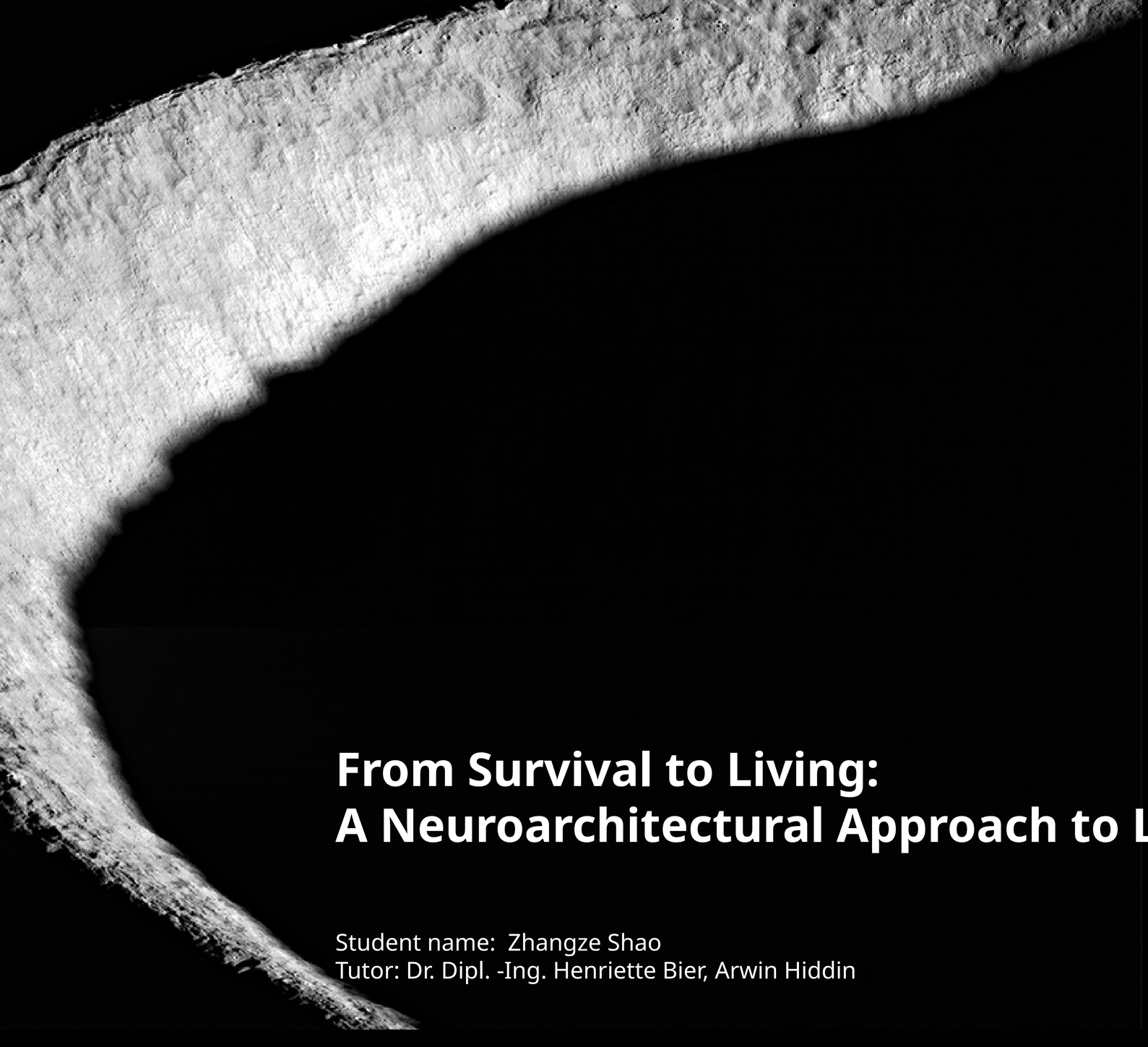

From Survival to Living:
A Neuroarchitectural Approach to Lunar Habitation

Student name: Zhangze Shao
Tutor: Dr. Dipl. -Ing. Henriette Bier, Arwin Hiddin

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Part.1 Introduction

As humanity transitions from temporary lunar cells to permanent colonization, the fundamental challenge of space architecture shifts from basic survival to mental wellbeing...

Space traveller
Hajime Sorayama

Problem Statement

Beyond 'surviving' to 'living':

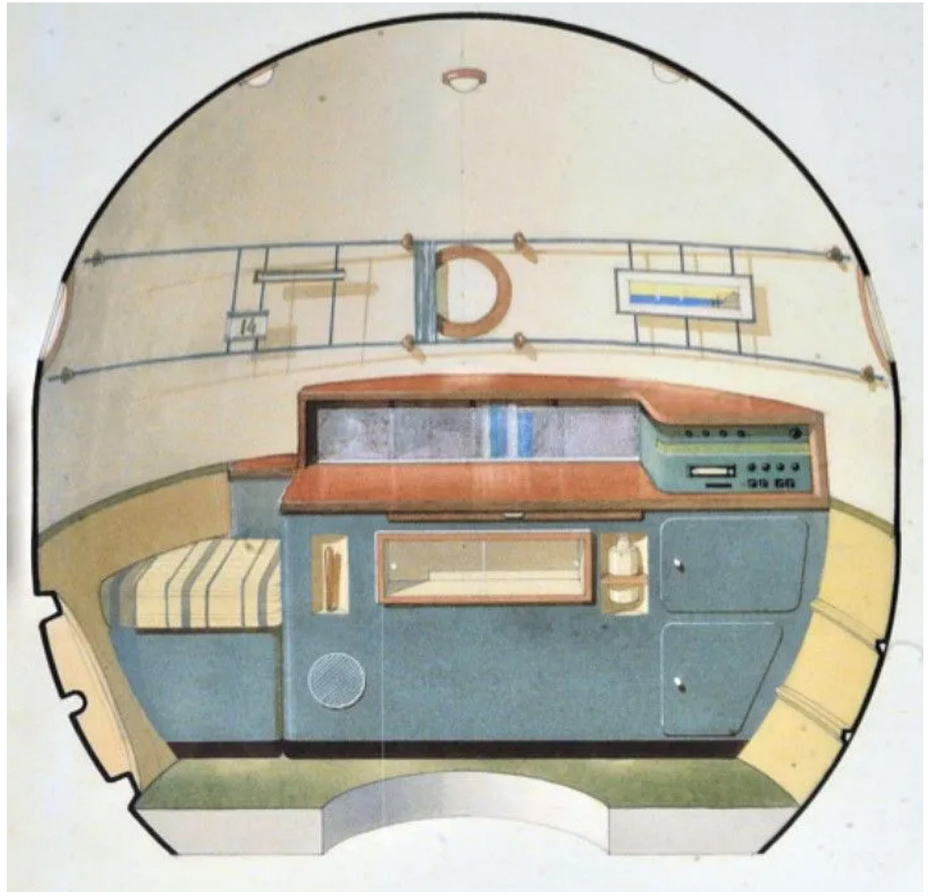
Now we landed on the Moon, then what?

Current design focuses on

- Engineering and modular
- Minimal layout
- Functionality and efficiency

But ignored the habit part

- Mental health
- Sensory change
- Ergonomics



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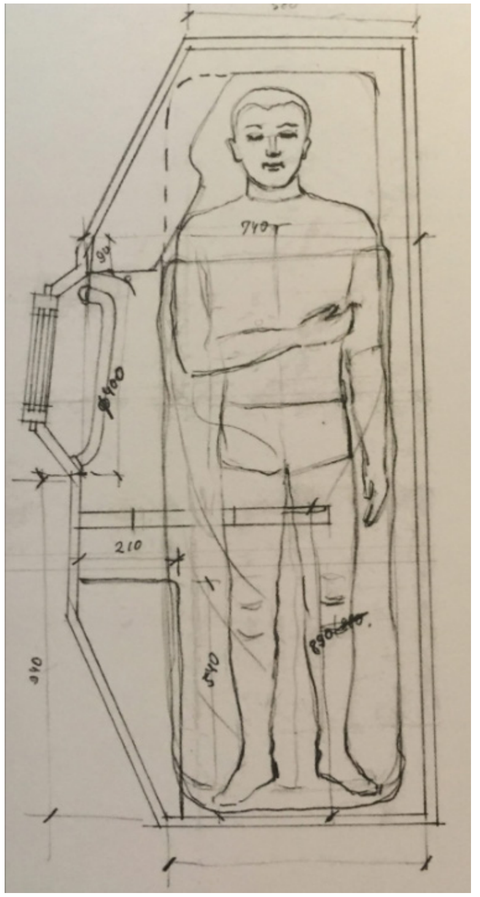


2

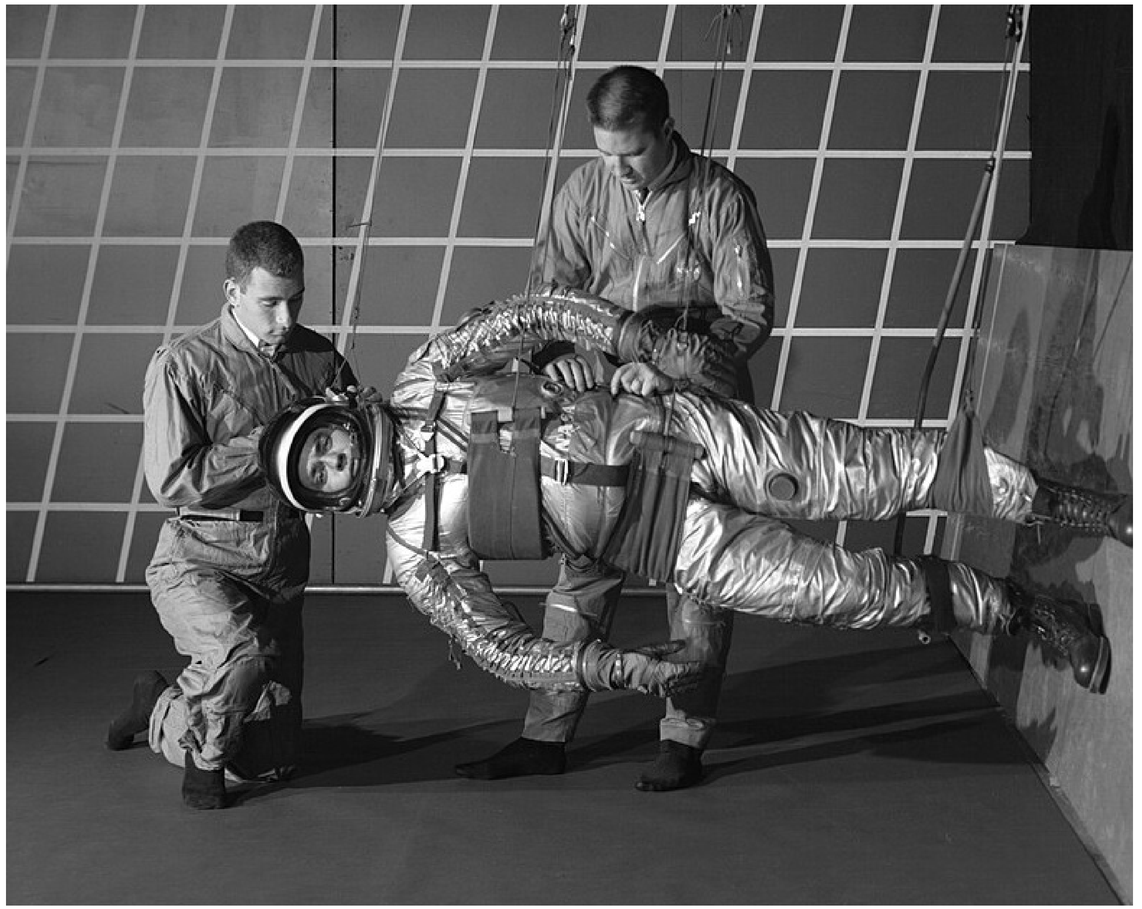
Figure 1 & 2
Mir sleeping cell

http://kvadratinterwoven.com/out-of-this-world-the-space-age-designs-of-galina-balashova

