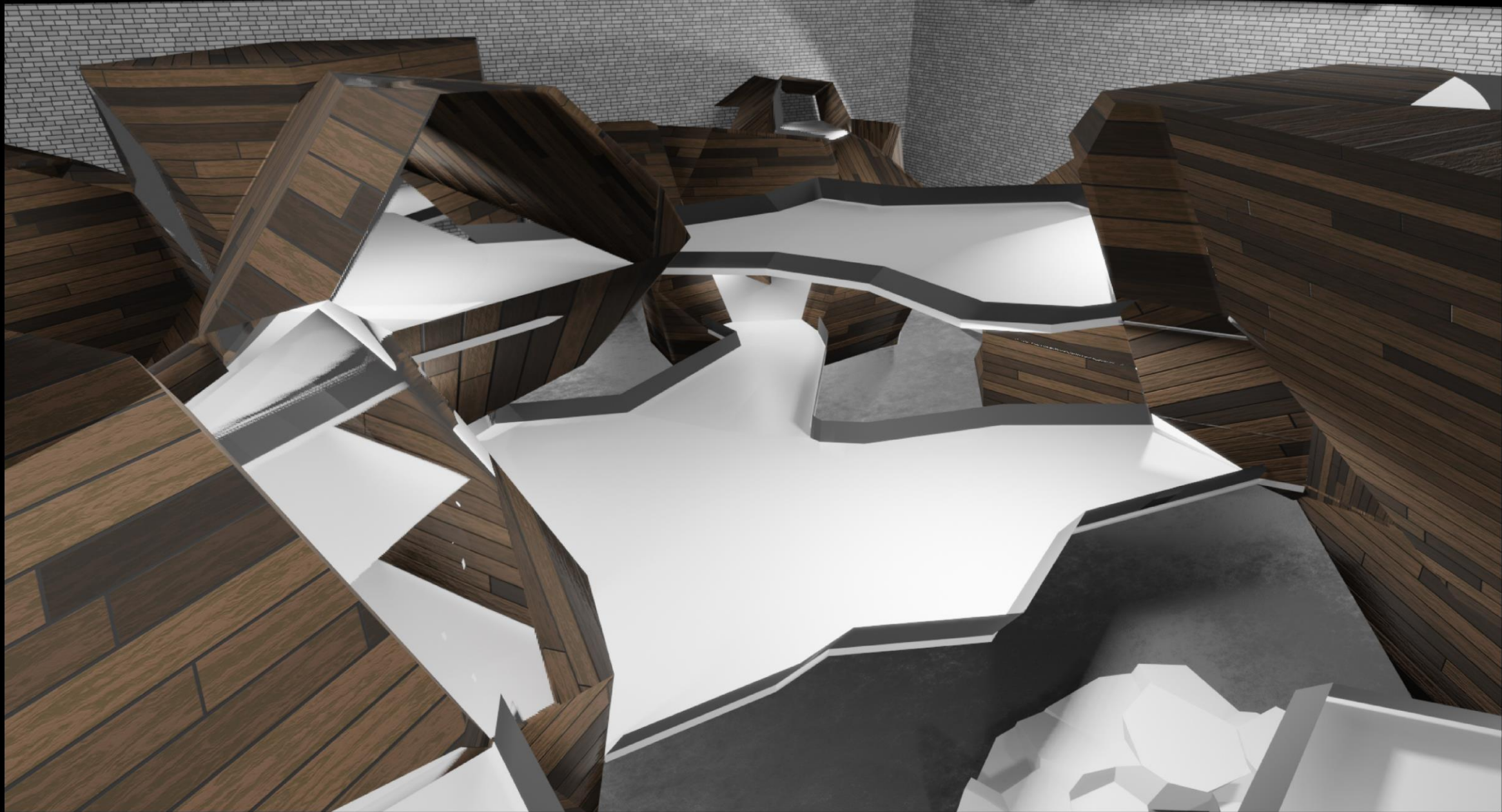
The goal was to create a space that is surreal to the subject matter but also transcendental in surrounding and feeling. The design of the interior relies on a continuous white curving surface that casts no shadows and has no depth.

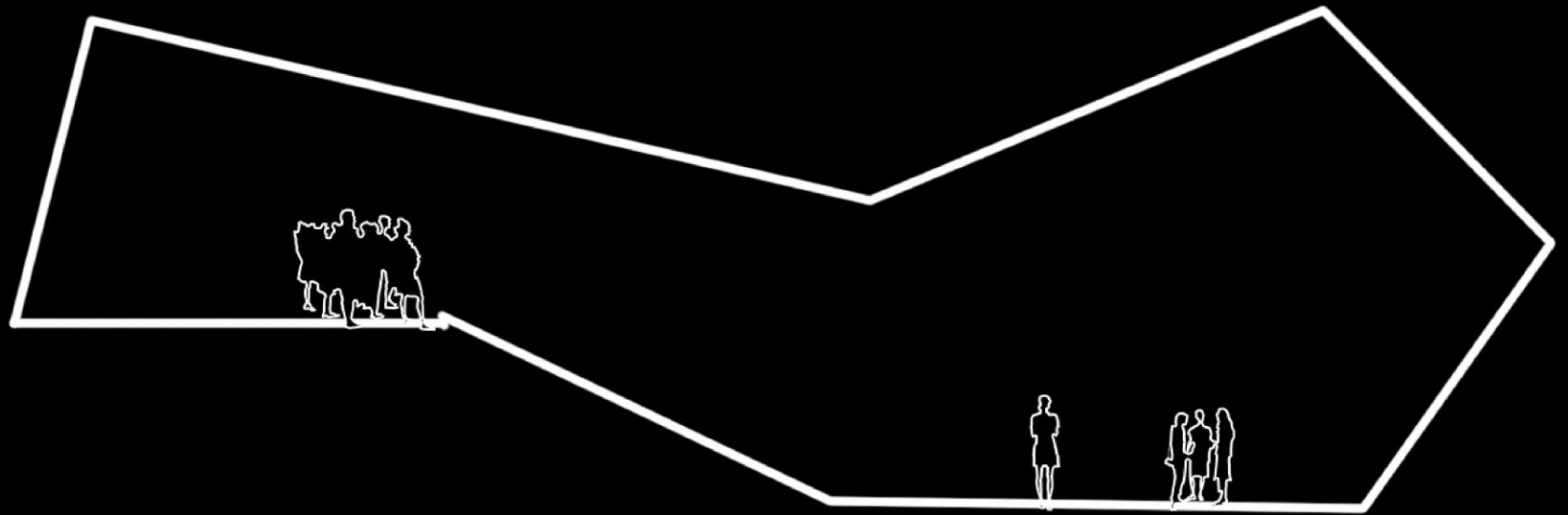


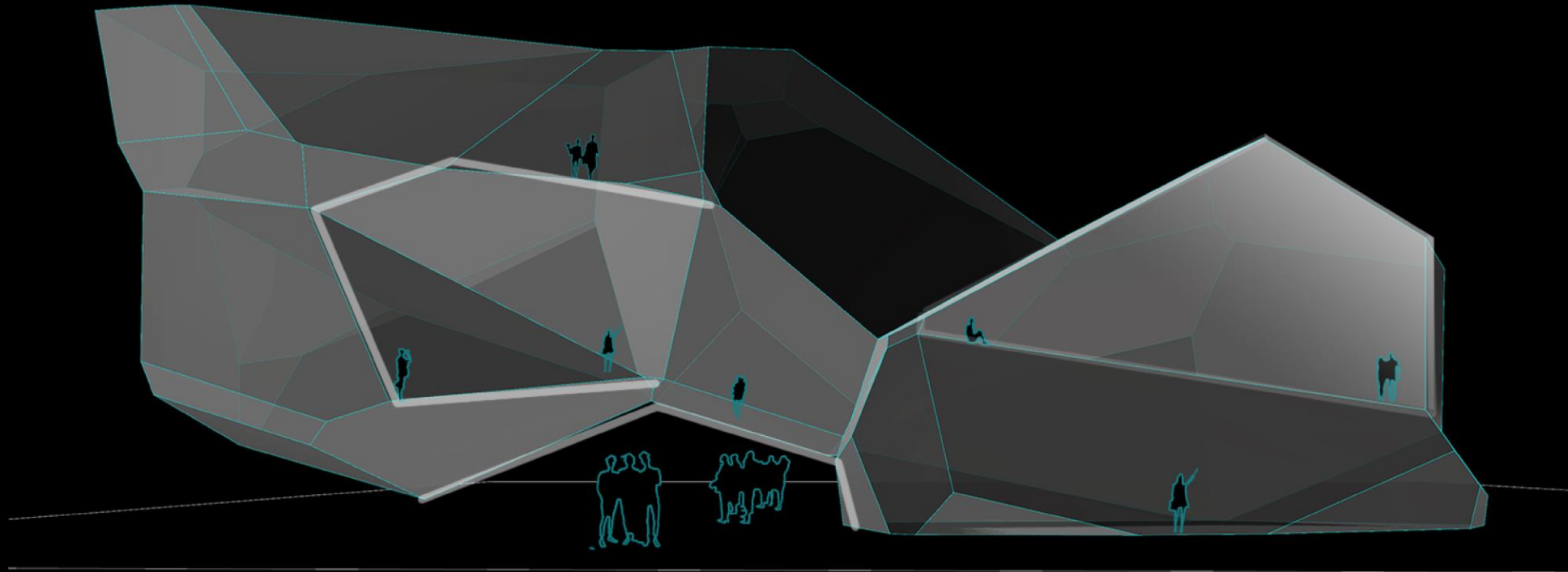




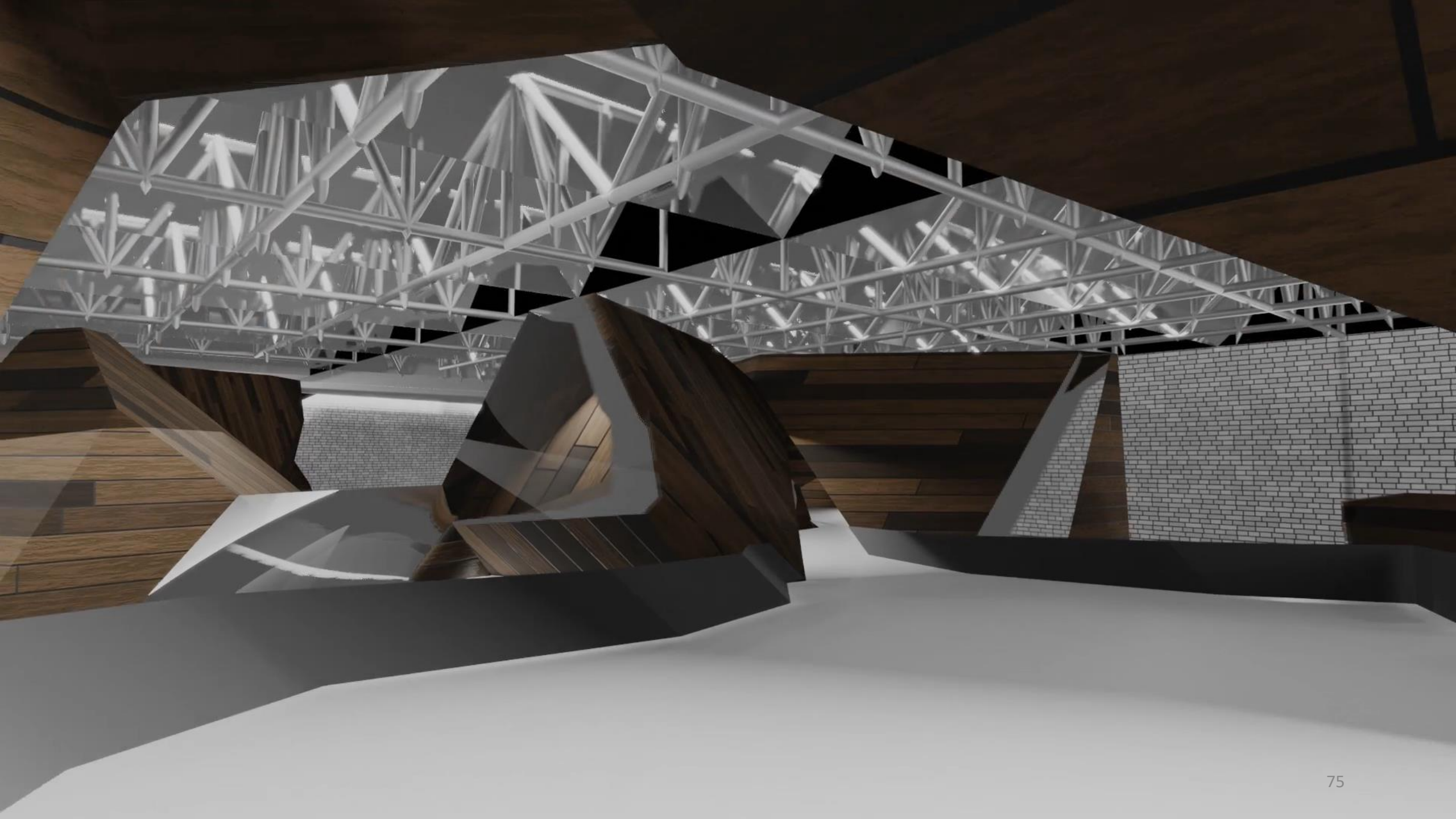
FORMATION OF A "KNOT"

