

The
Hitchhiker's
Guide
to the
Moon

a **Mind & muscle** Approach
to **Spatial Perception** in
Long-term Lunar Habitation

Contents

Part 1: Introduction

Problem statement
Relevance
Objective and motivation
Research questions
Site
Scope
Programmes

Part 2: Approach

Muscular perception
Visual perception
Anchor interpretation
Translation
Evaluate output
Case study

Part 3: Proof of concept

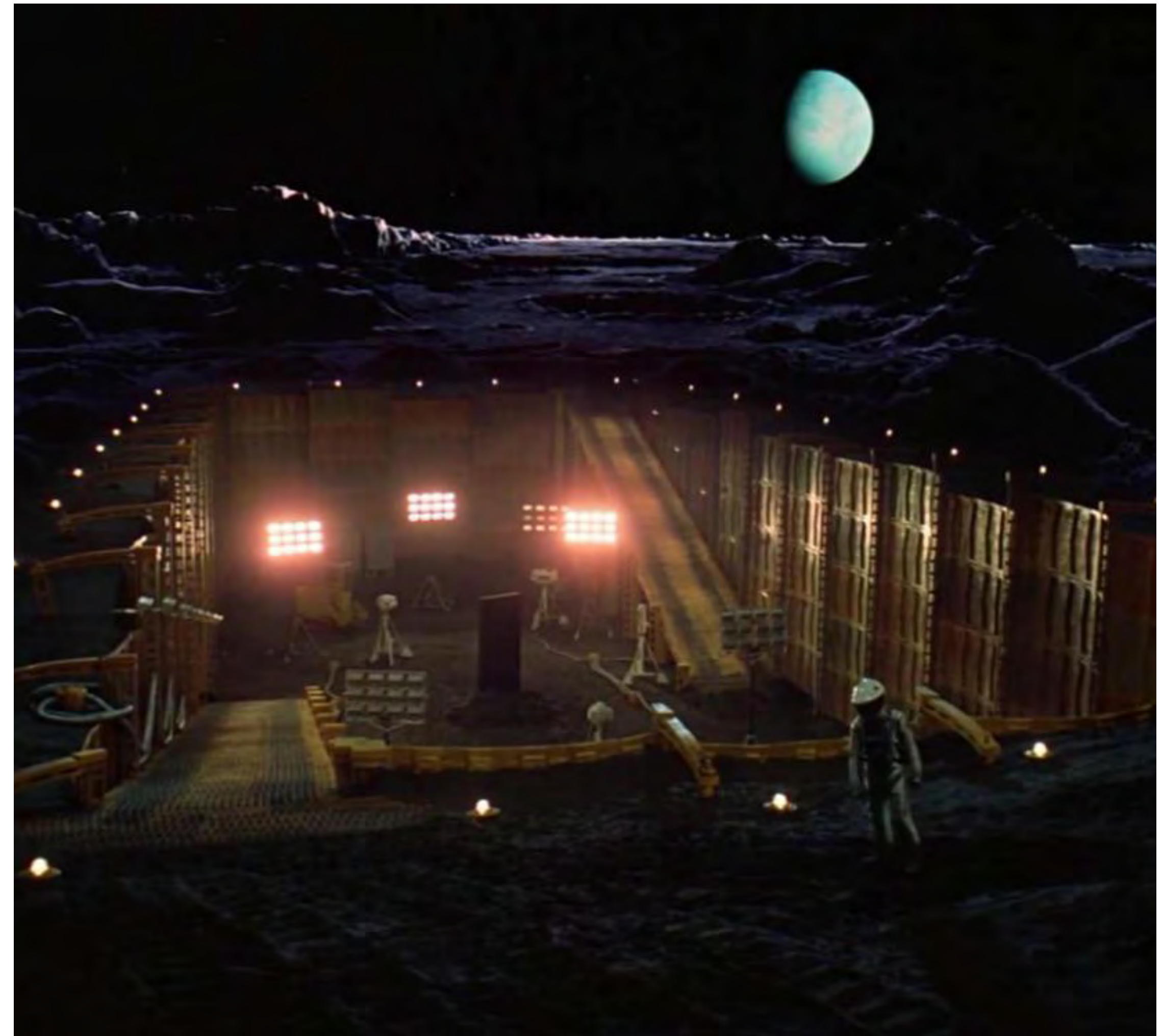
Reflection
Reclaim anchor strength
Mind-muscle simulation



Part.1

Introduction

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



Film scene
2001: Space Odyssey
1968

Problem Statement

The essential of 'living': Missing of 'Plumb Line'

Your inner ear provides a solid signal for verticality. However, the Moon's gravity is too weak to be the primary anchor.

Based on NASA researches, brain often defaults to mind and muscle vector: Down is simply measured by eyes or wherever your feet are pointing, regardless of the actual slope.



NASA testing moon gravity cognition, in a horizontal way
From the NASA Archive: The Lunar Walking Problem
1965

<https://www.wired.com/2009/07/nasaarchive-gravitysimulator/>

Relevance

Everyday of visual & object vertical

Subtle influence of multiple anchors

Even without gravity, we can still obtain cues for spatial perception because geometry triggers our visual and muscular responses.

When multiple anchors are considered, it'll

Reduce sensory load

Improve cognition and well-being

Improve Spatial perception



De Stijl movement
1923

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. Sensing spaces
2. Mind over matter
3. Physical survival challenge

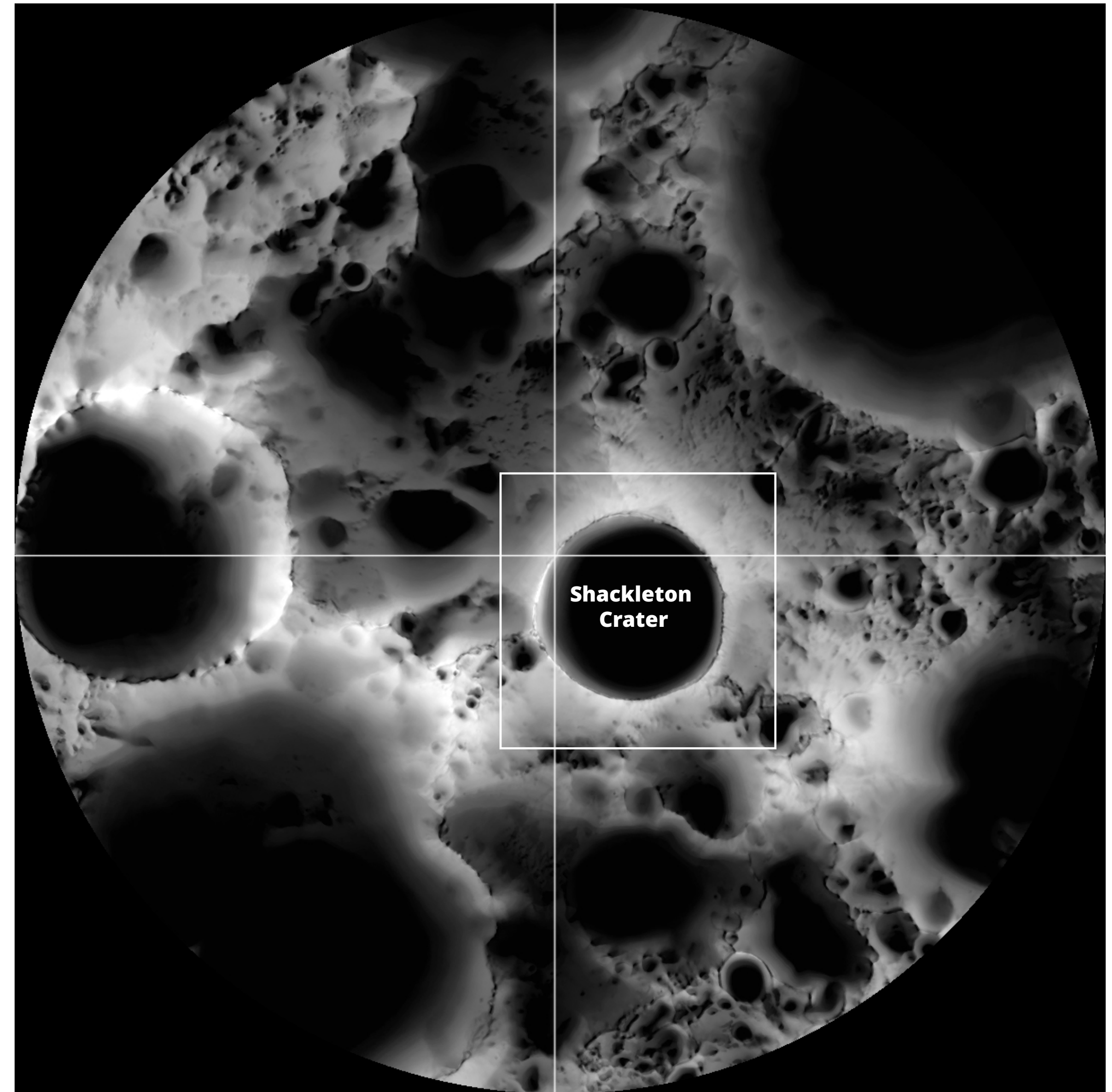
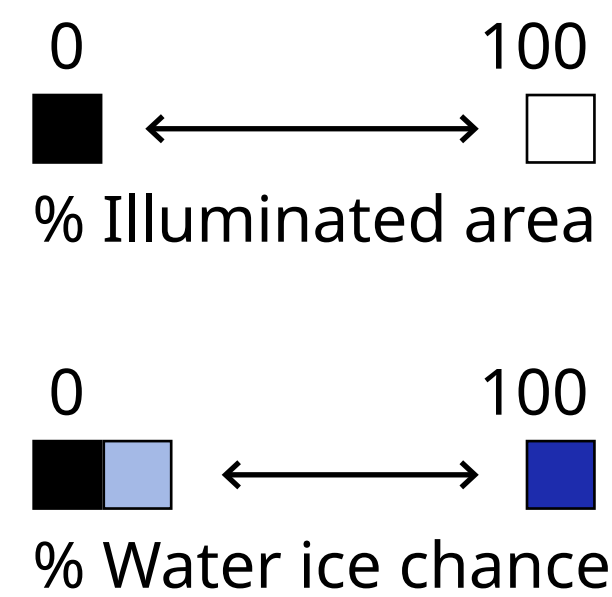
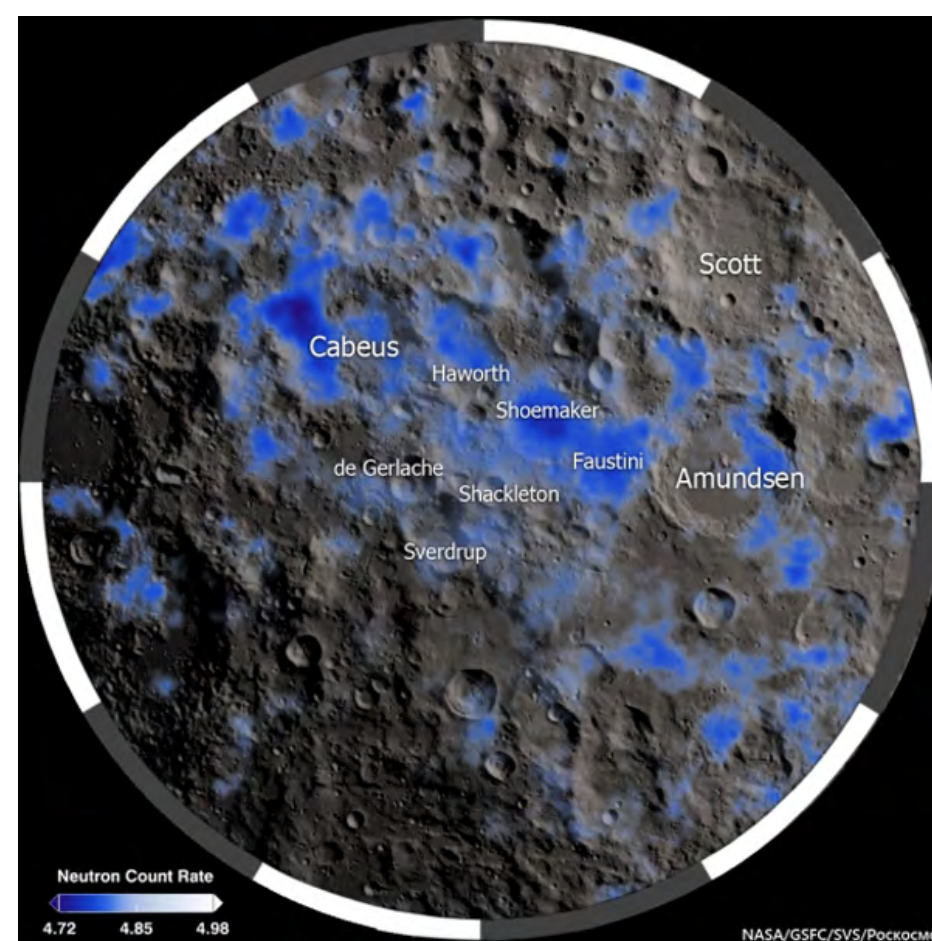
Site