The essential of 'living':

Missing of ‘Plumb Line’

Cognitive disorder due to lack of gravity vertical

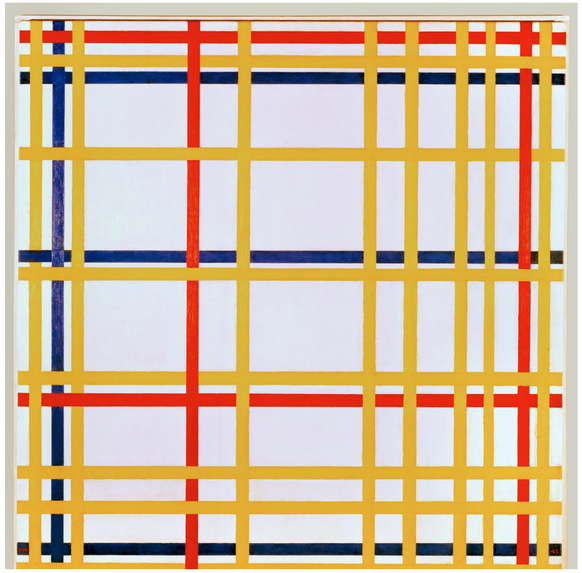


NASA testing moon gravity cognition, in a horizontal way

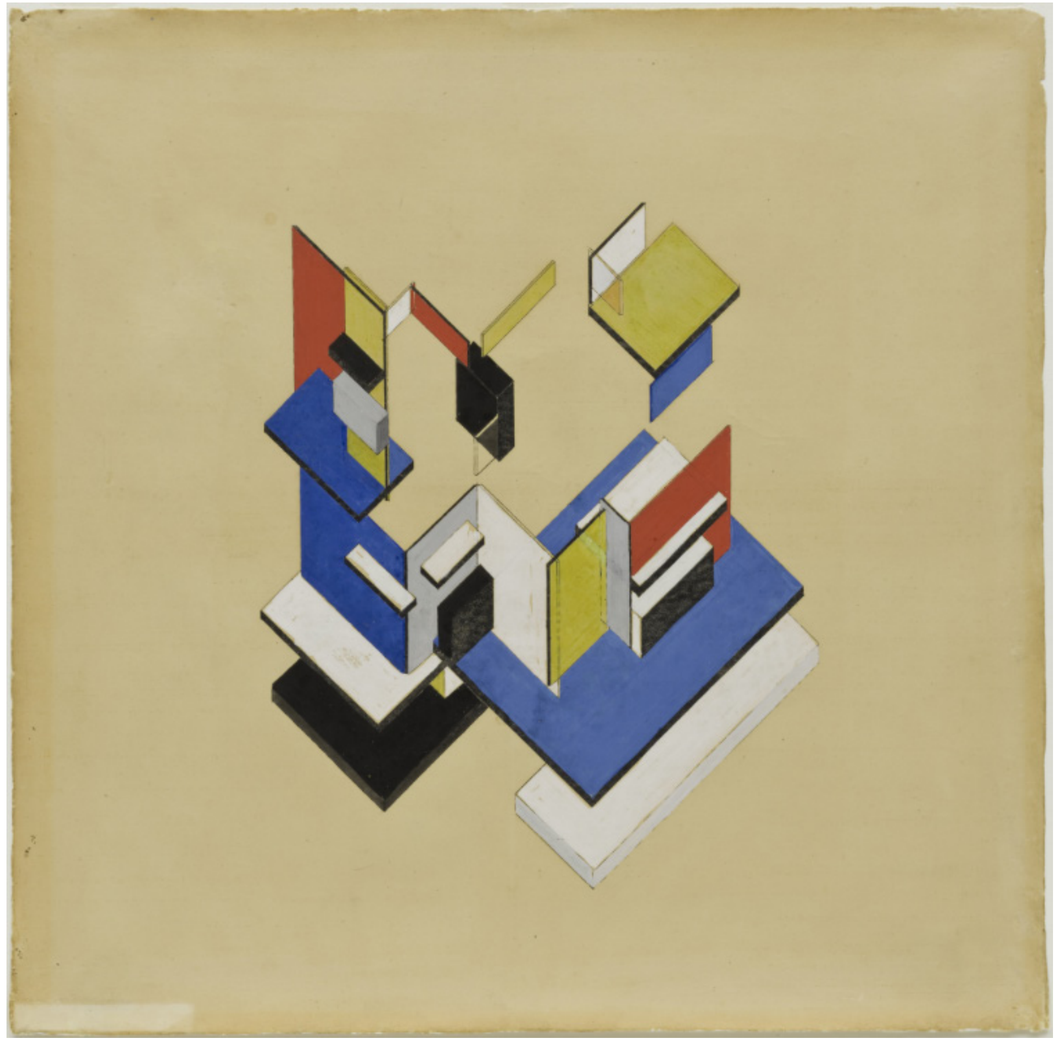
Relevance

Embracing visual & object vertical in space age:

Humans perceive space not only through body measurement, but visual anchors.



...and Piet Mondrian's artwork was displayed upside down for 75 years.



De Stijl movement (1923)

Reduce sensory load

Aware and reduce the risk of brain's "plumb line" and its "visual vertical" stop agreeing with each other.

Improve cognition and well-being

Design to tackle with cognitive decline, depression, or social conflict.

Improve Spatial perception

Spatial research could improve design process by taking individual's perception into consideration

Contribution to UN's sustainable goals

The study of disorientation could help improve living environment for people who are experiencing cognitive decline.

When available space is very limited, visual anchor improvements could help building mental resilience among residents

Objective & Motivation

Architectural:

Space colonization: Indicate a guideline for about **lunar lifestyle** more than just survival, and bring technological consciousness where space can be determined more than merely **volume** but also **minds**

Technical:

Space-resilience: Embody cognition to **spatial cues** when designing lunar base, **ISRU technology** in Robot building and maintenance

Research questions

Main: Design for mental wellness in extra terrestrial environment

Sub-questions:

1. Physical survival challenge
Premise - Design must be based on conscious research of physical ICE[1] conditions in constructing and inhabiting lunar bases with ISRU

2. Sensing spaces
Dealing with sensory deprivation and monotony with visual cues and movement study

3. Mind over matter
Sequel - between individuals, coping with imbalance between privacy and social interaction using architectural expressions

Reference

1. Isolated, Confined, and Extreme (ICE) challenge, developed by NASA
Oman C, M. et, al. (2006). The Role of Visual Cues in Microgravity Spatial Orientation. https://ntrs.nasa.gov/citations/20030068201

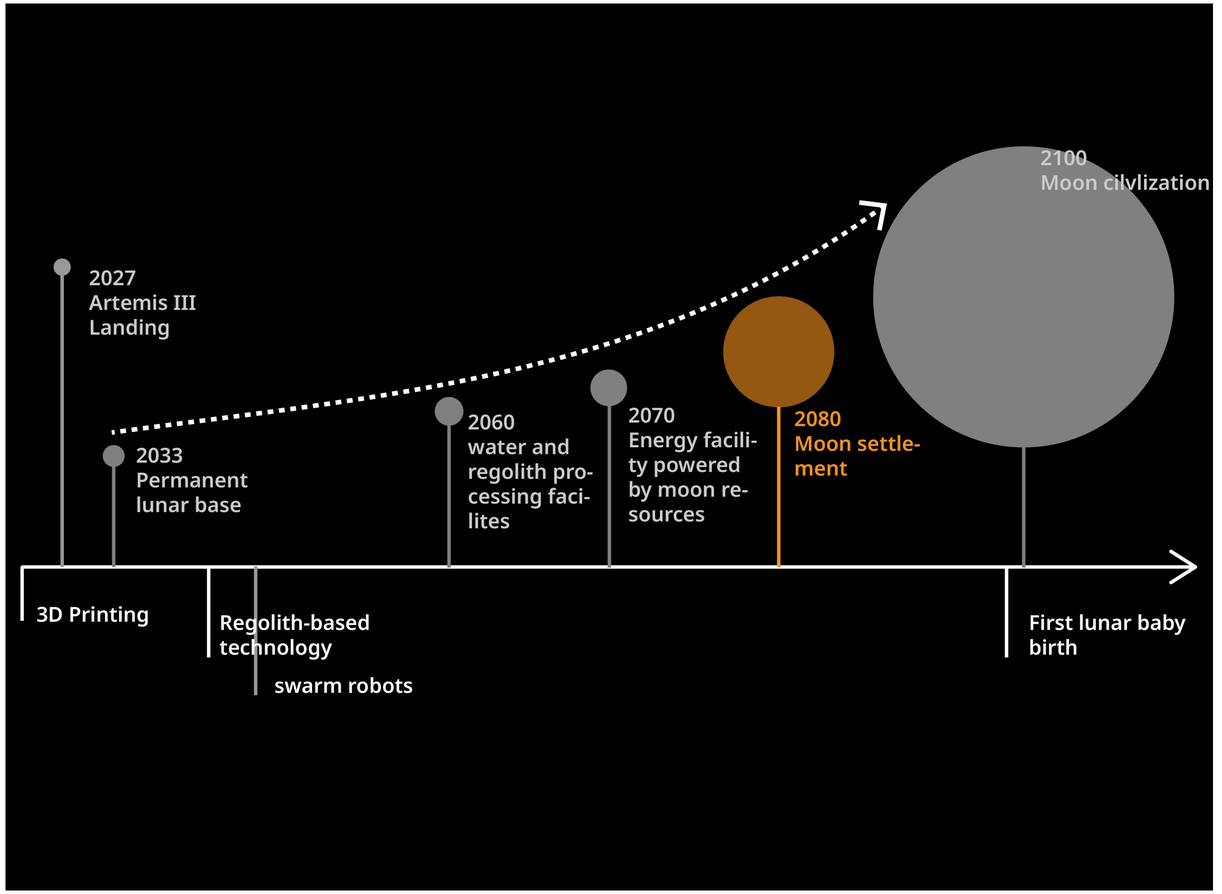
Scope

Design phase

After successful landings of multiple short-term lunar modules, this habitat is considered to be **self-maintaining**, lasting over a generation while developing to form their own space colonize culture.

