

1:1 Interactive Architecture Prototype

Urban Furniture

MSc Arch Elective Seminar (AR0122), 2021, Tutor: Henriette Bier, Max Latour, Vera Laszlo

Group 1

Francesca Guarnieri (5372852)

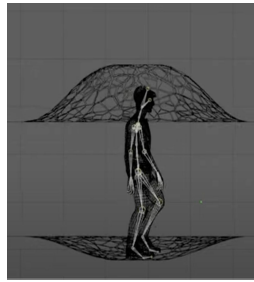
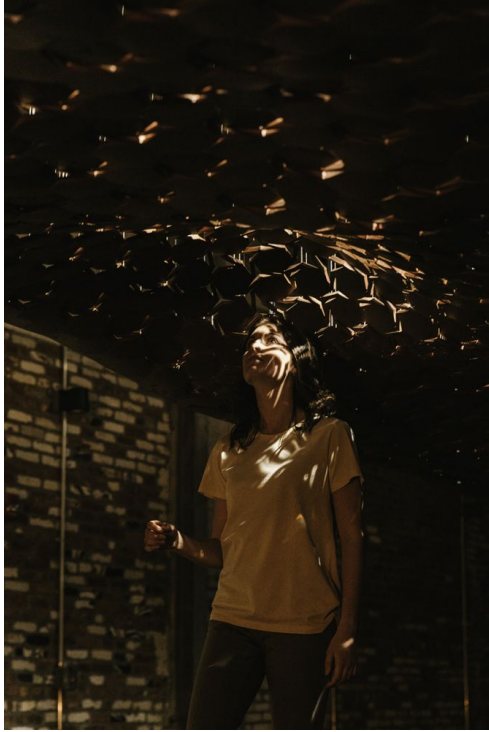
Romeny Koreman (4735633)

Alara Külekci (5305861)

Taija Love (5239869)

Michael Tong (5240913)

Reference 1: Kinetic Urban Furniture

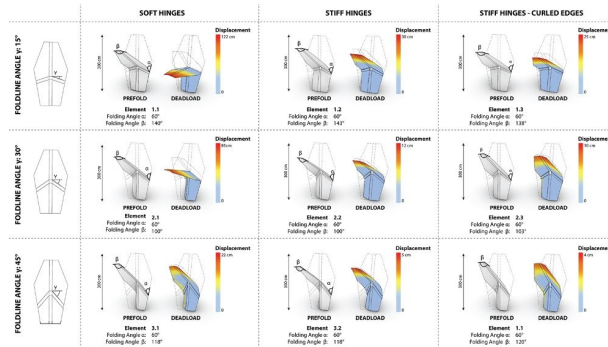


Urban Imprint, Studio Ini

The installation involves materials often used in construction and made flexible & reactive. As a visitor steps into the installation, a flexible floor depresses around their foot, triggering a system of pulleys that tighten and lift the roof into a dome shape above the inhabitant's head. The design intends to revert the typical relationship humans have with the urban environment. Here the structure adapts to people.

The leather-like skin is made from a mixture of rubber and concrete and is coloured dark red, picking up on the hues of the brick walls. As the honeycomb pattern allows free movement, punctures allow natural light to filter through.

Reference 2: Kinetic Urban Furniture

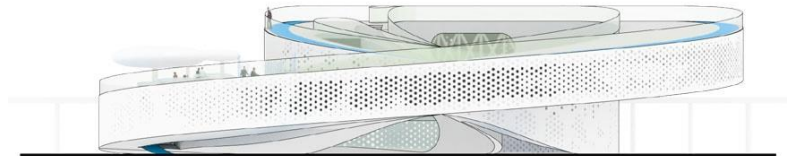
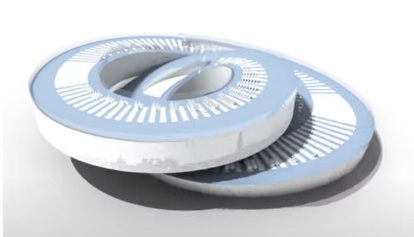


- showcasing the potential of computational design, simulation and fabrication processes in bio-inspired architecture
- inspired by the folding mechanisms of the Coleoptera coccinellidae (Ladybug) wings.
- composed of two adaptive folding elements made of carbon and glass fibre-reinforced plastic.
- create a shelter and seat for the users

Reference 3: Interactivity



The pavilion has an iconic double-looped shape, a spiralling exhibition space, biking lanes, a pool of water and a dynamic illumination of both inner spaces and outer facades. During nighttime the facade displays a vibrant show of patterns and animations that made the building come to life. The media facade has 3600 pixels along the spiralling outer surface produced by a pattern of holes, which were fitted with diffusing tubes in different sizes. Each tube has a multi-color LED fixture and was controlled by a custom media playback system. This system is also tied in with a series of light and temperature sensors around the building, thereby controlling both light intensity and color temperature.



The Denmark Pavilion (Expo 2010-Shanghai, BIG)

Site: Nieuwe Maas, Rotterdam



1 Makers District



2 St. Jobshaven Terminal



3 Parkkade Terminal

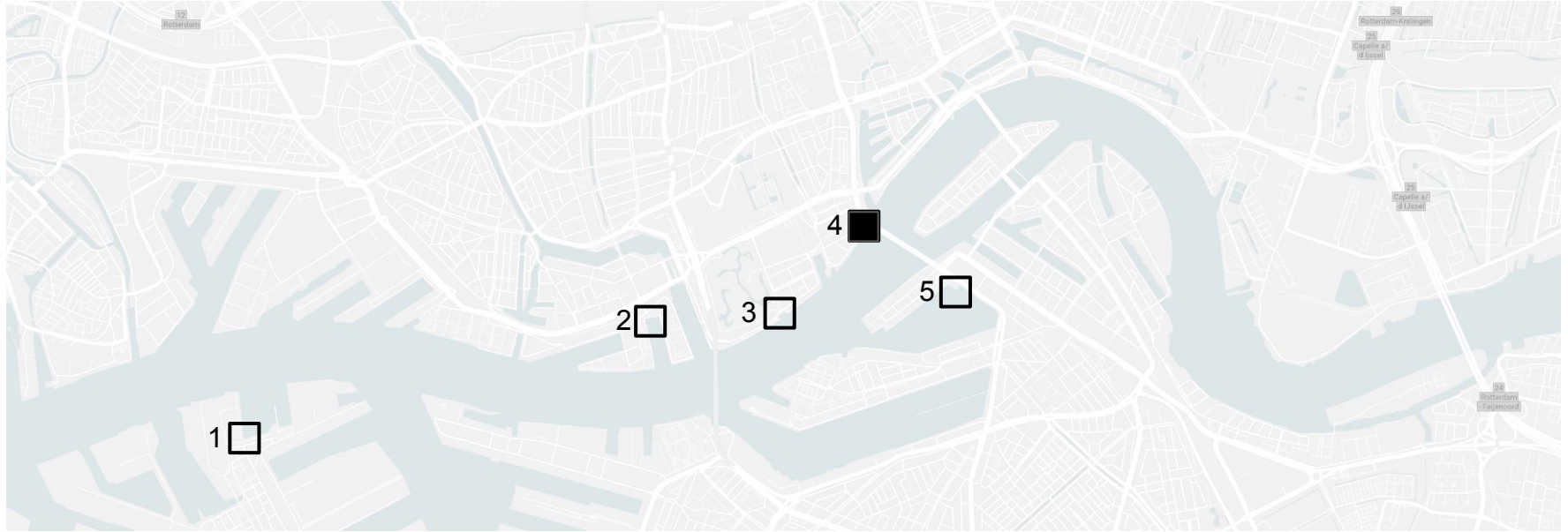


4 Erasmusbrug Terminal



5 Wilhelminapier

Site: Willemsplein, Nieuwe Maas, Rotterdam



1 Makers District



2 St. Jobshaven Terminal



3 Parkkade Terminal



4 Erasmusbrug Terminal



5 Wilhelminapier

Site: Willemsplein, Nieuwe Maas, Rotterdam





References: River Precedent

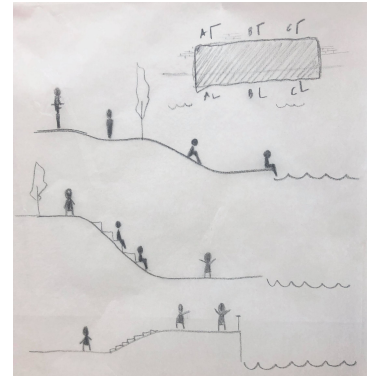
Cheonggyecheon Stream

Seoul, South Korea

- urban renewal and beautification
- gentrification of adjacent areas
- Species of fish, birds, and insects have increased significantly
- promoted the urban economy through amplifying urban infrastructure for a competitive city in the business and industrial area centered on the stream.
- functions: popular for tourist, locals, lunch place for office workers.
- dynamically changes along the stream to meet different requirements for each area
- gathering along. river motion - movement.

Dutch version:

bike path, walking, vegetation sitting, ledge walking, amphitheatre, stage walking, seating / stairs, tourist viewpoint



Focus

Ideas on what your group project will (or could) focus on and what the individual foci within each group will be with respect to D2RP&O

The approach involves D2RP&O with the aim is to improve process- and material-efficiency in construction as well as embed intelligence in the built environment by (1) robotically optimizing material distribution and by (2) embedding sensor-actuators that are enabling interaction between users and physically built environment.

The 3D printed pieces of furniture such as stools/chairs, benches, pavilions, moorings and water taxi/info/food booths with integrated sensor-actuators will be proof of concept for:

- (a) Process- and material-efficiency achieved through smart robotic (i.e. selective) material deposition. Material considered is 3D printed wood polymers.
- (b) Smart operation by integrating sensor-actuators such as light dependent resistors, infrared distance sensor, pressure sensor, etc. informing lights, speakers, ventilators, etc. in order to allow users to customize operation and use of the urban furniture.

Group Brief

Interactive Data Ideas

1. Human activity (walking, sitting, laying down, etc.) and required space
2. Shelter (rain, solar, radiation, etc.)

Sensors/Inputs

1. Humidity
2. Temperature
3. Pollutants
4. Pressure
5. Proximity
6. Motion
7. Sound
8. Vision
9. Manual input, etc.
10. Wind



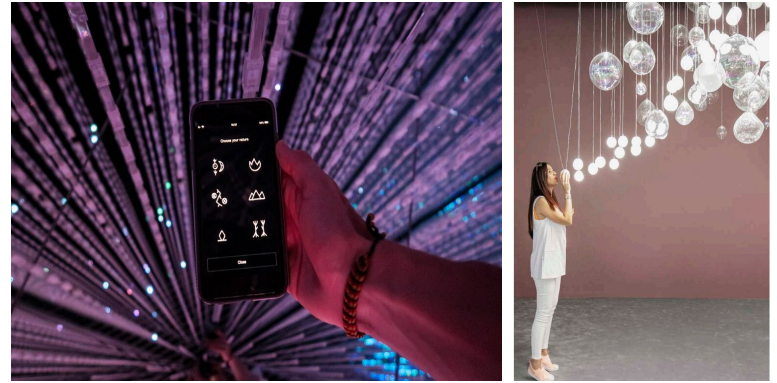
Group Brief

Actuators

1. RGBW lighting
2. AR
3. Kinematics
4. Pneumatics
5. Sound
6. Watering, etc.

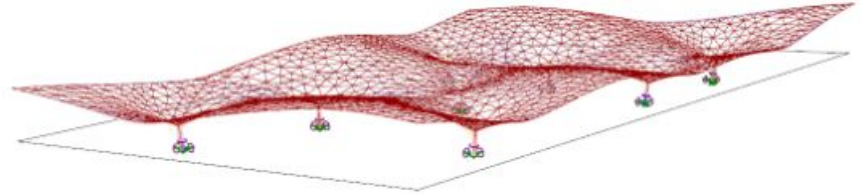
UI

1. Illumination brightness, color, and turn on/off rhythm
2. Watering
3. Kinematics
4. Pneumatics, etc.

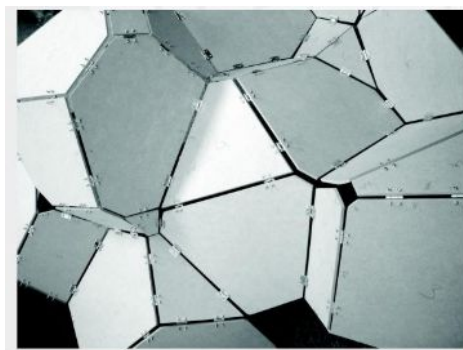
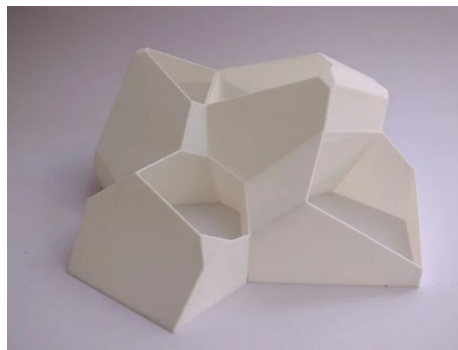
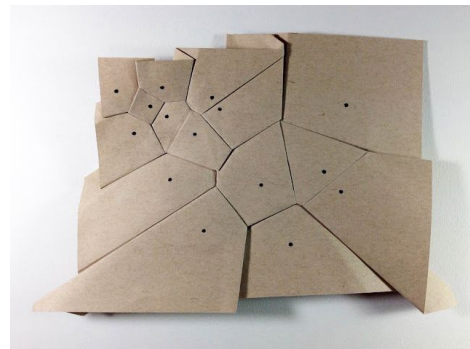
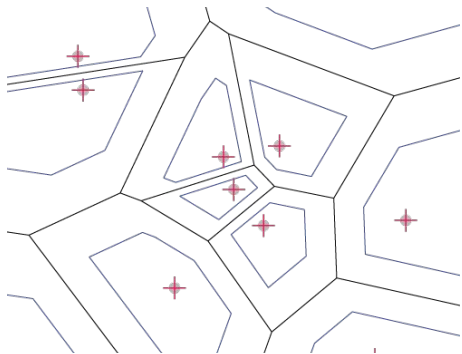


Structure: Voronoi Diagram

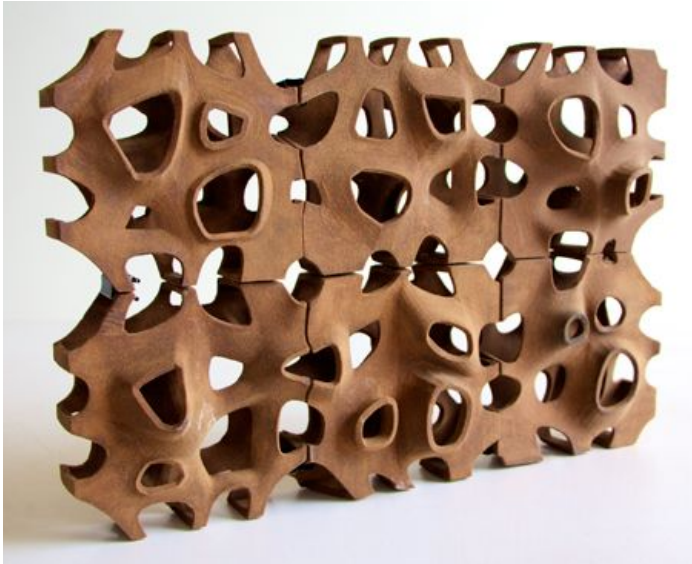
In mathematics, a Voronoi diagram is a partition of a plane into regions close to each of a given set of objects. In the simplest case, these objects are just finitely many points in the plane (called seeds, sites, or generators). For each seed there is a corresponding region consisting of all points of the plane closer to that seed than to any other. These regions are called Voronoi cells. The Voronoi diagram of a set of points is dual to its Delaunay triangulation.