South pole

Peak rim of Shackleton Crater

Resource driven:

1. Permanently shadowed regions (PSRs) may contain water ice and other materials
2. Solar energy for more than 90% of the year



LUNAR RECONNAISSANCE ORBITER: Permanently Shadowed Regions on the Moon
2010
www.nasa.gov

Scope

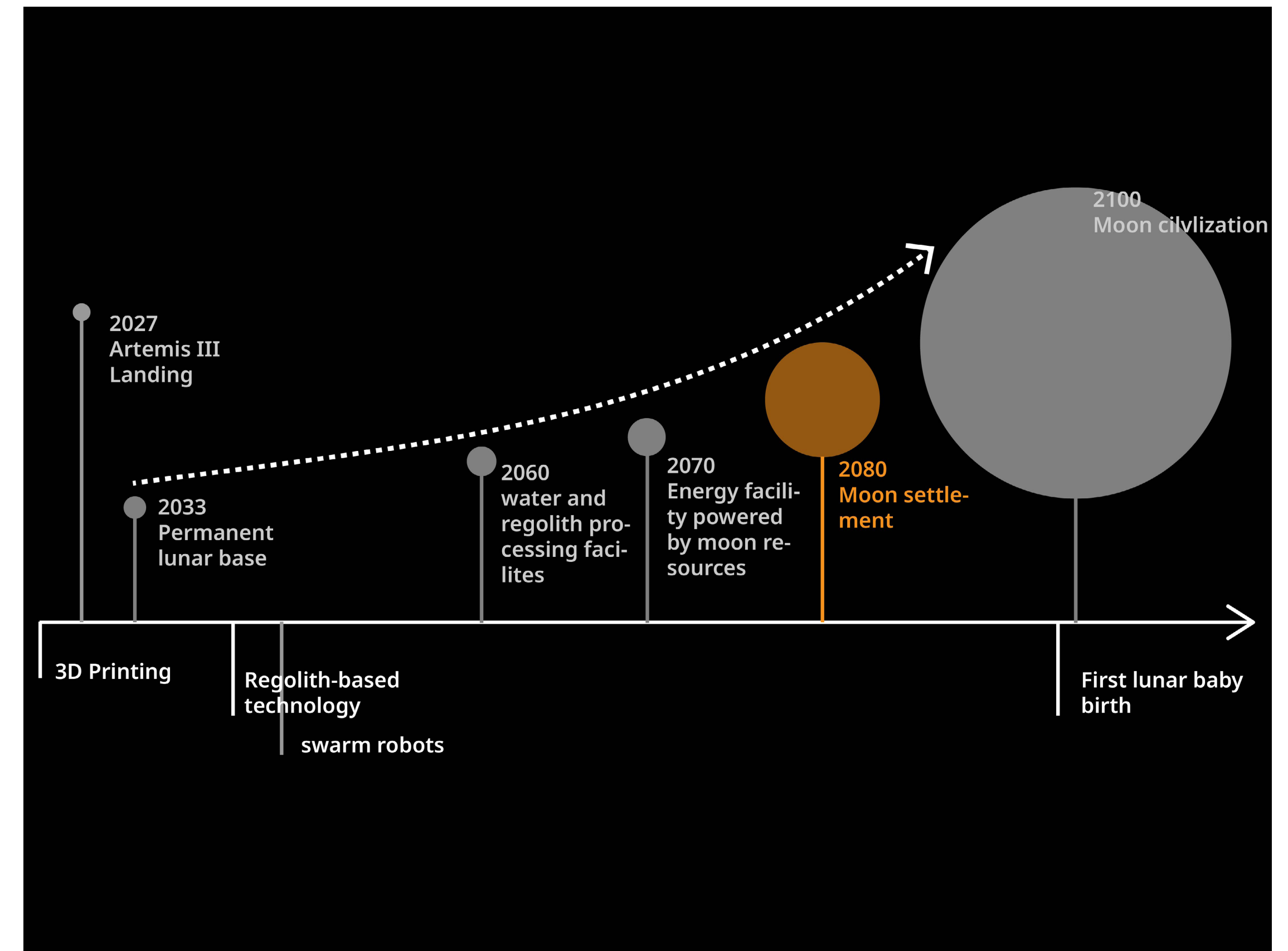
Design phase

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

Team size

8 visiting: research, tourism or Mars transit¹
2 long term: maintenance and operation

1. Based on Space X Starship mission, while 100 is the capacity, 10 is considered ideal for long-duration interplanetary missions to manage resources and mental health.
<https://www.spacex.com/vehicles/starship>