Team size

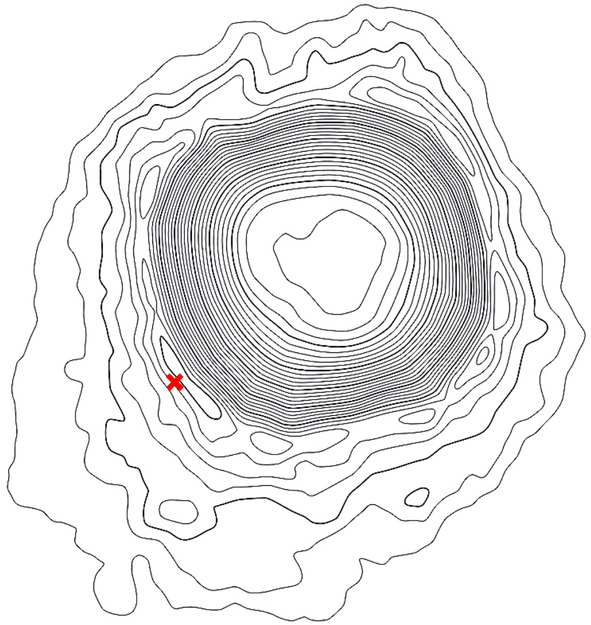
8 visiting: research, tourism or Mars transit
2 long term: maintenance and operation

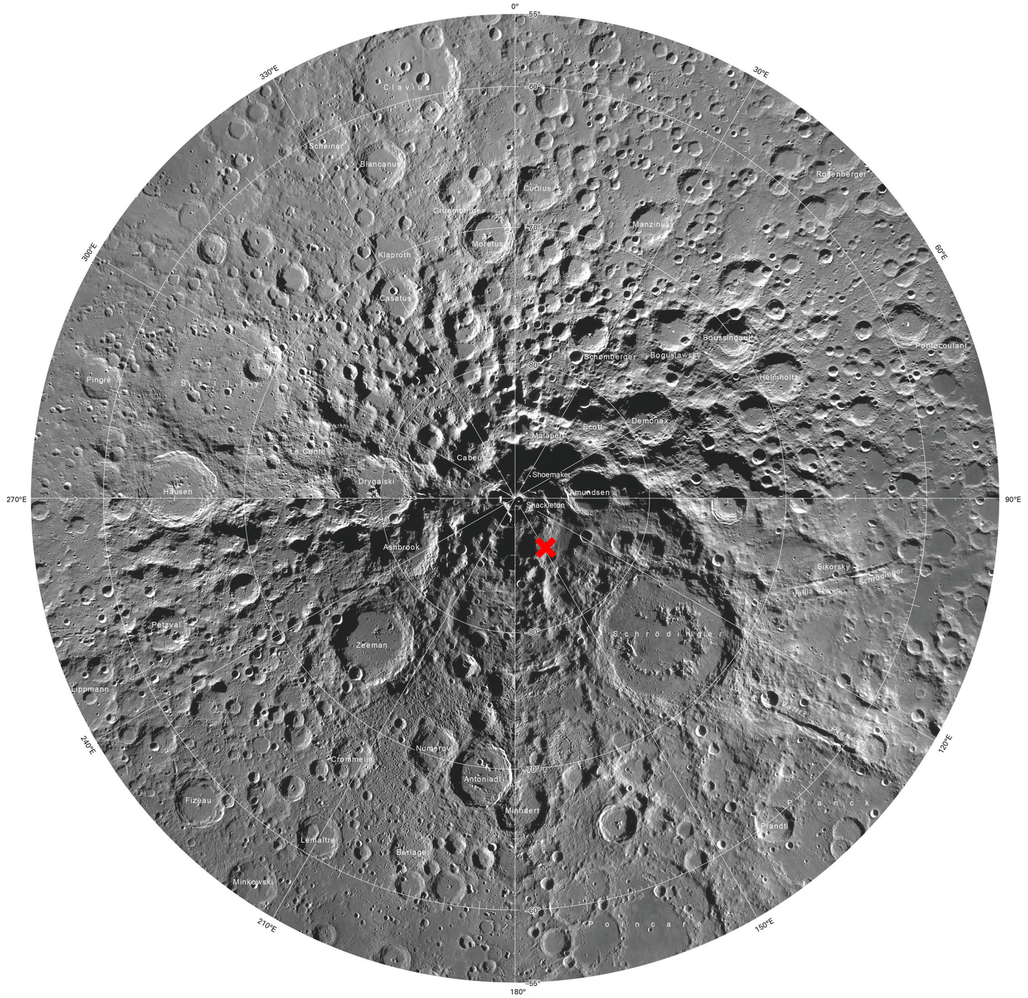


Site

Location: Lunar South Pole

On sunlit peak point of rim
at Shackleton Crater





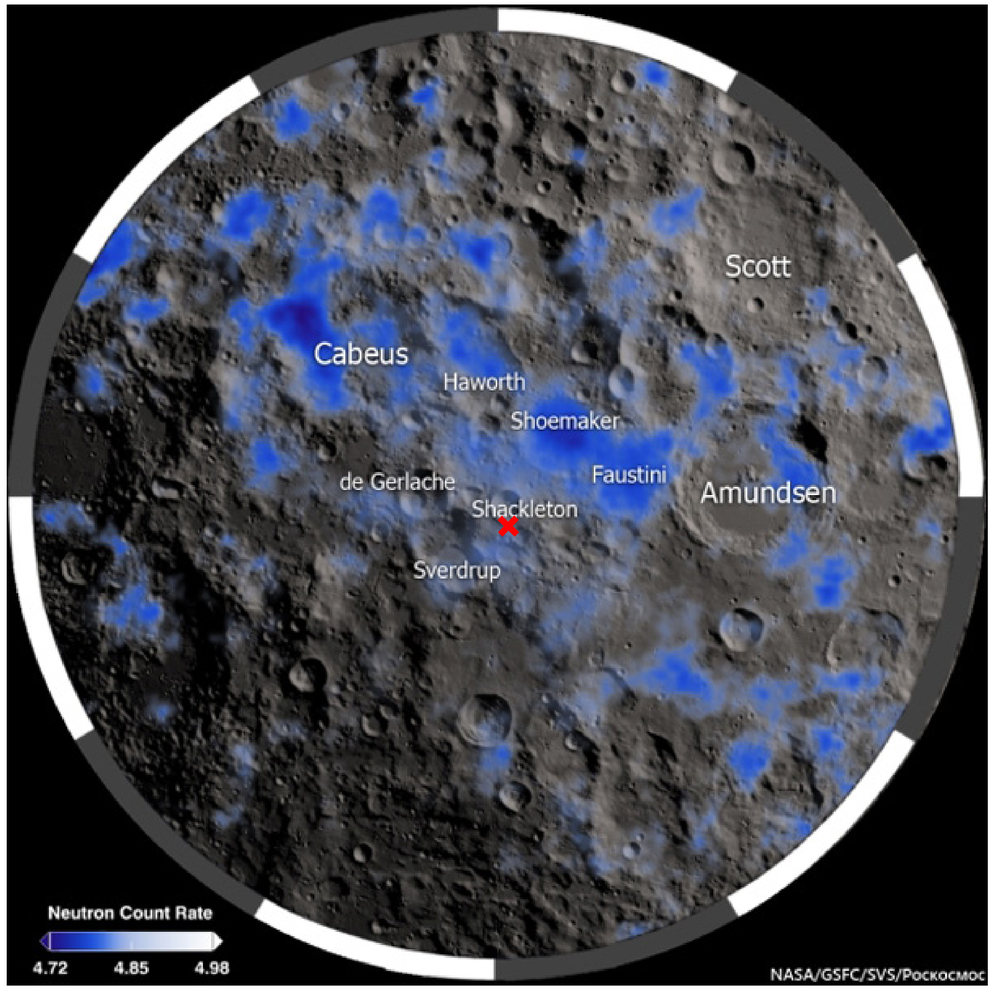
https://science.nasa.gov/image-detail/svs-lend-20130601-580-2/

Site

Resource driven

Permanently shadowed regions (PSRs) may contain water ice and other materials

Solar energy for more than 90% of the year at the sunlit side



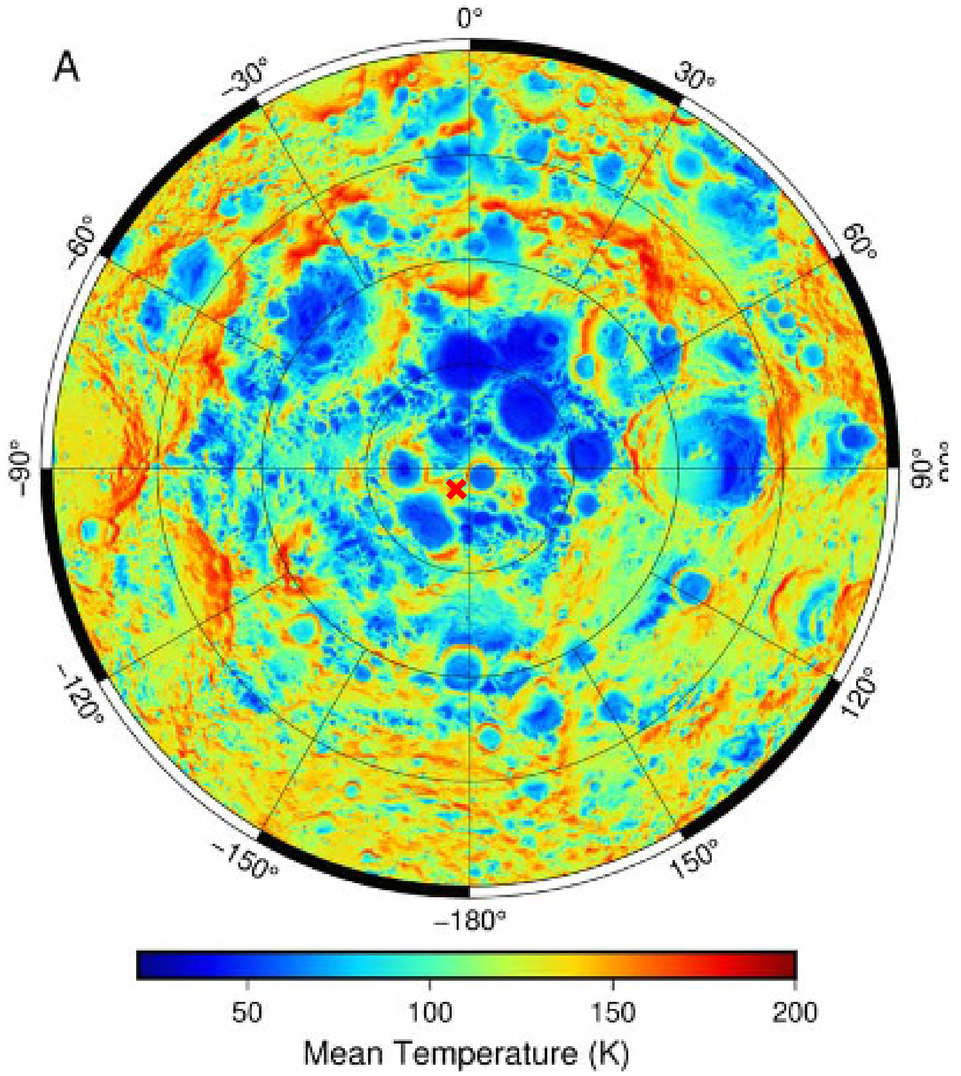
https://science.nasa.gov/image-detail/svs-lend-20130601-580-2/

Site

Core challenge

Sunlit area temperature (stable but lower: 90% at -3°C and 10% reduced to -53°C).

Cosmic radiation



https://www.diviner.ucla.edu/single-post/new-diviner-south-polar-data-products-released-on-pds

Part.2 Approach

Buildings on Earth are mostly built with hierarchy (or floors), but when there’s no or less “below” or “above” hierarchy, people’s cognition, habits, … will inevitably change as well.