Structure: Voronoi Origami



Material: 3D printed wood polymers



Poroso Wall, Emerging Objects



Stonefil filaments. Source: Formfutura

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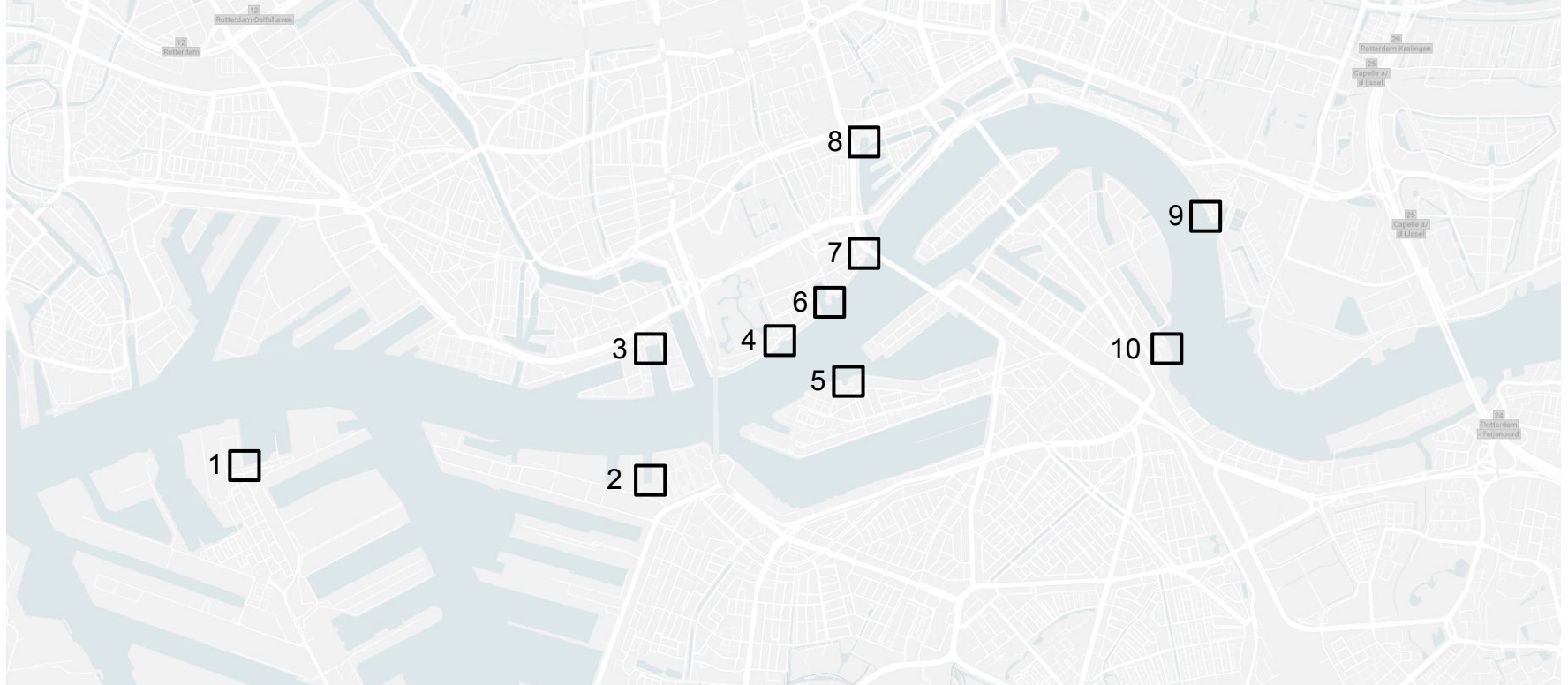
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Site

Ferry Terminals, Nieuwe Maas, Rotterdam



Ferry Terminals, Nieuwe Maas, Rotterdam



1. RDM



2. St. Janshaven



3. St. Jobshaven



4. Veerhaven



5. Katendrecht



6. Erasmusbrug



7. Willemsplein



8. Leuvehaven

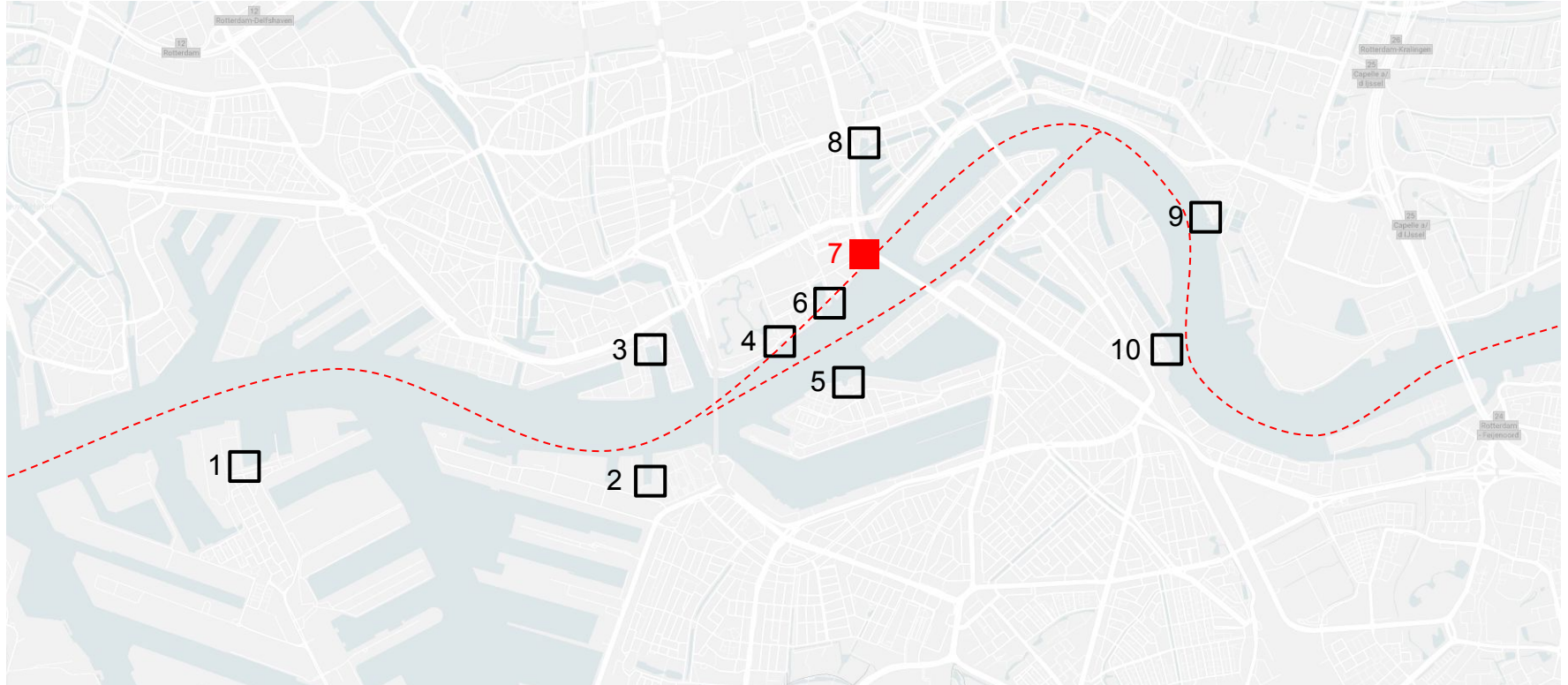


9. Plantagelaan



10. Piekstraat

7. Willemsplein, Nieuwe Maas, Rotterdam



7. Willemsplein, Nieuwe Maas, Rotterdam



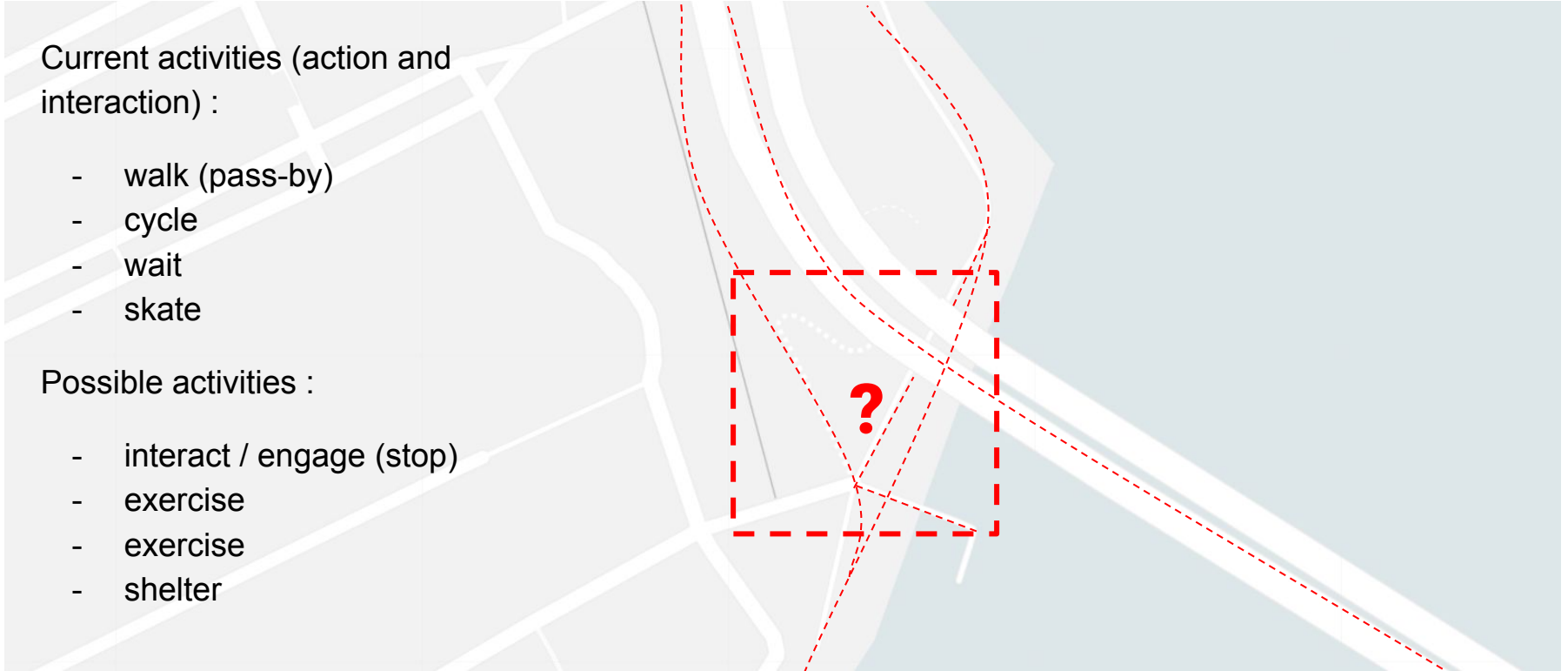
Willemsplein Activities Mapping

Current activities (action and interaction) :

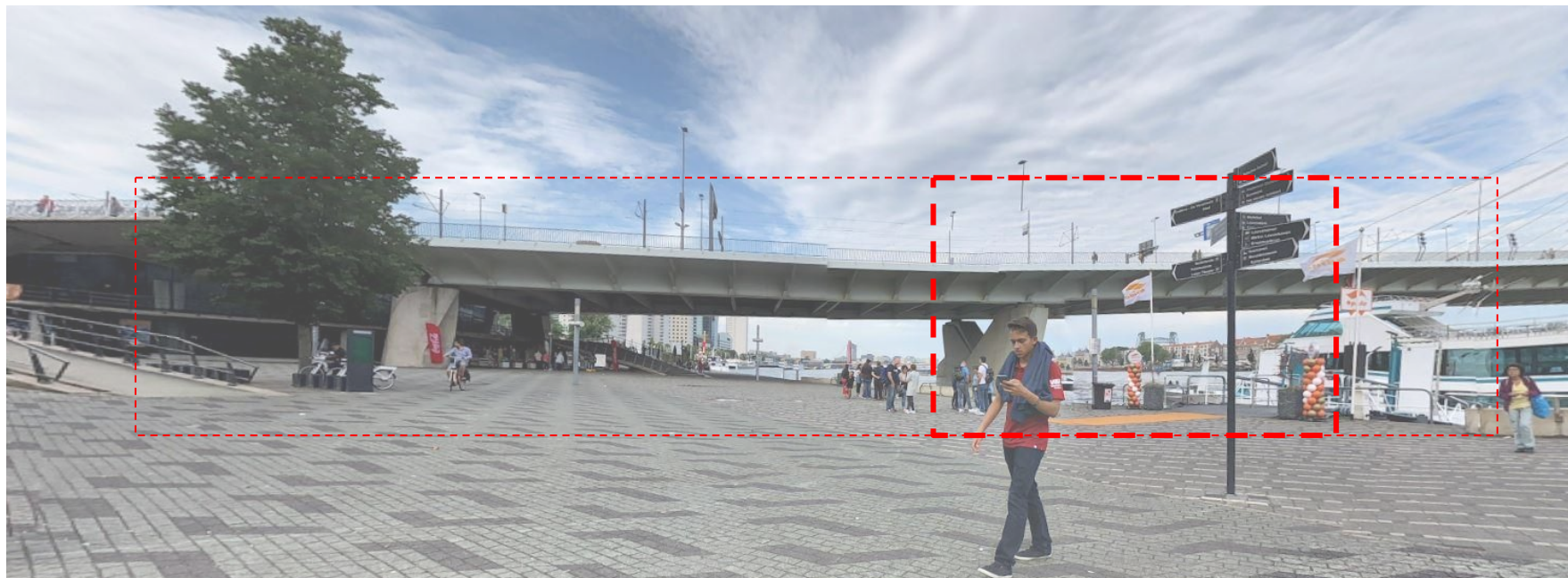
- walk (pass-by)
- cycle
- wait
- skate

Possible activities :

- interact / engage (stop)
- exercise
- exercise
- shelter



7. Willemsplein, Nieuwe Maas, Rotterdam



Waterbus

- battery-operated passenger ferry since 2018
- to operate for sixteen hours per day and be charged two times an hour
- high-end lithium battery with a long lifespan
- do we want to power HVAC capacity from the batteries? Or do we want to include another power source
- -> dedicated seat heating and cooling,