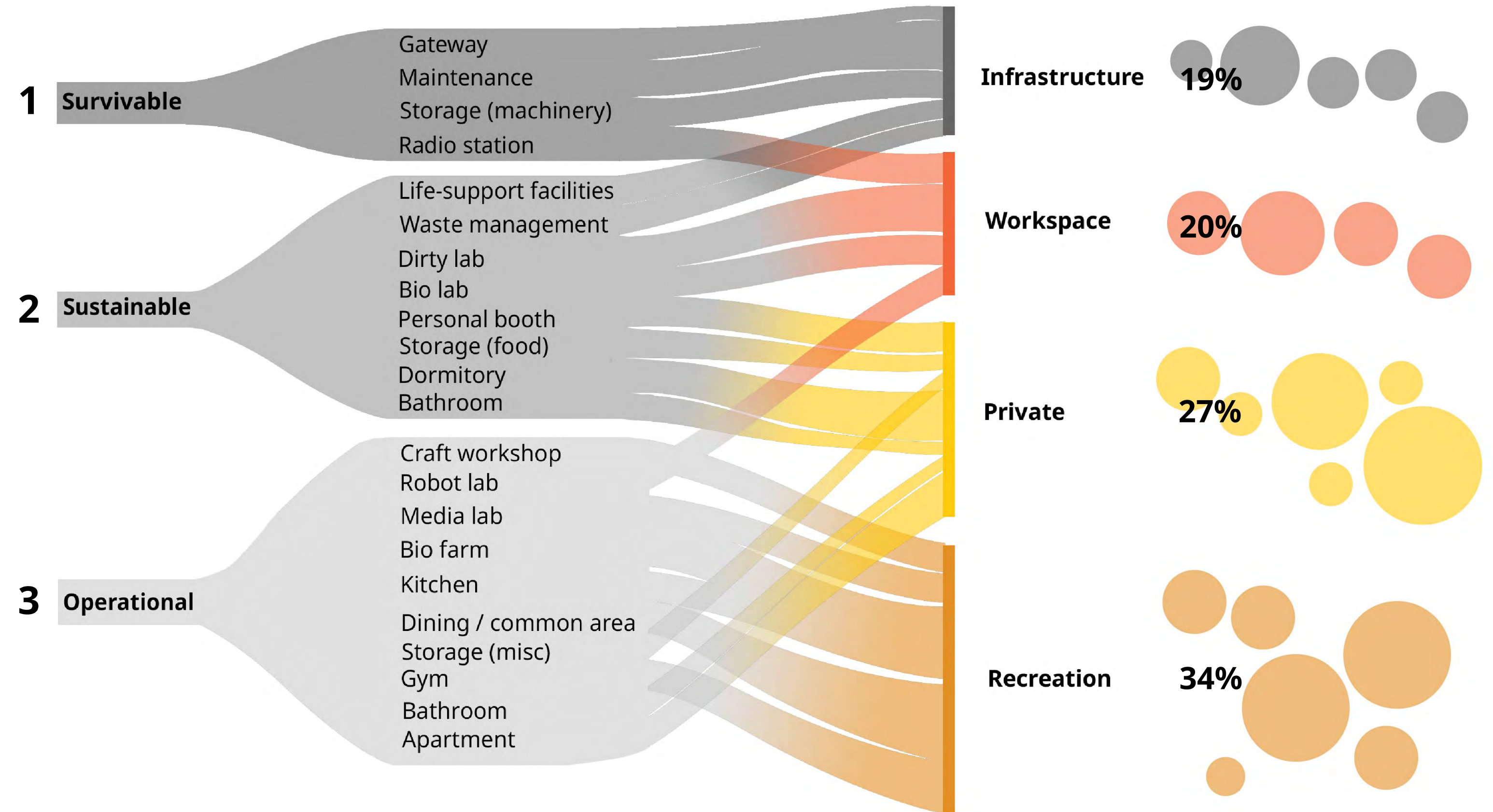
Programmes

Programme visualization

There are three phases in construction of a moon base:

Survivable, sustainable and operational¹.

Each phase then form spaces to required functionality

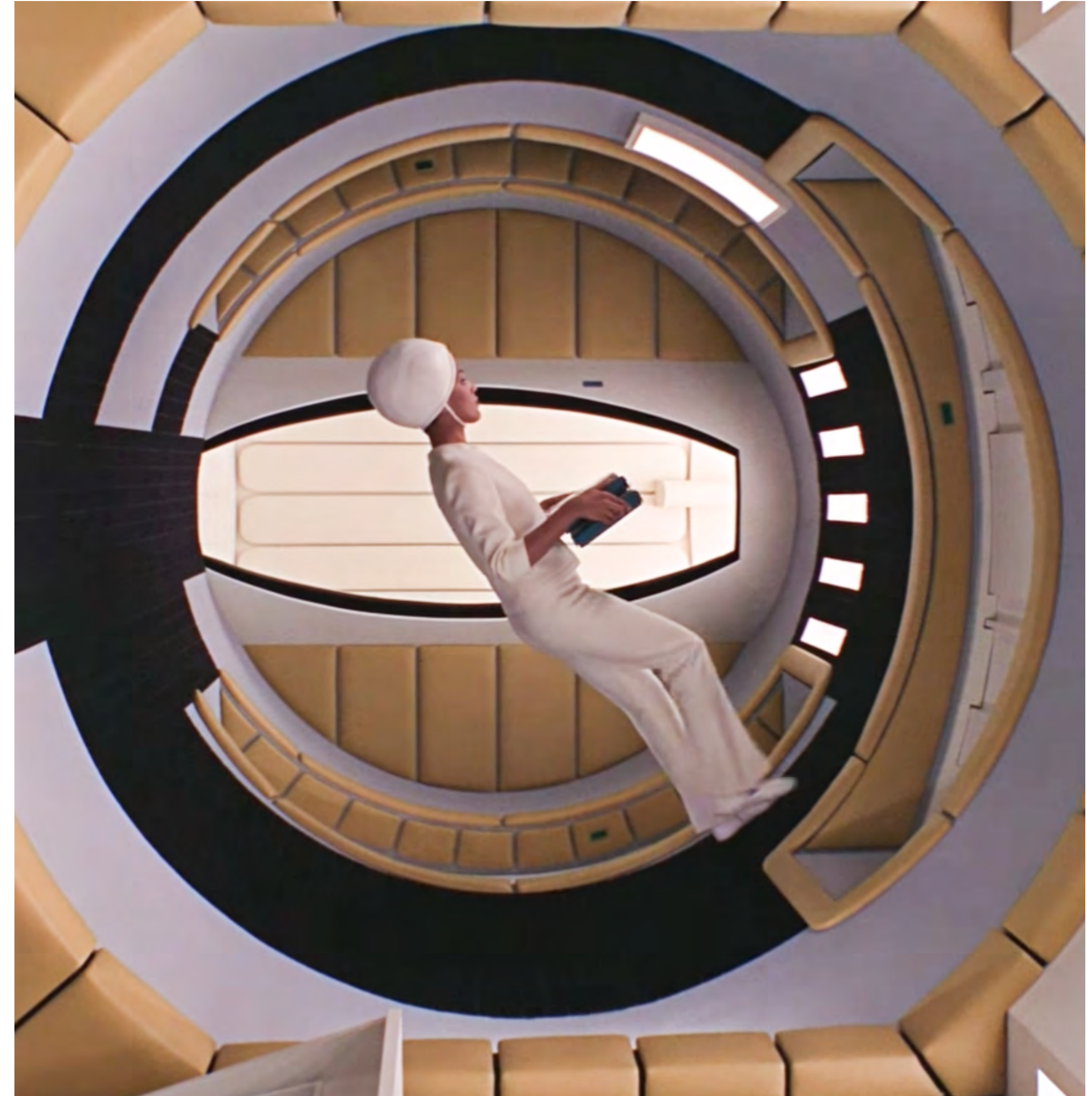


1. ESA. Imagining a Moon base.
https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Imagining_a_Moon_base

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.



<https://www.youtube.com/watch?v=tKXZf0Q9ulo>
1:33 - 2:15

Film scene
2001: Space Odyssey
1968

Design approach

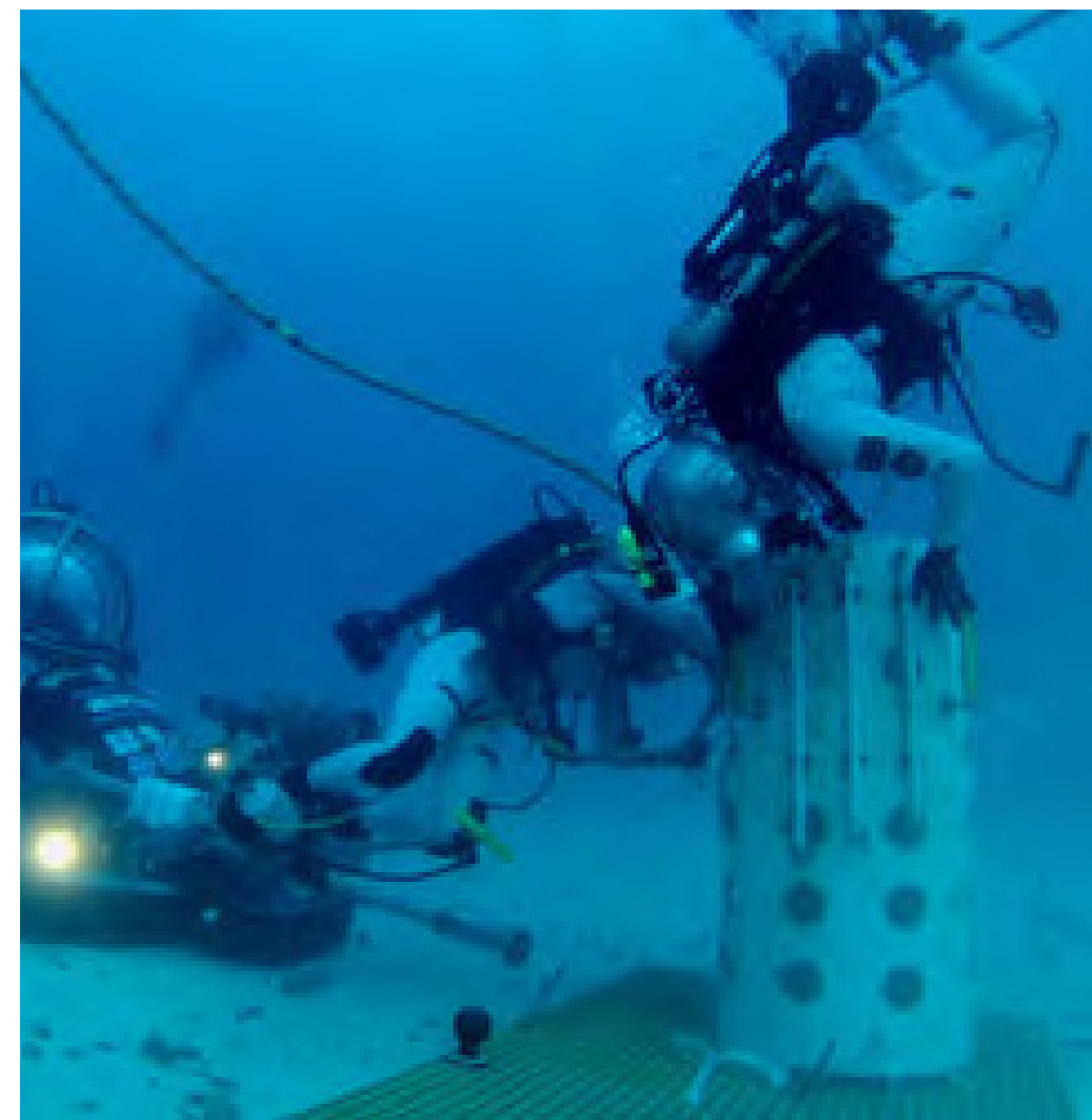
Muscular perception

Experiments



1. Footage of Apollo 17 astronaut walk on the moon

Video clip
Apollo 17 moon mission
NASA



2. Training for moon mission under water

Video clip
Underwater astronaut on the Moon
ESA



3. Simulate force on a sloped wall that counter-balance gravity

Research
Running horizontally could help future lunar settlers stay in shape on the Moon
Prof. Alberto E. Minetti MD, LOOP