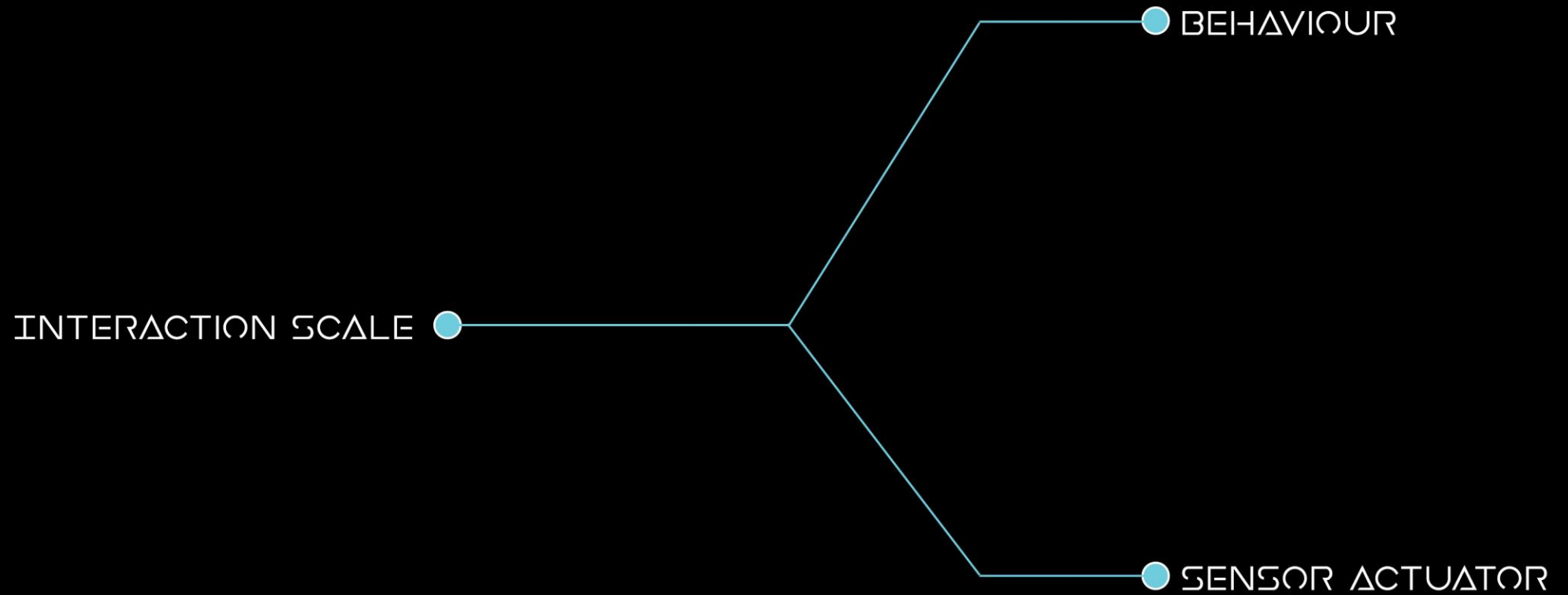


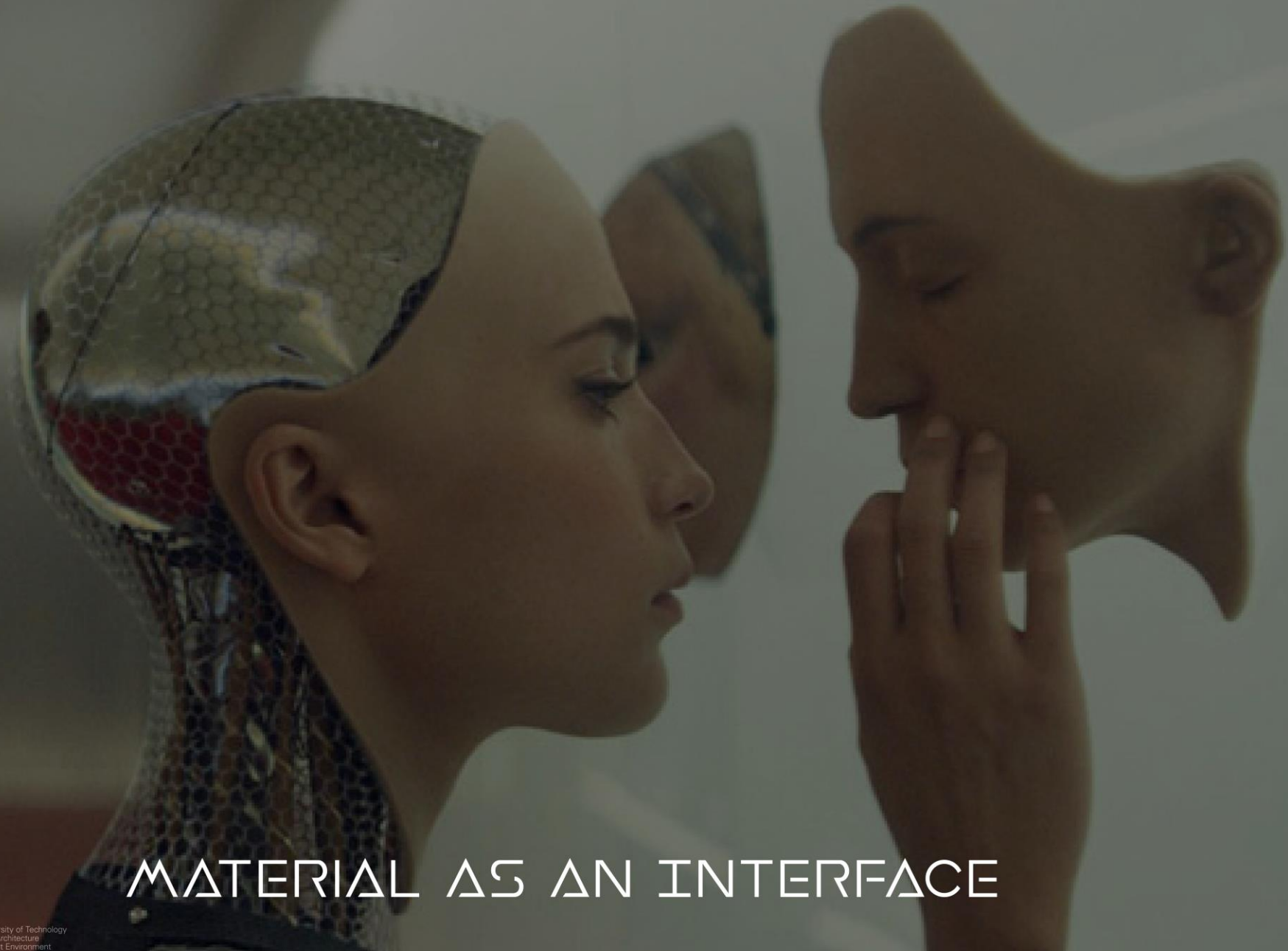




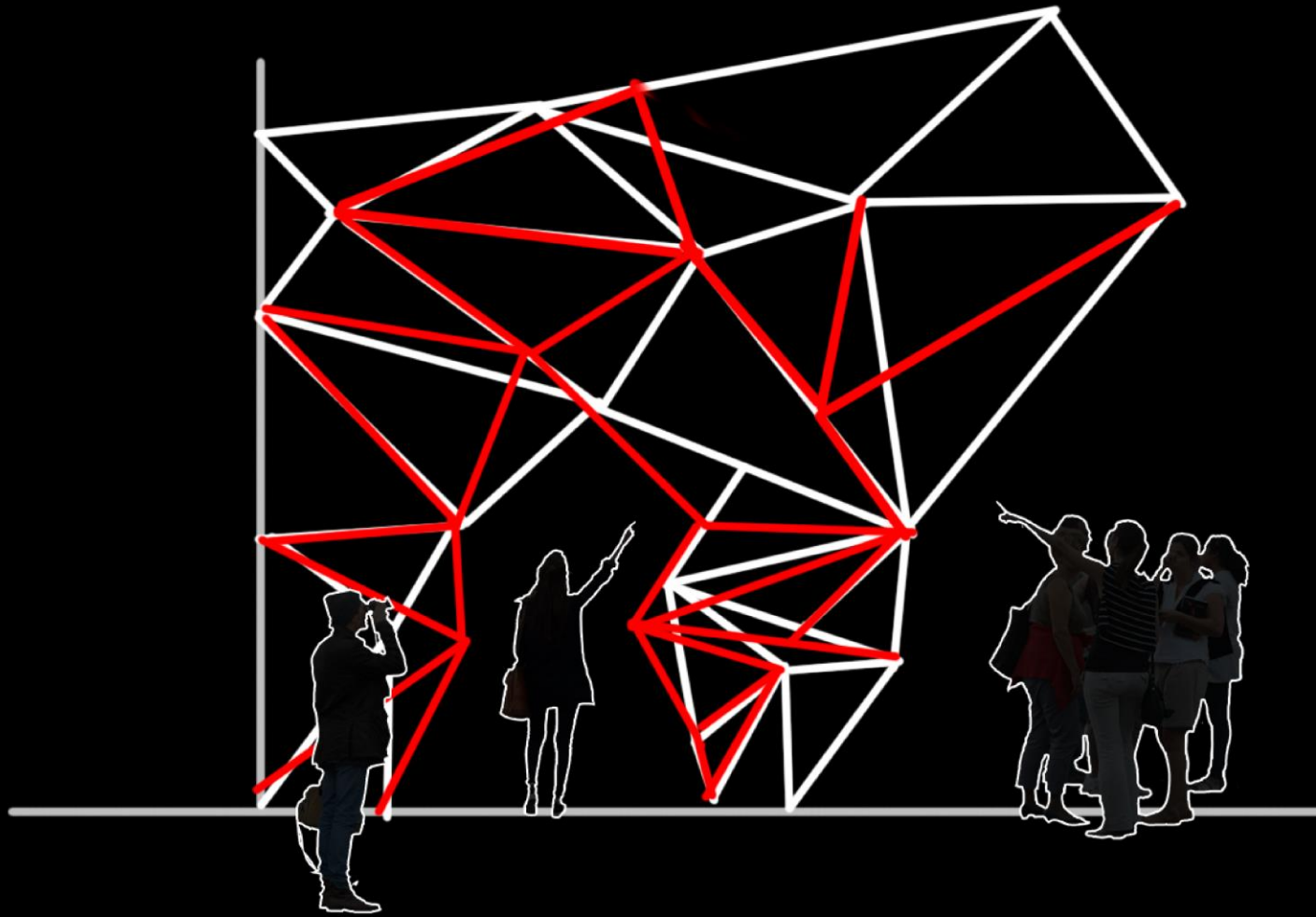




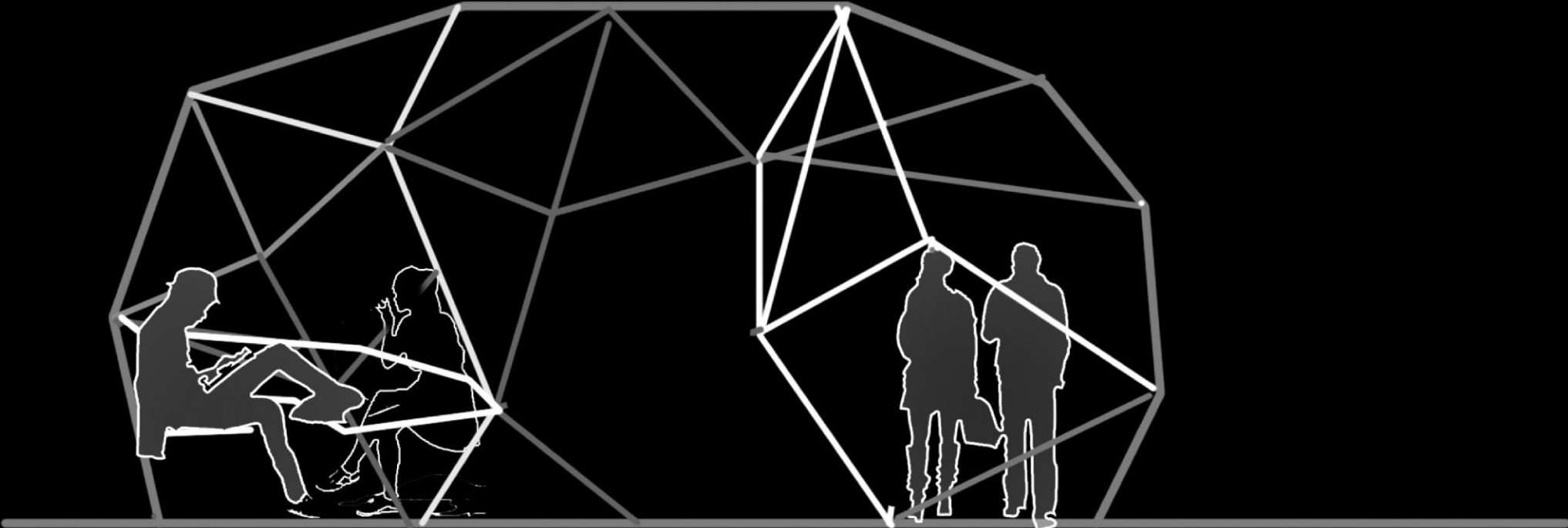




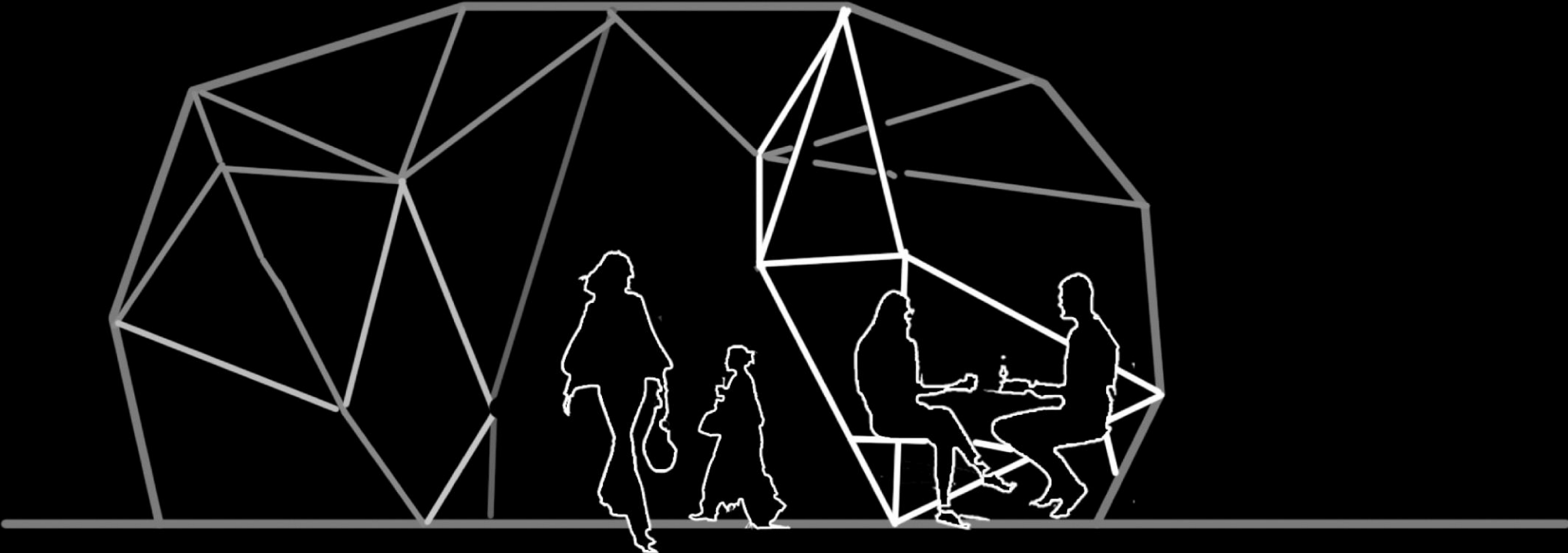
# MATERIAL AS AN INTERFACE



# SOCIAL INTERACTION



# SOCIAL INTERACTION



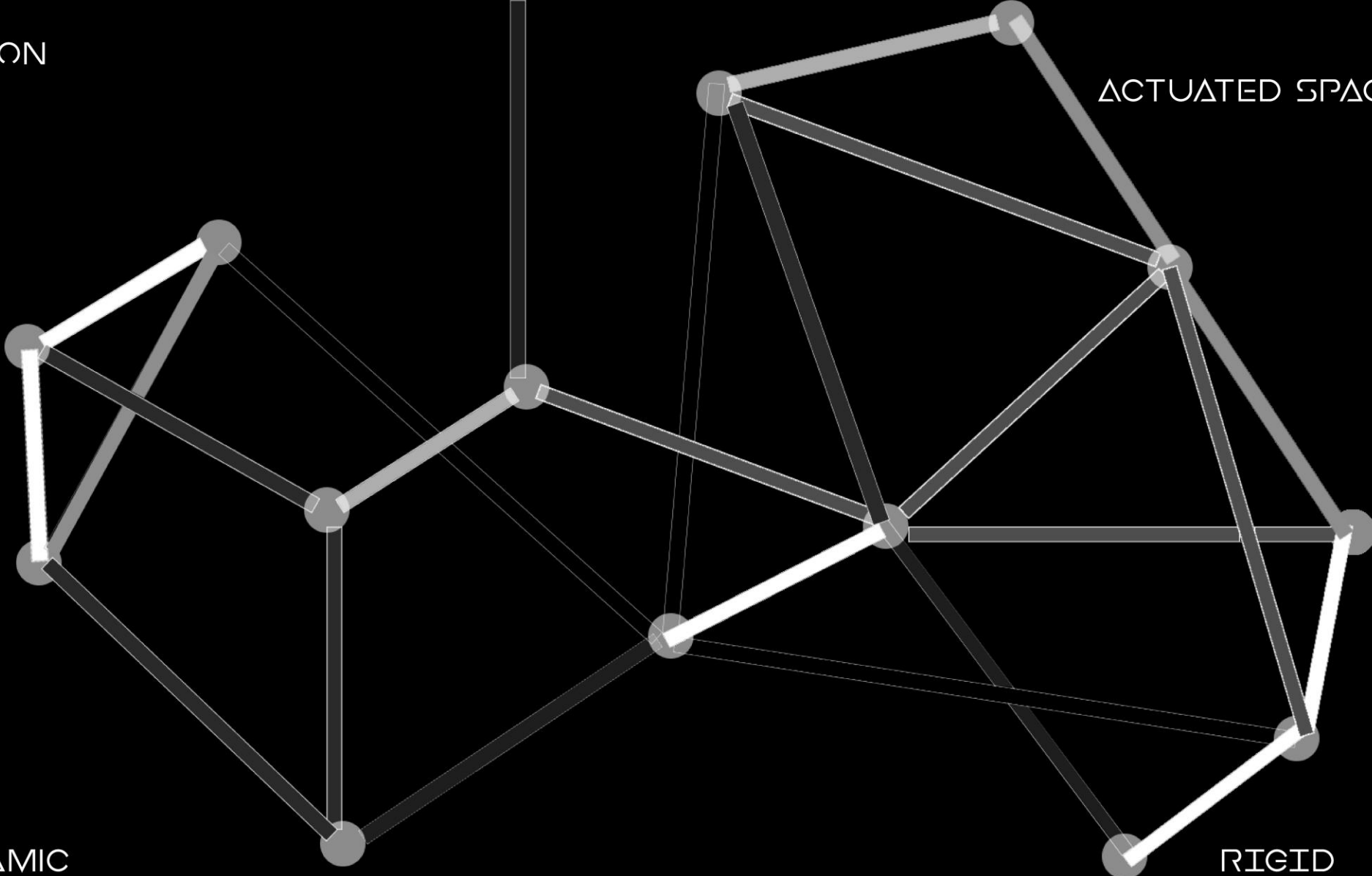
MATERIALIZATION

ACTUATED SPACE FRAME

MODULAR

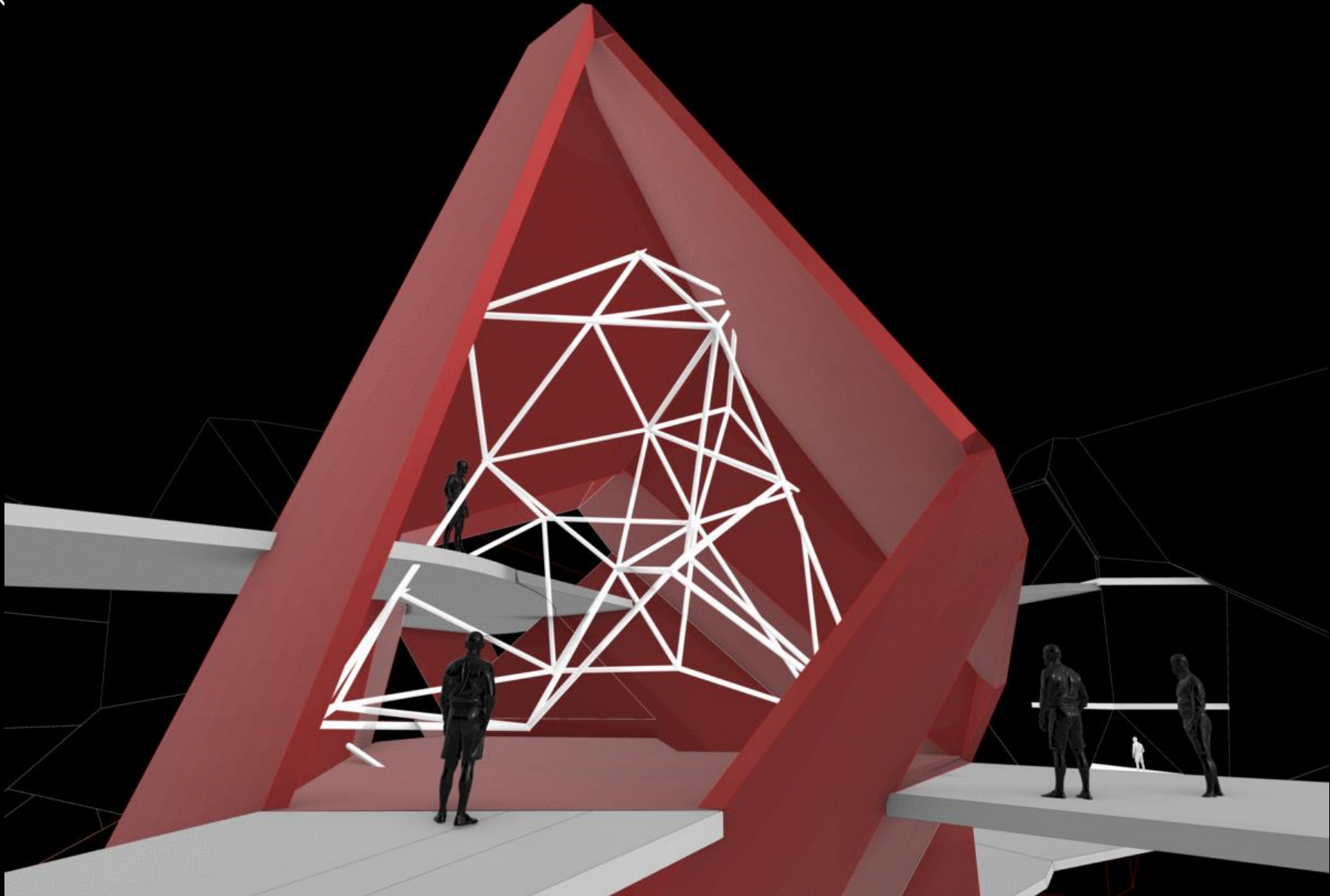
DYNAMIC

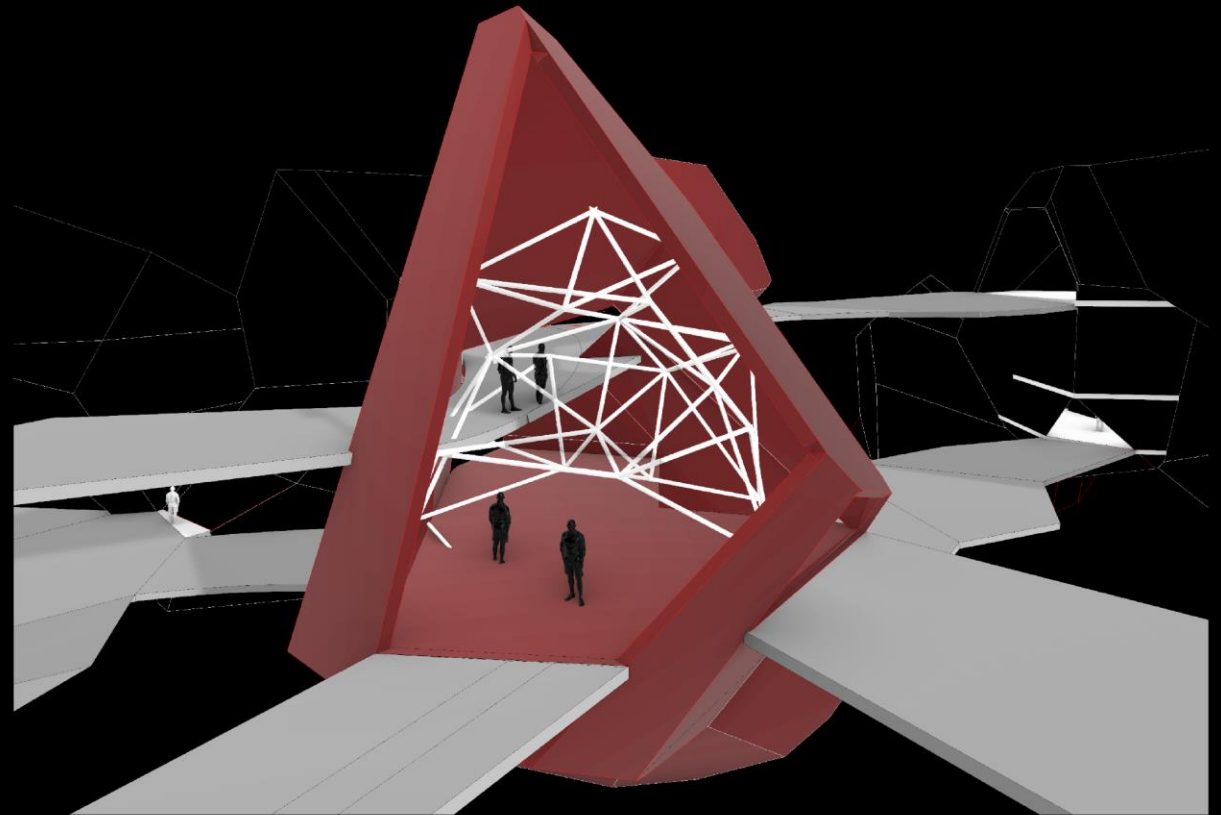
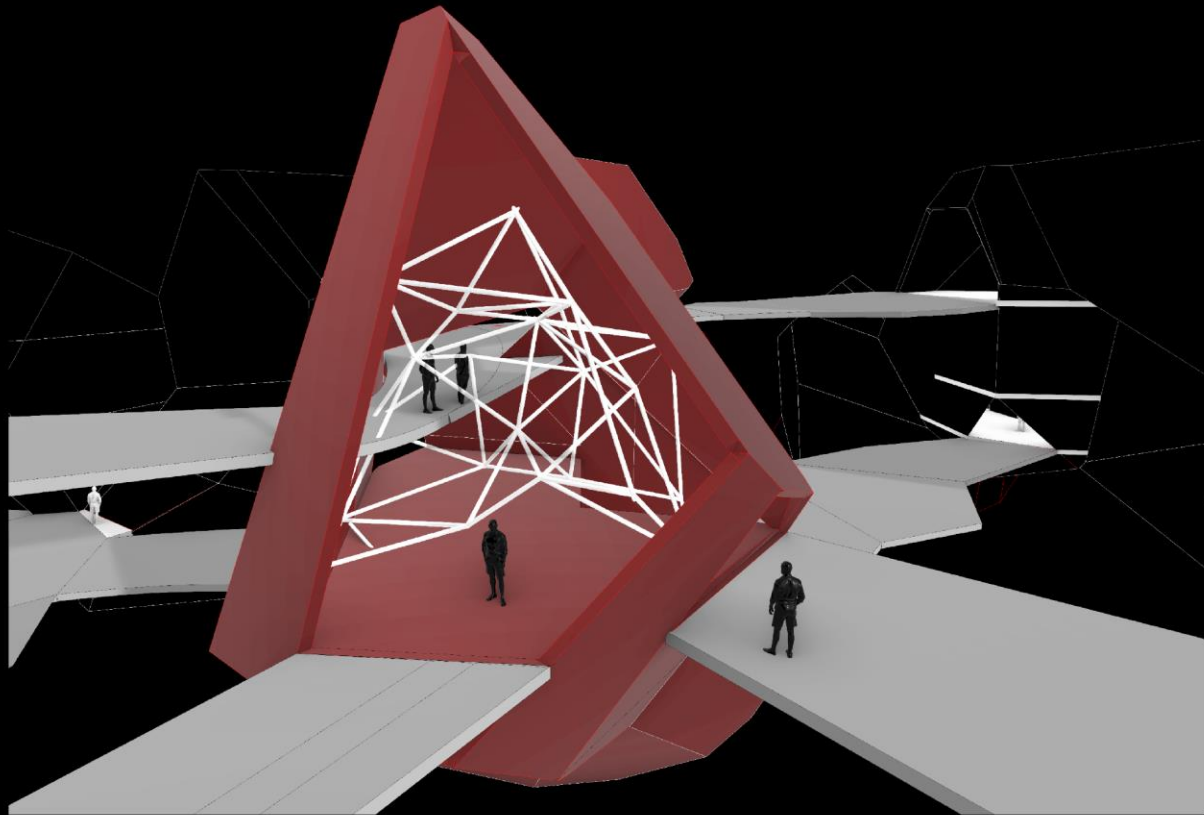
RIGID