= decreased operational costs and zero carbon emissions



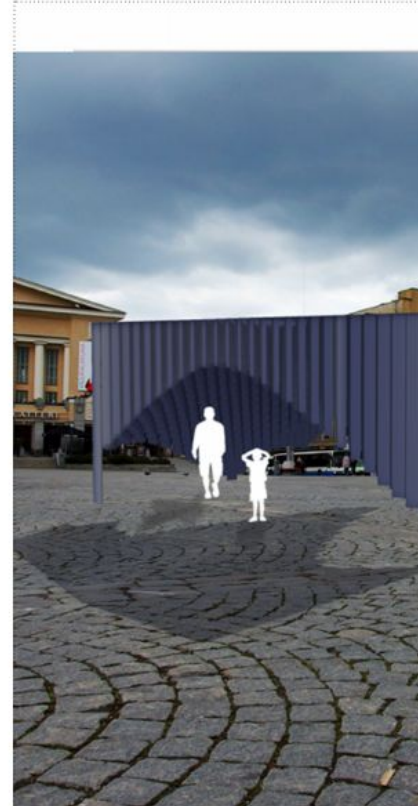
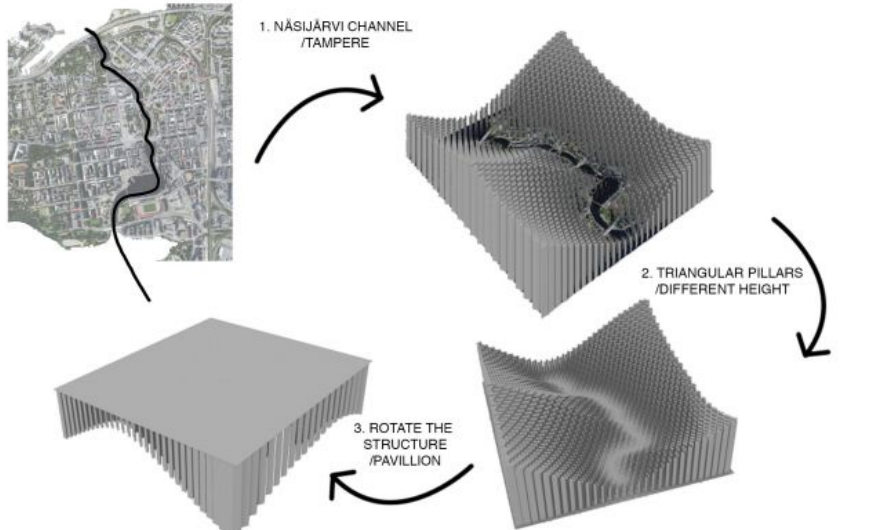
Precedents

Form: River Inspired



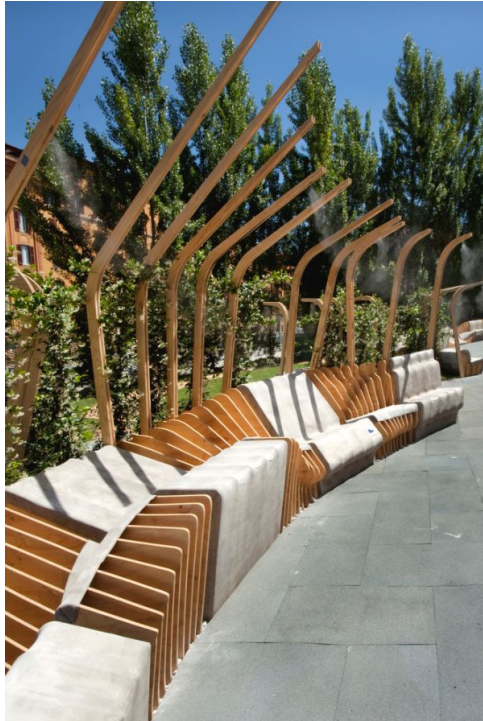
The design of this pavilion, located in Keskustori, comes as a result by combining architecture and landscape: the starting point of the project is the coast line of Nasijärvi channel in Tampere city center, which is used as an attractor to build a complex canopy.

The structure, together with the ceiling, is composed of triangular pillars, while the outer roof is flat, made with a rhinoceros function.



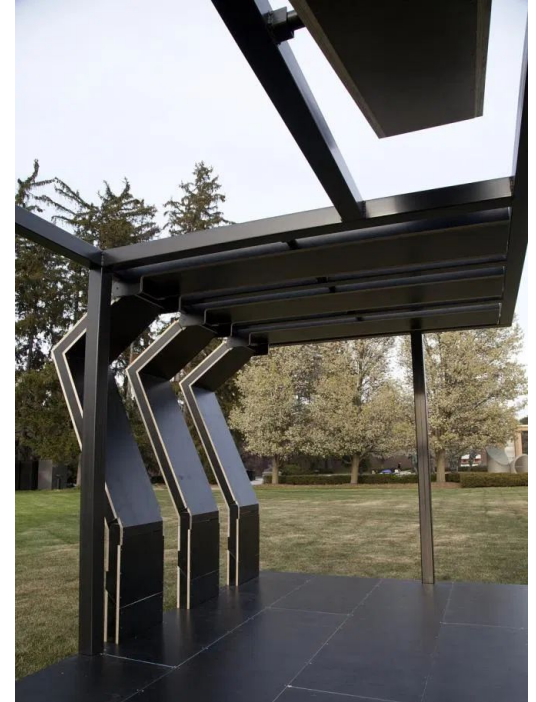
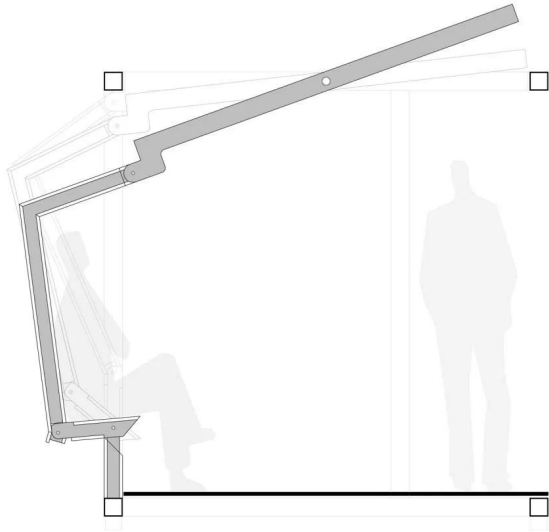
Form to Challenge Interaction

- Body challenging

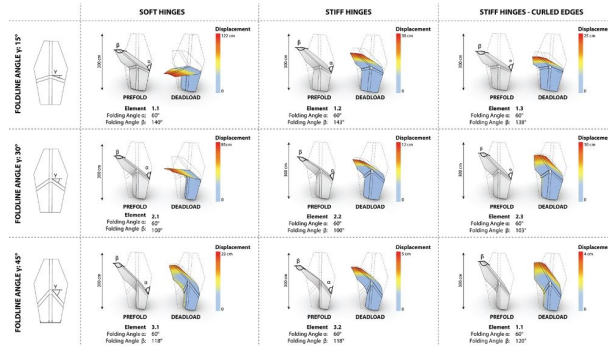


Kinetic: Adaptive Seating for Interaction

- body activated / body responsive



Reference 2: Kinetic Urban Furniture

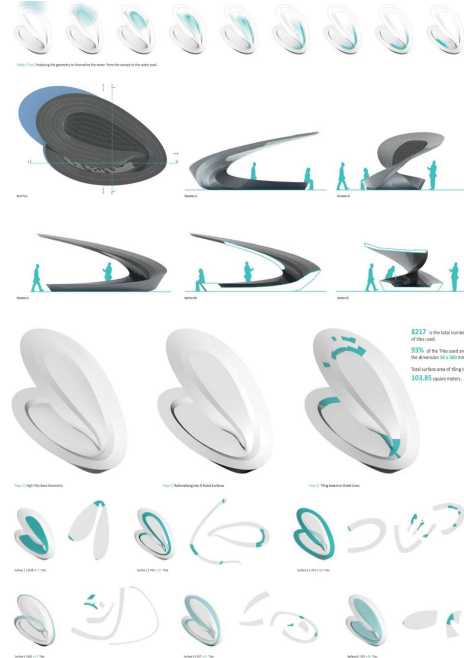


- showcasing the potential of computational design, simulation and fabrication processes in bio-inspired architecture
- inspired by the folding mechanisms of the Coleoptera coccinellidae (Ladybug) wings.
- composed of two adaptive folding elements made of carbon and glass fibre-reinforced plastic.
- create a shelter and seat for the users

Urban Furniture - Idea 2



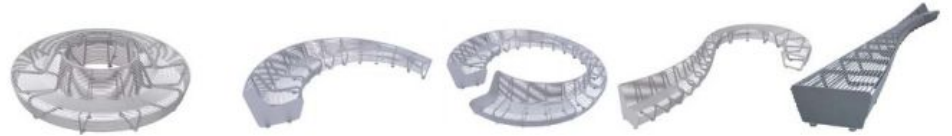
Urban Furniture as fountain, bench, shelter imbedded all in one body



Modularity

Infinity system:

- 4 elements: flat; medium-low, medium-high-high
- 2 different degrees of curvature
- → circular, semi-circular, linear



Materialisation

Materials



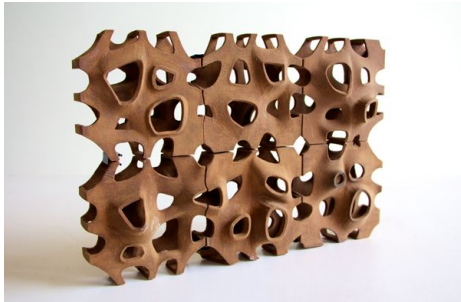
EXPANDS
concrete / rubber polymer



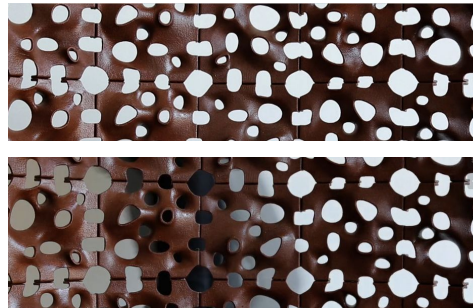
COMPRESS / STRETCH
Thermoplastic elastomer



LIFTS / FALL
Plywood, Elastic bands



3D Printed Wood Bio-polymers



Energy: solar-powered electricity for sound and lighting

Solar powered bench for

- device charging
 - sound/music production
 - lighting on other hand to project shadow on semi-transparent structure
 - cells above seat open/ close according to lighting condition
- related to energy efficiency of waterbus (ferry)



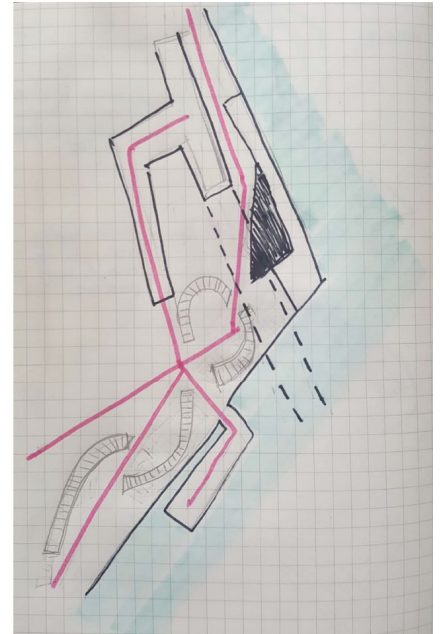
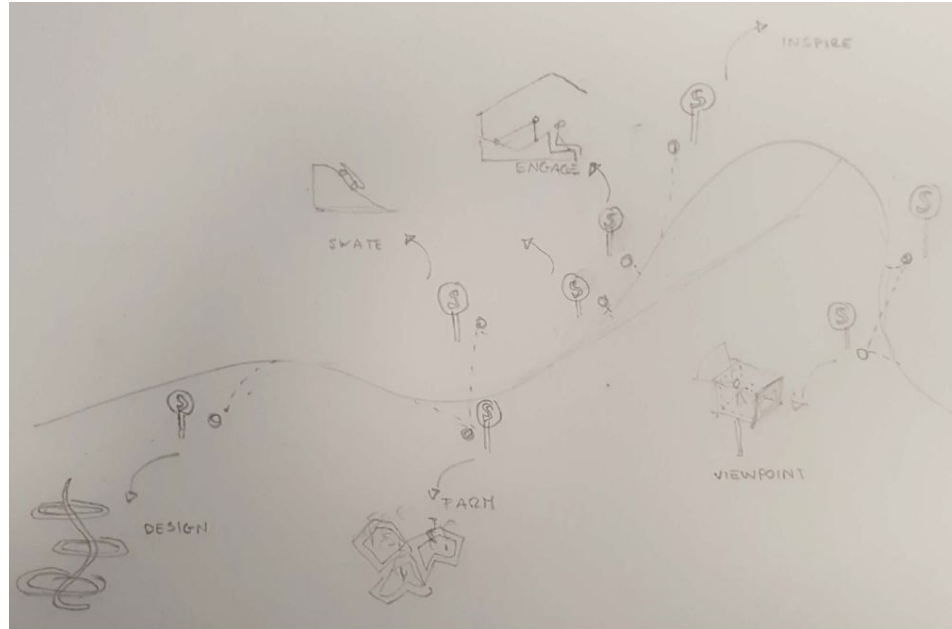
Concept

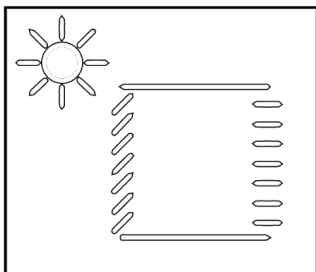
Idea 1: Infinity System + Hacking Urban Furniture

- Network of urban furniture placed along the river at each Waterbus terminal.
- Design detailed for Willemsplein Terminal for its key location: historic - new; multi-modal intersection; proximity to big park; number of users.
- To provide better shelter and (un?)comfortable seating with element of playfulness to revive a gray & static zone and to change the sedentary lifestyles promoted by the built environment.
- To allow stations to inform each other about the number of users at each station + Sensor Unit will allow Urban Furniture Network owner to get feedback from each installation.