Design approach

Muscular perception

Architectural Theory

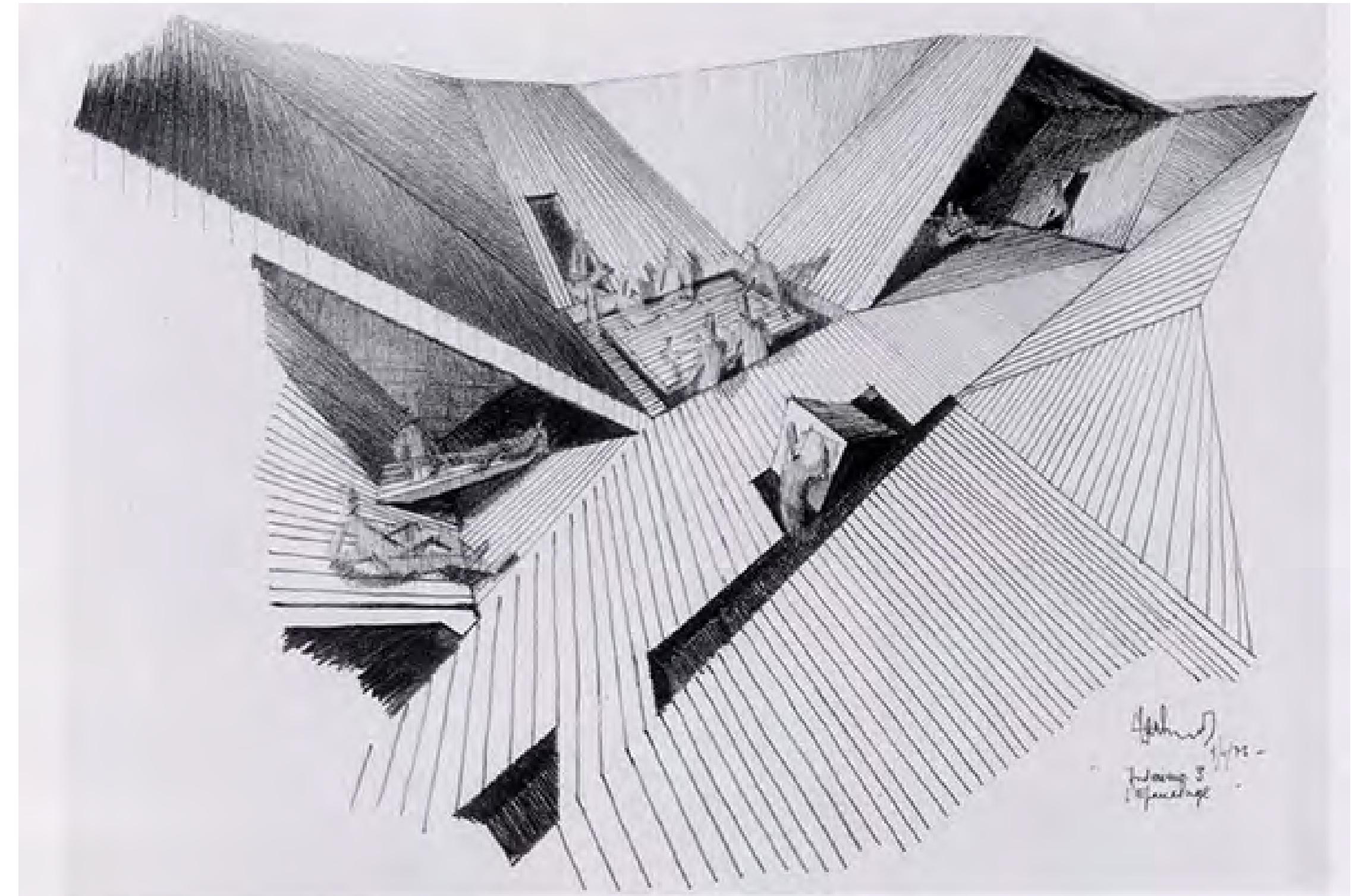
Oblique Function

Surface reflects on the strength increase in muscular tension and compression in relation to human experience in different activities.

To summarise:

[Internal focus]

pay attention to keep body steady



Oblique Function

Claude Parent (architect) and Paul Virilio (philosopher)

Design approach

Visual perception

Psychology research

The geometry of vision

Moving beyond sight seen to sight encountered (isovist)

Fields of affordance (meaning of vision)

we don't just see geometry, we see what an object affords us (Gibson, 1979; 2014)

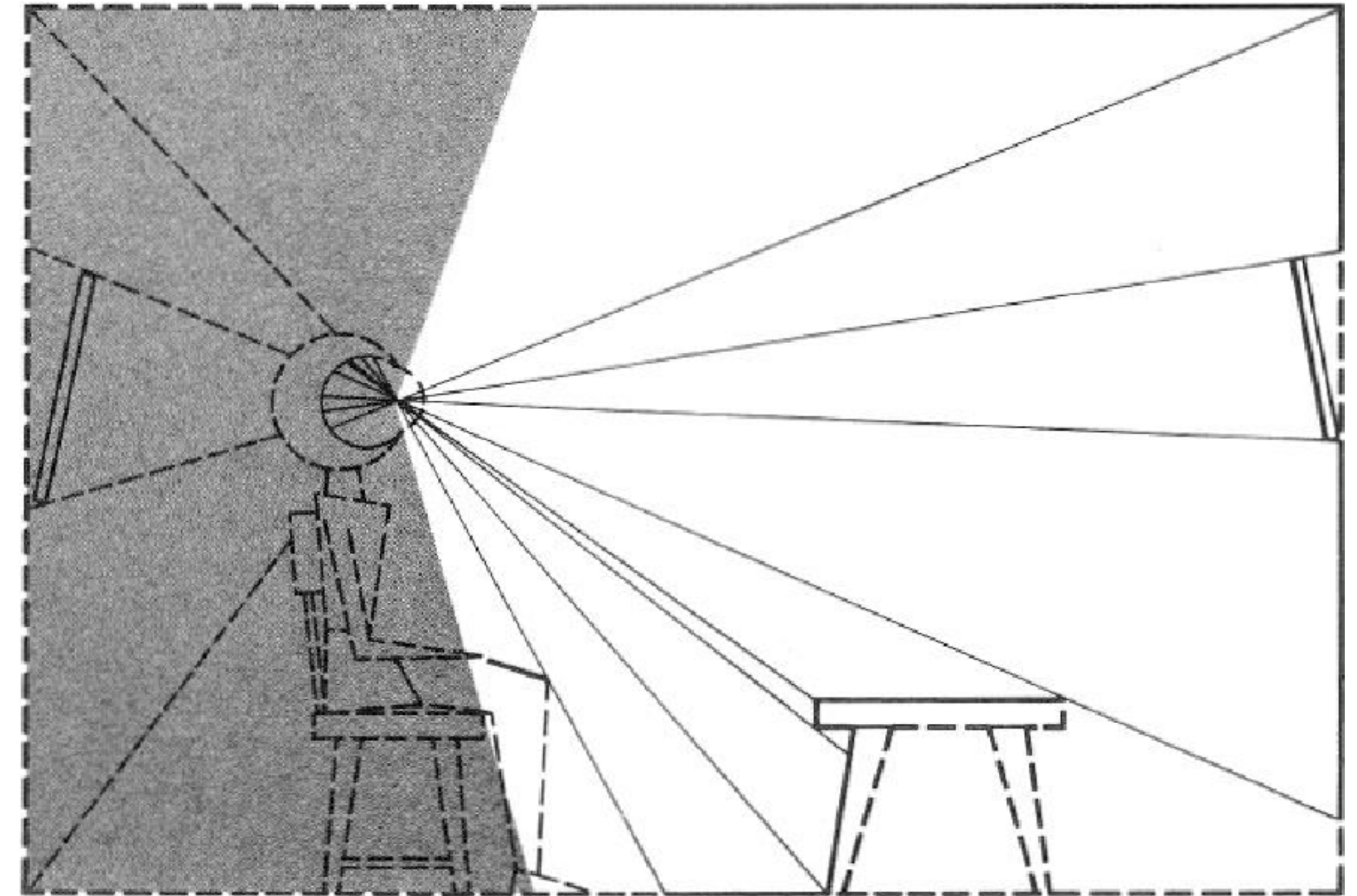


Figure from *The Ecological Approach to Visual Perception*
James J. Gibson
1979

Design approach

Visual perception

Architectural Theory

The new vision

The original diagram dated back Bayer's work at the Bauhaus and his interest in exhibition design. Display surfaces should be angled to meet the eye perpendicularly, regardless of where they are placed in a room.