# HUMAN BUILDING INTERACTION

USE SOFT ROBOTICS TO ENHANCE AND OPTIMIZE SPATIAL USER EXPERIENCES





# DIGITAL TWIN

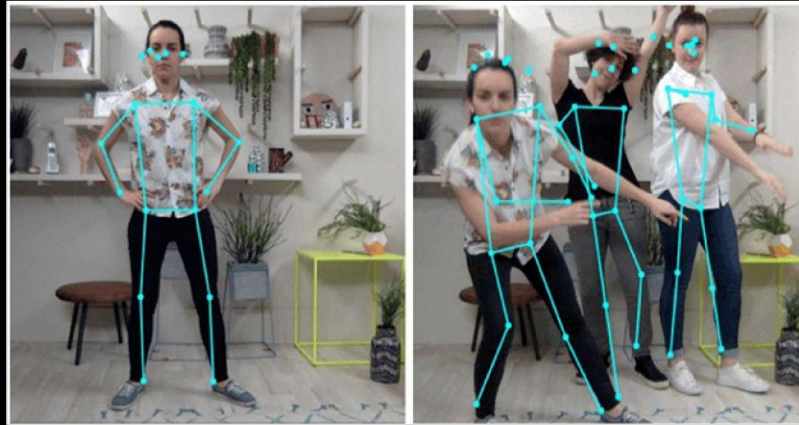
VIRTUAL MODEL

PHYSICAL CONSTRUCT

# AI INTEGRATION

# GOOGLE'S VISION API

Infrared Sensor



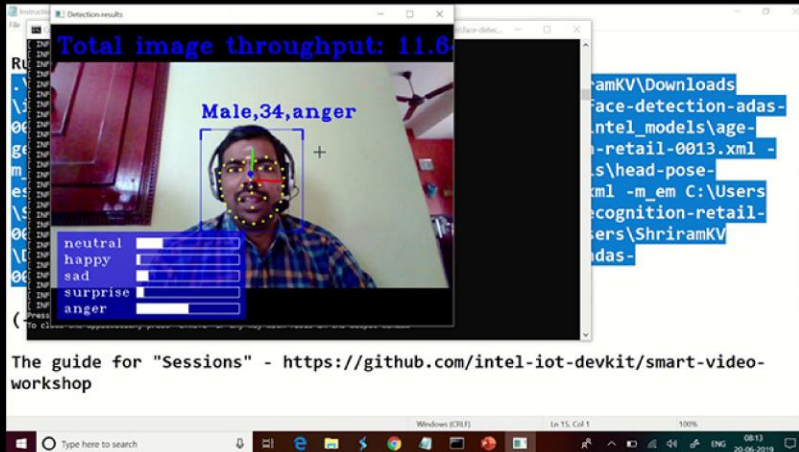
PoseNet Identification



Human Movement



Camera



Mood Detection AI EmoNet

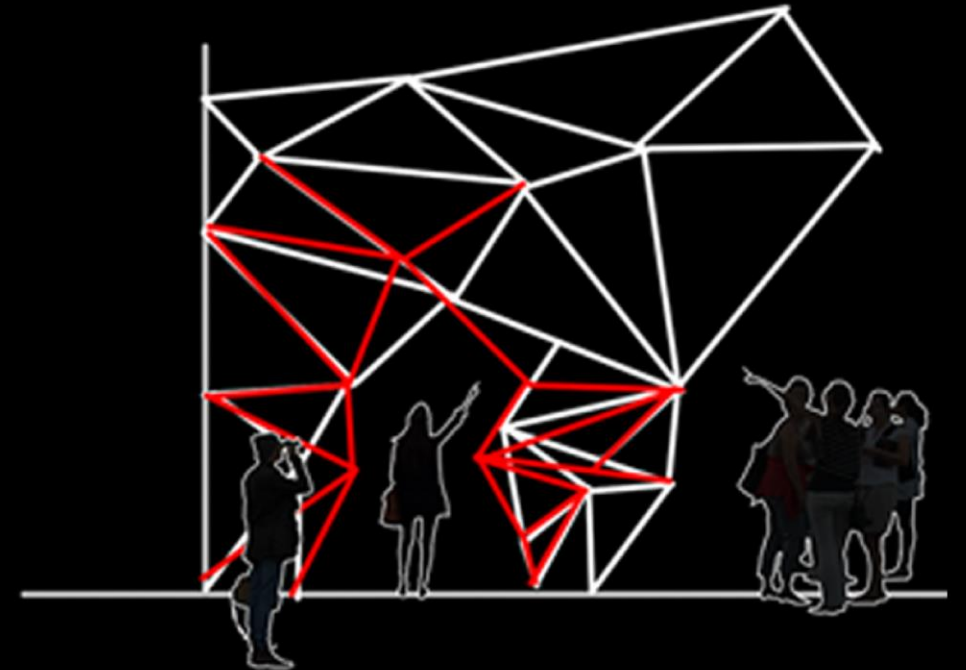


Plotting real time position in Digital Twin



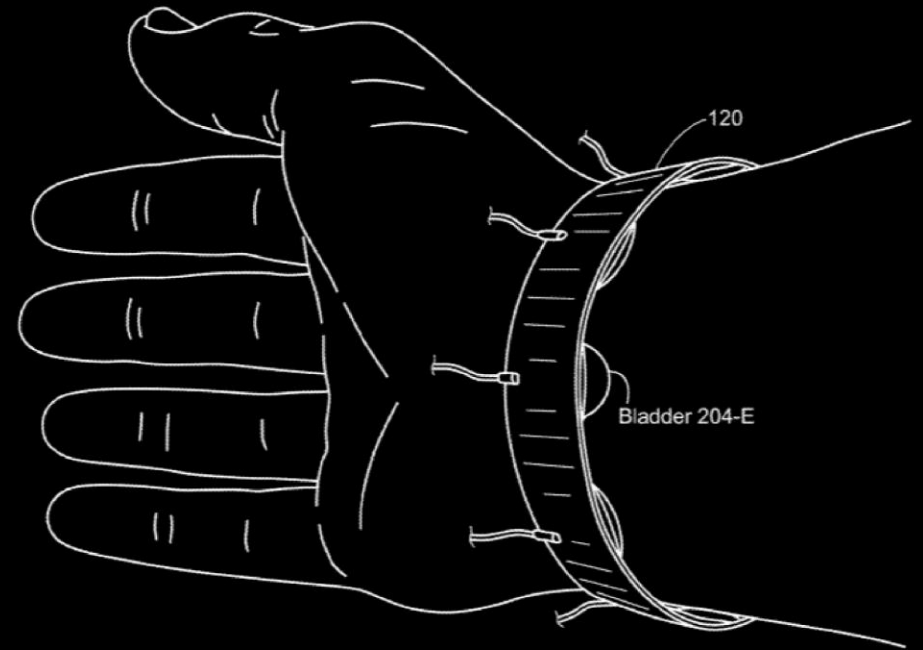
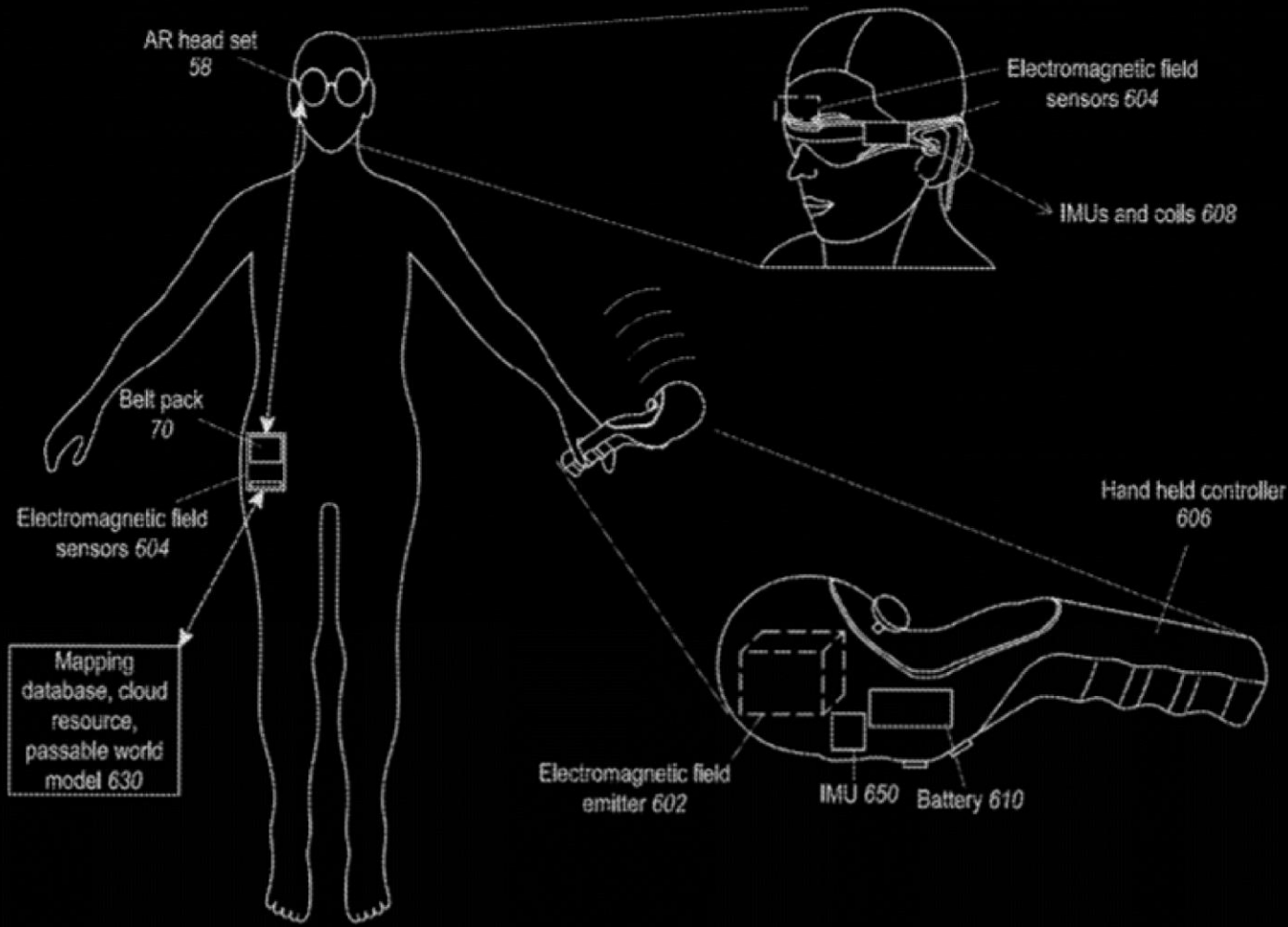
Dynamic Crowd control in real time