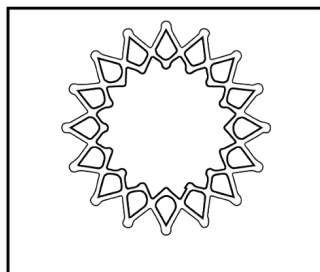
Idea 1: Sketches

- Modular system according to seating required /terminal
- Adaptive use according to specificity of /terminal
- Lightens up through light sensor
- Shape inspired by the river

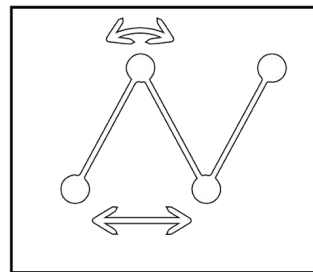




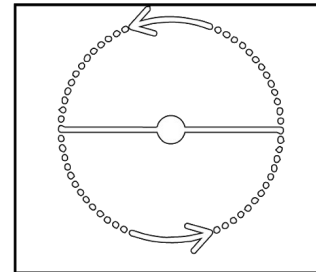
Responsive



Kinetic



Foldable

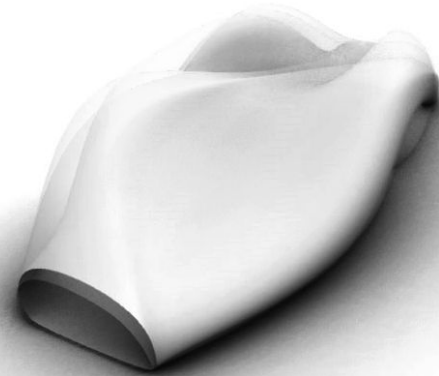


Transformable

Urban Furniture Idea

Idea 1: Sketches

A modular furniture system inspired by the motion of the river that promotes the freedom of movement of our bodies. The furniture system challenges the user to find new ways of seating and expressing the body. The furniture also undulates like waves, and has a kinetic shading system to provide shade when needed.



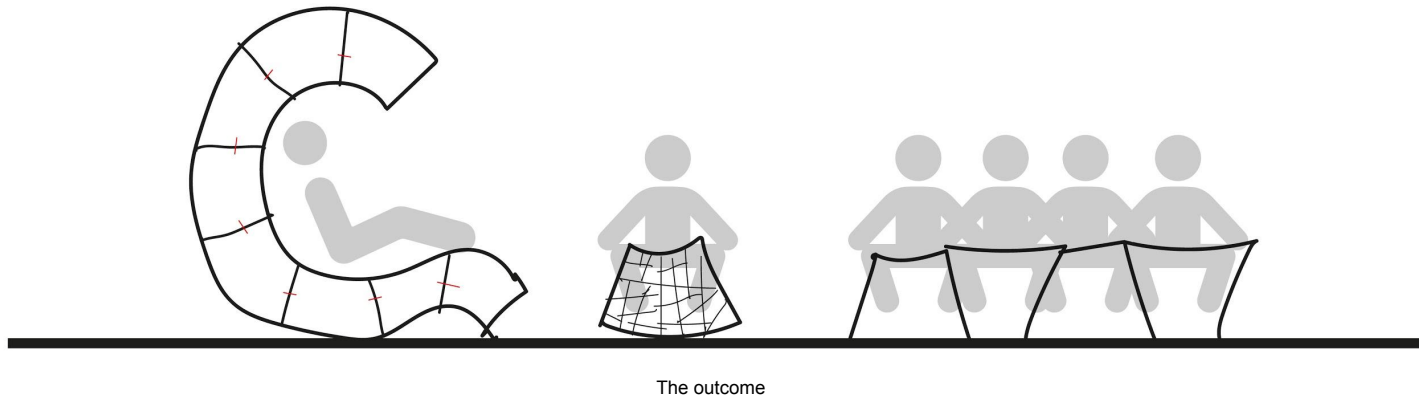
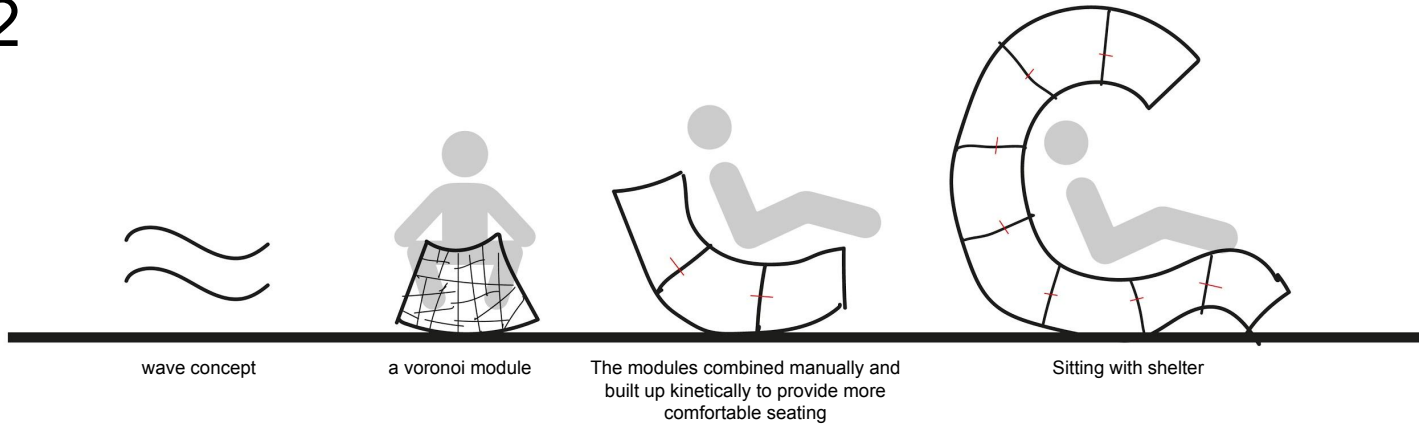
Idea 1: Sketches

- provides seating for ferry terminal
- seating for adjacent office areas
- shelter for people waiting for the ferry
- art piece / beautification of the local area



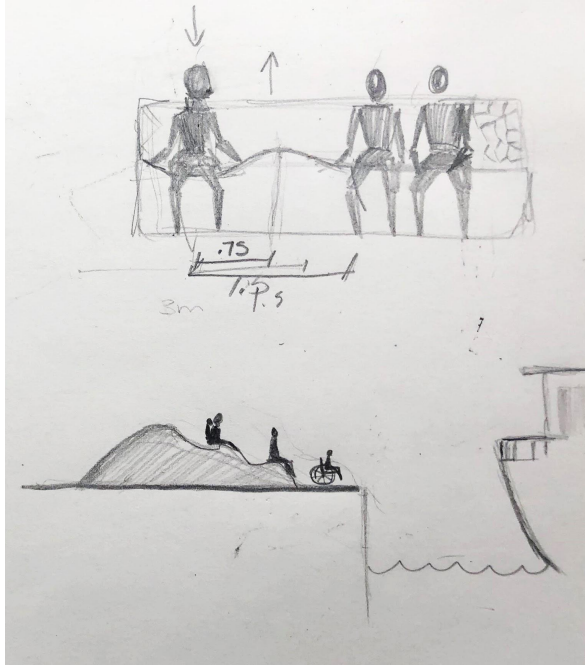
Concept Design

Idea 2



Further Ideas / Questions

Urban Furniture - Idea 4



Social distance Seating:

- Seating for ferry terminal
- pressure from one point pushes mesh down and lifts corresponding part up 750mm (highest point) away
- enforces social distancing measures for pandemic / post-pandemic society - or just enforces strangers away because no one likes sitting next to strangers
- useful as people in small groups can sit with each other and 750mm barrier moves relative to seating / pressure
- Inspired by Variable Stiffness

Interactive element: Recognises how many people are sitting on the bench and informs other terminals

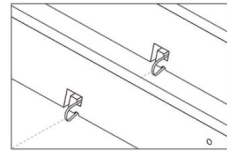
To be developed:

How long will this bench be?

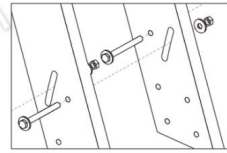
Multiple levels? Amphitheatre seating?

Q: Does the furniture have to be printed as one element? Flexibility and range of the elements?

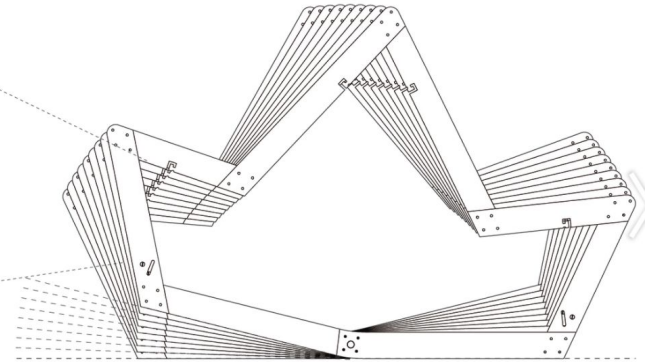
Urban Furniture Idea 4: Precedent



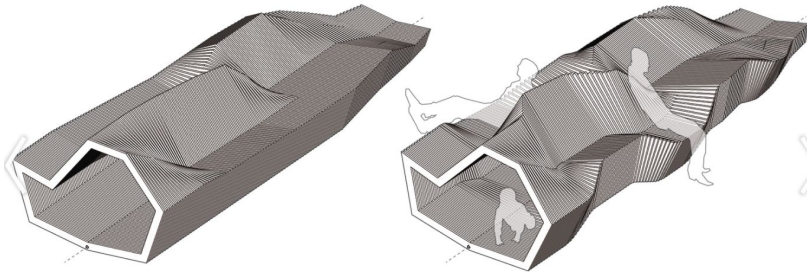
Elastic Band Connection



Sliding Bolt Connection



Activated State Elevation



Passive State Seating

Active State Seating



Urban Furniture Idea 4: Materiality



EXPANDS

concrete / rubber polymer



COMPRESS / STRETCH

Thermoplastic elastomer



LIFTS / FALL

Plywood, Elastic bands

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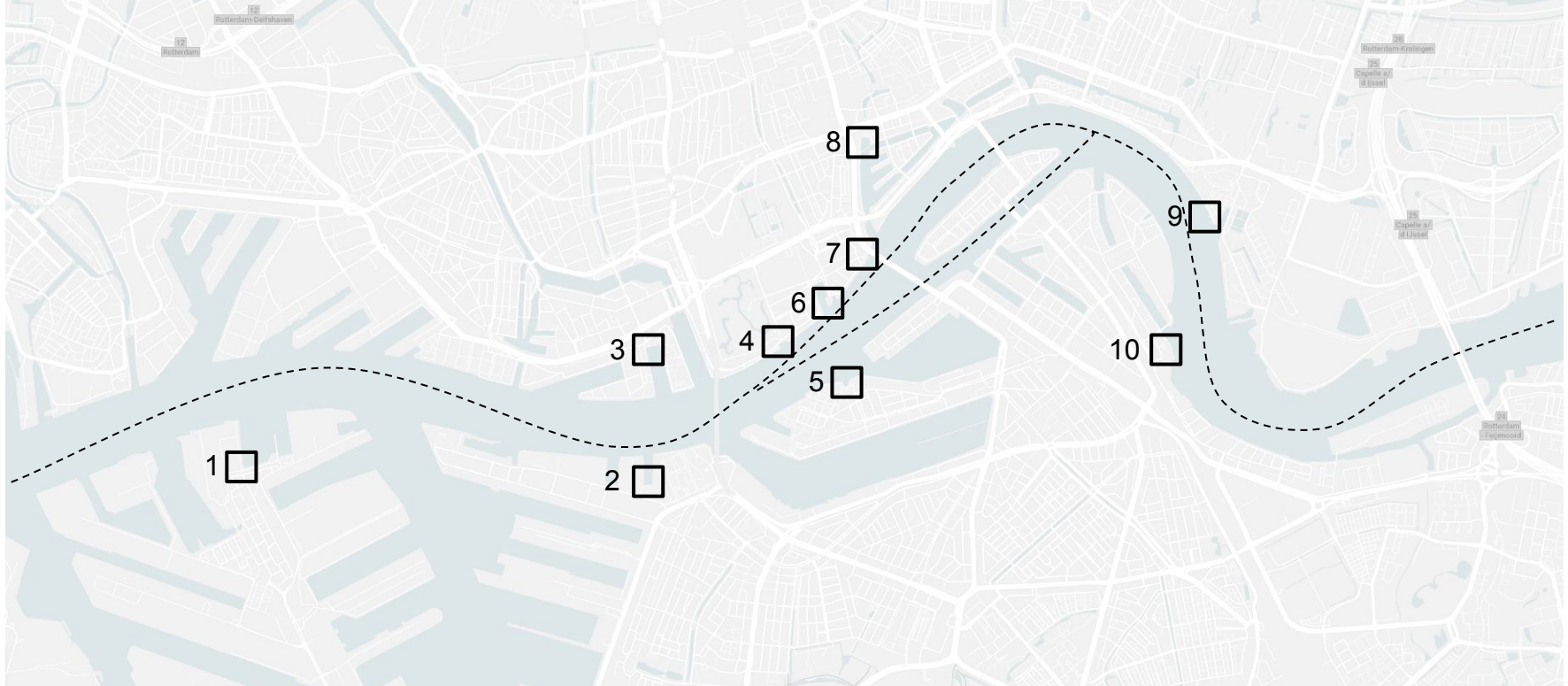
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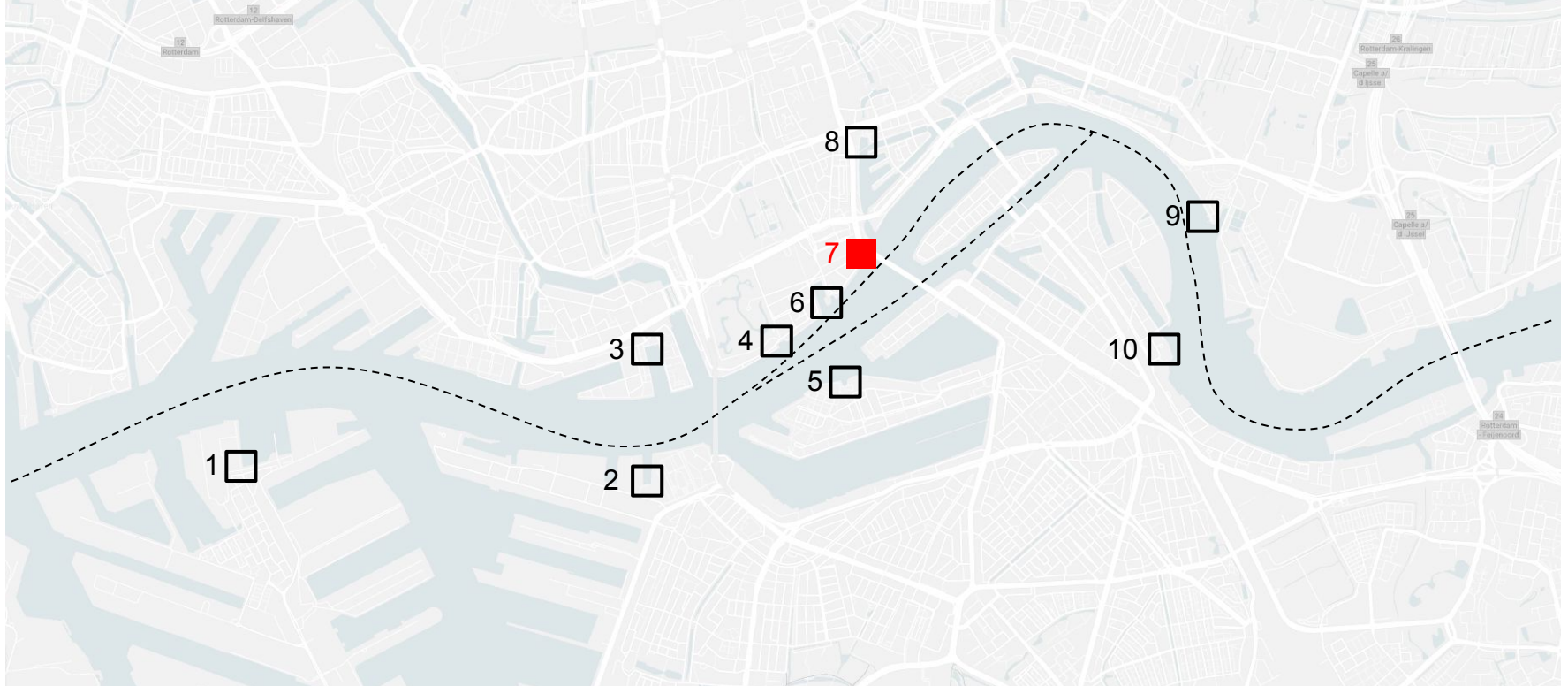
Michael Tong (5240913)