To summarise:

[External focus]

Reception, interaction and outcome with ambient environment

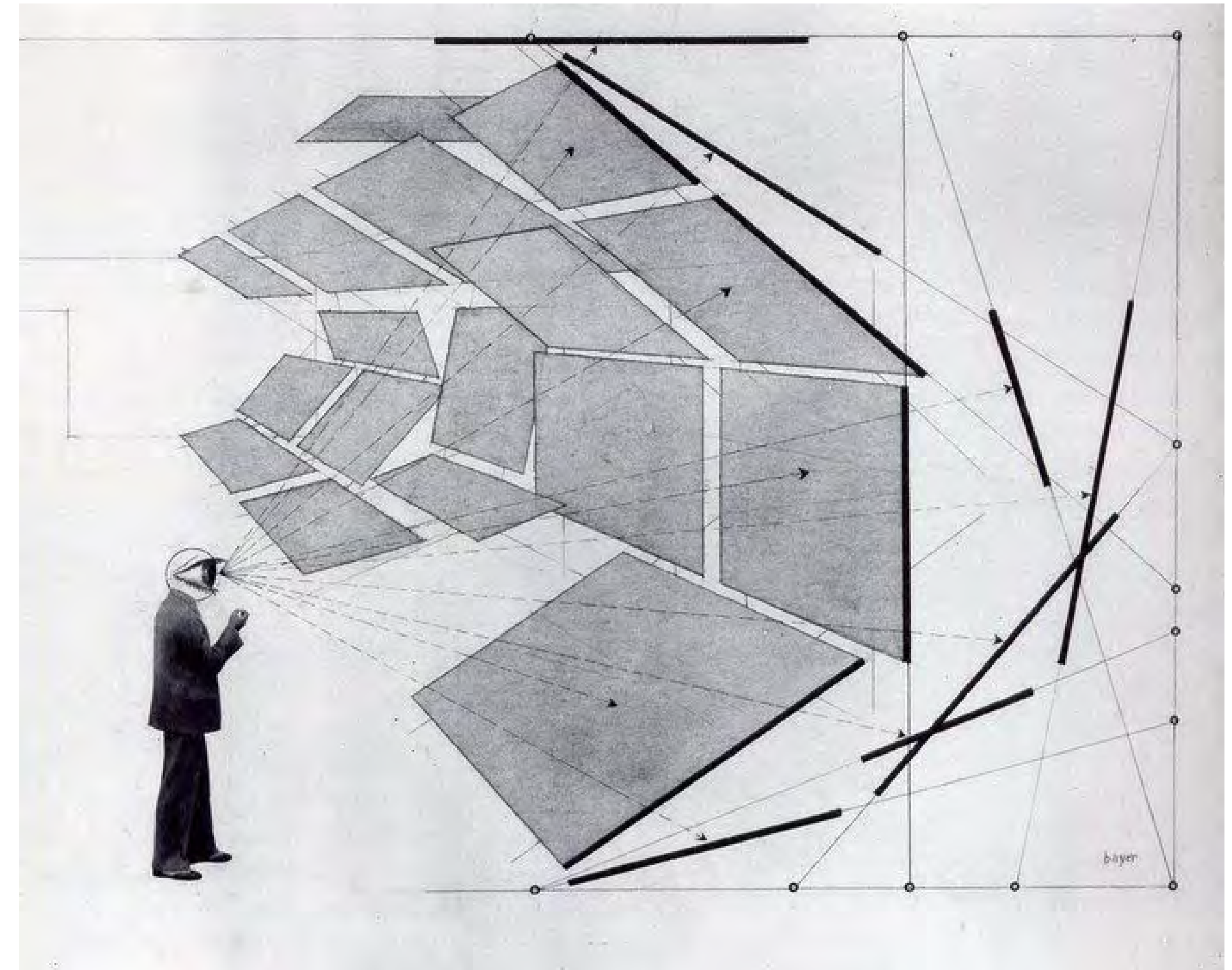


Diagram of the Extended Field of Vision
Herbert Bayer
1930

Design approach

Analysing current designs (in an archaeological way)

Visual anchor

- Lighting
- Monitors, indicator lights
- Rail (visual geometric protrusion)
- Signs, customization

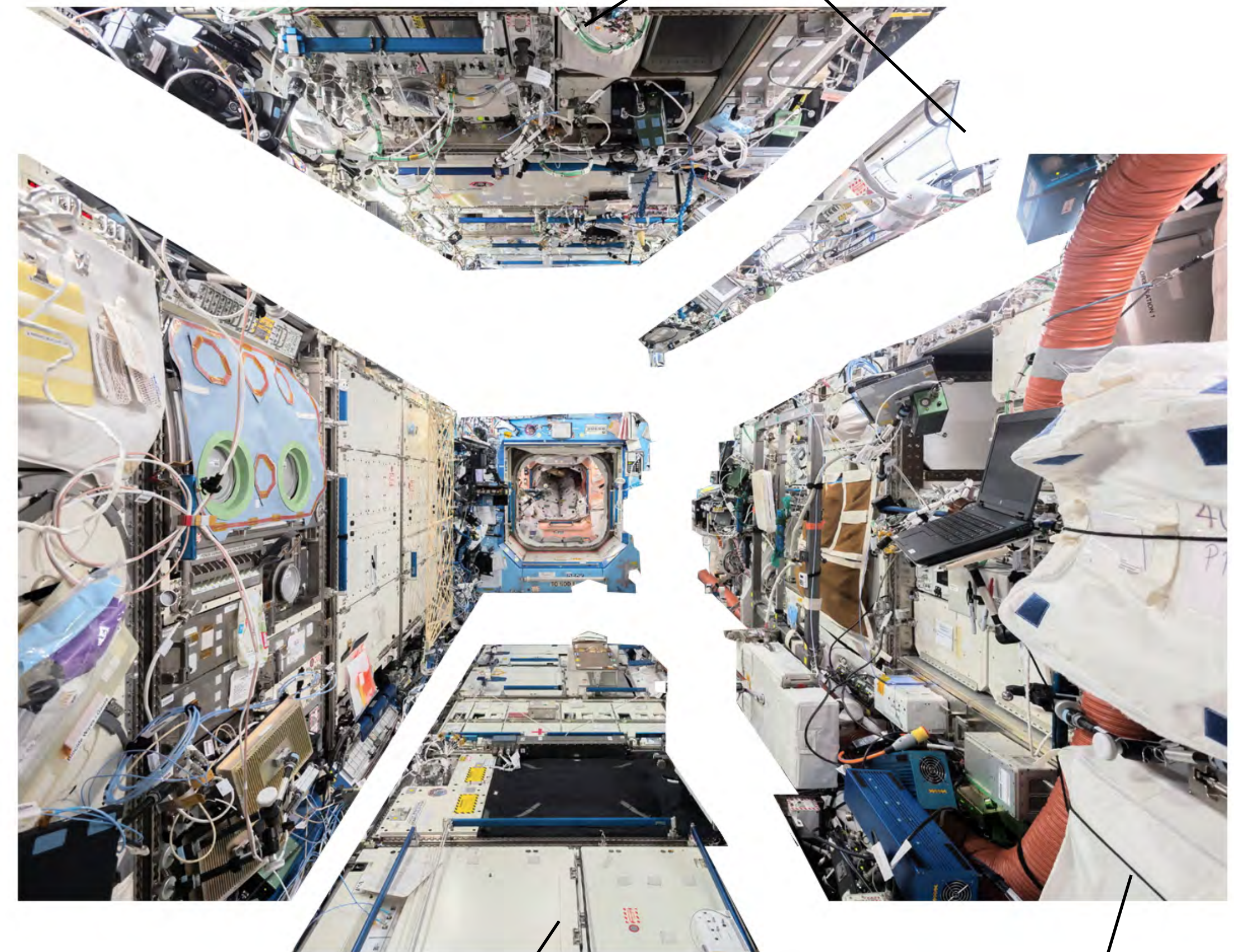
Strength anchor

- Positioning
- Working plane
- Buttons, panels
- Decking

Force anchors are charge points and visual anchors appear as a series of leading lines that draws the eye, balances the layout, and creates emotional harmony