Altering the soft robot movements based on the location



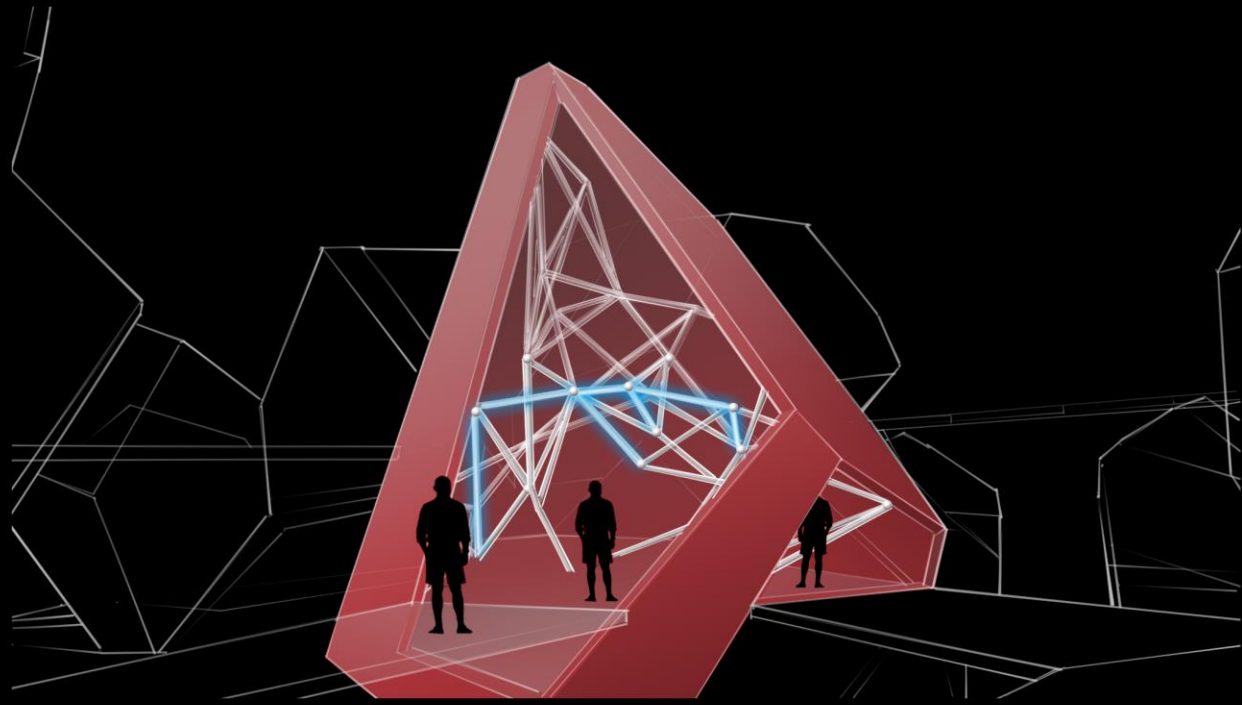
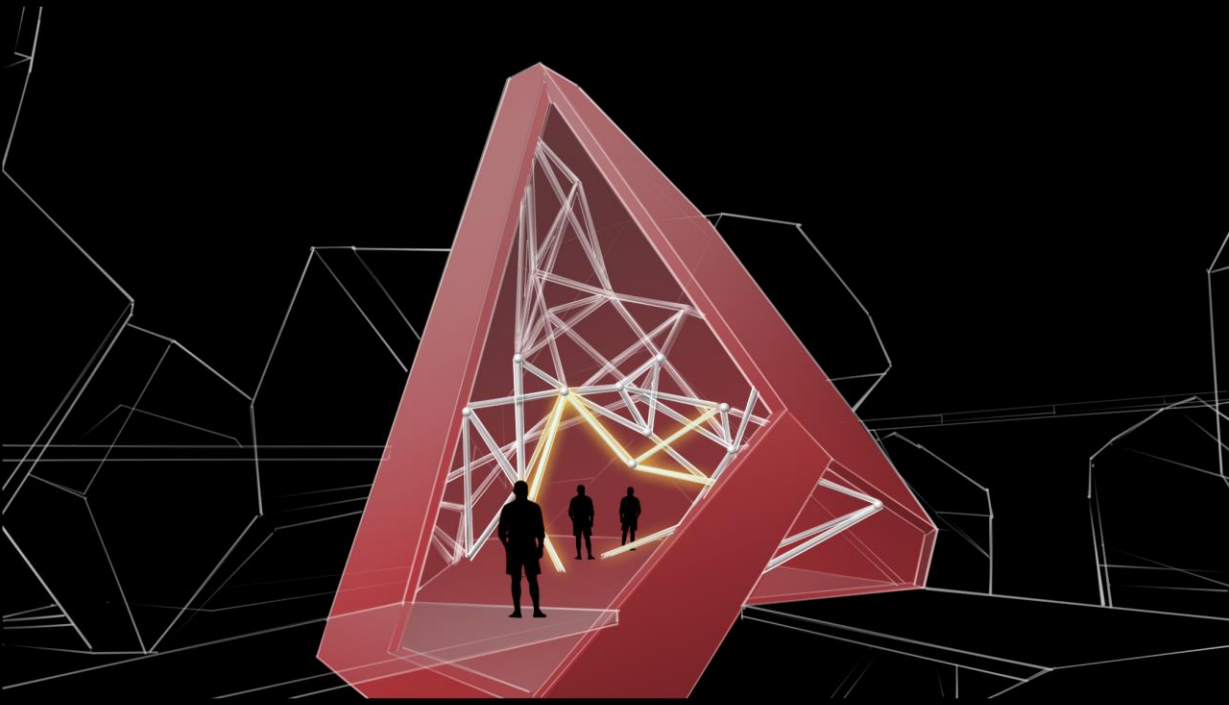
Lighting based on mood

# WEARABLES

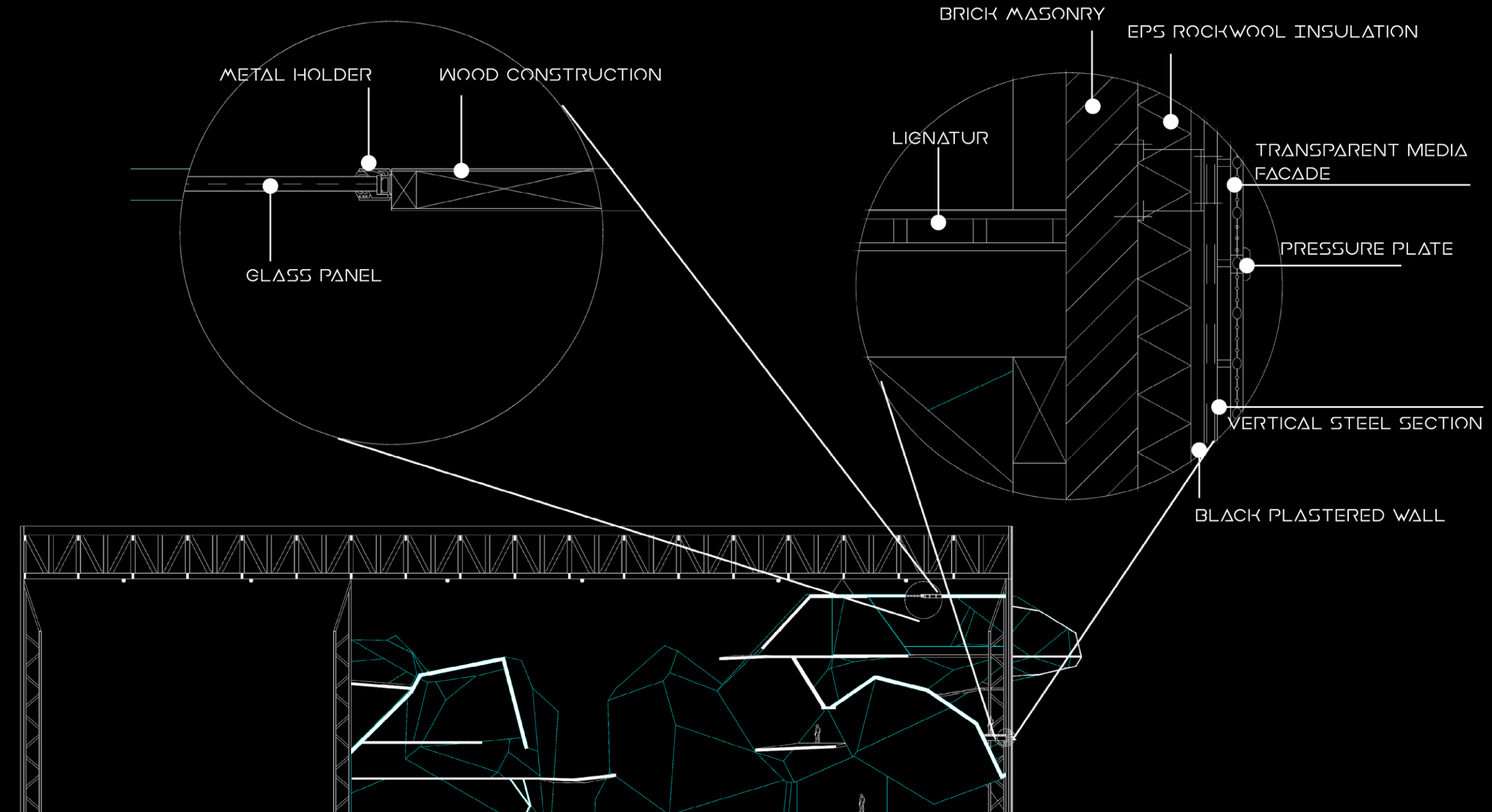


Haptic feedback arm band patented by Facebook

# LIGHTING INTEGRATION



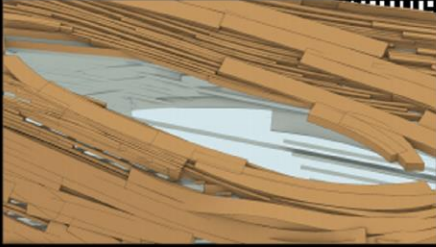
# MATERIALIZATION: STRUCTURE



# MATERIALIZATION REFERENCE

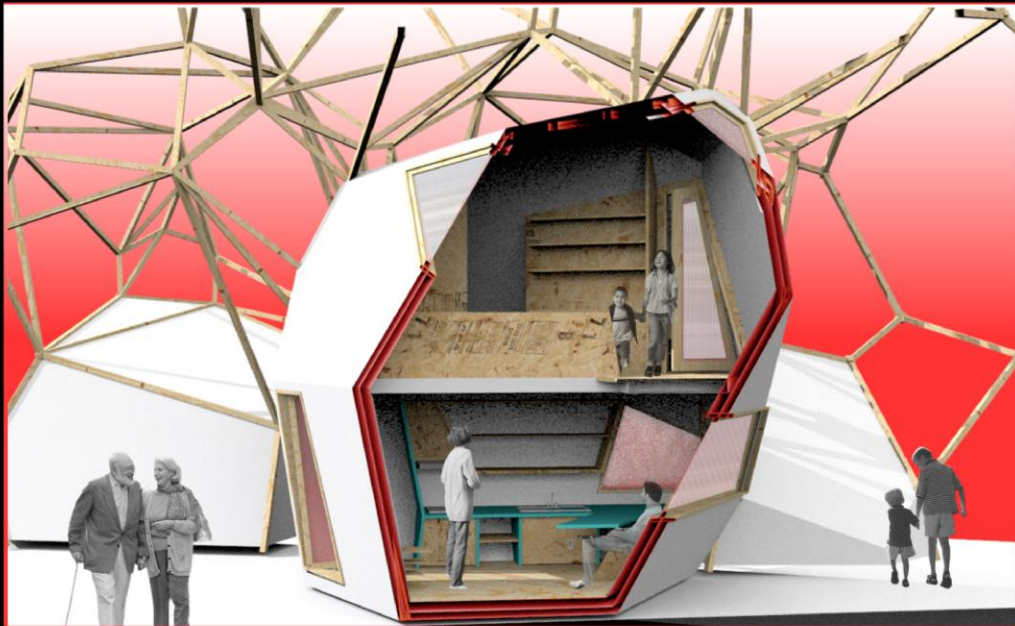
## HIDDE MANDERS - GRADUATION

<https://repository.tudelft.nl/islandora/object/uuid%3A922eaac4-c1f7-4106-836a-d1fa614d6c56>

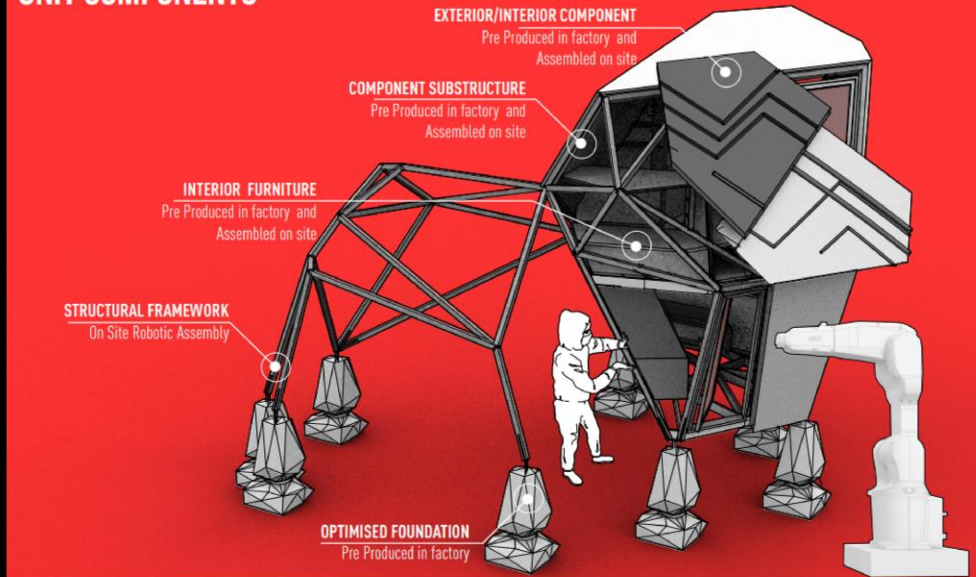


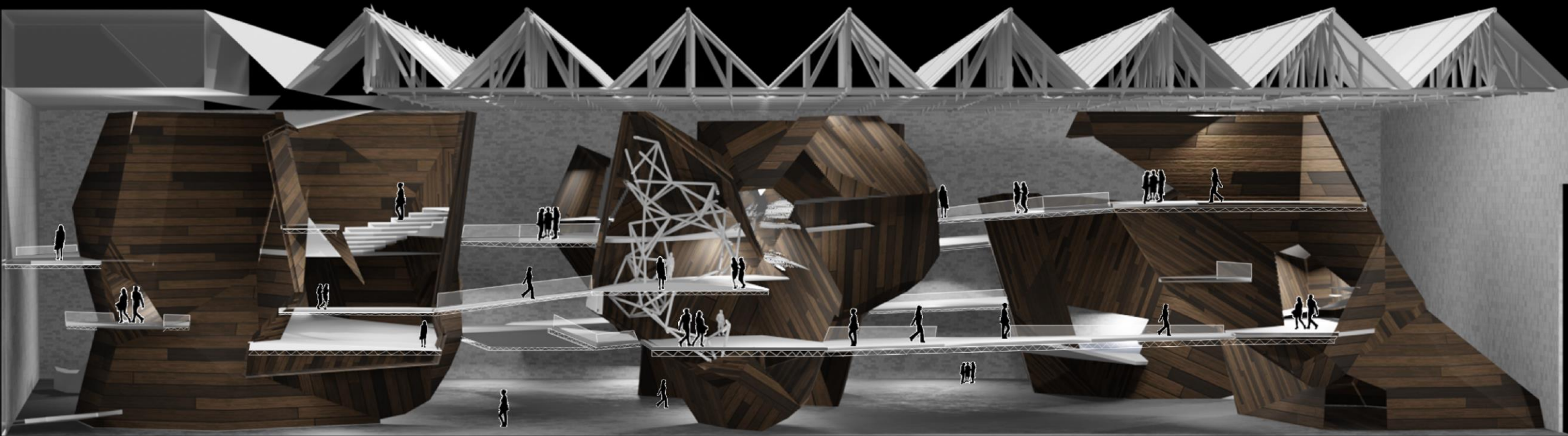
## MARCO GALLI - GRADUATION

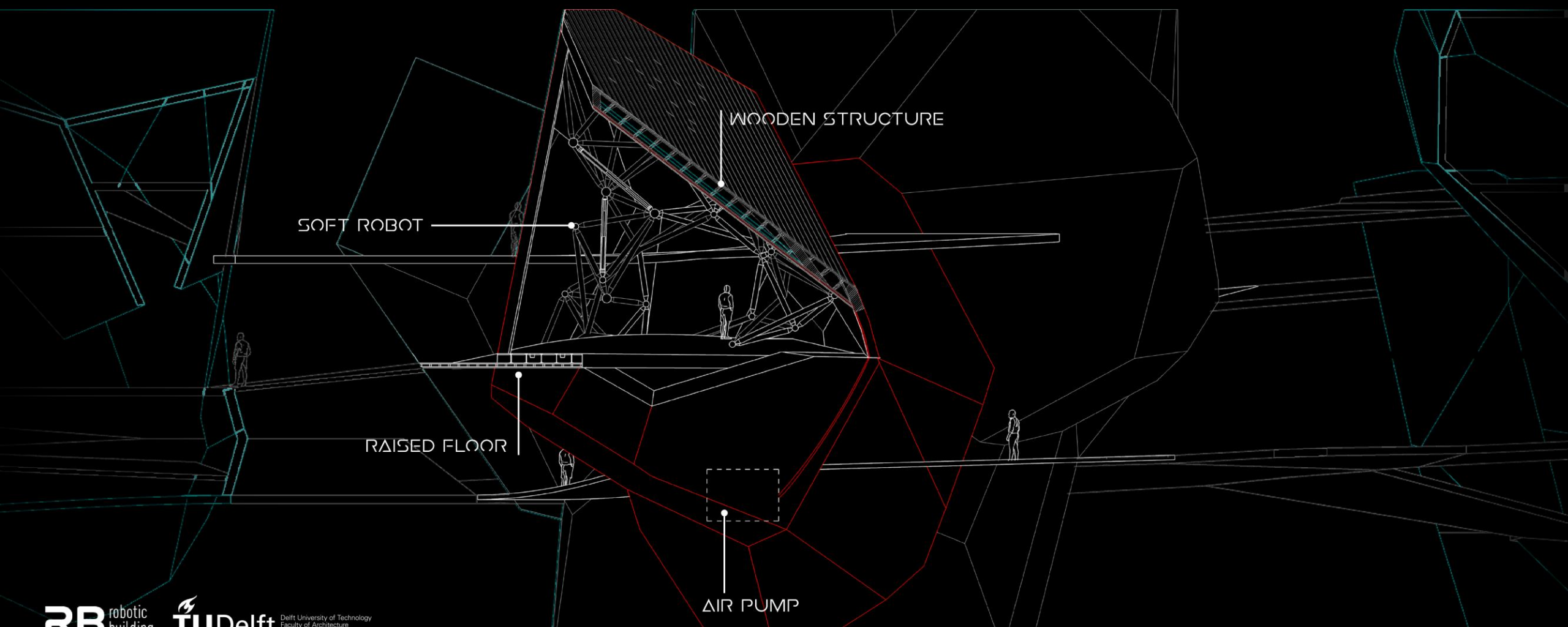
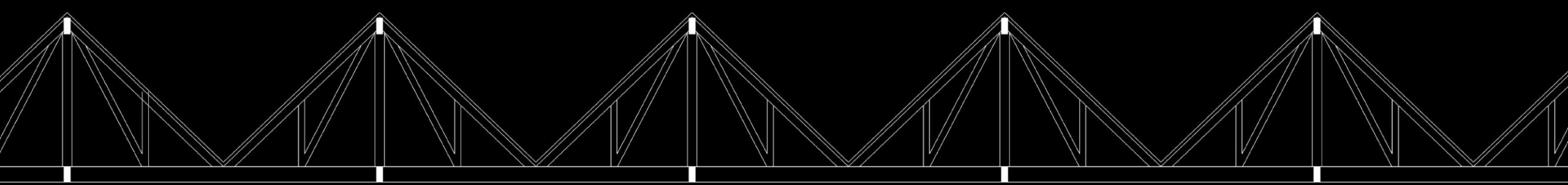
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## UNIT COMPONENTS