2001: Space Odyssey
1968

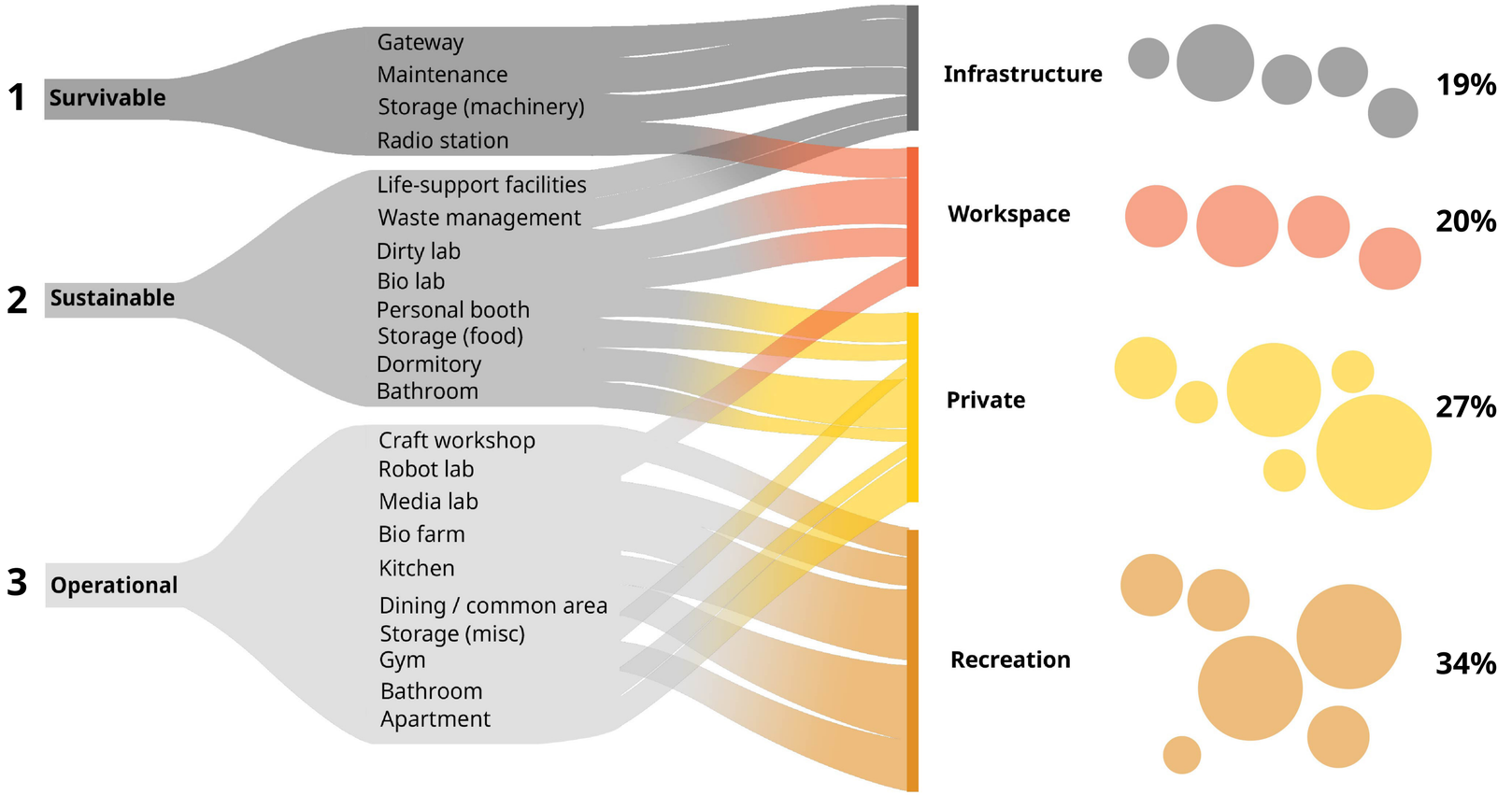
Programme visualization:

Categorize the expansion of a moon base

There are three phases in construction of a moon base:

Survivable, sustainable and operational[1].

Each phase then form spaces to required functionality



Programmes

Programme expansion:

1. Survival

Fundamental and rigid

Fixed connection

Key space

Main transition

Adjacency

Public access

Programmes

Programme expansion:

2. Sustainable

Resource first, limited service

Fixed connection

Key space

Main transition

Adjacency

Public access

Programmes

Programme expansion:

3. Operational

More flexible and recreational

Fixed connection

Key space

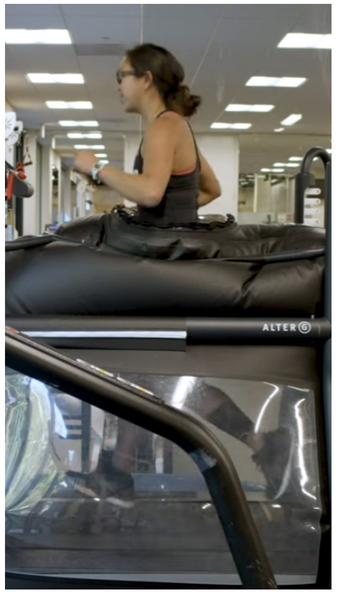
Main transition

Adjacency

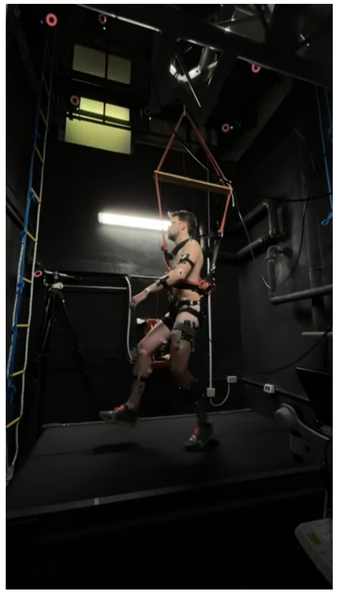
Public access

Muscular perception

Experiments



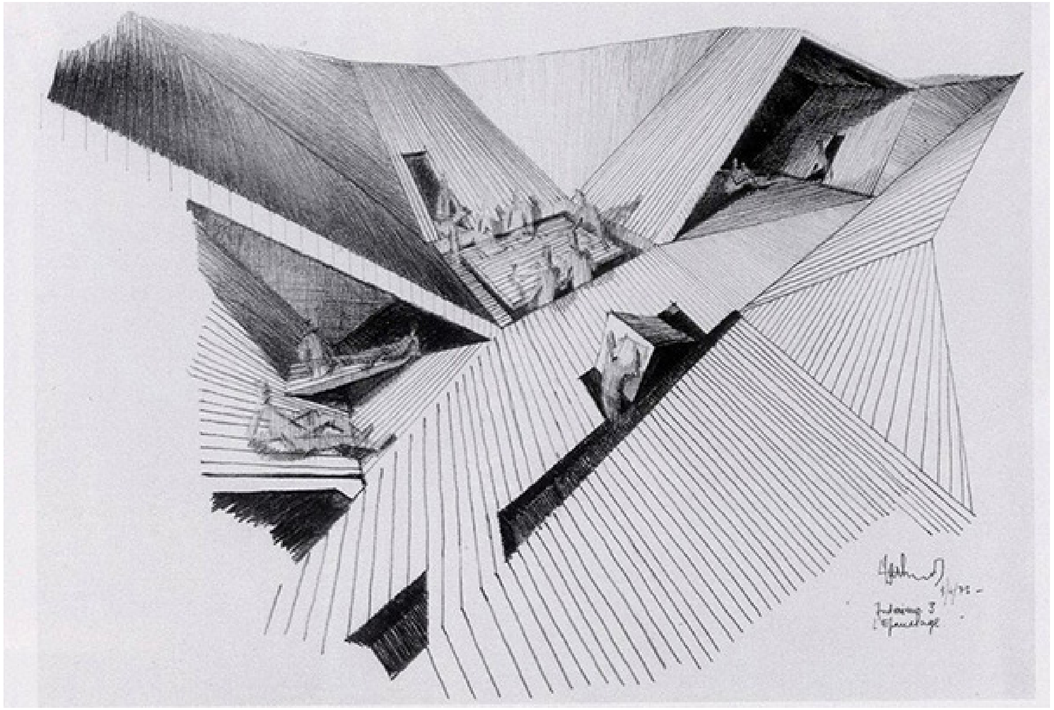
Walk to Run Transition
with Altered Gravity



Practice moon walk with
low gravity environment

Apollo 17 astronaut walk
on the moon

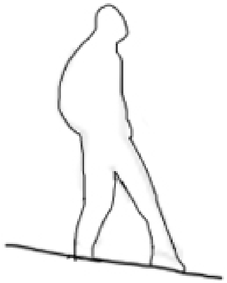
Theory



Oblique Function
By Claude Parent (architect) and Paul Virilio (philosopher)

The Function of the Oblique: The Architecture of Claude Parent and Paul Virilio, 1963-1969

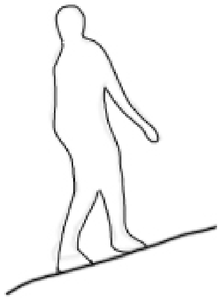
Interpreting perception to muscular strength