Site

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Willemsplein, Nieuwe Maas, Rotterdam



Ferry Terminals, Nieuwe Maas, Rotterdam



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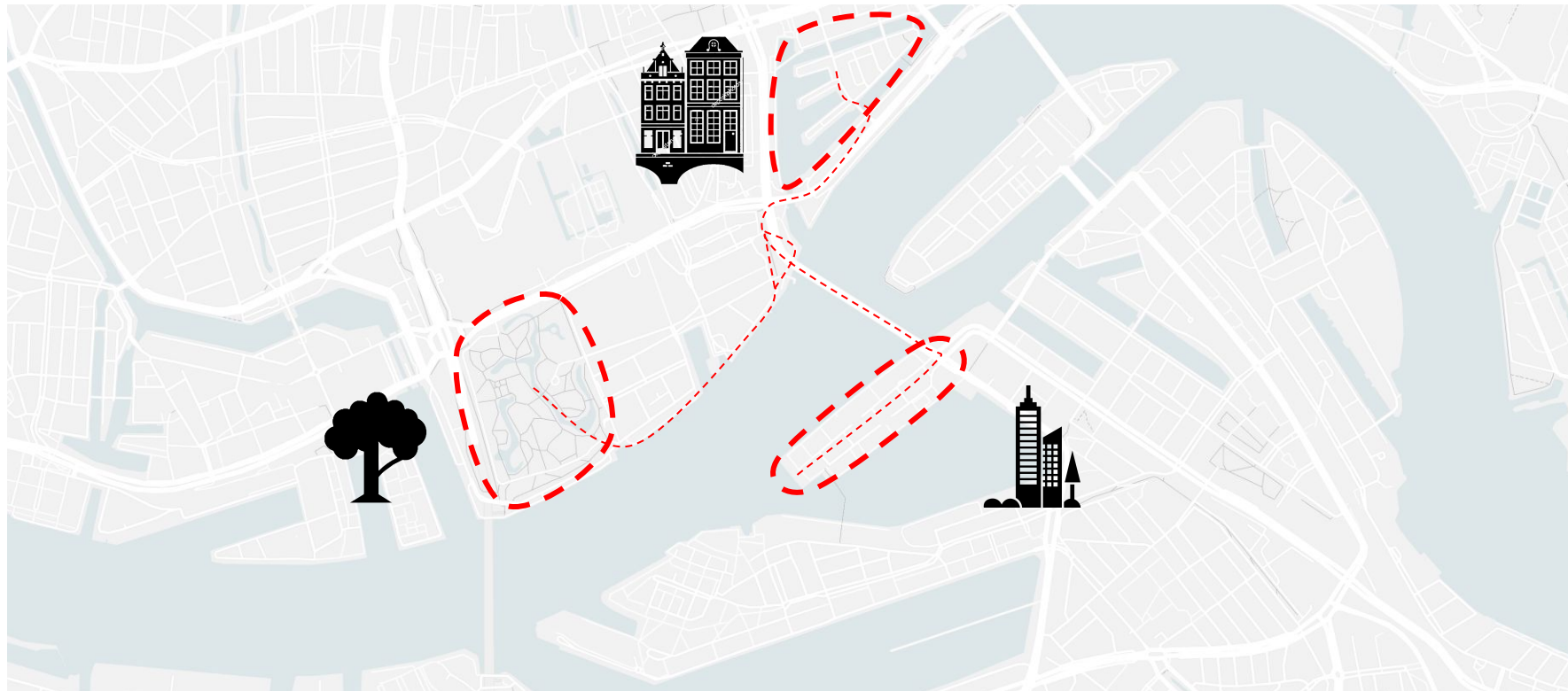


9. Plantagelaan

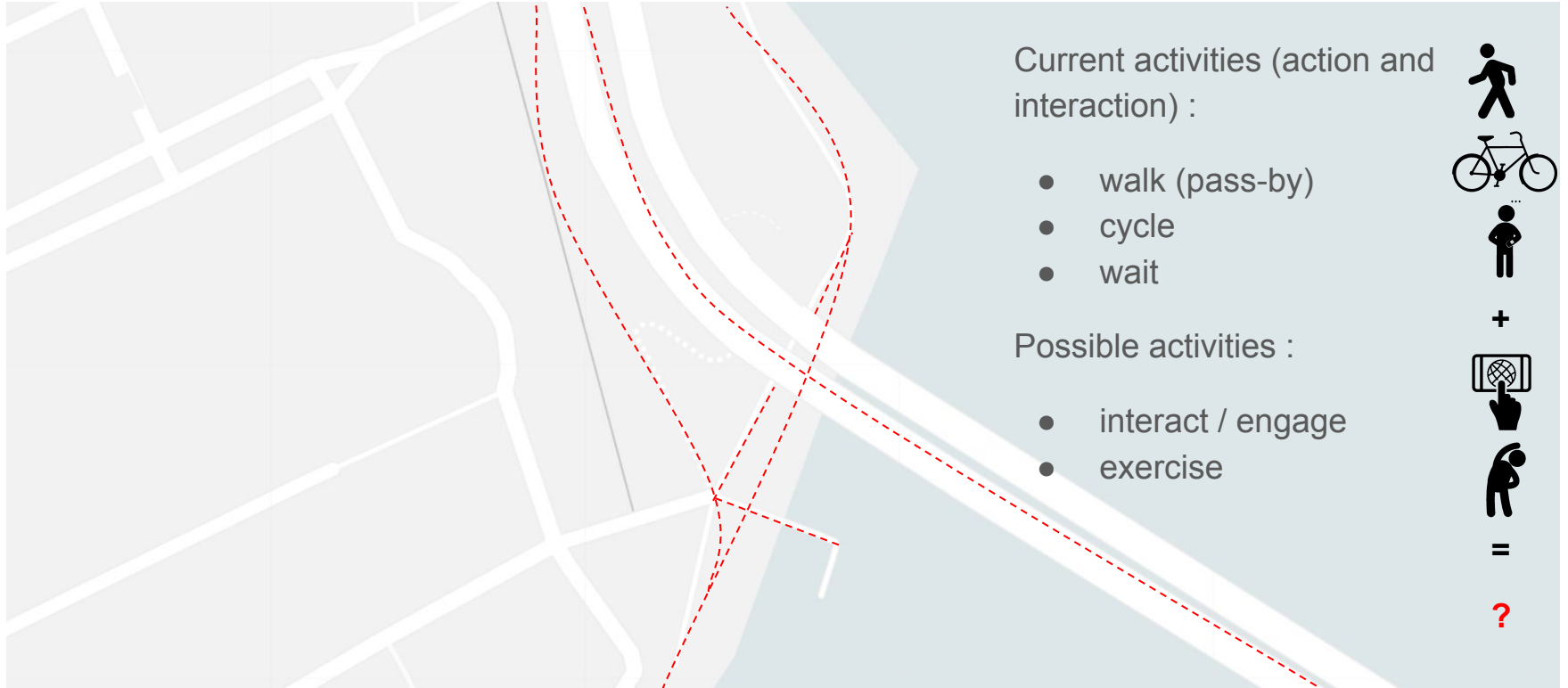


10. Piekstraat

7. Willemsplein, Nieuwe Maas, Rotterdam



Willemsplein Activities Mapping



7. Willemsplein, Nieuwe Maas, Rotterdam



Waterbus Sustainability Strategy

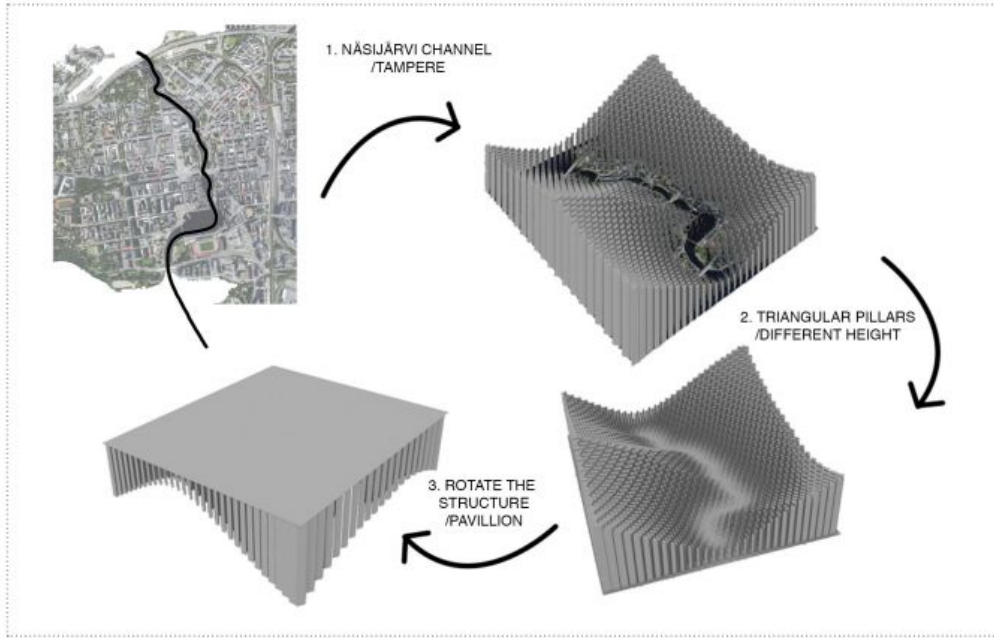


- battery-operated passenger ferry since 2018
- to operate for sixteen hours per day and be charged two times an hour
- high-end lithium battery with a long lifespan
- do we want to power HVAC capacity from the batteries? Or do we want to include another power source
- -> dedicated seat heating and cooling,

→ less operational costs + zero carbon emissions

Precedents

River Inspired Shape



Form to Challenge Interaction



- Body challenging
- body activated / body responsive

Form Inspiration



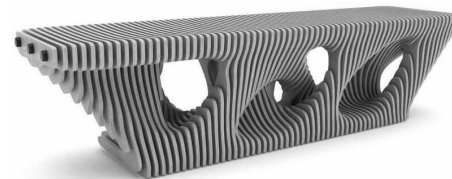
Wolkenteppich © Philipp Podesser



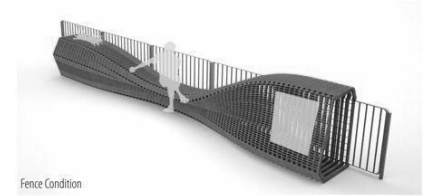
Lounge Furniture "Layers of Tribeca" © Philipp Podesser



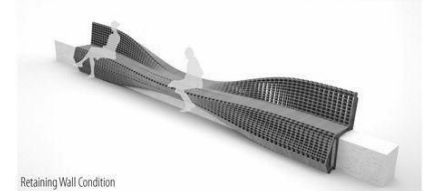
on site



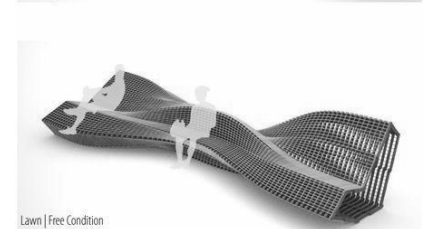
Retaining Wall Condition



Fence Condition



Retaining Wall Condition



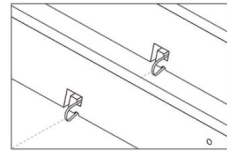
Lawn | Free Condition



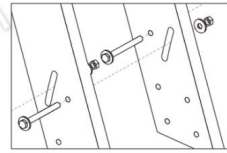
Old Idea New Manifestation



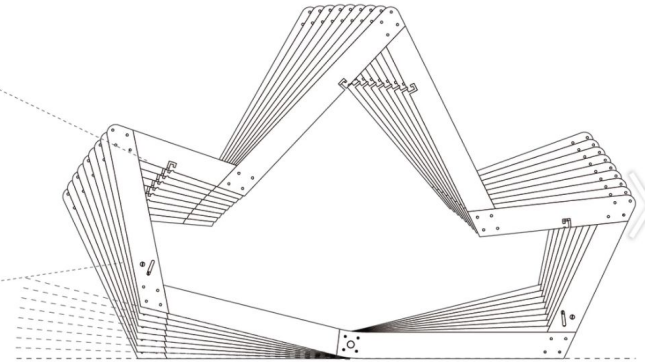
Adaptable Structure



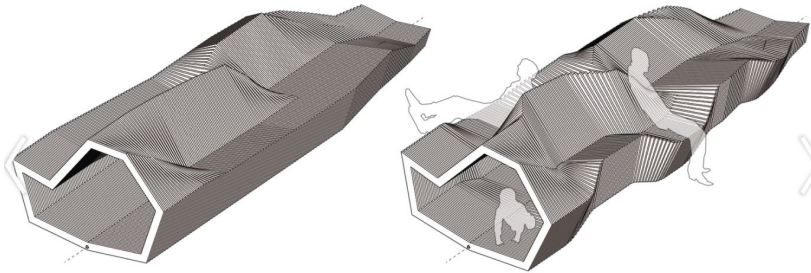
Elastic Band Connection



Sliding Bolt Connection



Activated State Elevation



Passive State Seating

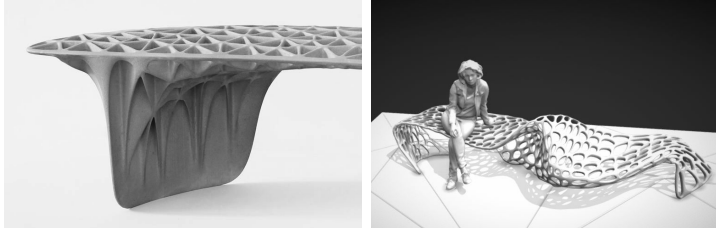
Active State Seating



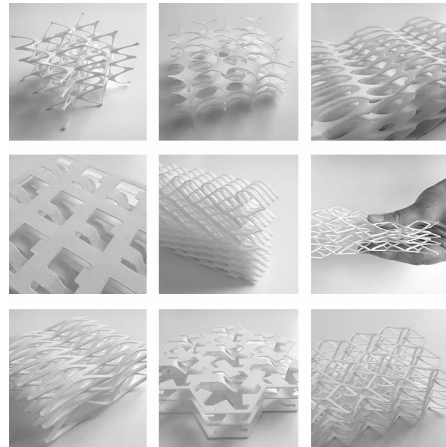
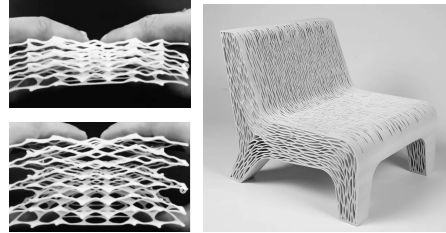
Structure