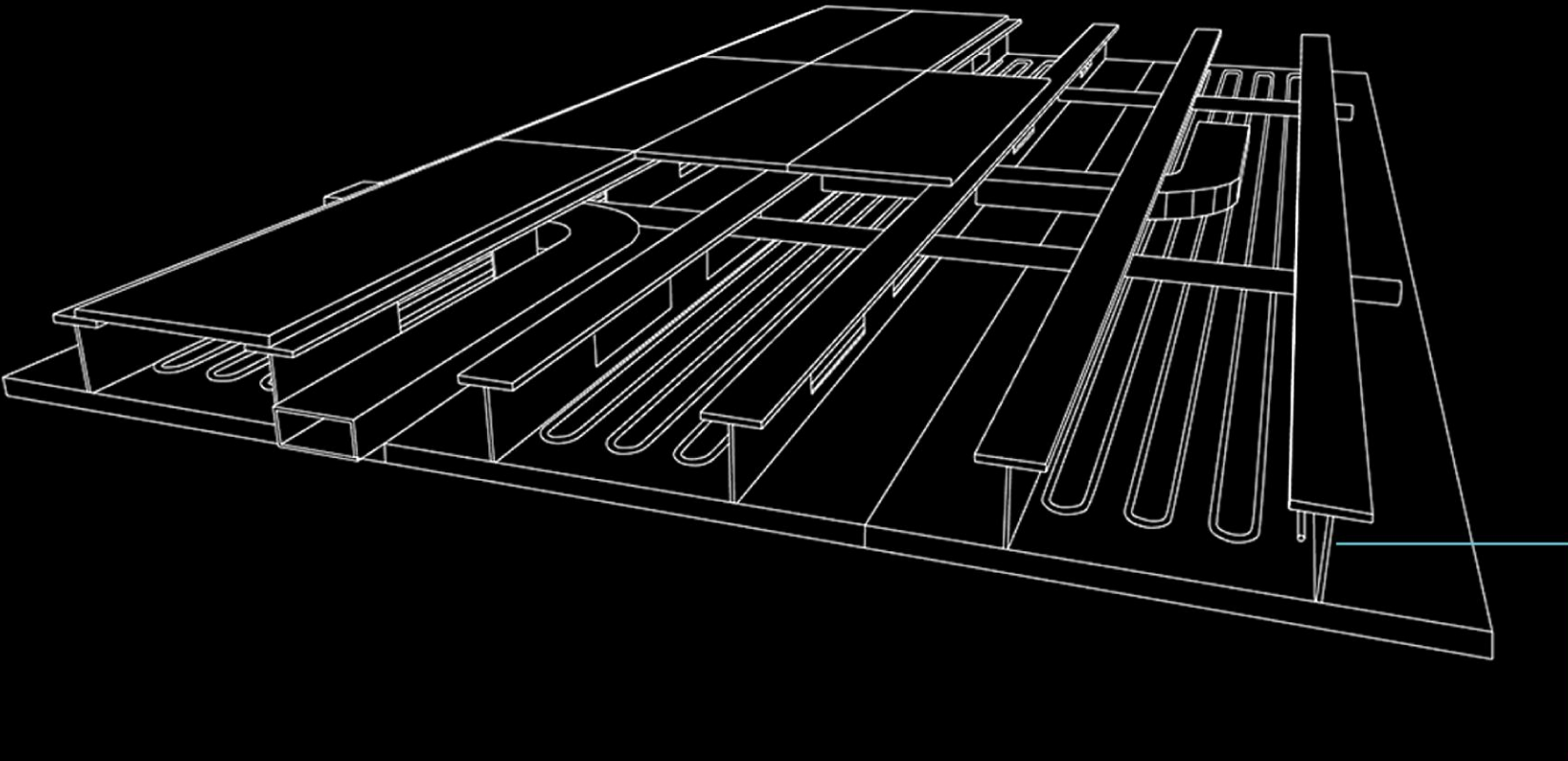




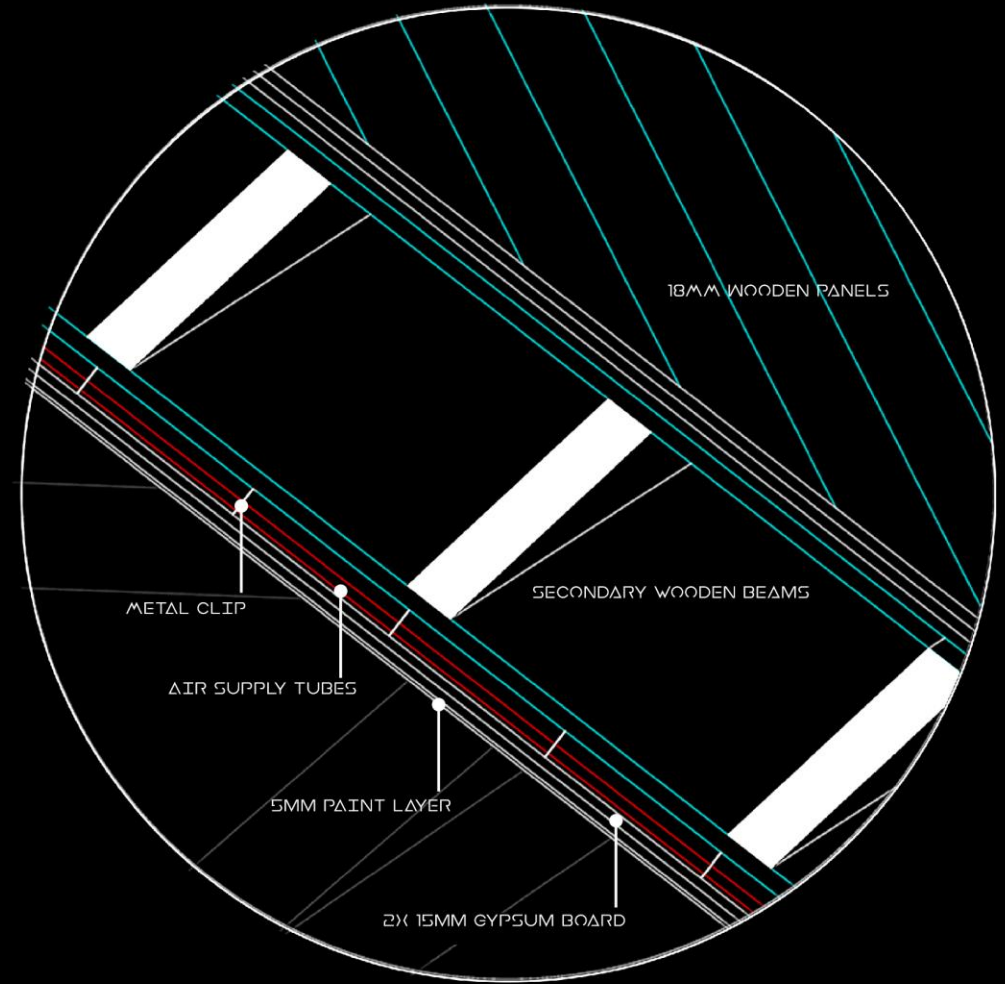
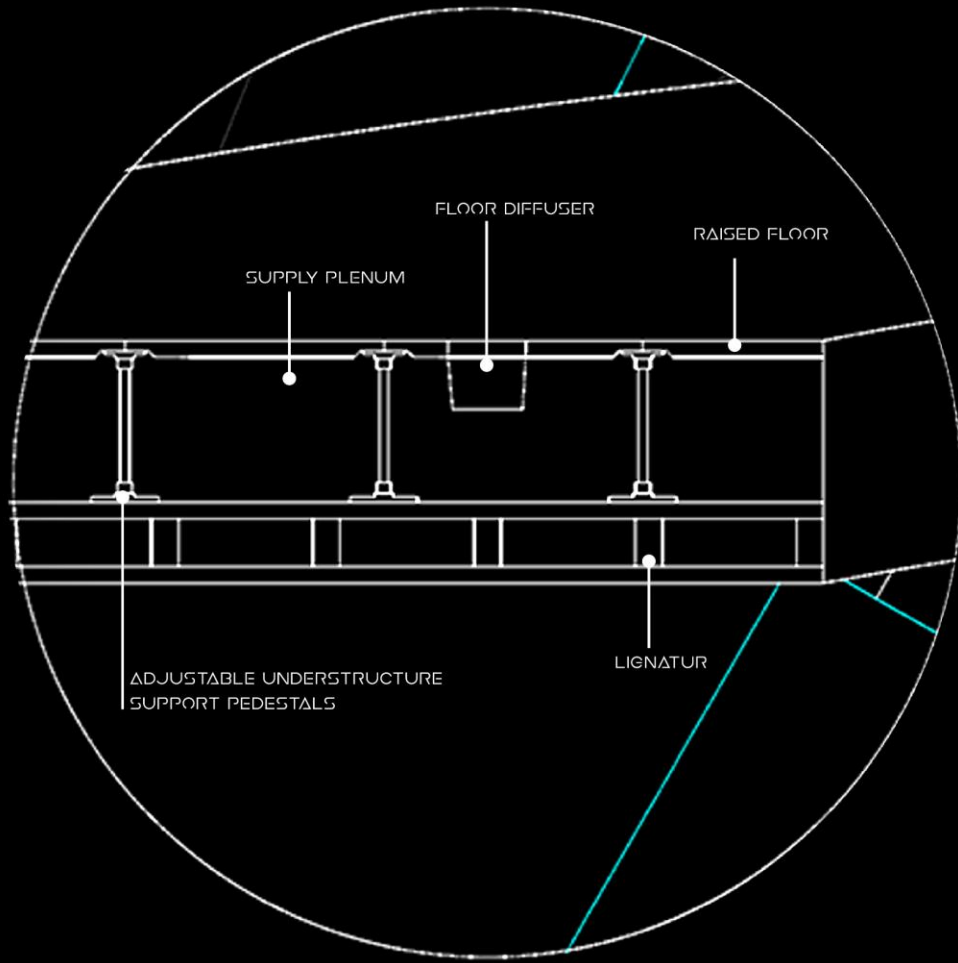