Descending

Speed

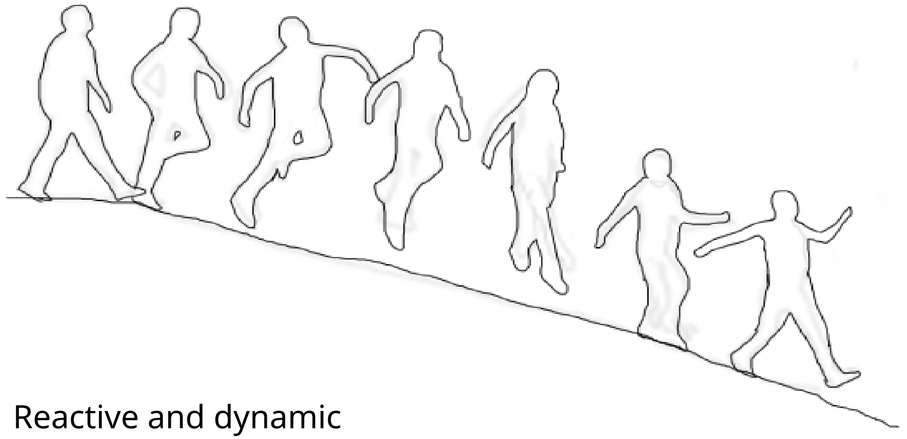
Brake with muscular control



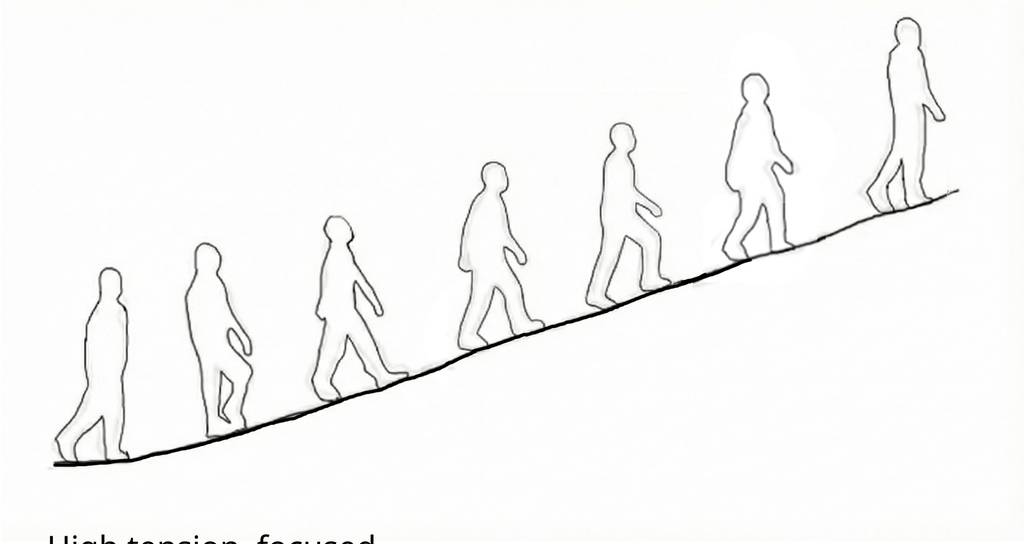
Ascending

fatigue

The exertion of muscular strength



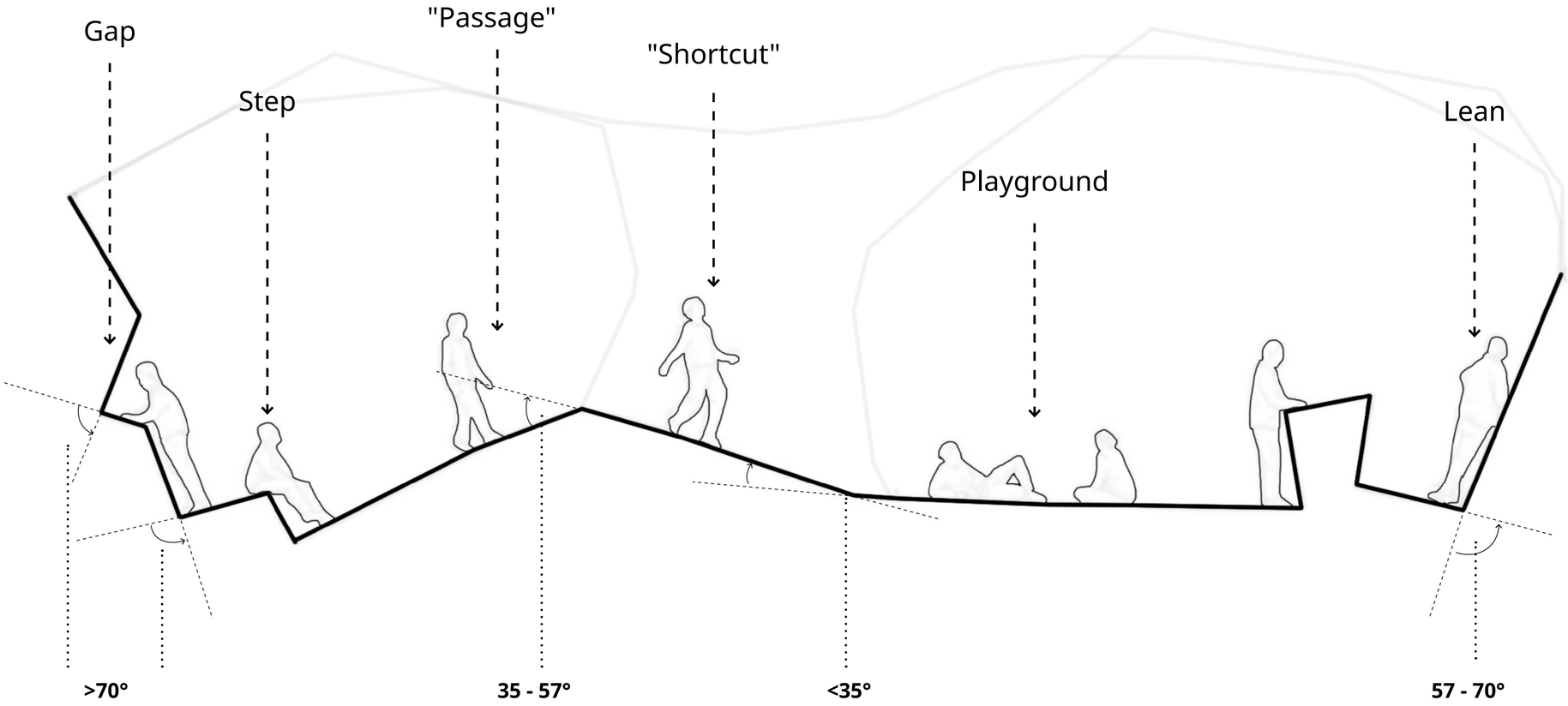
Reactive and dynamic



High tension, focused

Visualization perception

Geometry triggers physical conscious



Case studies

Ku.Be House
MVRDV + ADEPT

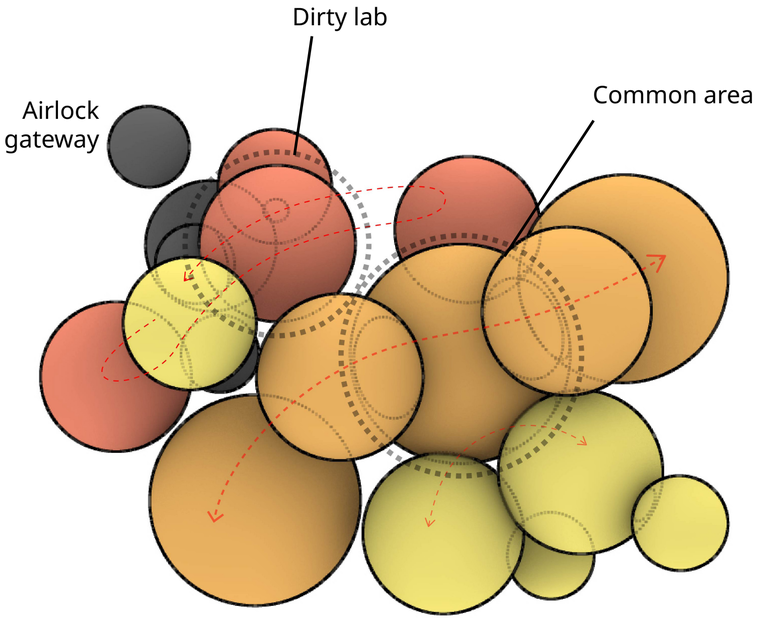
Verticality as Play: Instead of defining levels (1st, 2nd, 3rd), Ku.Be uses “The Labyrinth,” “The Mousetrap,” and “The Net” to move “upward.”