Voronoi Applied to Bench Design

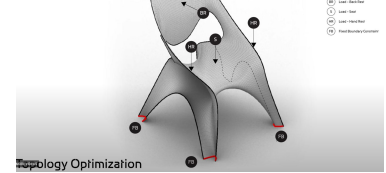
Design & Material Optimisation in Biomimicry



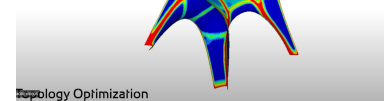
Biomimicry for Flexibility & Strength



Human Weight:
80 Kg
Material:
RGD | Polyjet



Human Weight:
80 Kg
Material:
RGD | Polyjet
Tensile Strength:
50 - 55 MPa
Modulus of Elasticity:
2000 - 3000 MPa
Poisson's Modulus:
2200 - 3200 MPa
Poisson Ratio:
0.35



Face Extrude

Minimum

Maximum

Thickness

Minimum

Maximum

Color 1

Red

Green

Blue

Color 2

Red

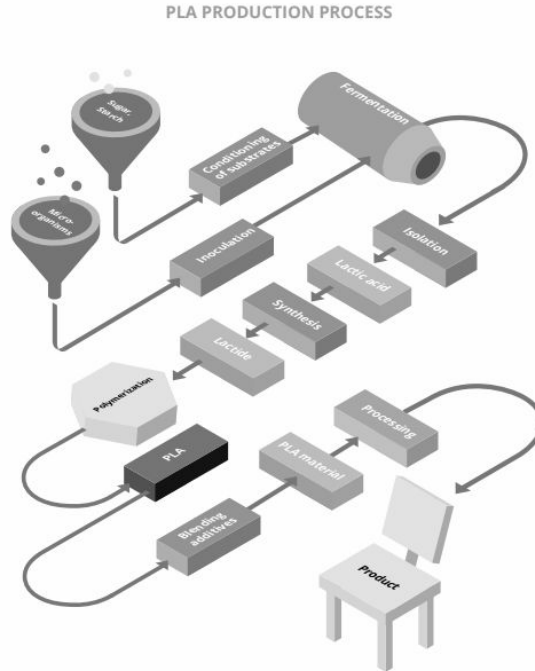
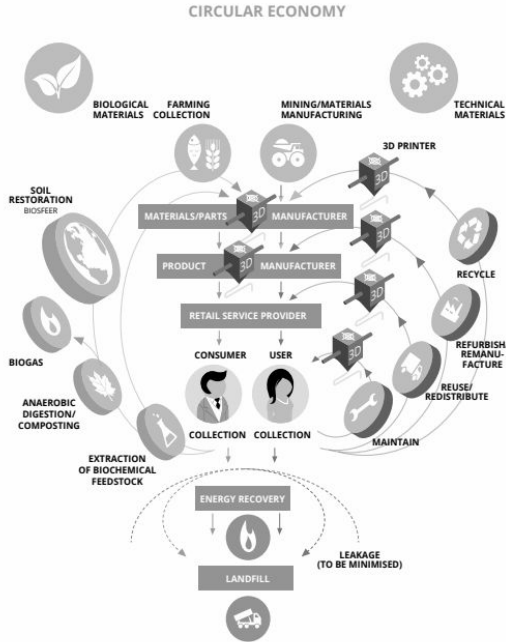
Green

Blue

Parametric Design Tool / color variation

Materialisation

Circular Additive Materials



FOSSIL ABS VERSUS BIO PLA ⁽⁴⁸⁾ (47)

	ABS	PLA
MELTING TEMP.	225 - 250 degree Celsius	190-240 degree Celsius
MOISTURE	ABS with moisture will bubble and sputter when printed, but easy to dry	PLA with moisture will bubble and sputter when printed Not easy to dry, can react with water and at high temperatures will de-polymerize
HEAT	Less deformation due to heating	Product can deform because of heat
SMELL	Plastic styrene smell	Corn like sweet smell
COLOR	Less color brightness	Bright, shiny colors and smooth appearance
HARDNESS	Very sturdy and hard	Less sturdy than ABS
FUMES	Hazardous fumes	Non-hazardous fumes
DETAIL	Higher layer height, less sharper printer corners, needs a heated printer bed for less warping	Higher max printer speed, lower layer height, sharper printed corners, less part warping
LIFETIME	Longer lifetime products	
ENVIRONMENT	Non-biodegradable Made from oil	Biodegradable Made from sugar, corn, soy-beans or maize

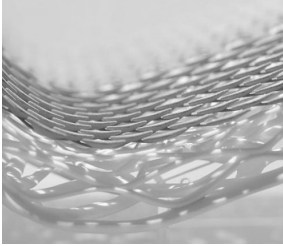
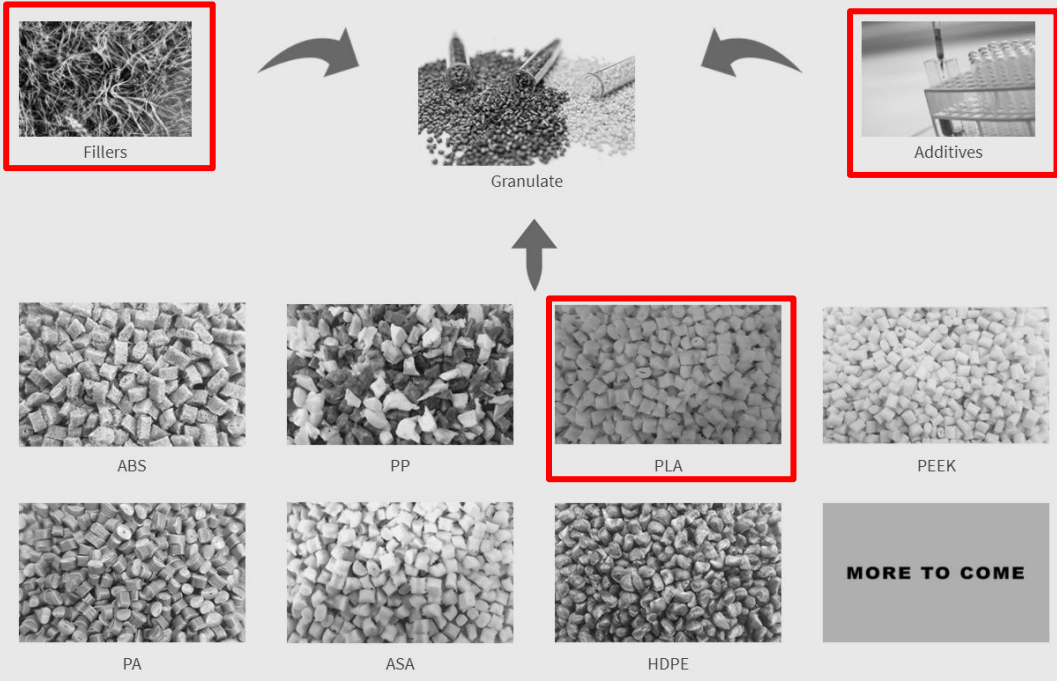
(FUTURE) BIOMATERIALS FOR 3D PRINTING

	PRODUCT MATERIAL	FEATURES
THERMO CHROME PLA	Regular PLA filament with thermo chrome feature	Changes color in response to temperature changes
FLEX PLA OR SOFT PLA ⁽⁵⁹⁾	Regular PLA filament mixed with unknown chemical to make it soft, tough and rubbery	Similar to regular PLA filament, only more flexible
NYLON 11 ⁽⁵⁹⁾	Polyamide 11 (PA11) or Nylon 11 from vegetable oil from castor beans	Reusable, strong and self-lubricating
BIO RUBBER ⁽⁵⁶⁾	TPE; thermoplastic elastomer from Rapeseed Oil	Strong, UV resistant, chemicals and temperature resistant
ARNITEL® ECO ⁽⁵⁷⁾	TPC; thermoplastic co-polyester made partially of rapeseed oil	Flexible, strong, C2C certified
BIOME3D ⁽⁵⁸⁾	Thermoplastic from plant starches	Biodegradable
STRAW BASED ⁽⁵⁹⁾	Straw based plastic made from rice and wheat stalks mixed with plastic and additives	Low cost material
BAMBOO BASED ⁽⁶⁰⁾	Filament made of finely ground bamboo	Low cost material
LAYBRICK ⁽⁶¹⁾	Filament made of finely ground chalk with a polymer binder	Feel like sandstone when printed, no layered look
LAYWOOD ⁽⁵⁹⁾	Filament made of 40% recycled wood with a binding polymer	Wooden look and smell, can also be handled like wood

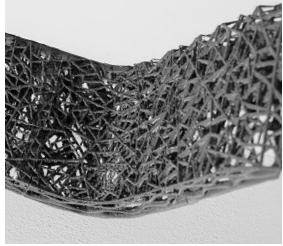
Bio-Polymer Components

3D printing technology is based on thermoplastics. 10XL uses both synthetic polymers as well as bio-based materials for printing. To improve the properties of the base polymer, we add fillers or additives. Glass, carbon, bamboo or stone fillers are used to strengthen your parts.

Additives improve UV and chemical resistance, or function as heat stabilizers, antimicrobials and flame retardants.



Structural Granulate:
 BIO-PLASTIC WITH
 CELLULOSE FIBRES
 FROM SAWDUST
 Good printing quality
 Rotterdam produced

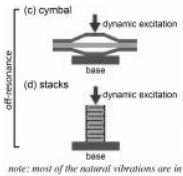


Cladding Filler:
 WOOD/ COCONUT /
 BAMBOO / CORK
 FIBER
 for comfort (softness)
 Den Hague produced

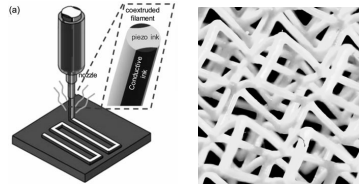


Additive:
 THERMOPLASTIC
 ELASTOMER for
 for flexibility
 (compress / stretch)

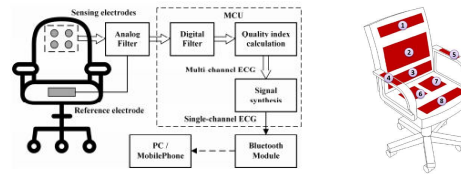
3D Printed Piezoelectric for Electricity Generation



Piezoelectric



3D Printed



Piezoelectric Chair

Compressive-mode piezoelectric energy harvester to Harness energy from deformation and stretching excitations.

The energy is to be used for:

- lighting responsive to user flow
- integration with the Waterbus sustainability scheme

Flexible piezoelectric composite for 3D printing materials that can be customized to:

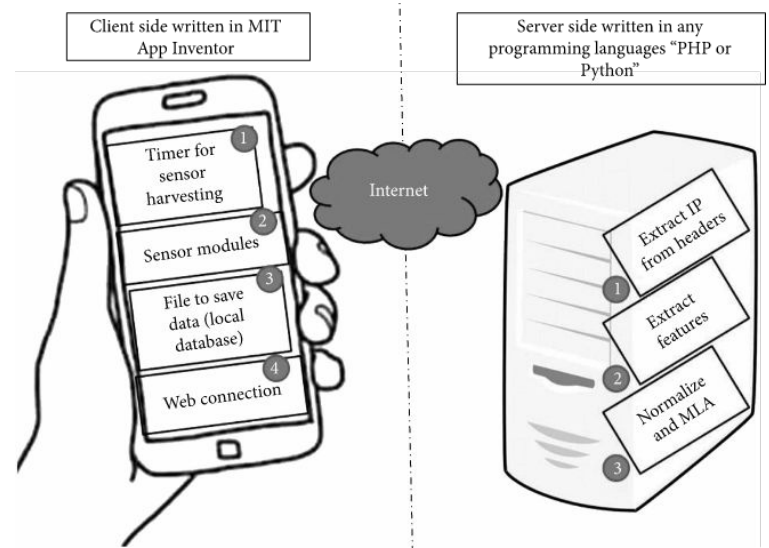
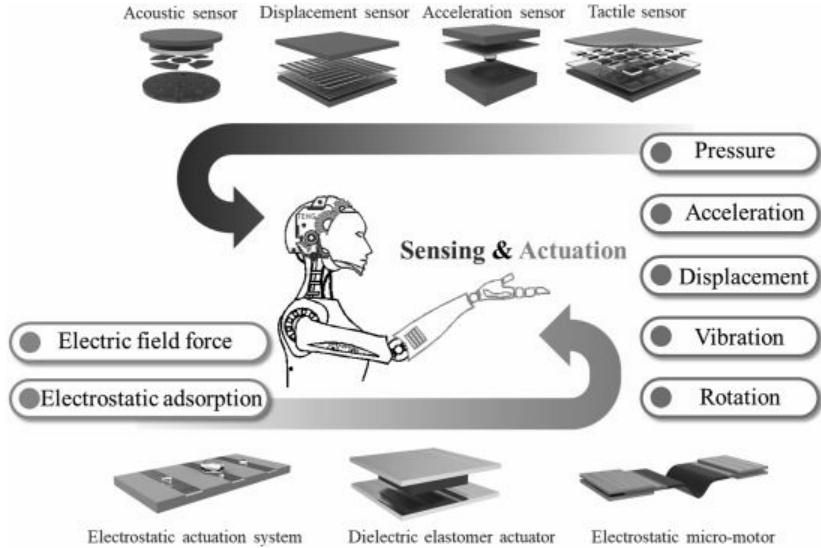
- **convert movement, impact and stress into electrical energy**
- **Here, the structure itself is the sensor—it can monitor itself**

By programming the 3D active topology, you can achieve pretty much **any combination of piezoelectric coefficients within a material**, and use them as **sensors** that are not only flexible and strong, but also **respond to pressure, vibrations and impacts via electric signals** that tell the location, magnitude and direction of the impacts within any location of these materials.