# RAISED FLOOR SYSTEM

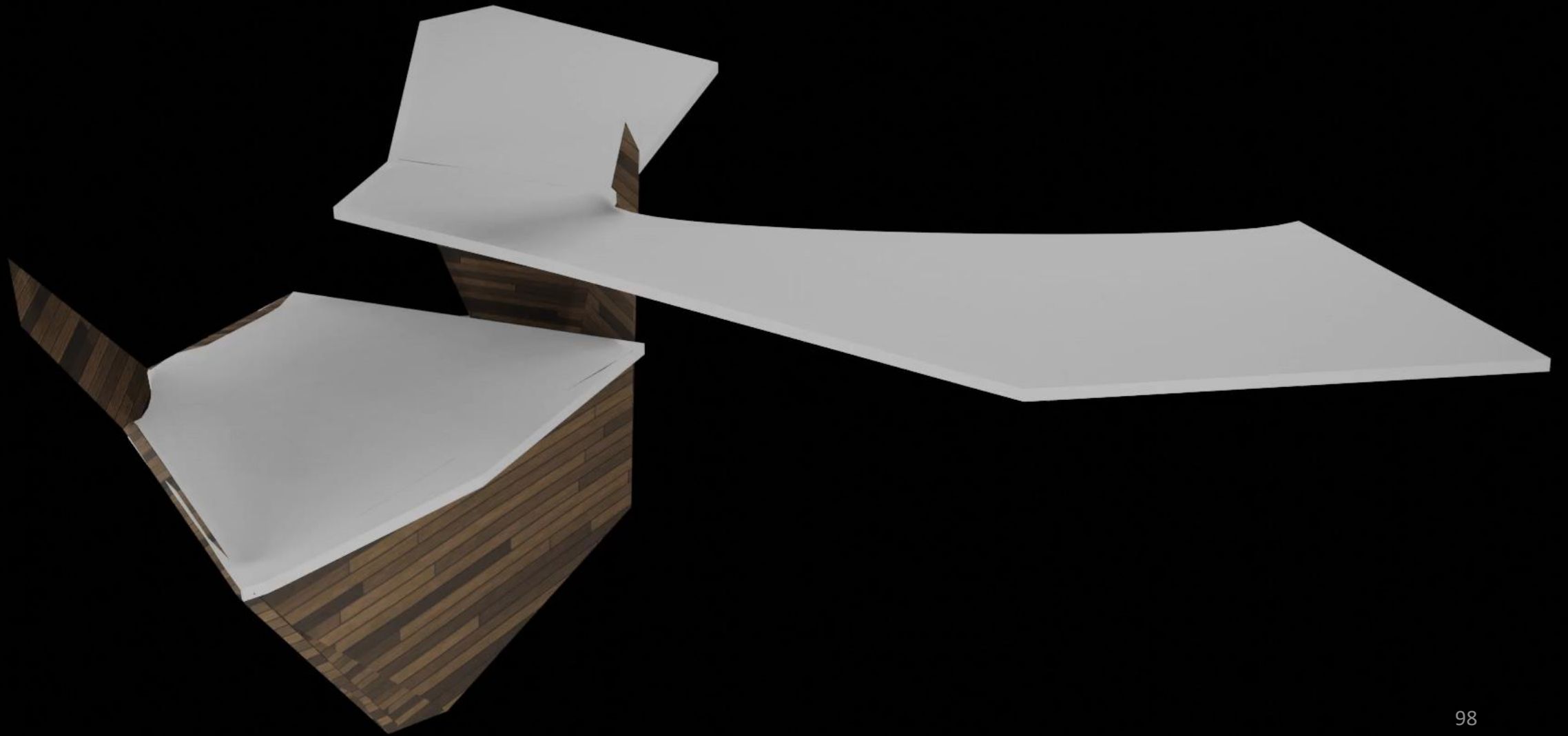
## DISASSEMBLE FLOOR SYSTEM FOR WIRING OF ROBOTS



DISASSEMBLE FLOOR SYSTEM FOR WIRING OF ROBOTS







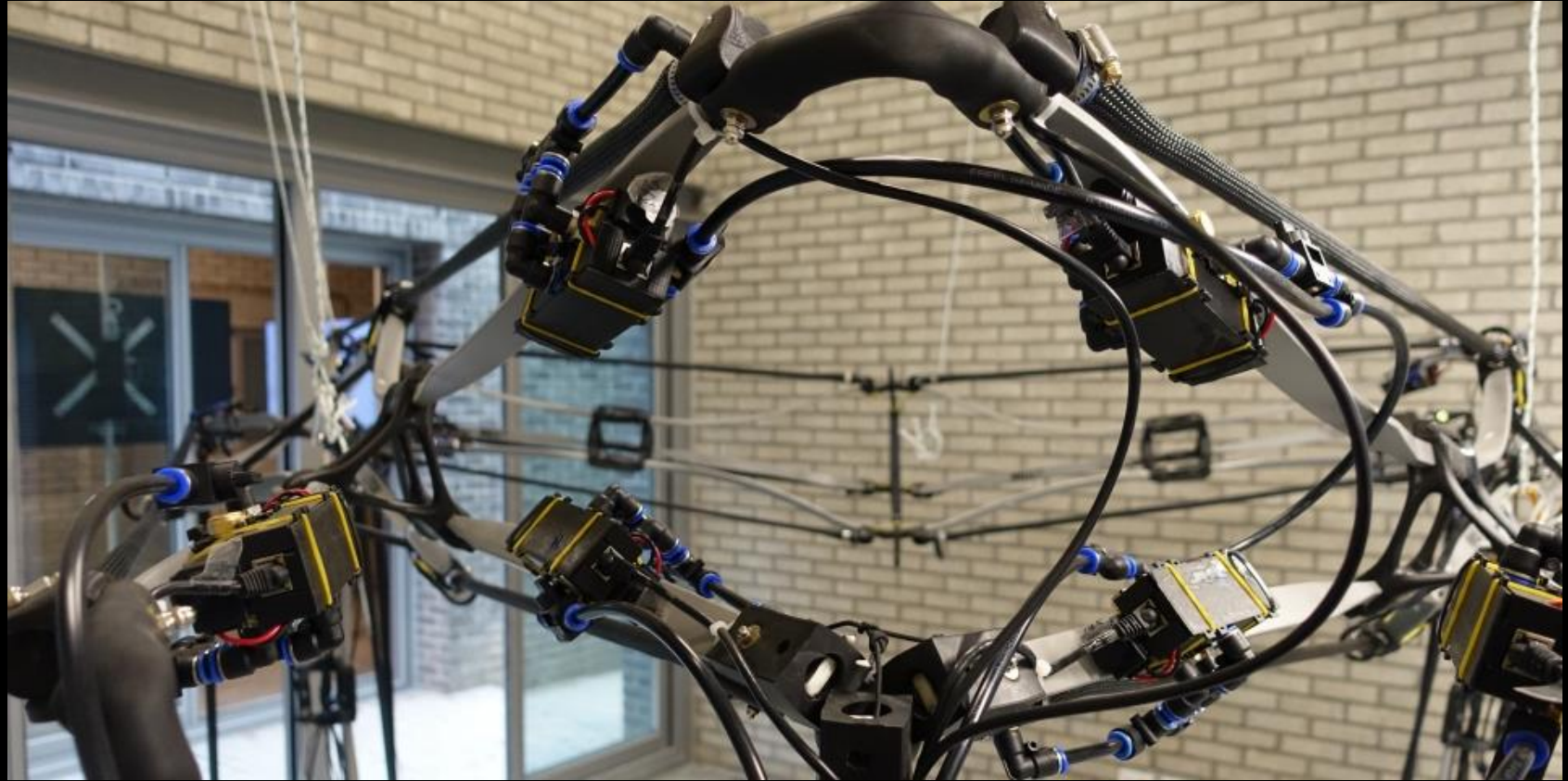
# MATERIALIZATION: SOFT ROBOT

# ARTIFICIAL INTELLIGENCE

FLEXING ROOM - AXEL HILLIAN



AMBIENT INTELLIGENCE



# HYPERBODY MUSCLE TOWER II



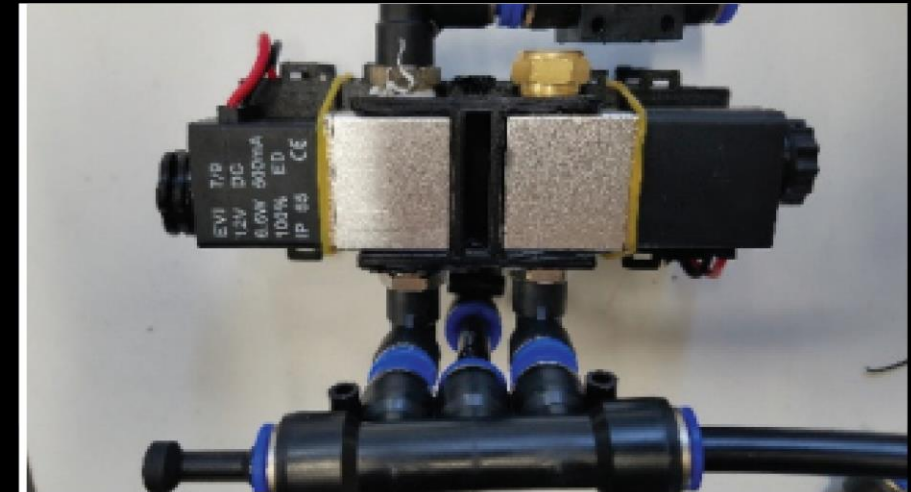


# SENSORS

## PASSIVE INFRARED SENSOR



## PROXIMITY SENSOR



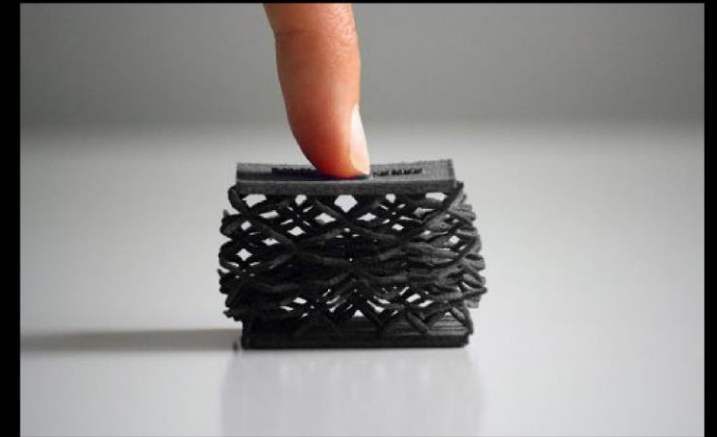
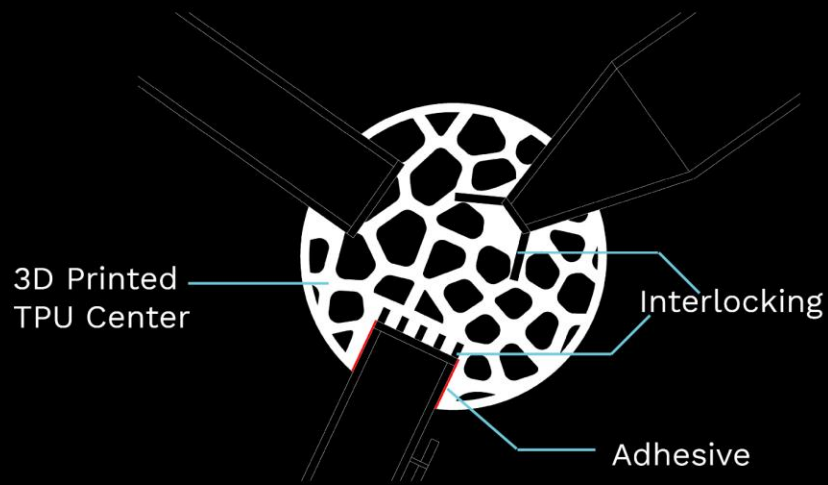
## PRESSURE VALVE

Reference : Flexing room, Axel Killian

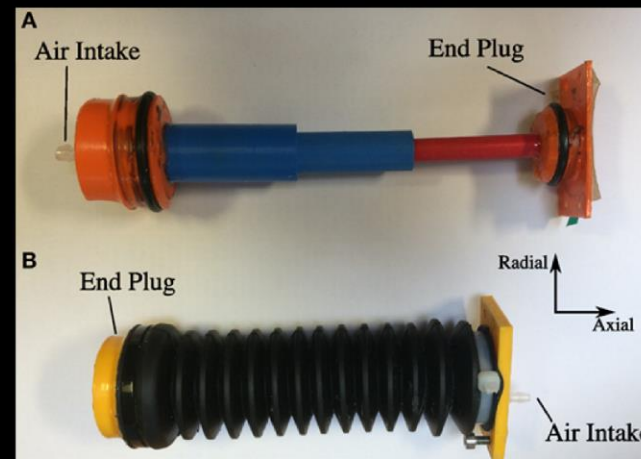
RAPID LIQUID PRINTING TECHNIQUE - SILICONE



NODE

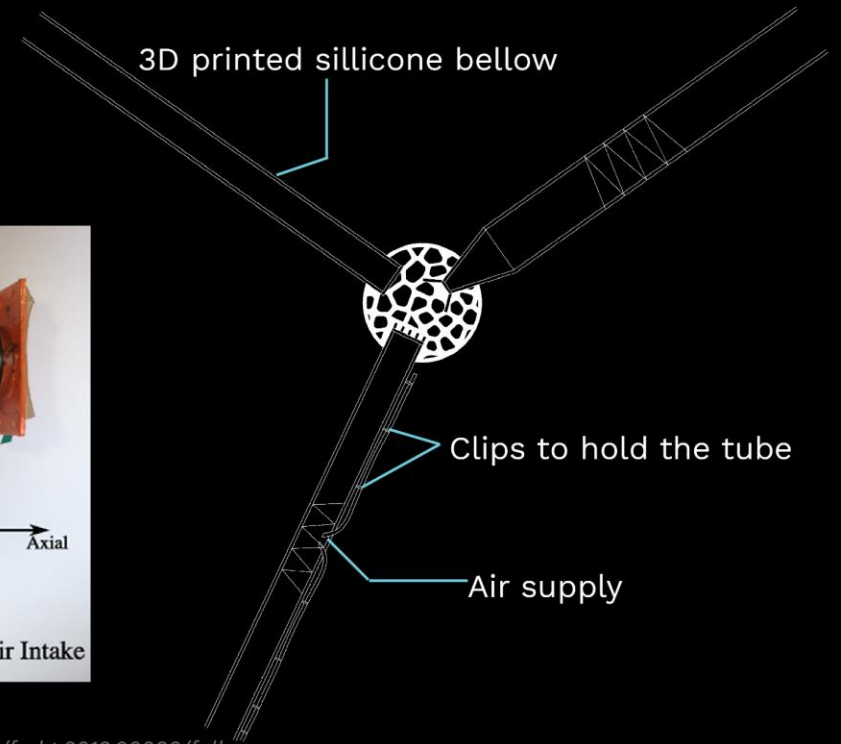


3D printed silicone bellow

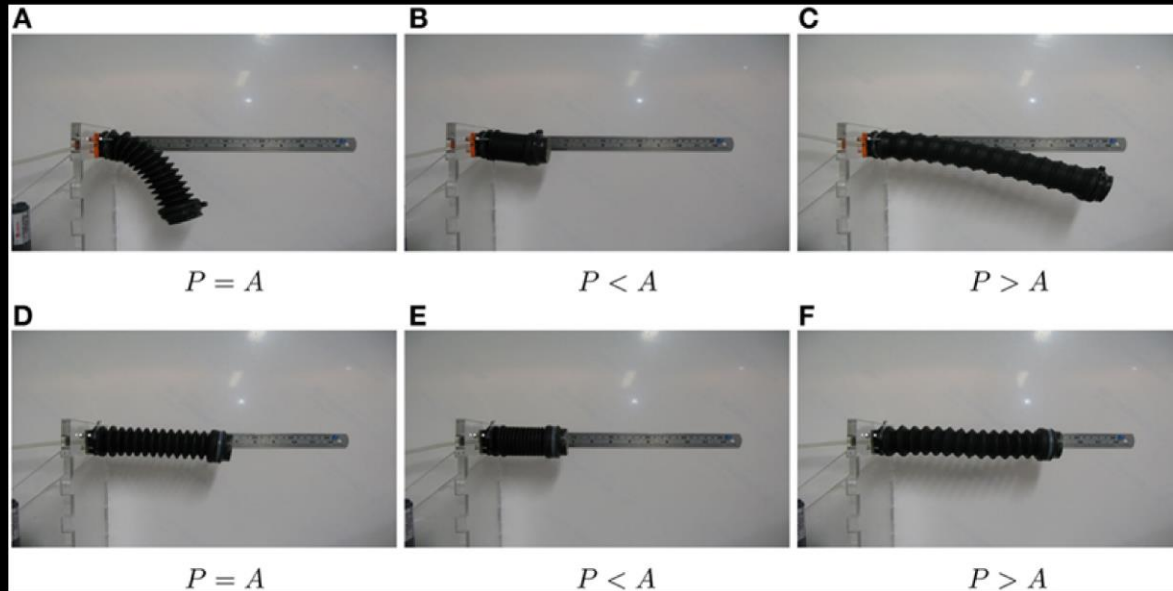


TELESCOPIC MODULE OF A LIMB

Reference: <https://www.frontiersin.org/articles/10.3389/frobt.2016.00080/full>

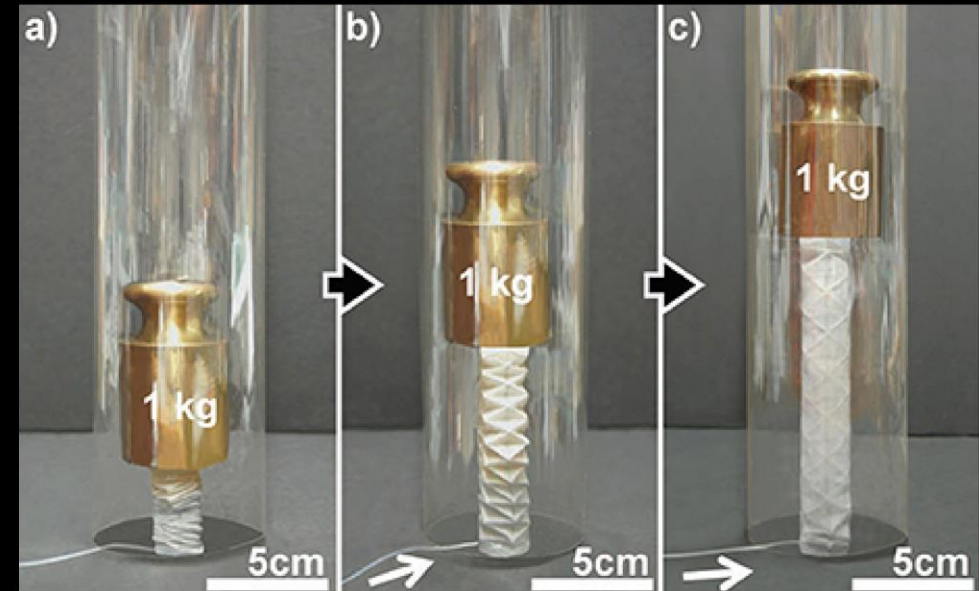


# SOFT ROBOT BEHAVIOUR



## STRENGTH WITH AND WITHOUT ENDOSKELETON

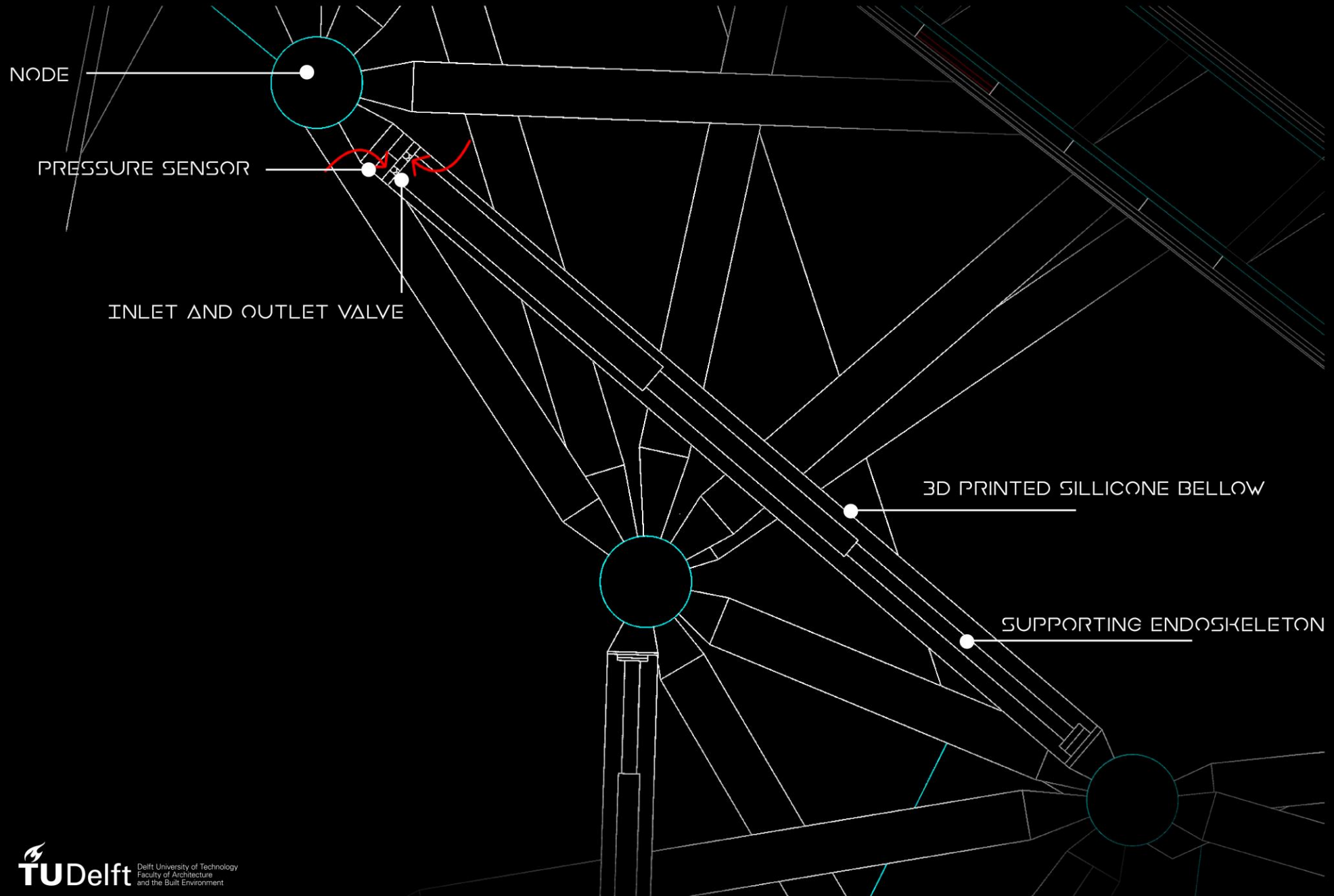
Reference: <https://www.frontiersin.org/articles/10.3389/frobt.2016.00080/full>