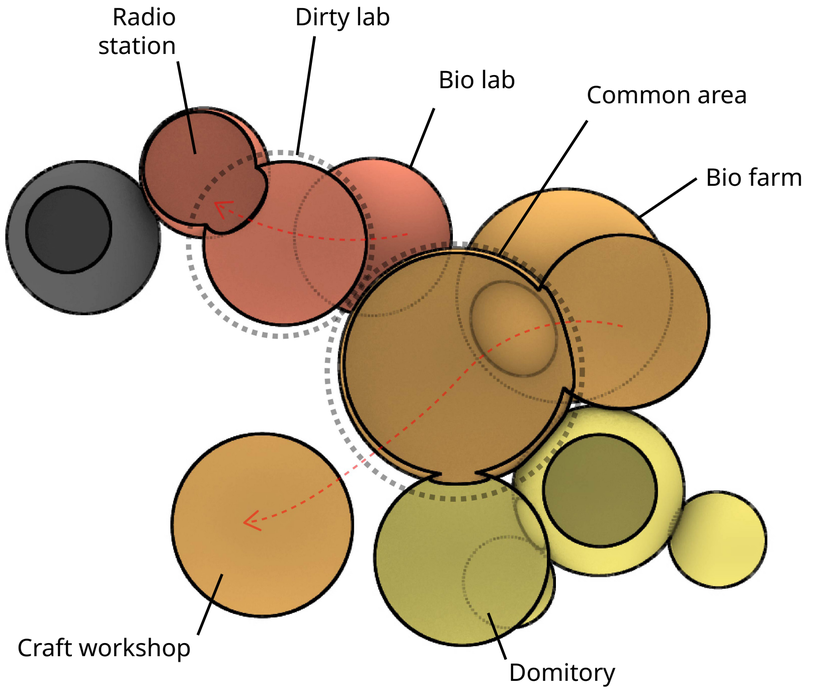
Project overview

https://www.topotek1.de/openSpaces/superkilen-2/

Schematic design

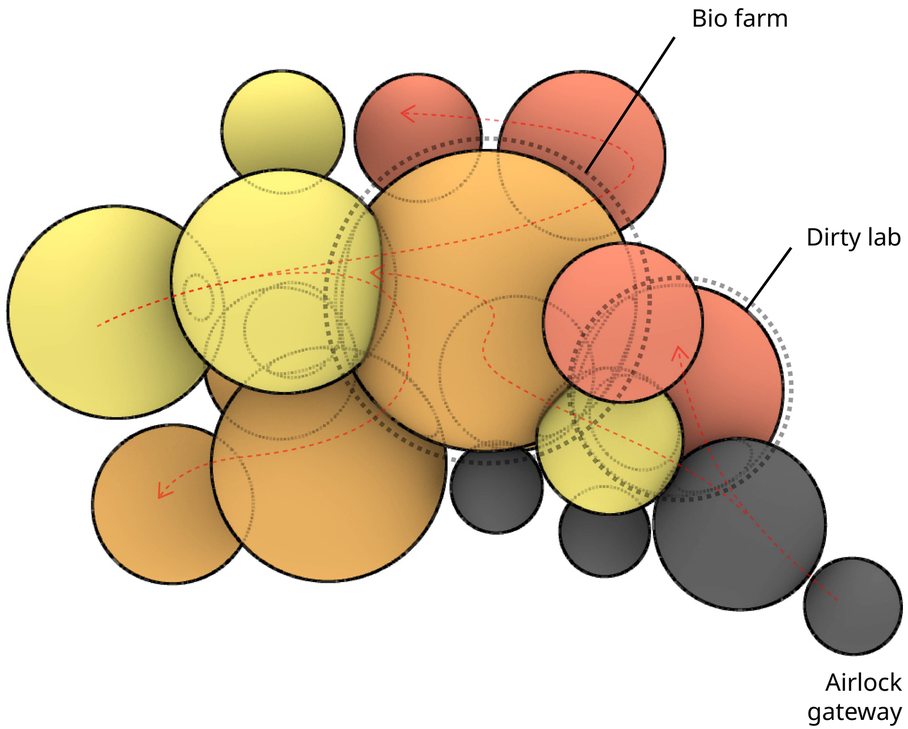
Iteration 1

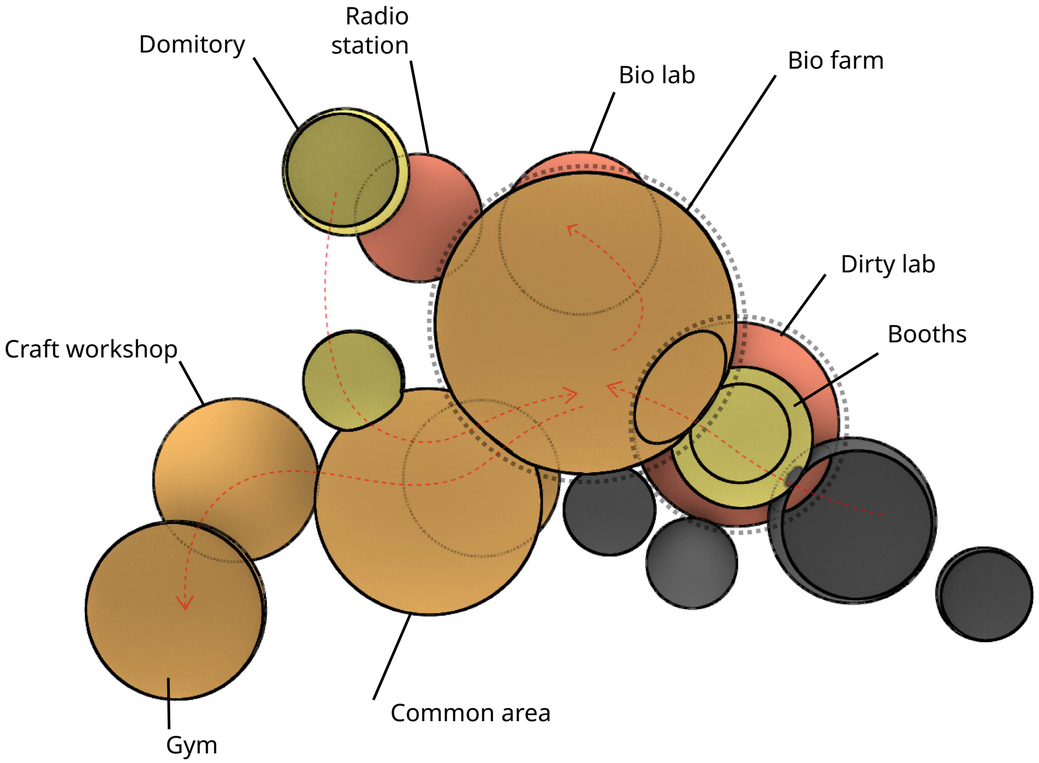




Infrastructure
Workplace
Private
Recreational

Iteration 2





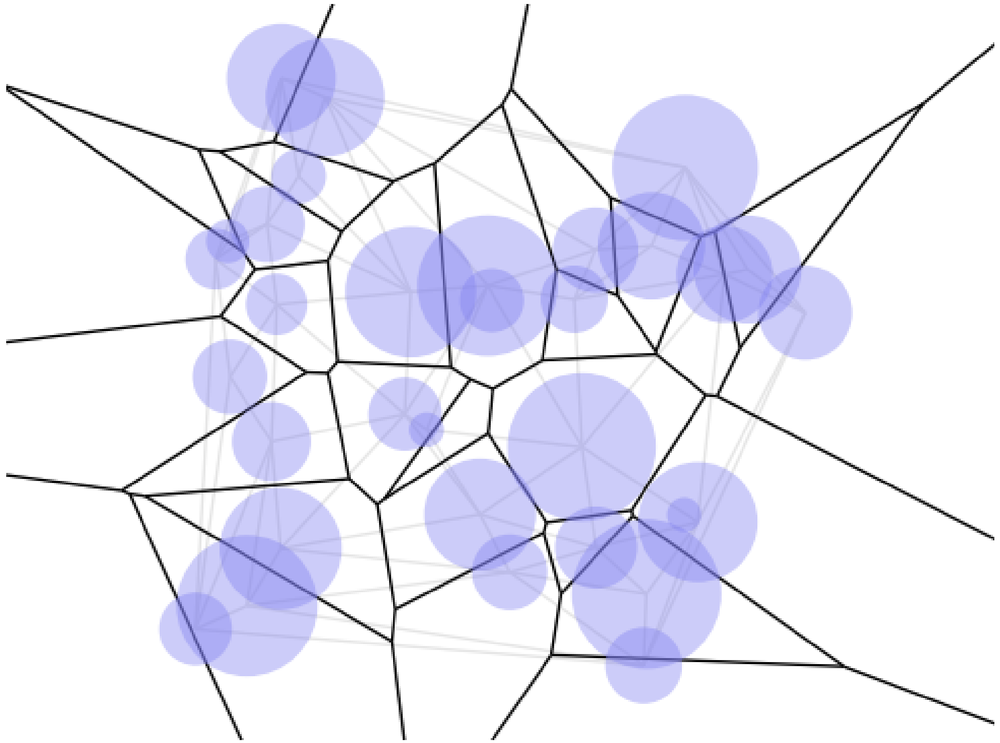
Infrastructure
Workplace
Private
Recreational

Volume design: Voronoi

Define visual anchors (volume)

Voronoi will be used to determine the relationship between visual anchors,

based on how visual anchors are needed for different level of safety and activities (proximity)

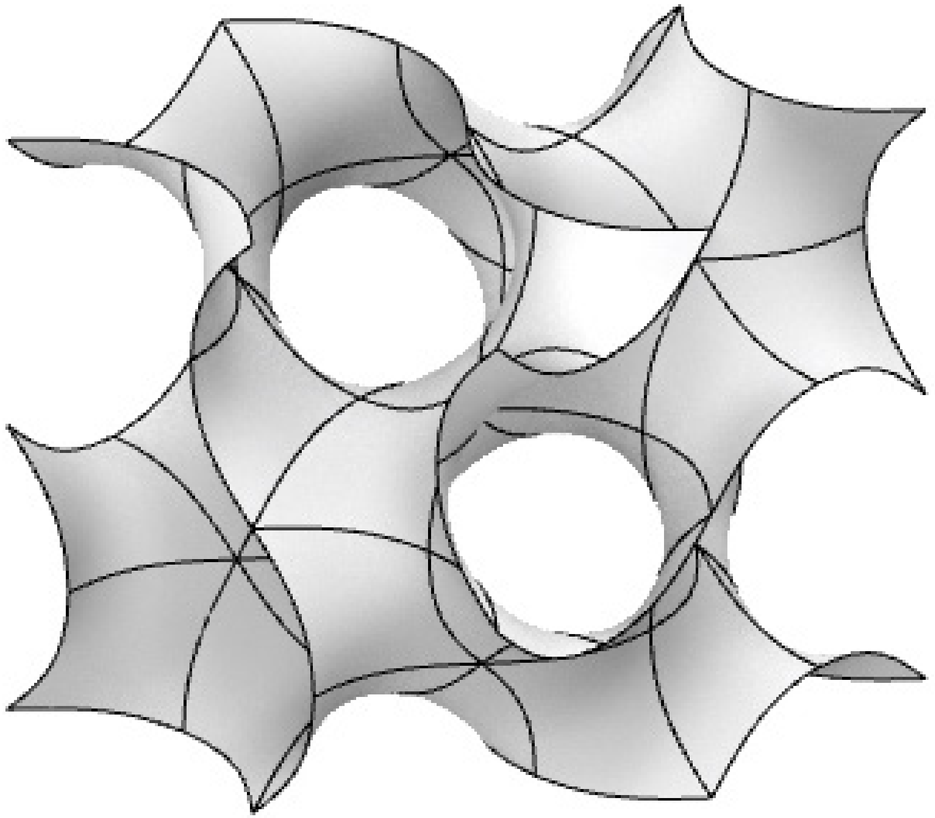


Experience design: Gyroid

Provide visual and physical connection

Gyroid: will be used to connect visual anchors, without defining the concept of “floor” (result of gravity vertical),

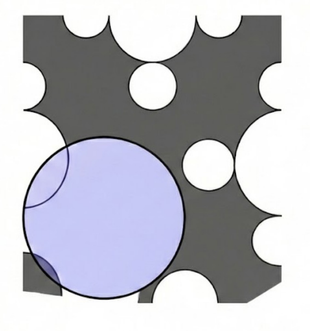
but focus on the visual cues of entering other spaces.

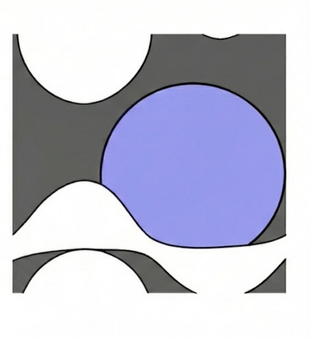


Experience design: Gyroid

By **combining Voronoi and Gyroid**,

the architectural representation can be both functionally and structural-ly logical as well as full of visual cues, achieving the goal of beyond survival to sustainable and operational living on the moon.





Urban Furniture
Gyroid Climber, 2013
Exploratorium, San Francisco

Frictions and tensions occur due to the irregular surfaces, along with diverse light and geometry

Project overview

https://mathtourist.blogspot.com/2015/09/gyroid-climber.html

Case studies

Creekside Pavilion
HCCH Studio
Huizhou

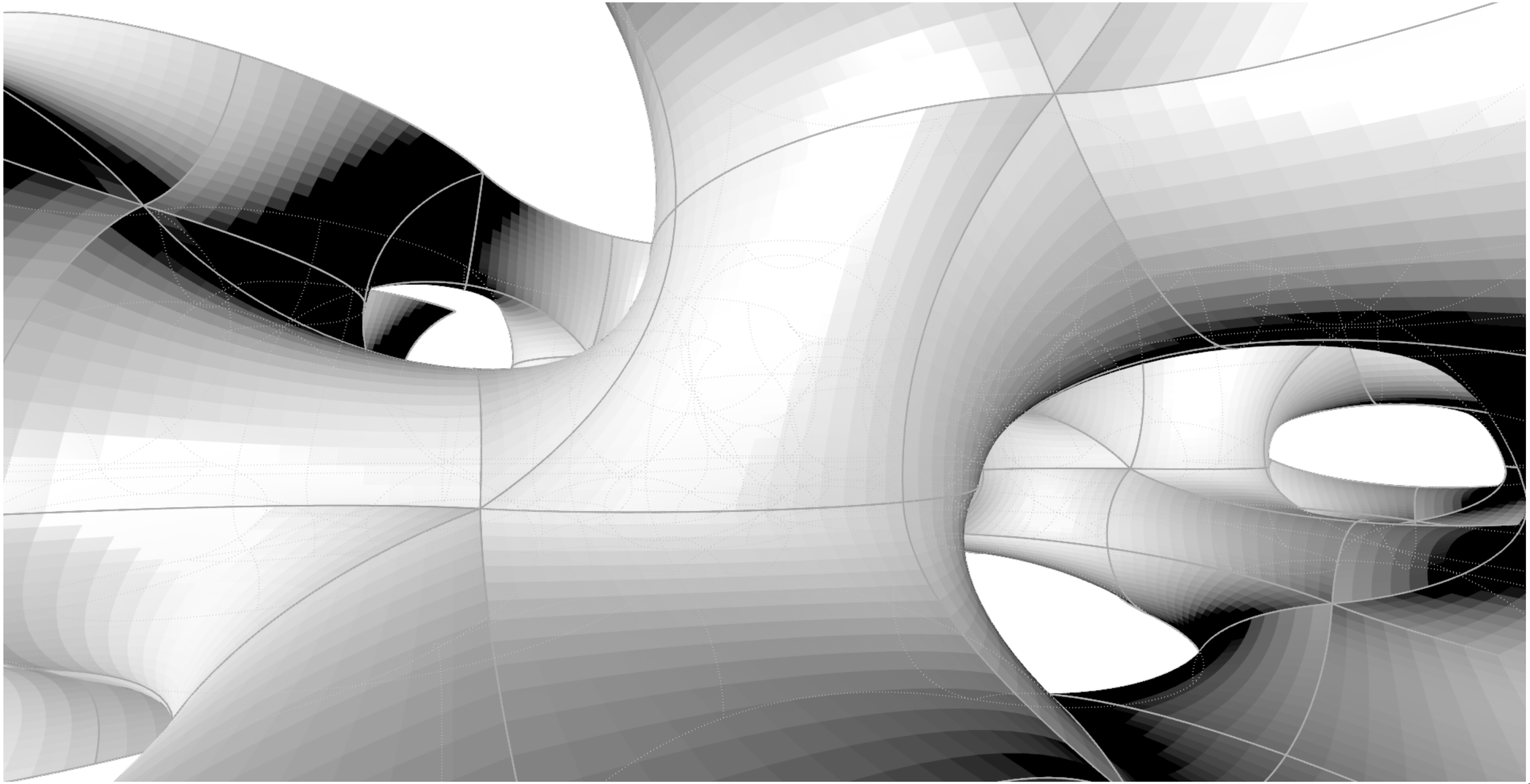
Concrete construction
Light and view integration