"above": rails, lighting and signs



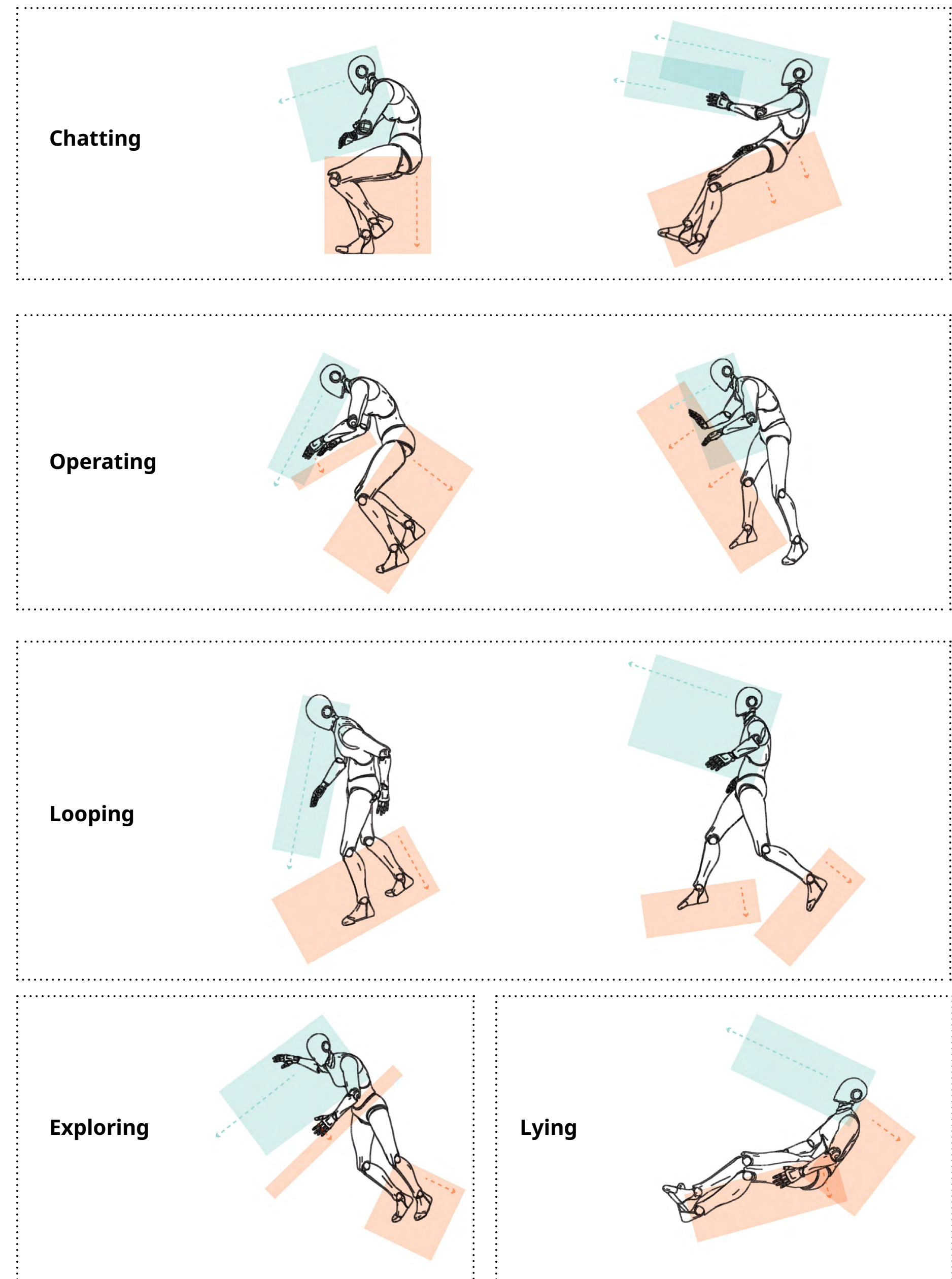
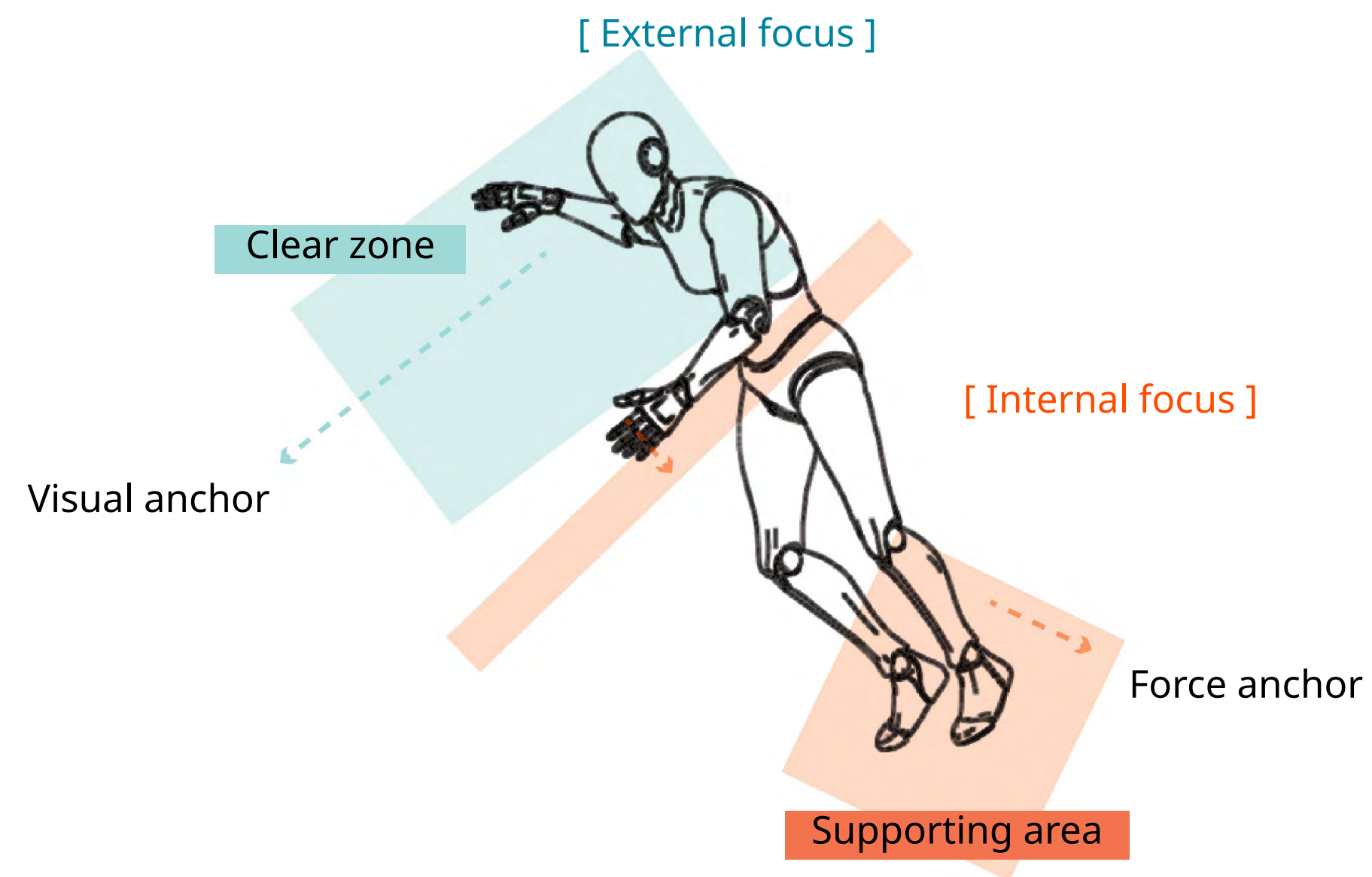
"bottom": rails that fix position

"wall": working planes

Design approach

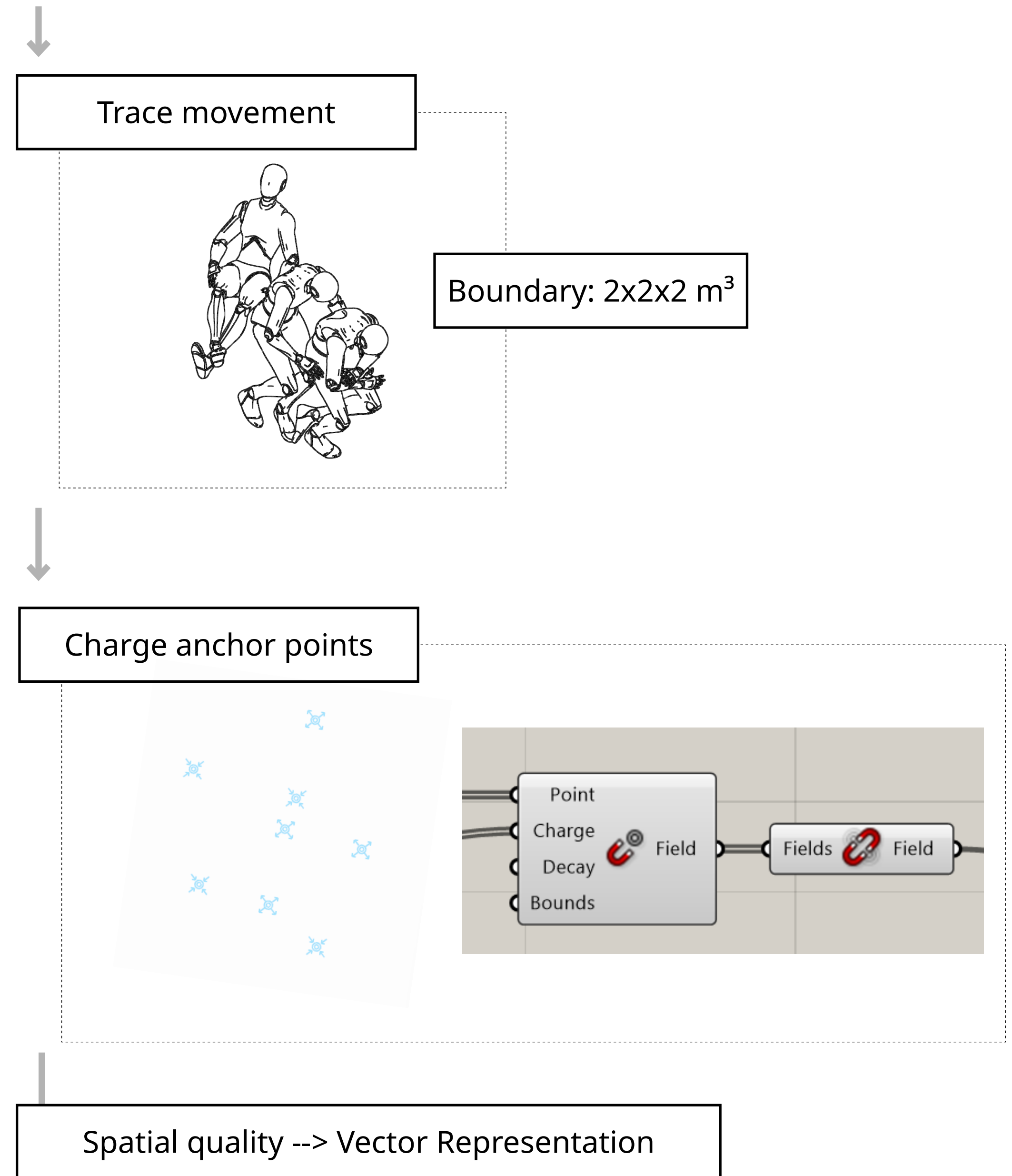
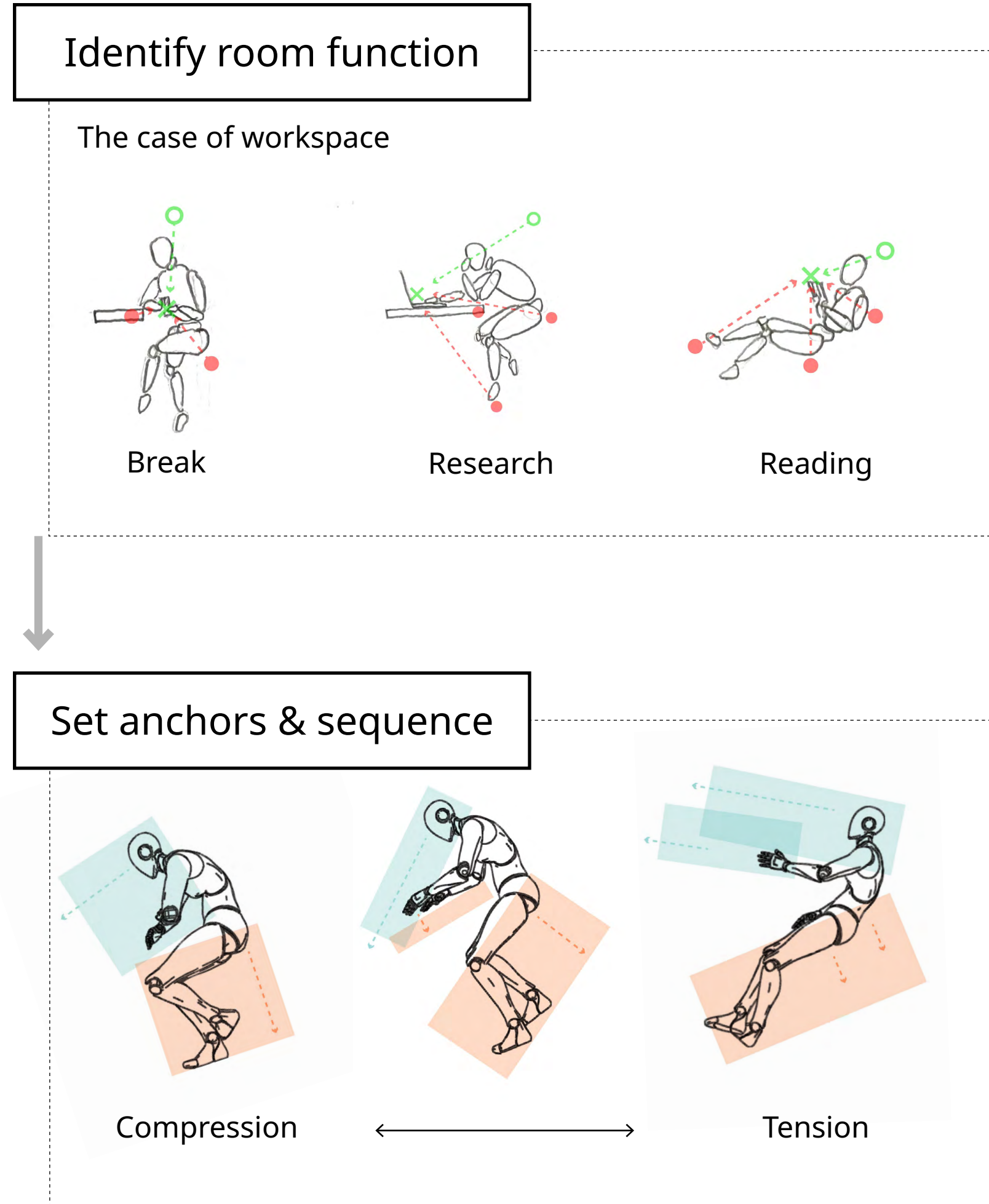
Anchor interpretation