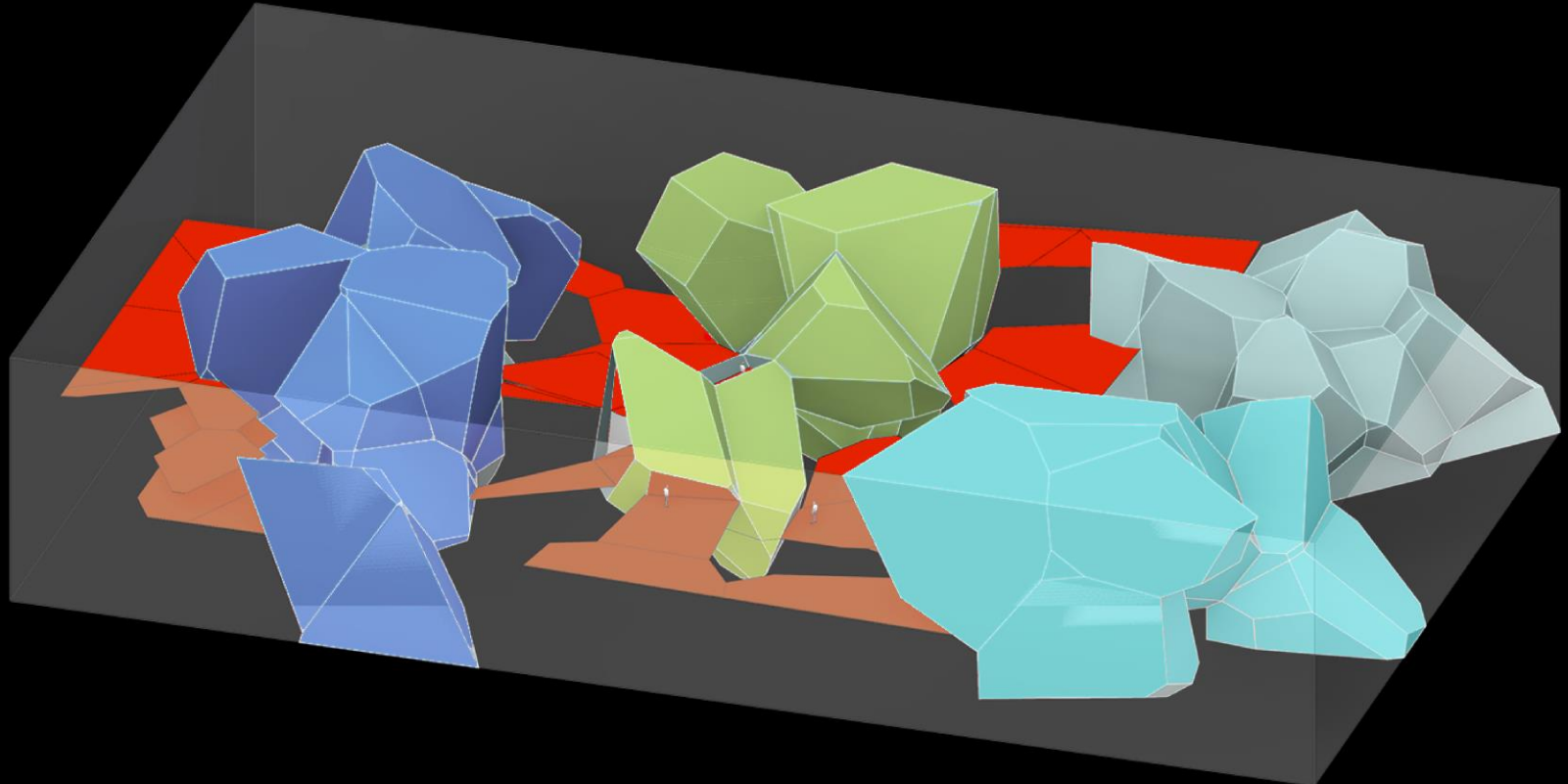
## SOFT LINEAR ACTUATOR SYSTEM ACTUATED USING PRESSURIZED AIR

Reference: <https://www.frontiersin.org/articles/10.3389/frobt.2018.00084/full>

# DETAIL



# CLIMATE



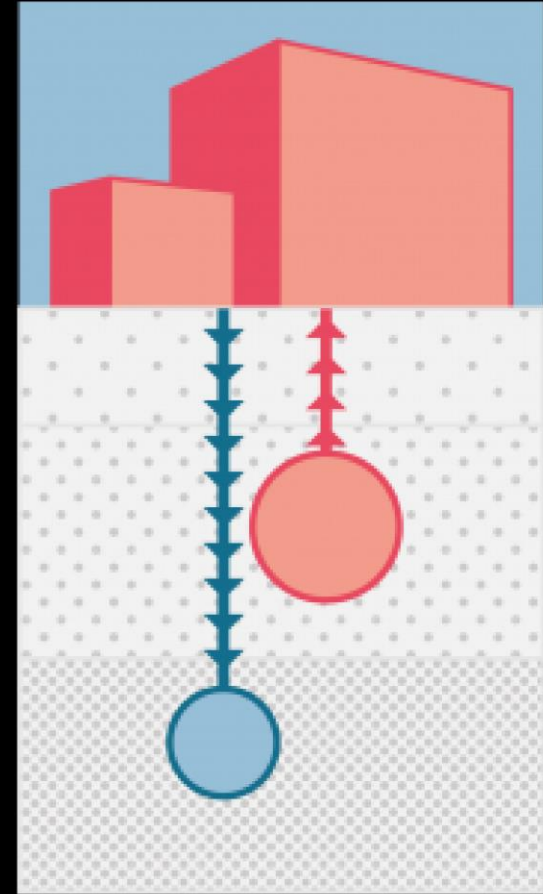
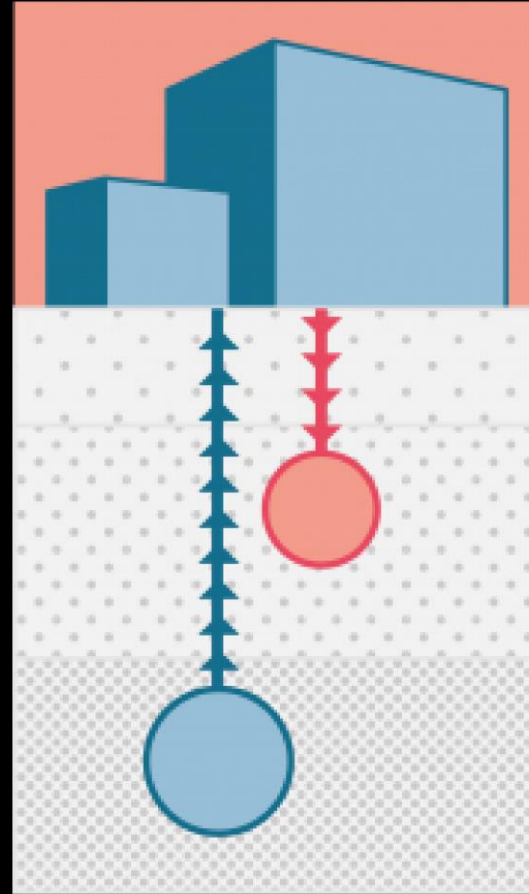
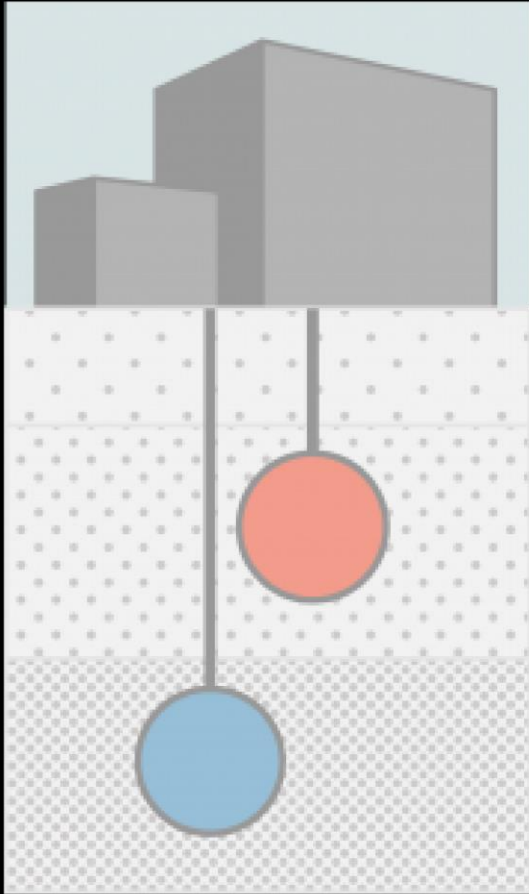
CLOSED