Project overview

https://www.gooood.cn/resting-loop-with-views-a-creekside-pavilion-among-hills-by-hcch-studio.htm

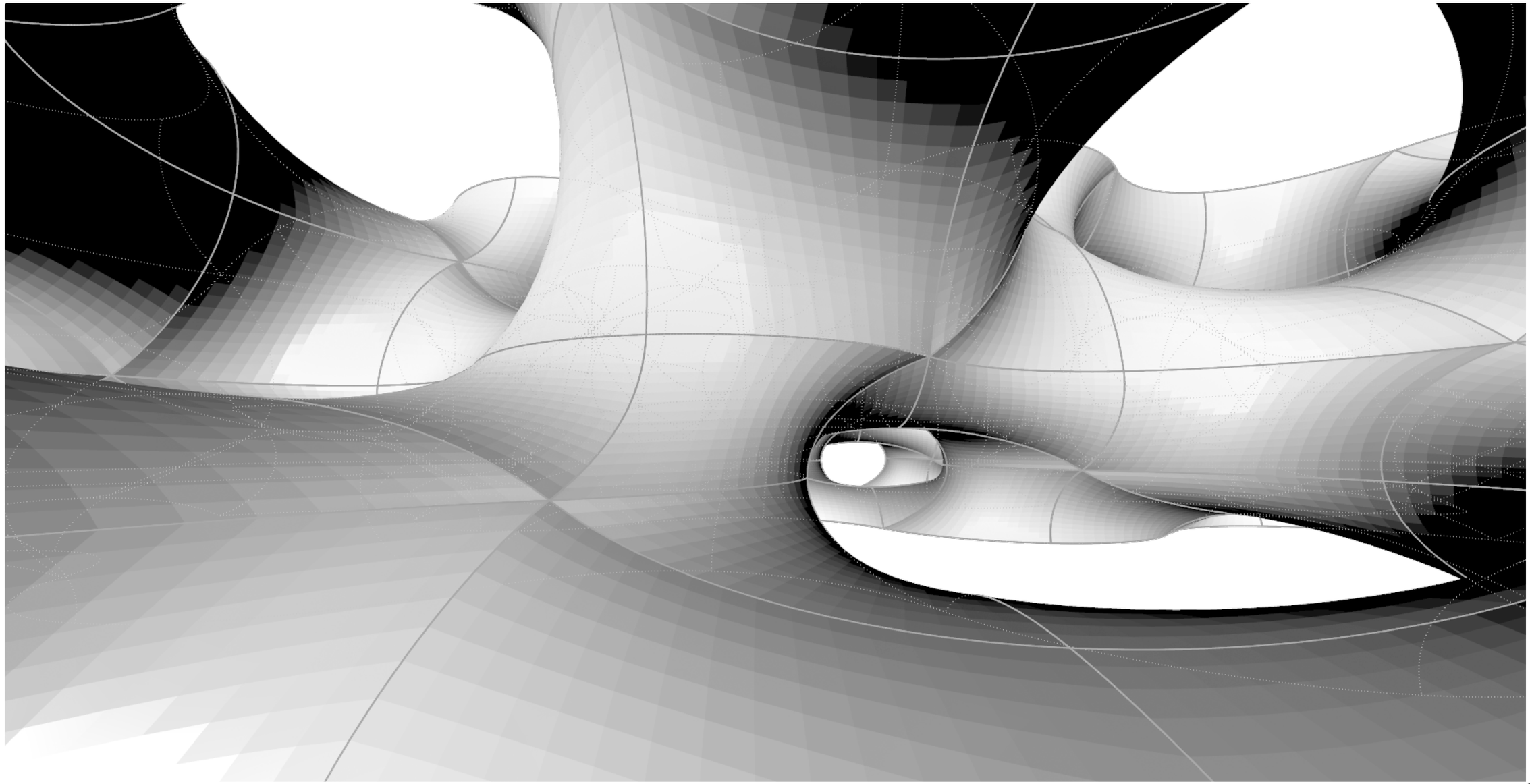
Experience design: Gyroid

Transition



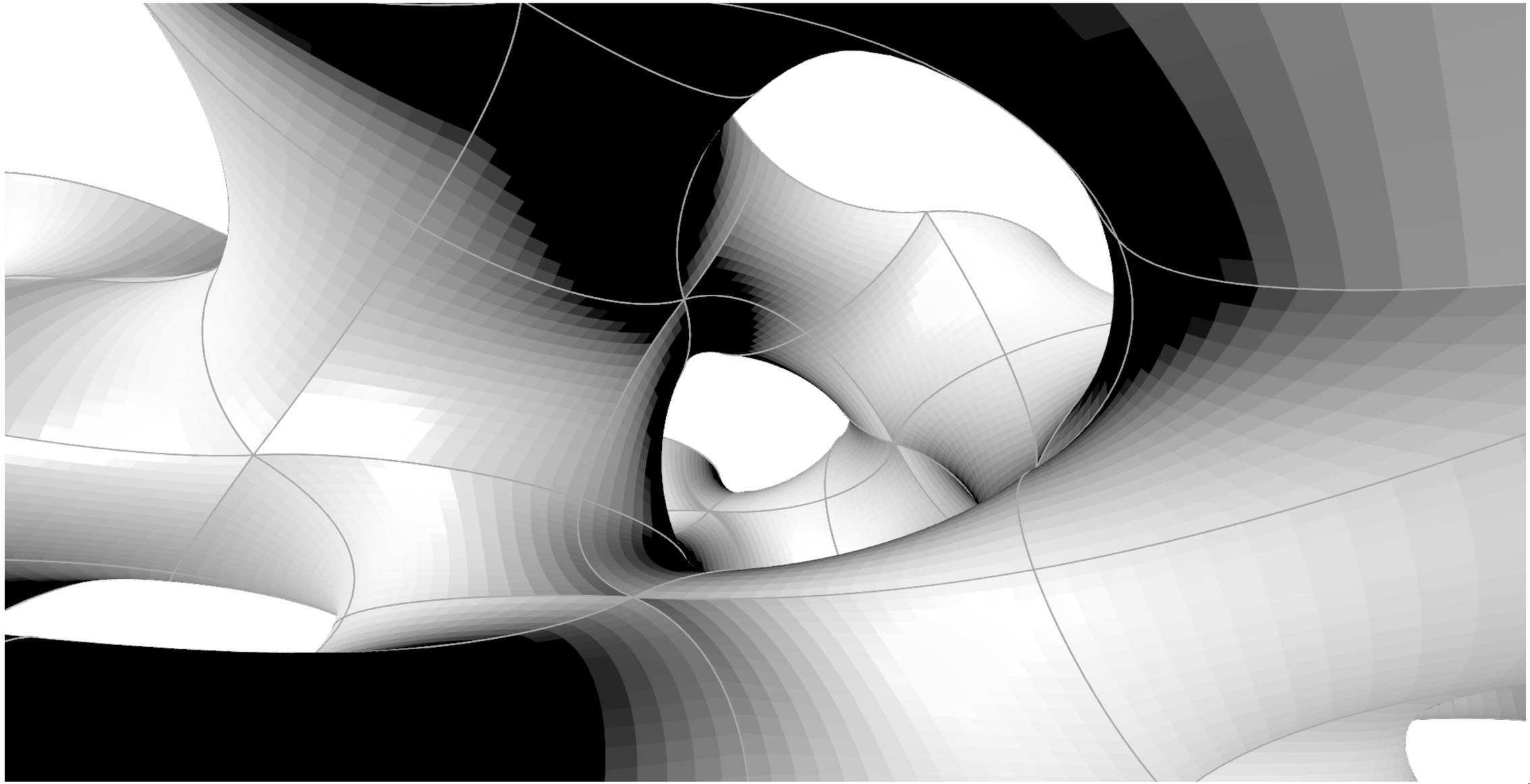
Experience design: Gyroid

Central atrium



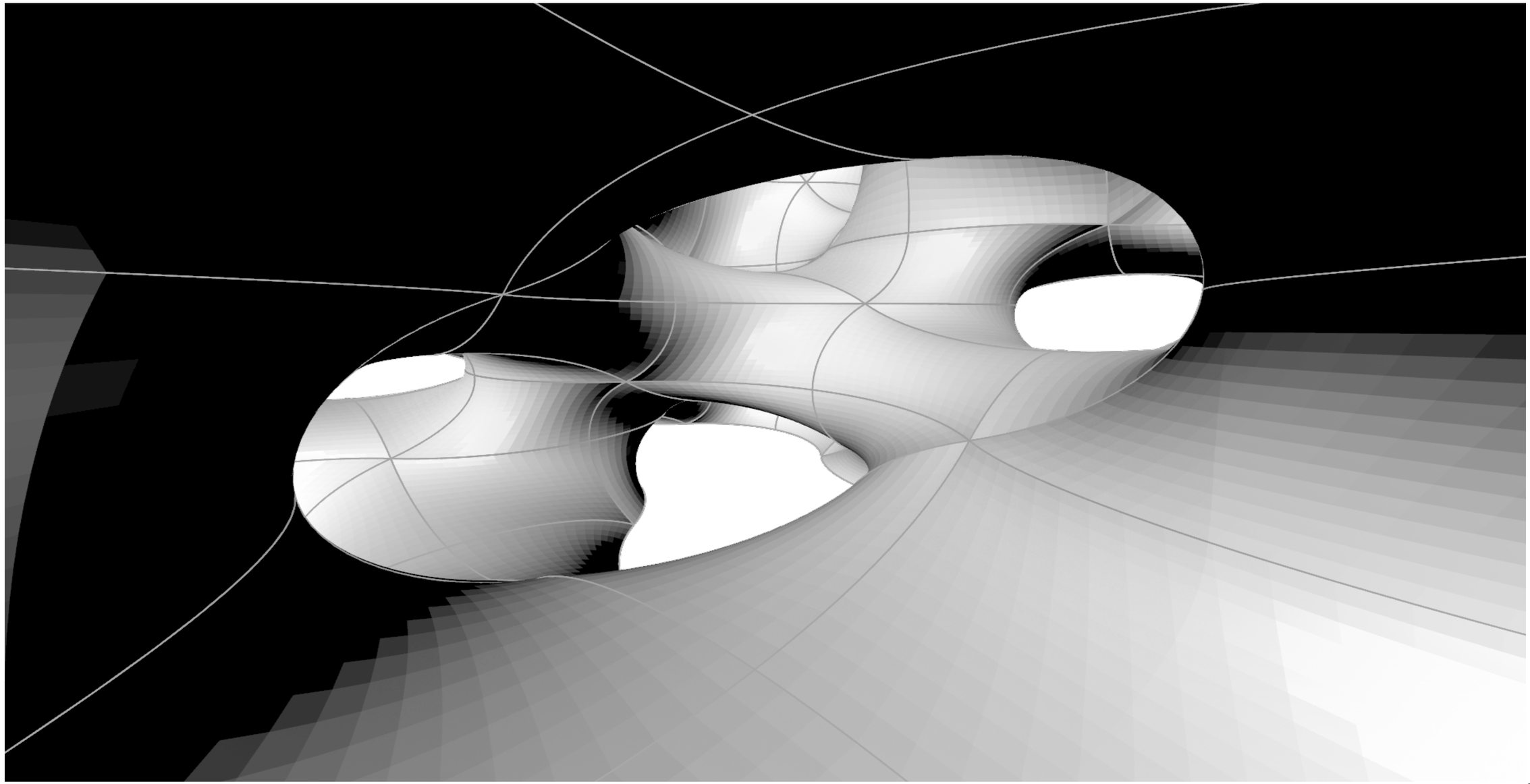
Experience design: Gyroid

Changing levels



Experience design: Gyroid

Private quarter



Materialisation

Material

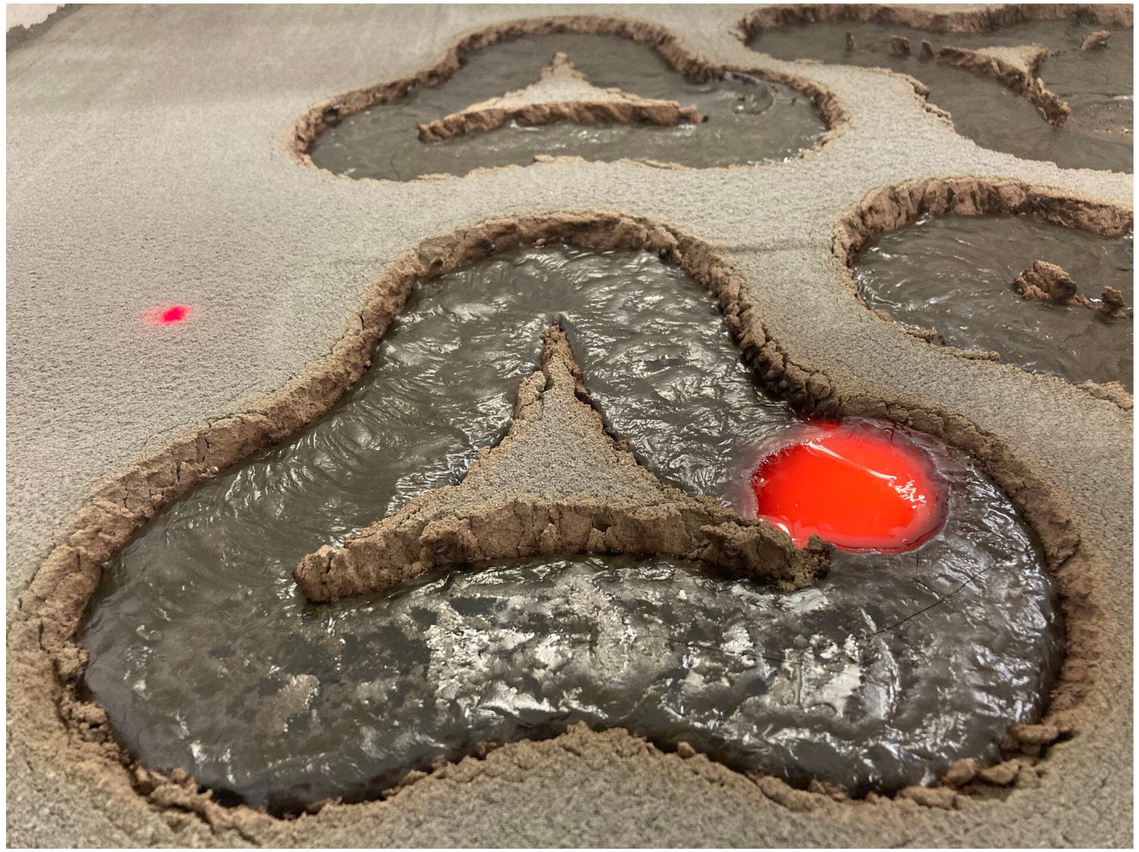
Lunar regolith

Method

3D printing