Before defining boundary and geometry, the correspond body position is analysed and divided into multiple anchors and attractors.



Design approach

Translation

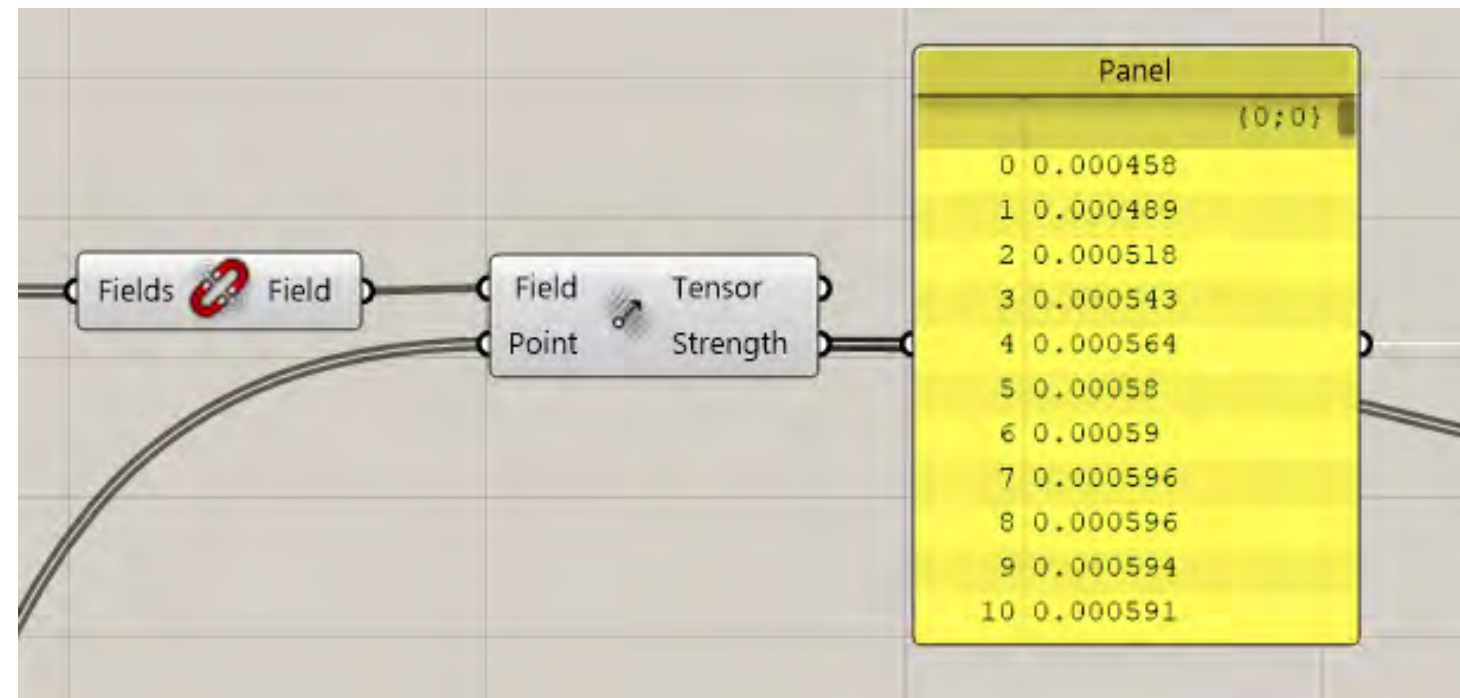


Design approach