Watch: [Engineers pioneer 3D printed piezoelectric materials for smart infrastructure \(3dprintingmedia.network\)](#)

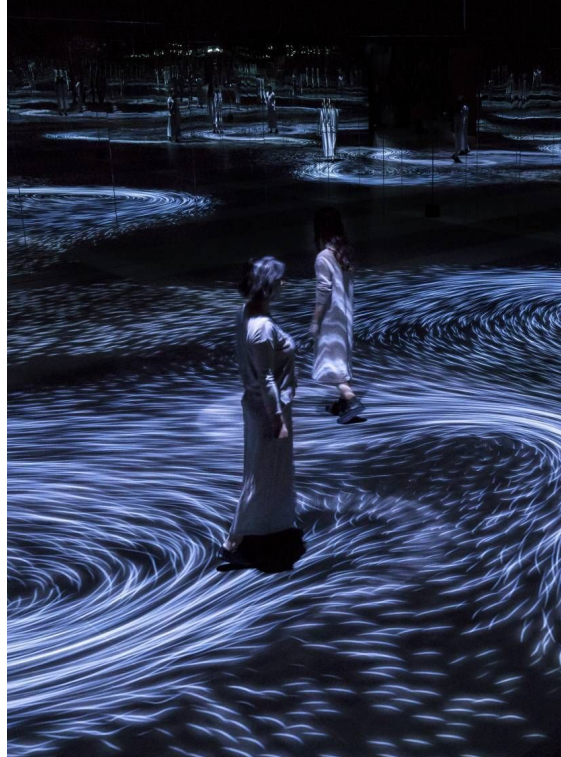
Sensors

Piezoelectric Sensor



Actuators

Interactive Lights



Sensor: pressure / light - realises how many people are seated.

Actuator: the lights running along the structure moves around the person like water.

Actuator: the pressure point sends a signal to an app / google maps that lets users know how many people are at the previous terminal / how full the ferry is.

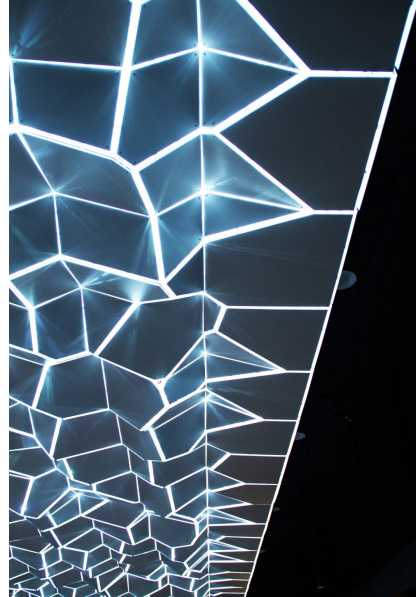
Function: to see the capacity of the ferry.

Other potential features:

- changes color depending on how many users there are waiting
- light flashes when ferry is approaching
- collects data on how often people use, what times, to go where and it sells data for marketing - find investors

Function: Beautification / tourist interaction.

Interactive light / sound



Rise Los Angeles, CA 2014

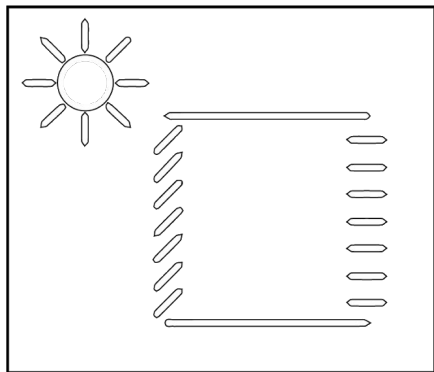
The ceiling installation extends the typical training soundtrack found in high-impact workouts into an immersive spatial environment. Once the workout begins and the lights are turned down the installation comes alive through a large array of internal LEDs. At first glance, the installation appears to just be a rocky surface, but the precise gaps between the panels allow the reflected light from the LEDs to pass through in irregular ways to create an animated surface that ranges between simple fades to a field of lighting. **The LEDs are programmed with various behaviors to accompany the different soundtracks played during workouts.** The installation serves as both a sculptural ceiling under normal conditions and a high-intensity interactive light field during workout sessions.

Ideas for our design:

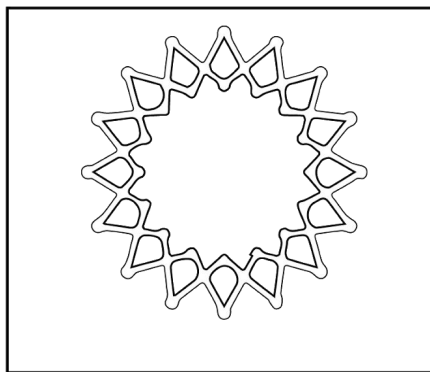
- Light reacts to the movement of passers-by
- Light reacts to ambient noise
- **Light flashes when waterbus arrives**

Design Development

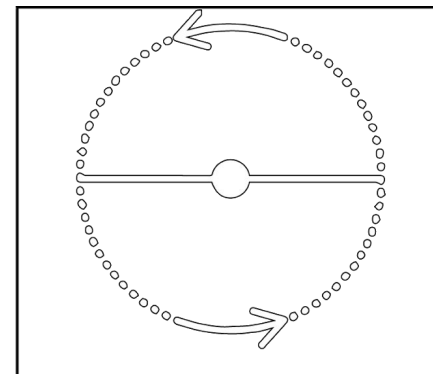
Overall Approach



Responsive



Kinetic



Transformable

Overall Concept: Shapes of the River



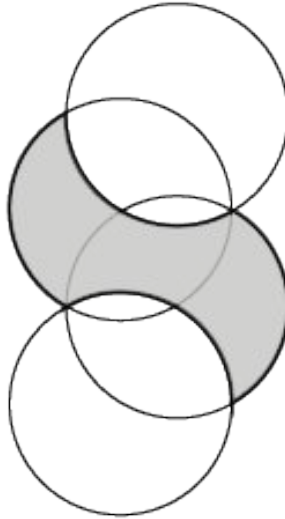
Overall Concept: Modular Assembly



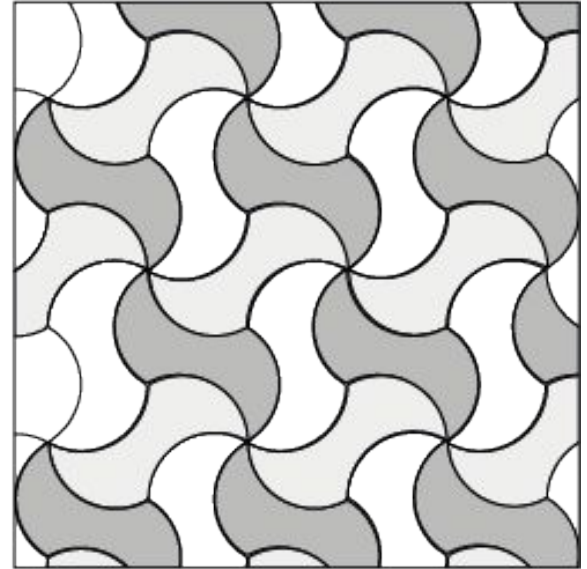
Design 1: Concept



Symbolic

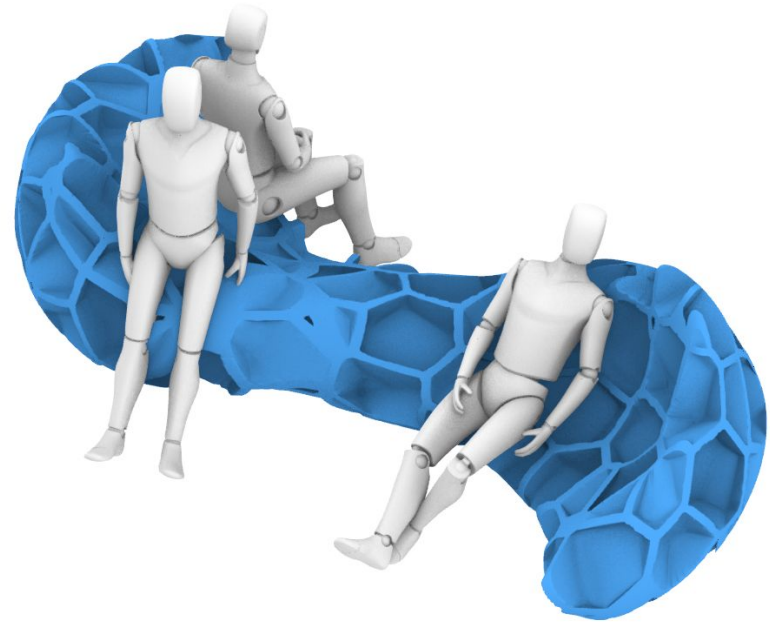
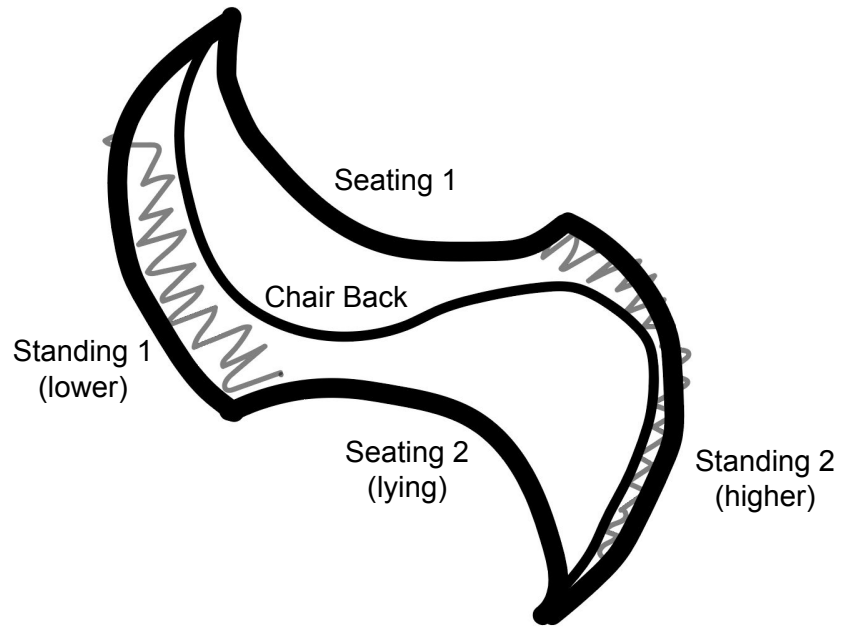


Modular

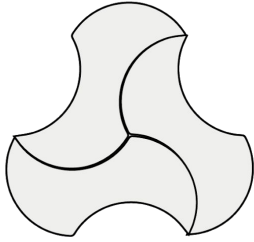


Pattern Based

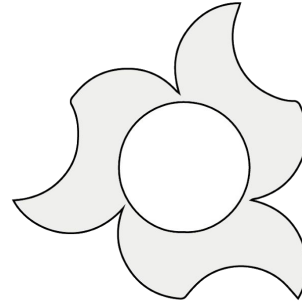
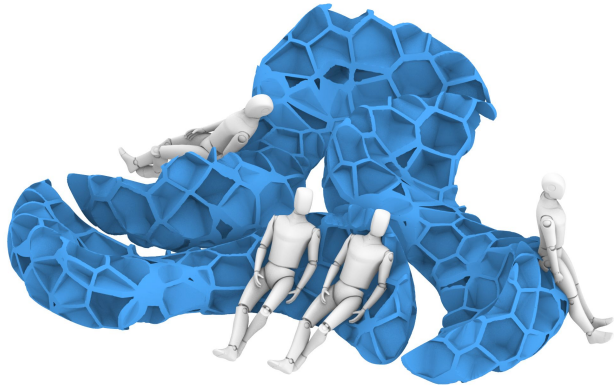
Design 1: Module



Design 1: Combinations



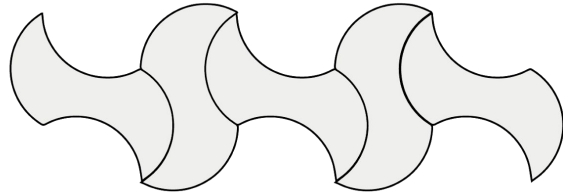
Compact seating
that offers views
to different sceneries



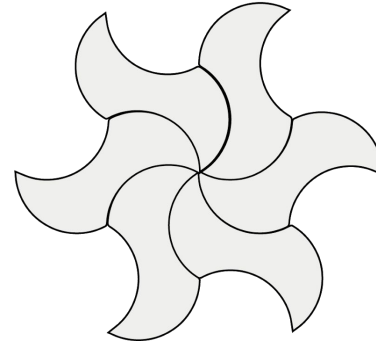
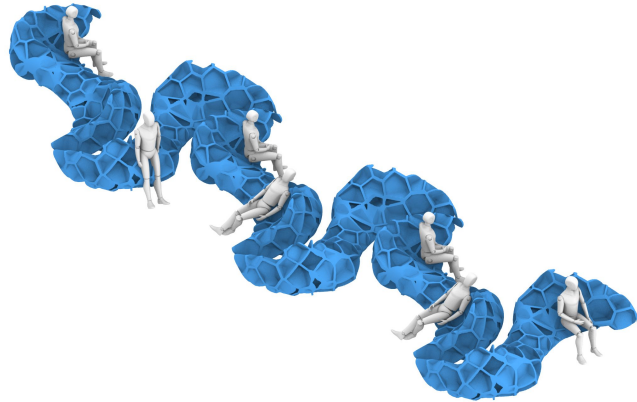
Forming a safe, collective
space in the middle (for
example kids)