Melt and harden in situ

Construction

Swarm robots
specialized in part of the construction



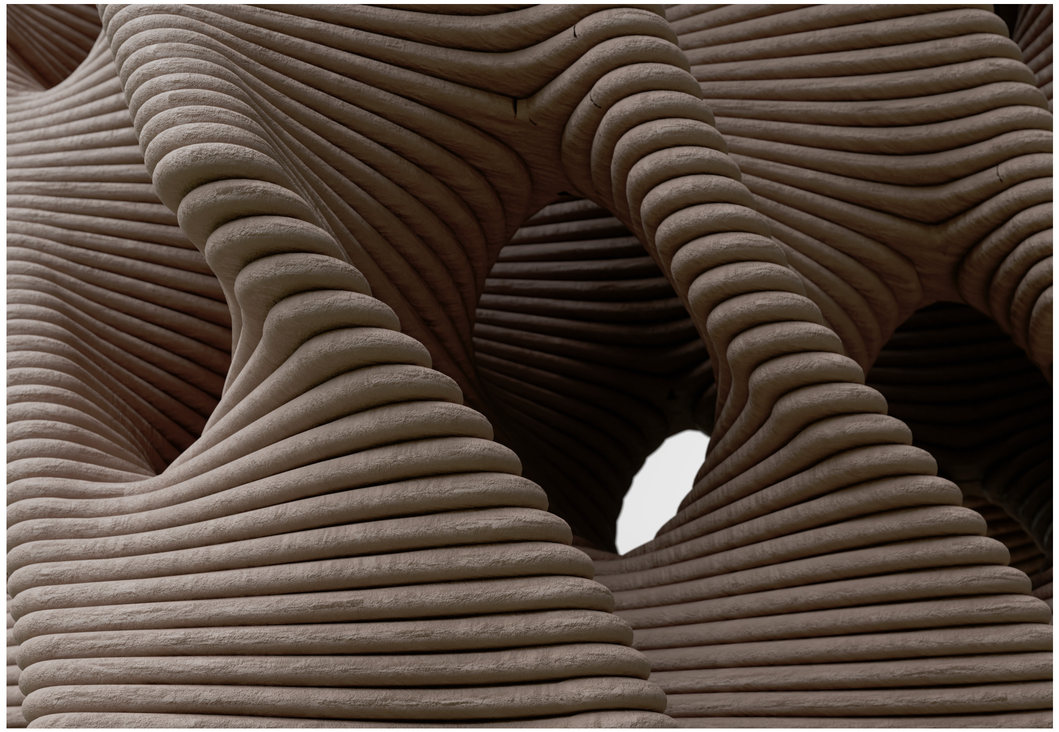
Laser melt and harden on regolith. ESA

Materialisation

Workshop

Prototype milling using robot arm

Precedent



Clay 3D Printing

Project overview

https://2025.acadia.org/forces-in-clay

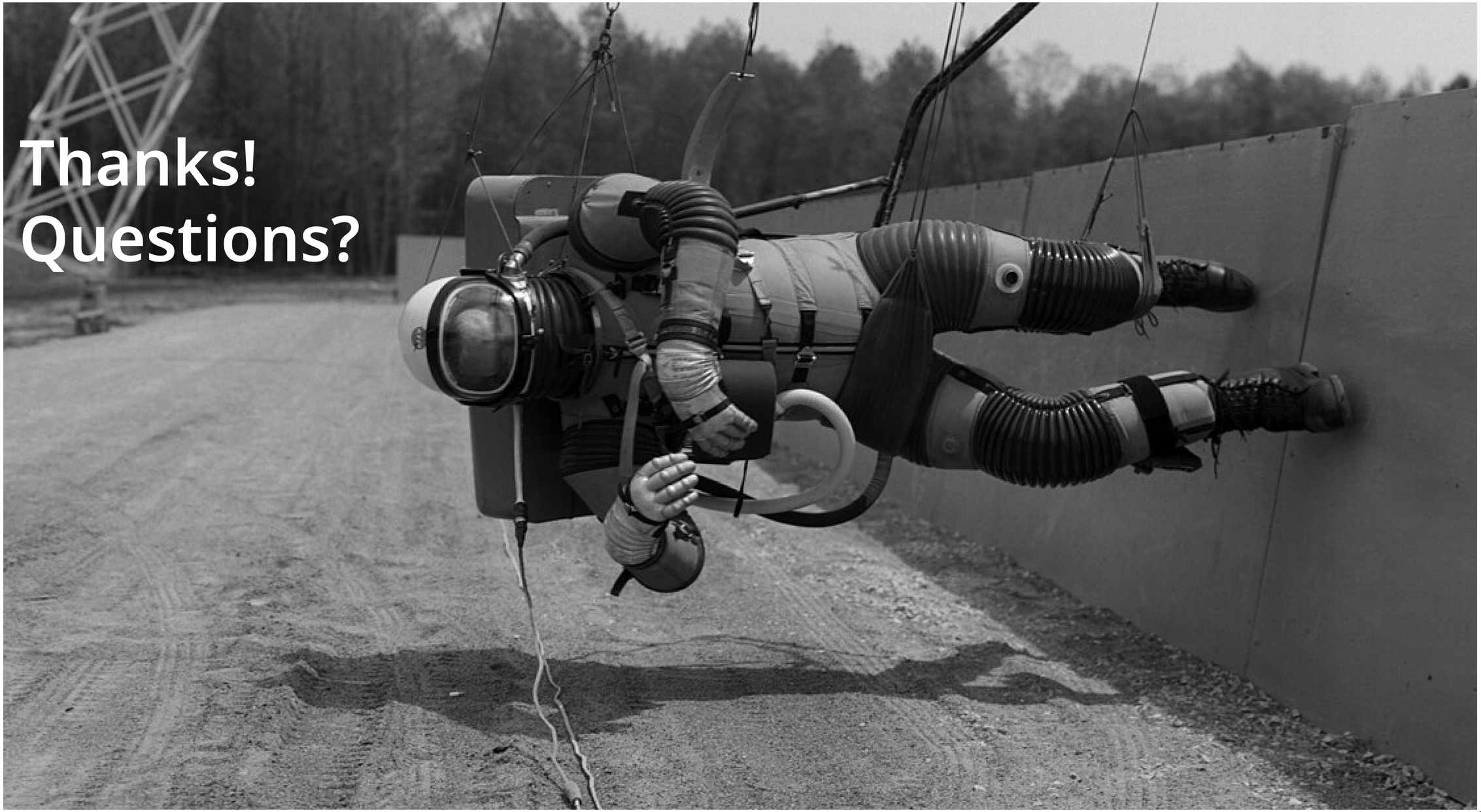
Next step...

Visual studies

Based on experiments rather than assumptions

Materialisation

Test the limitation of 3D print gyroid geometries


Thanks!
Questions?