OPEN SPACES

# ACTIVE COOLING AND HEATING

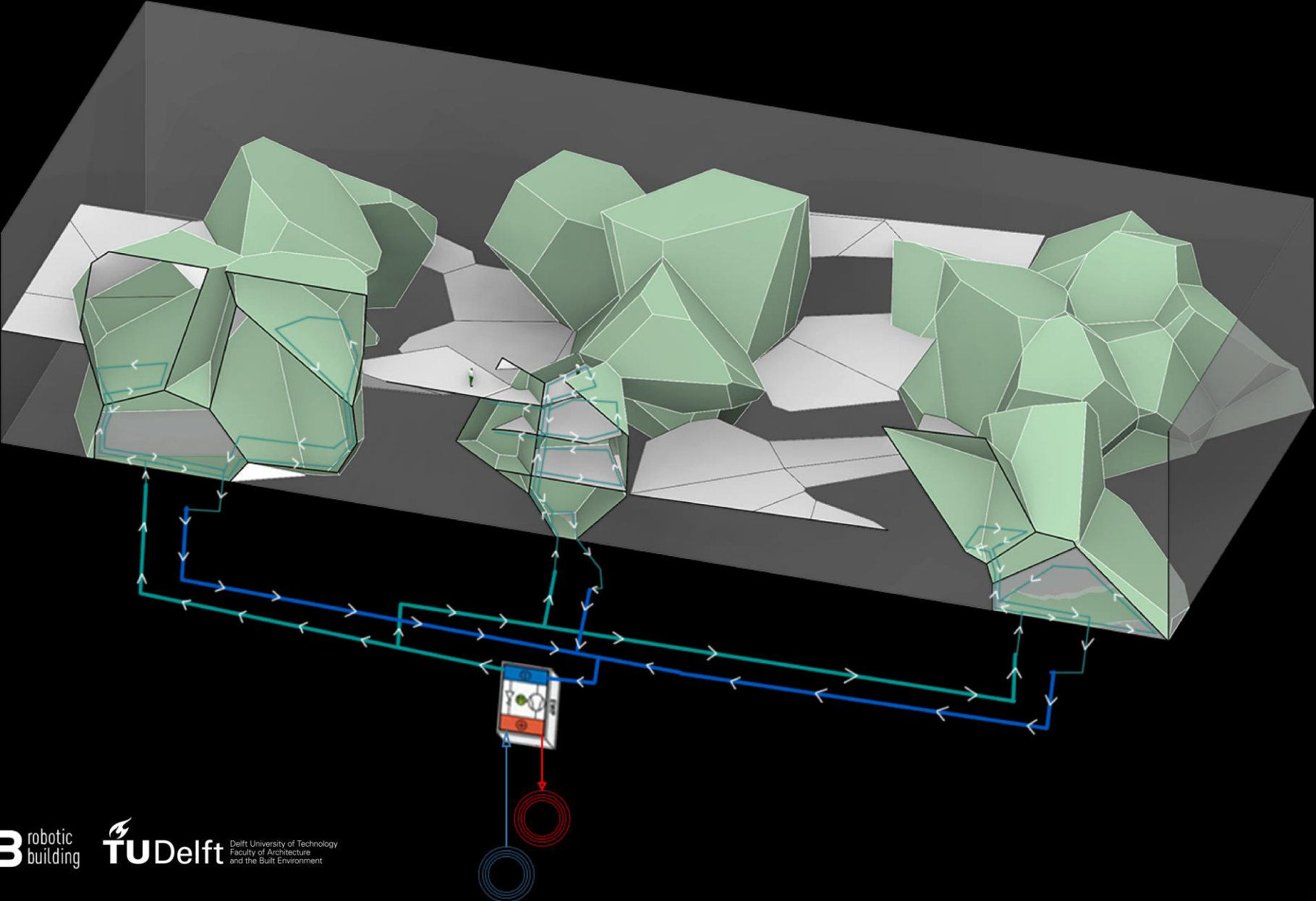
ATES SYSTEM

AQUIFER THERMAL ENERGY STORAGE

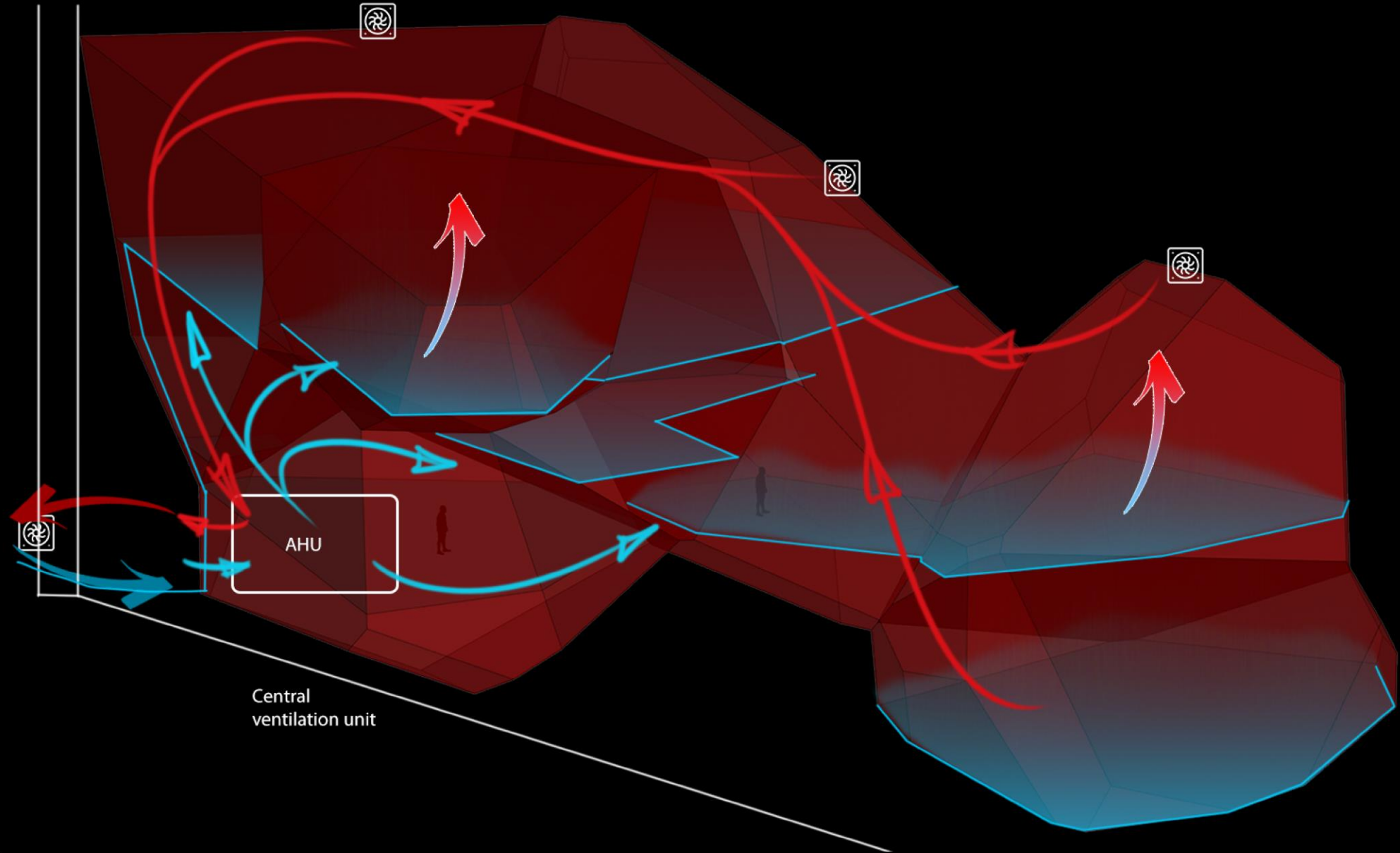


Reference : Dutch Ates

# COOLING DURING SUMMER



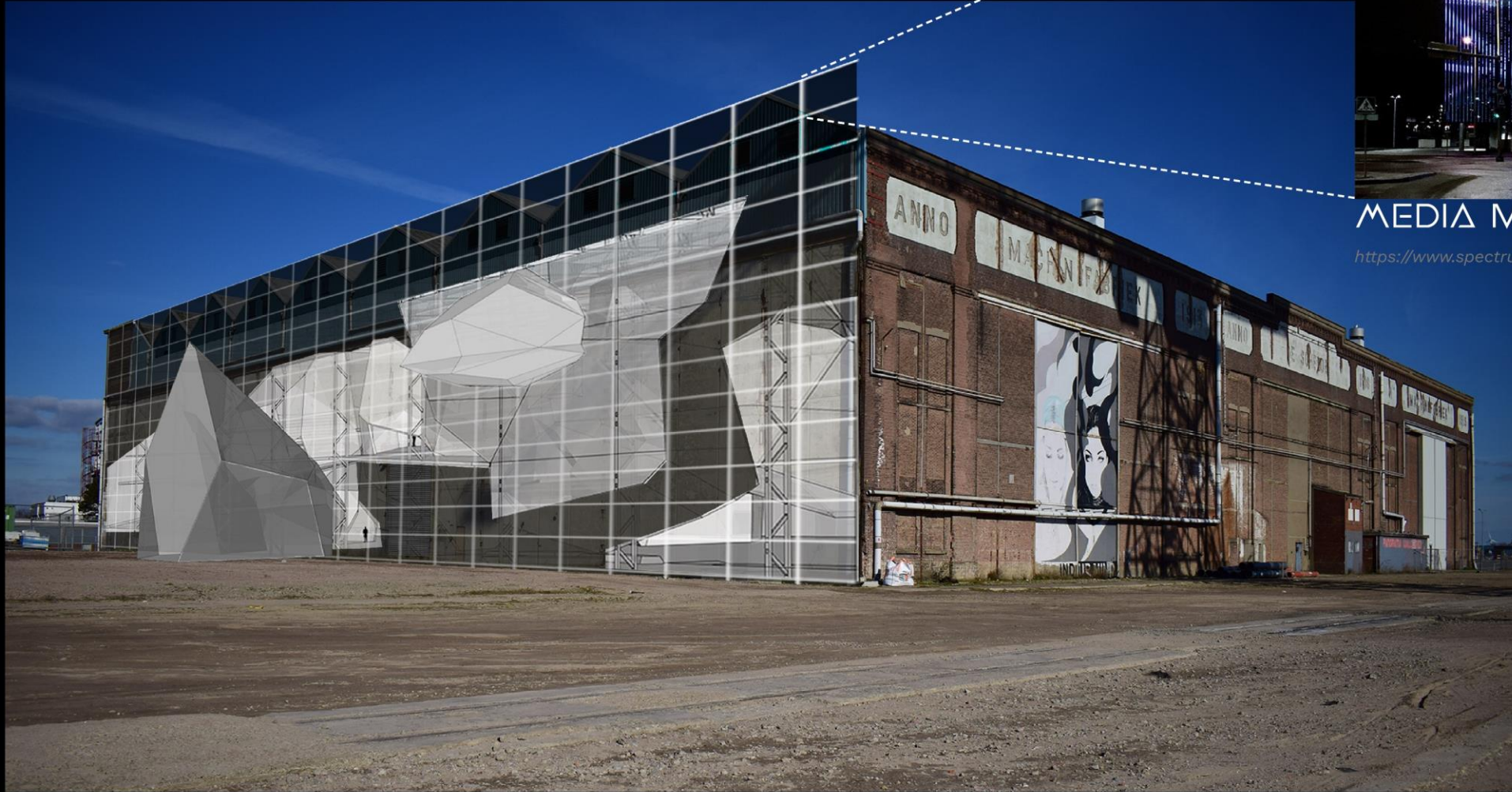
# TYPE D MECHANICAL VENTILATION



RESTORING

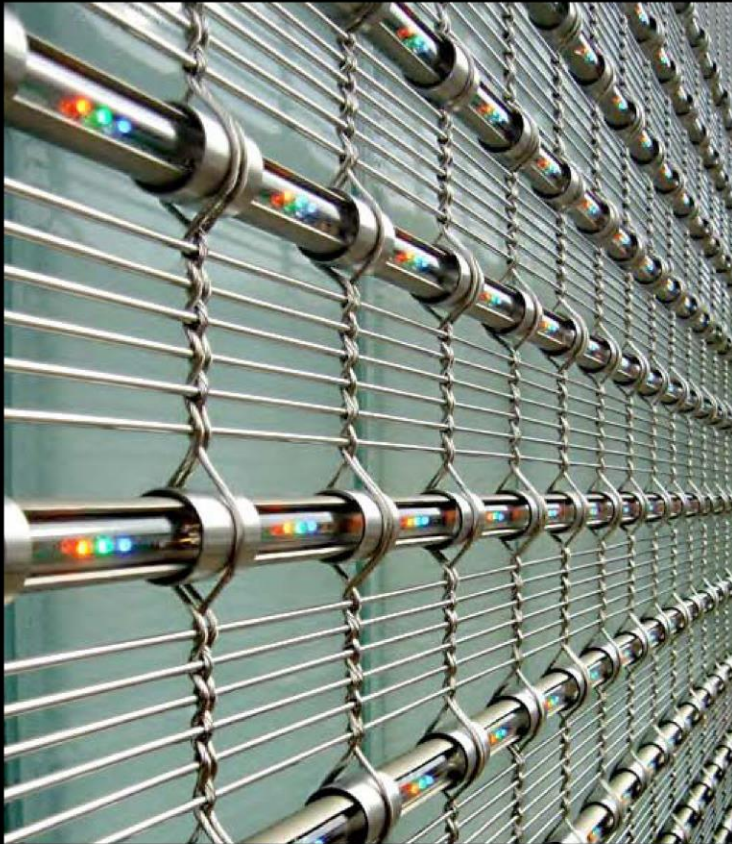


# INTERACTIVE MEDIA FACADE



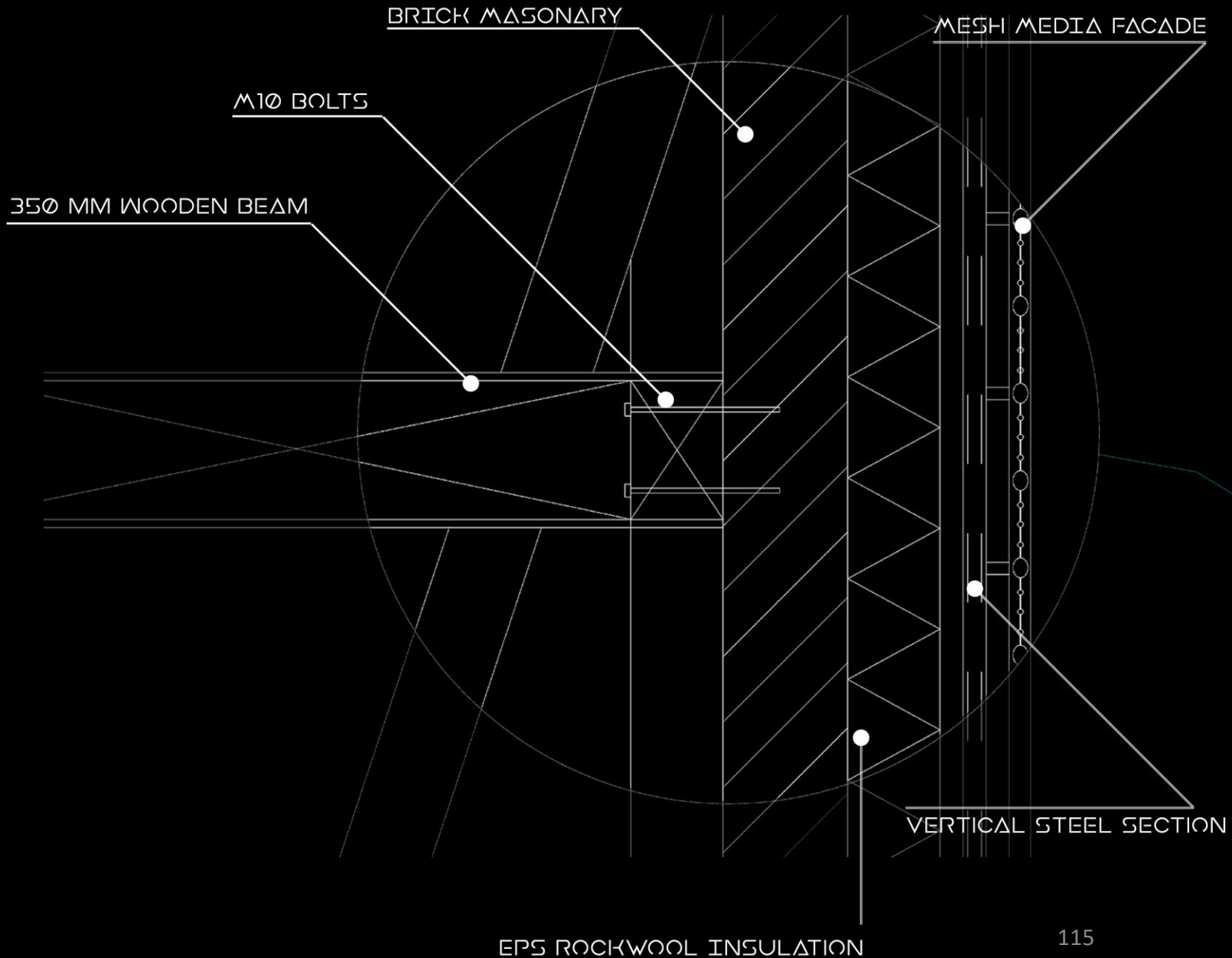
## MEDIA MESH FACADE

<https://www.spectrumlt.com/technologies/mediafacade/>



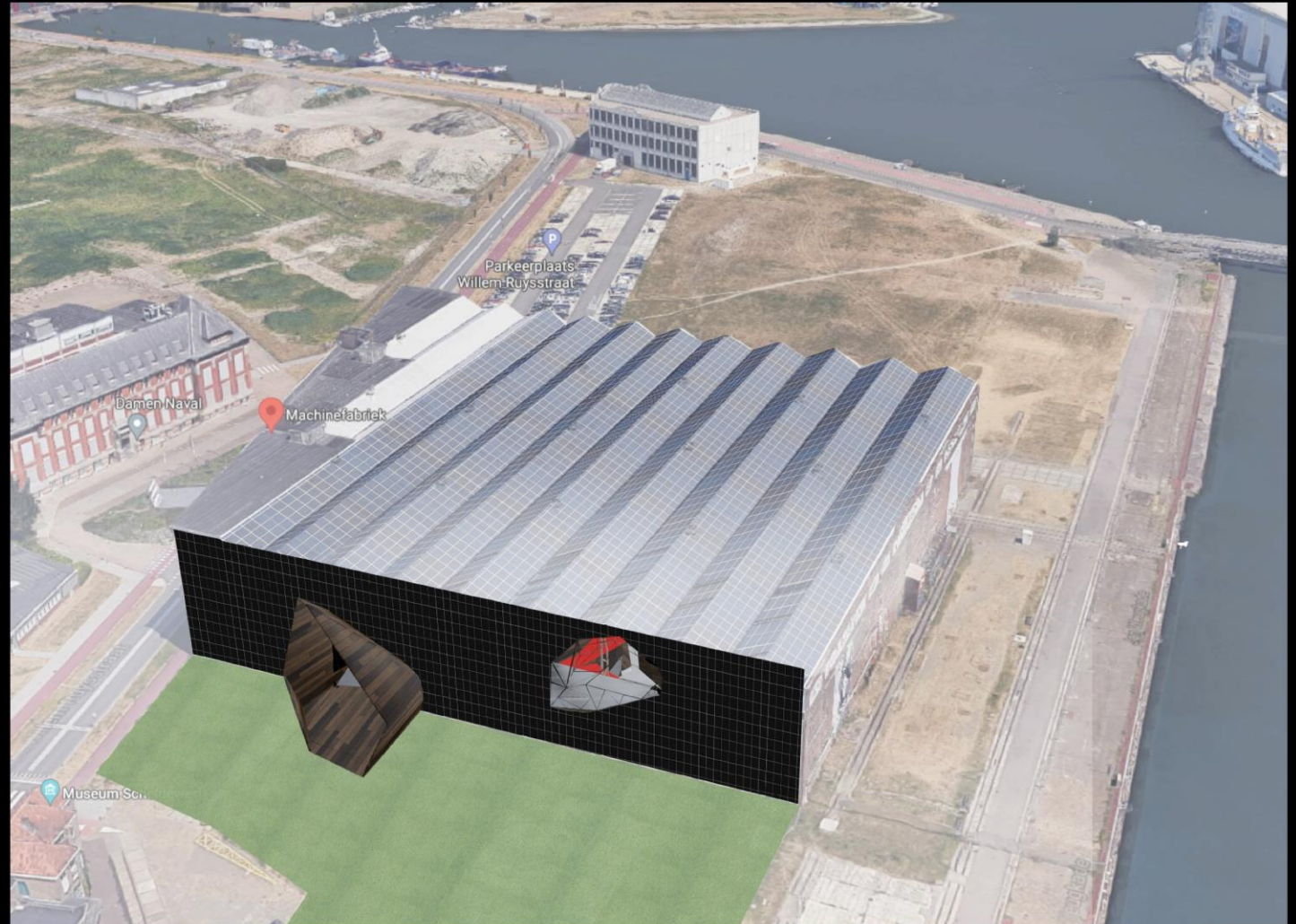
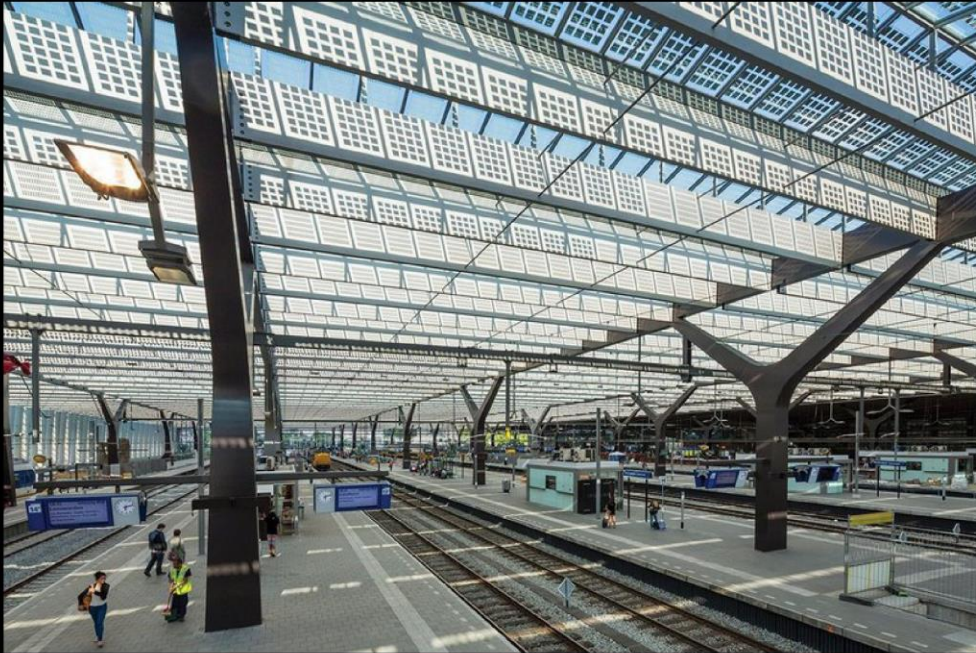
## MEDIA MESH FACADE

<https://www.archdaily.com/148961/nyc-port-authority-bus-terminal-gkd-metal-fabrics>

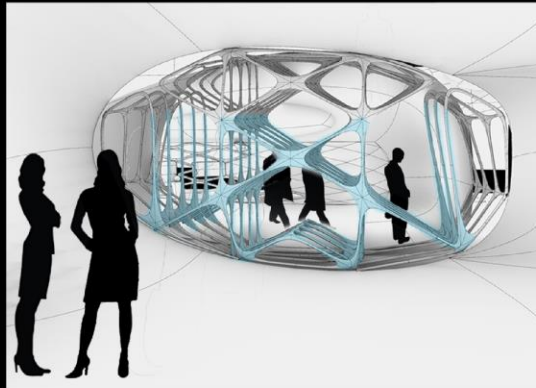
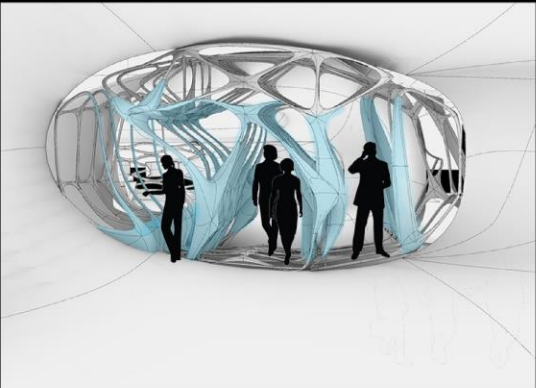
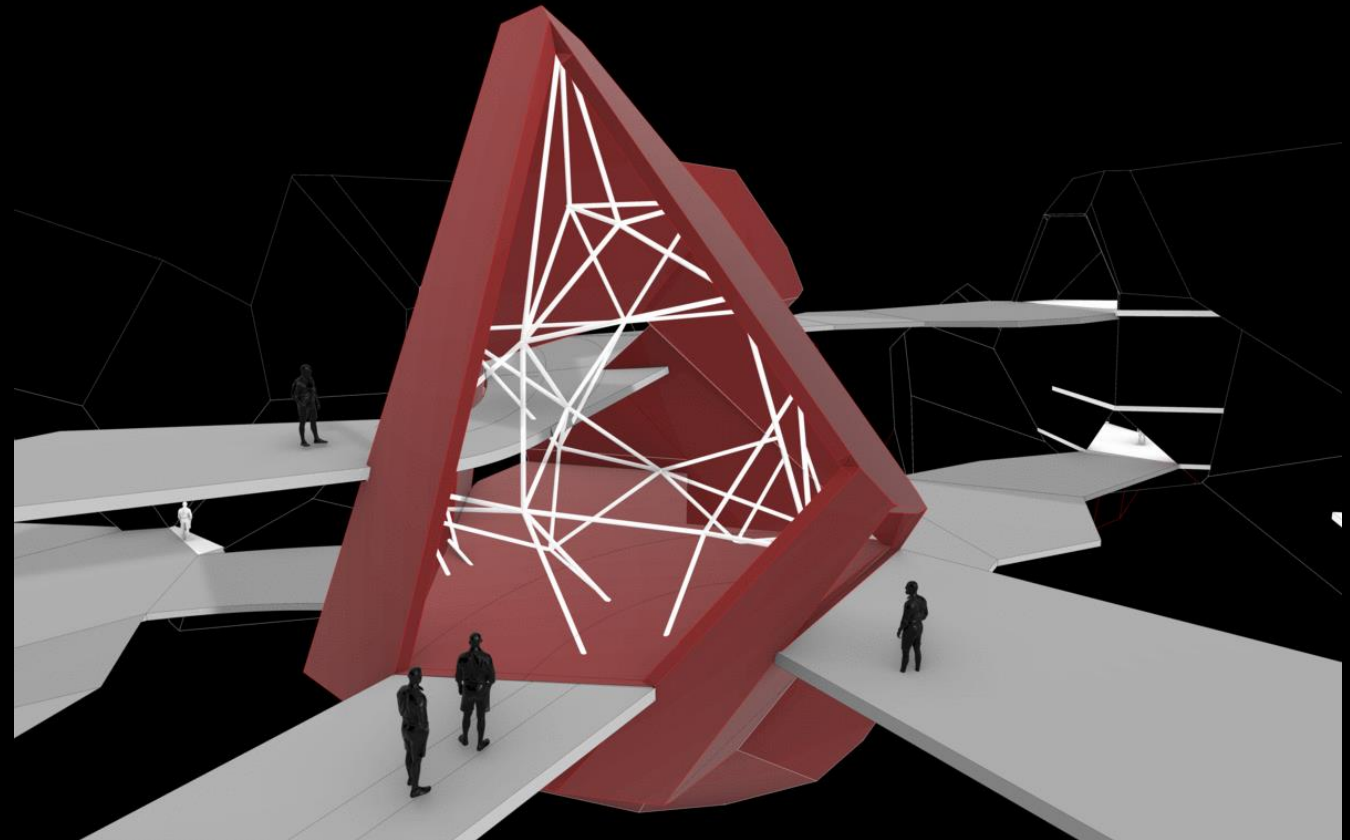
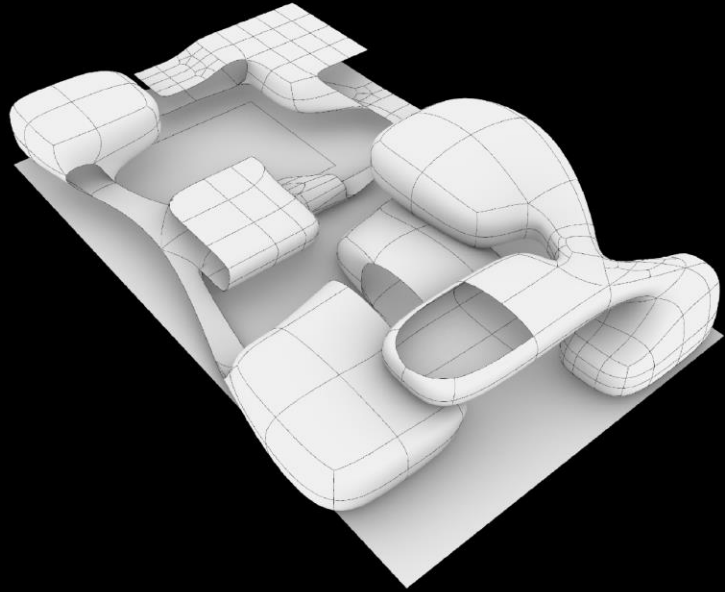


# POWER

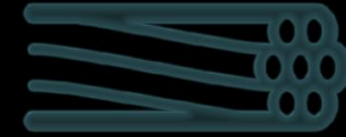
## BUILDING INTEGRATED PHOTOVOLTAICS (BIPV)



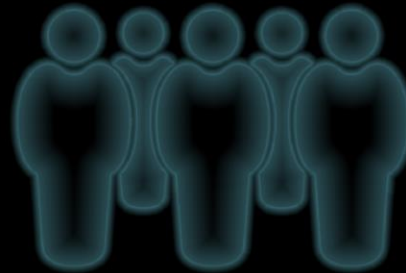
# REFLECTION



REDUCING THE HARDWARE IS KEY TO BEING ABLE TO INTEGRATE IT PUBLICLY



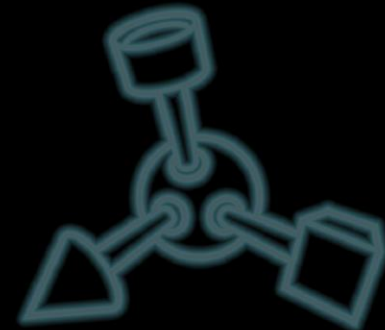
ETHICAL REPERCUSSIONS OF DATA COLLECTION



FUTURE APPLICATIONS SUCH AS CROWD CONTROL



RESEARCH POTENTIAL WITH RESPECT TO HUMAN BEHAVIOUR



PROTOTYPING TO WORK OUT THE MOVEMENTS

MACHINE FABRIEK

1919

THANK YOU!