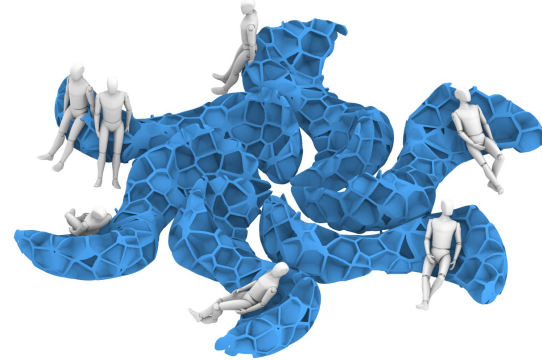
Design 1: Combinations



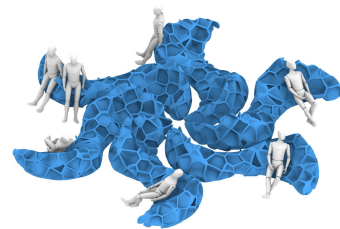
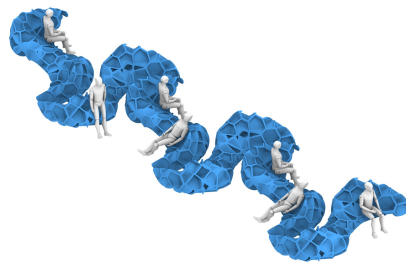
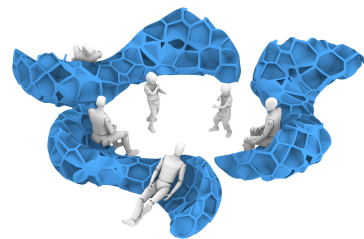
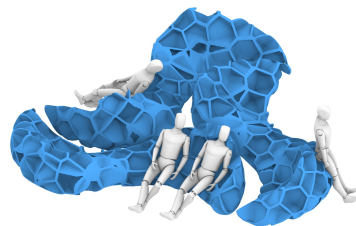
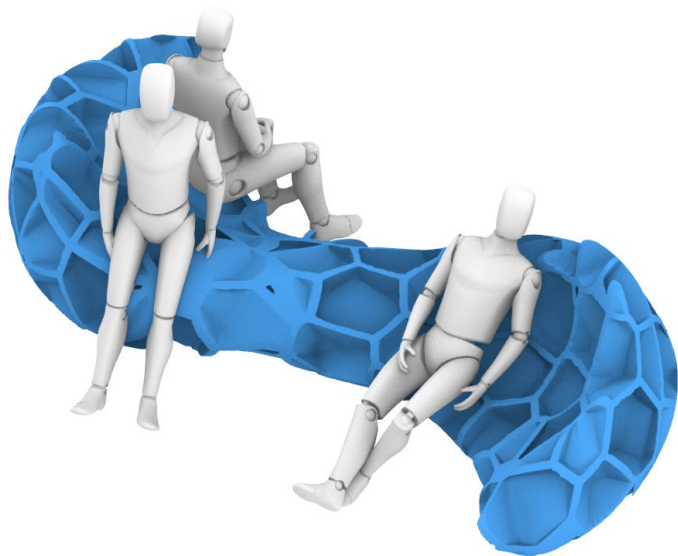
Linear form along
the river offering
more exposure to
the surrounding



Interconnected
seating that can be
used as a platform
for activities



Design 1: Visions

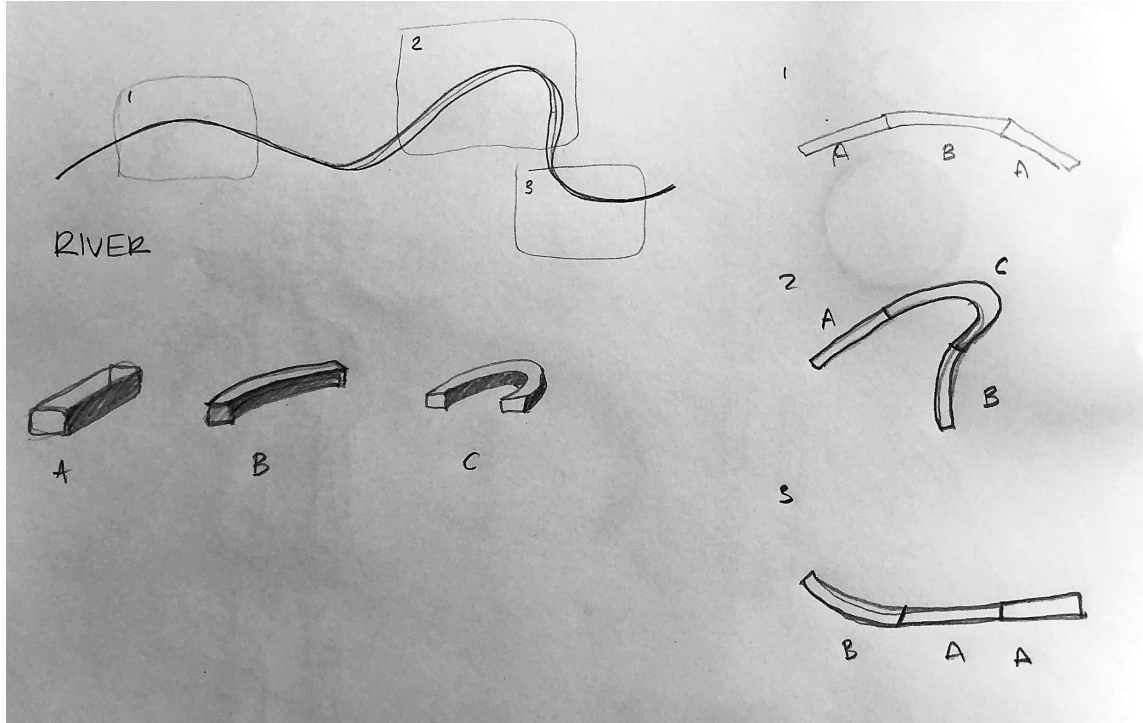


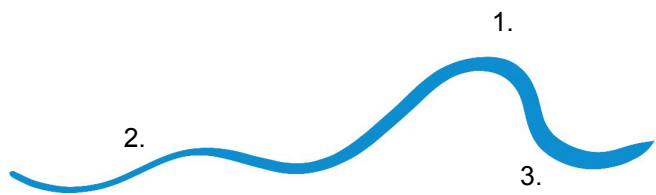
Design 2



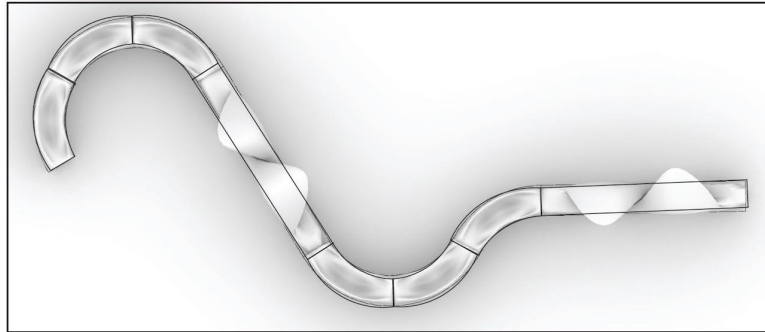
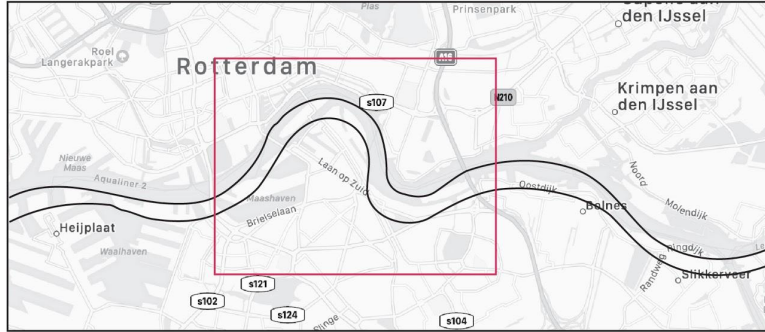
Design 2:

Plan





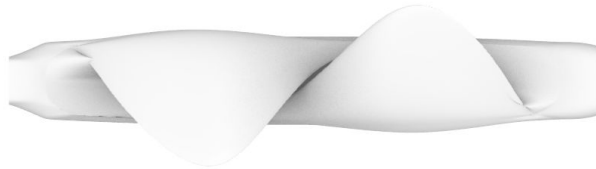
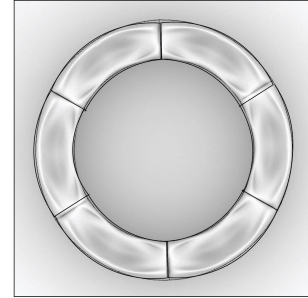
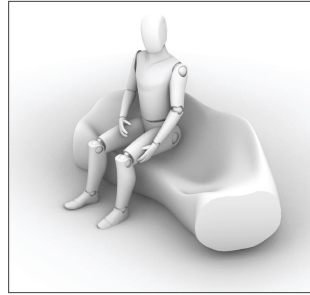
Design 3: Concept



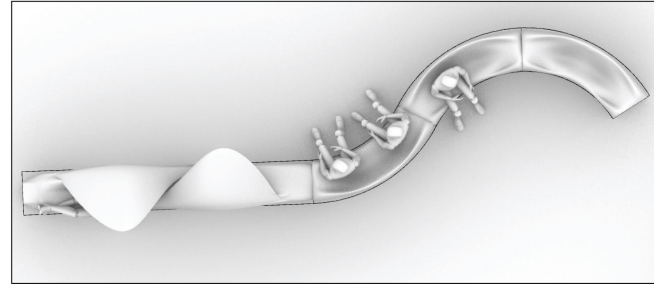
Design 3: Module



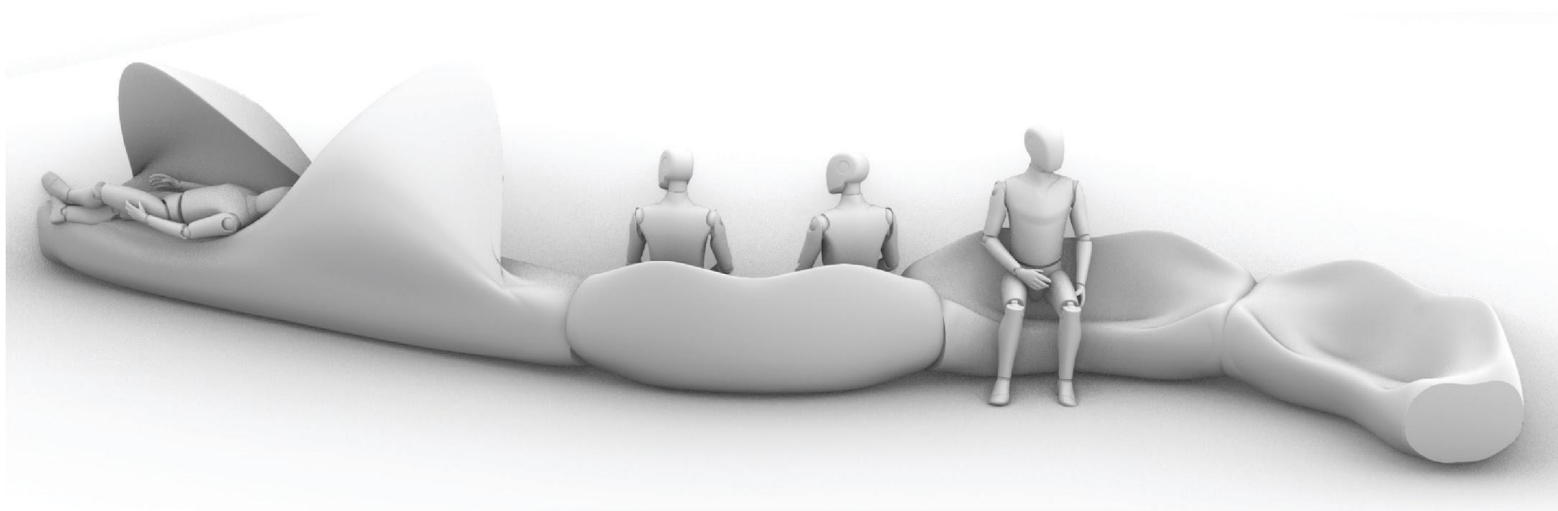
Module 1
Seating for 1 or 2 people



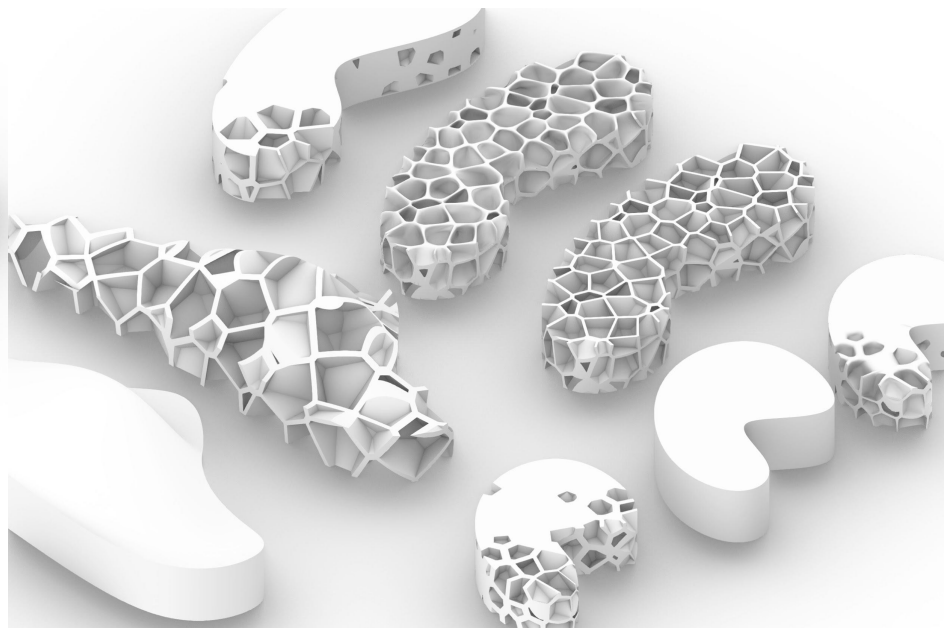
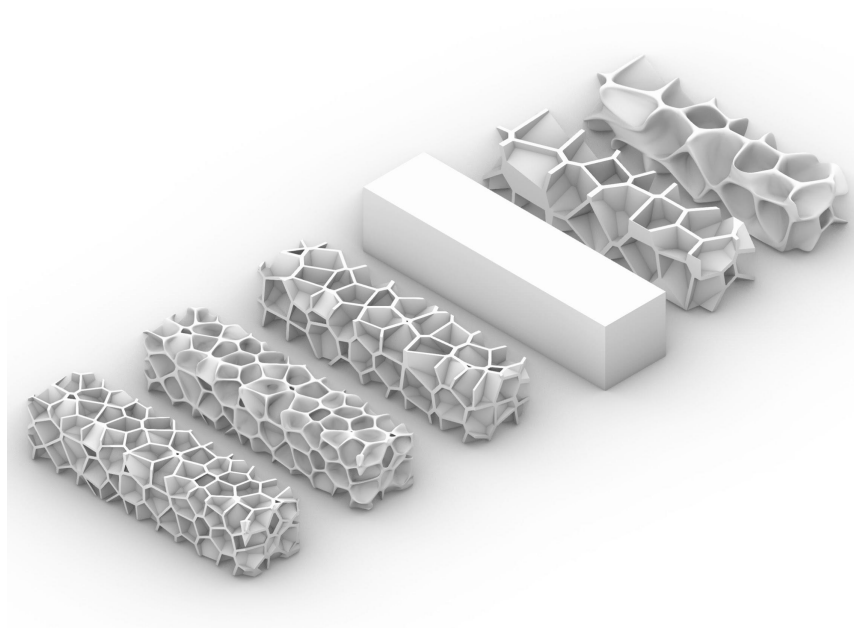
Module 2
Seating with shelter



Design 3: Vision



Voronoi



Questions

Question

- Do we need to put the finish on the furniture, or just the 3D print bio-polymer only?
- How do we integrate the sensors with the voronoi structure if it is with empty cells?