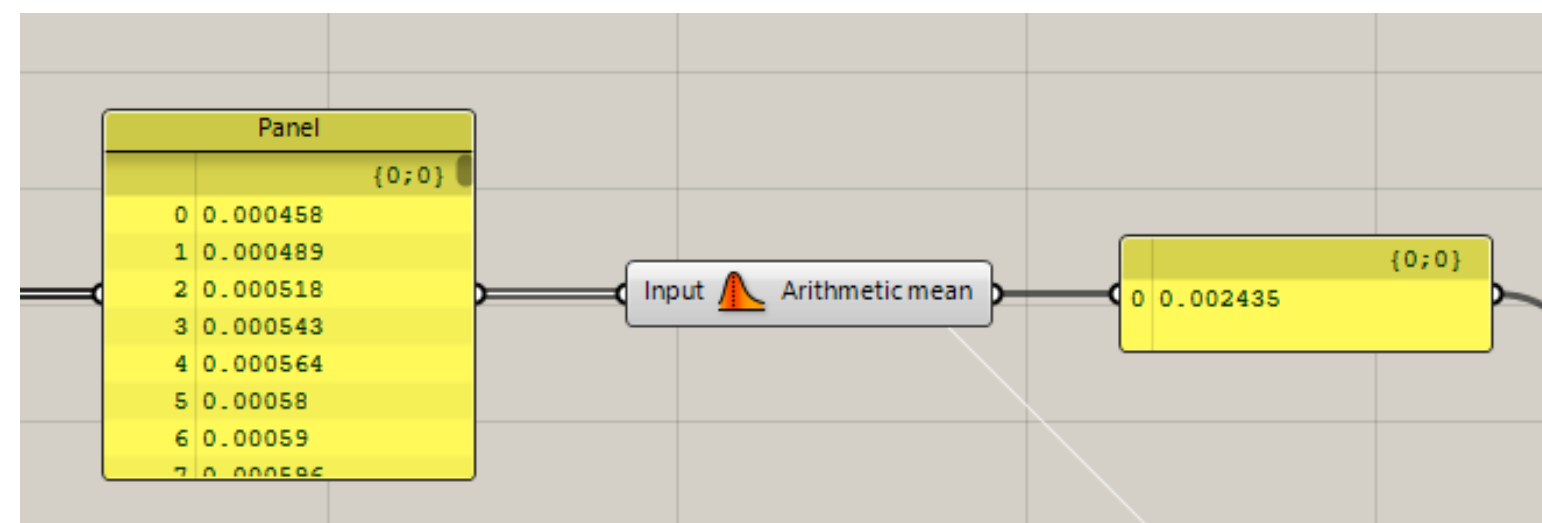
Translation



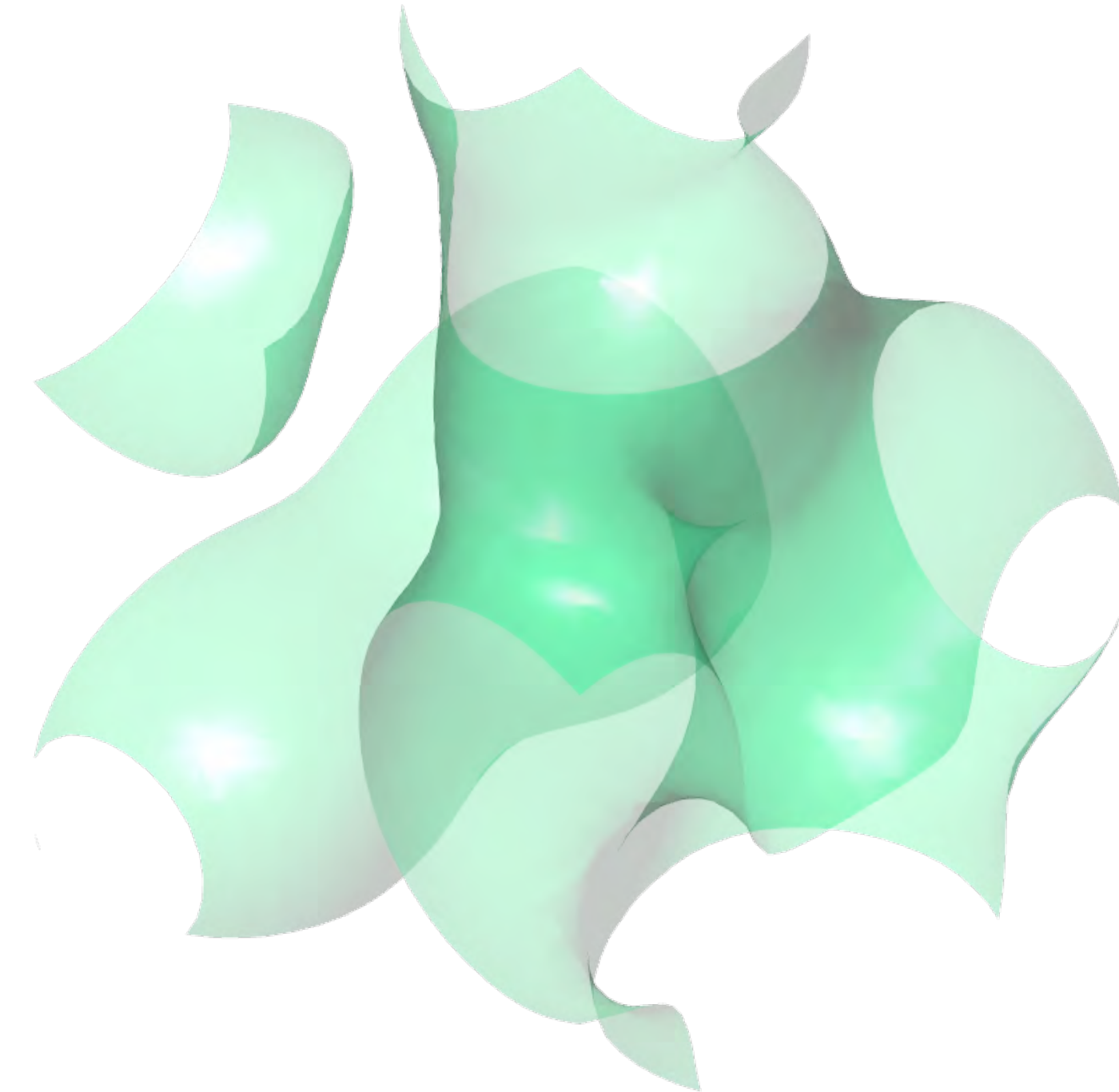
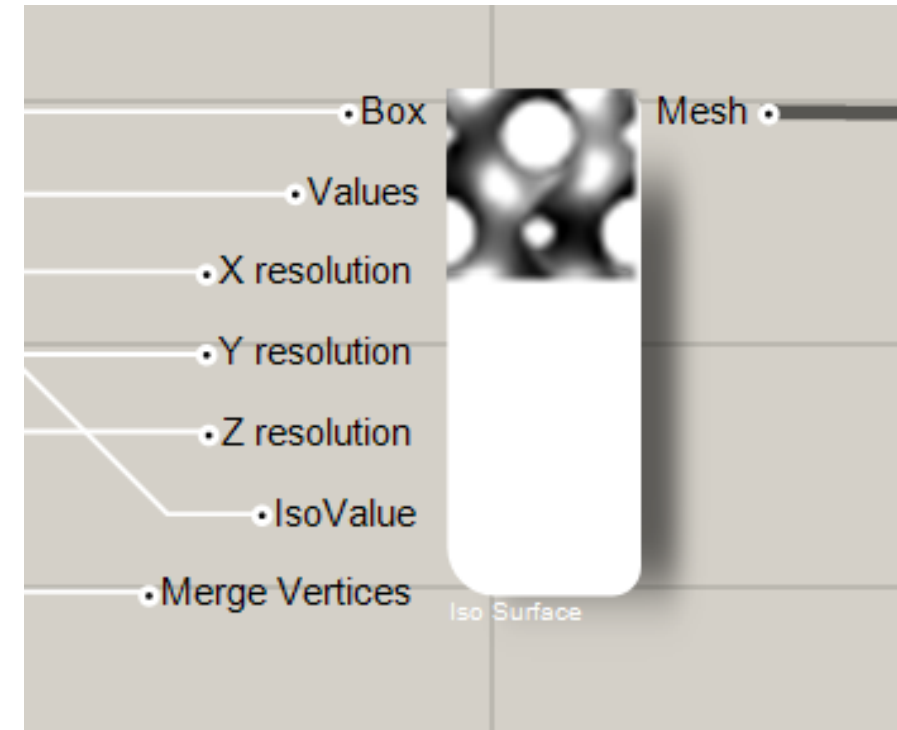
Evaluate strength



Test iso-values

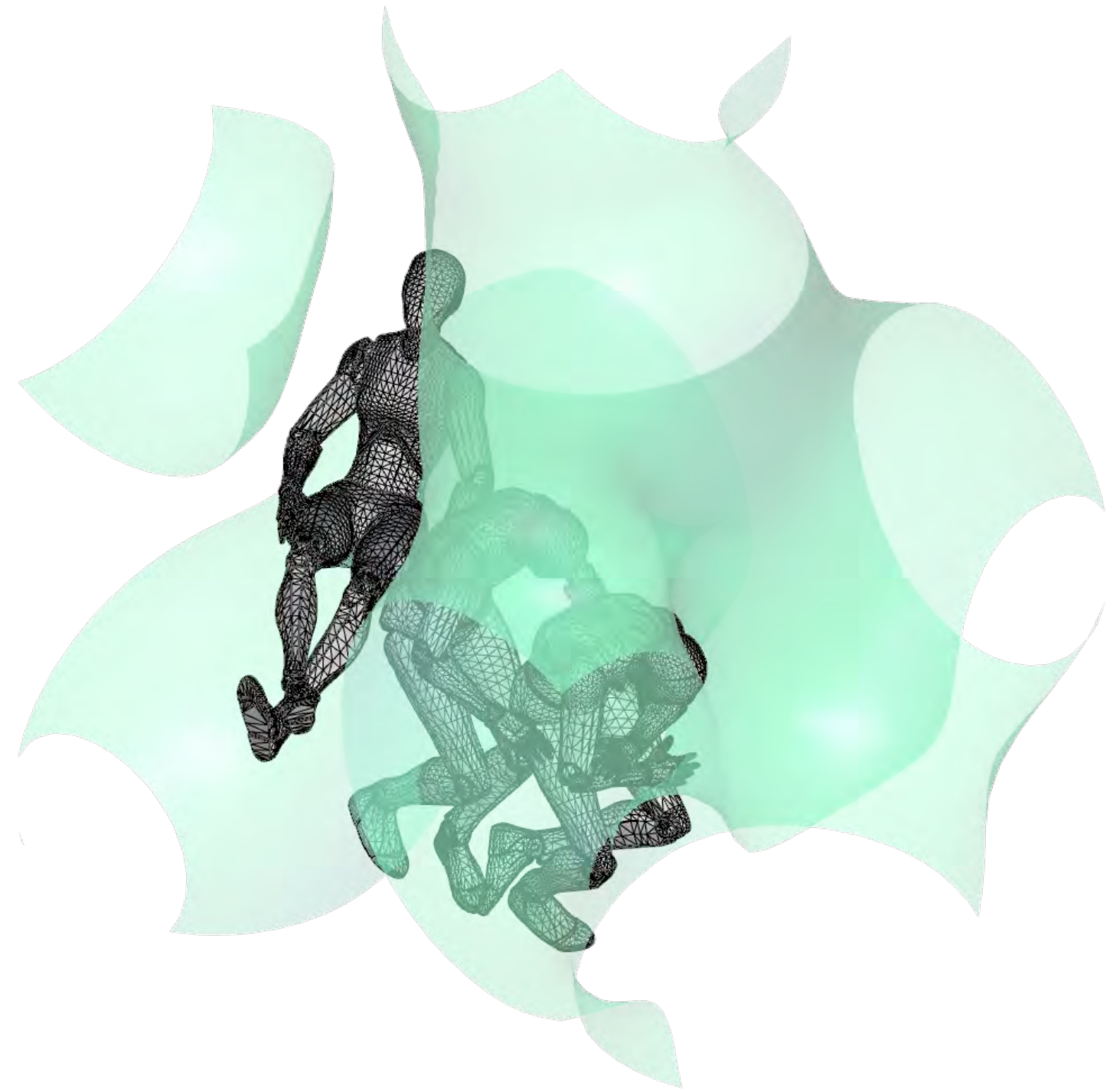


Generate output

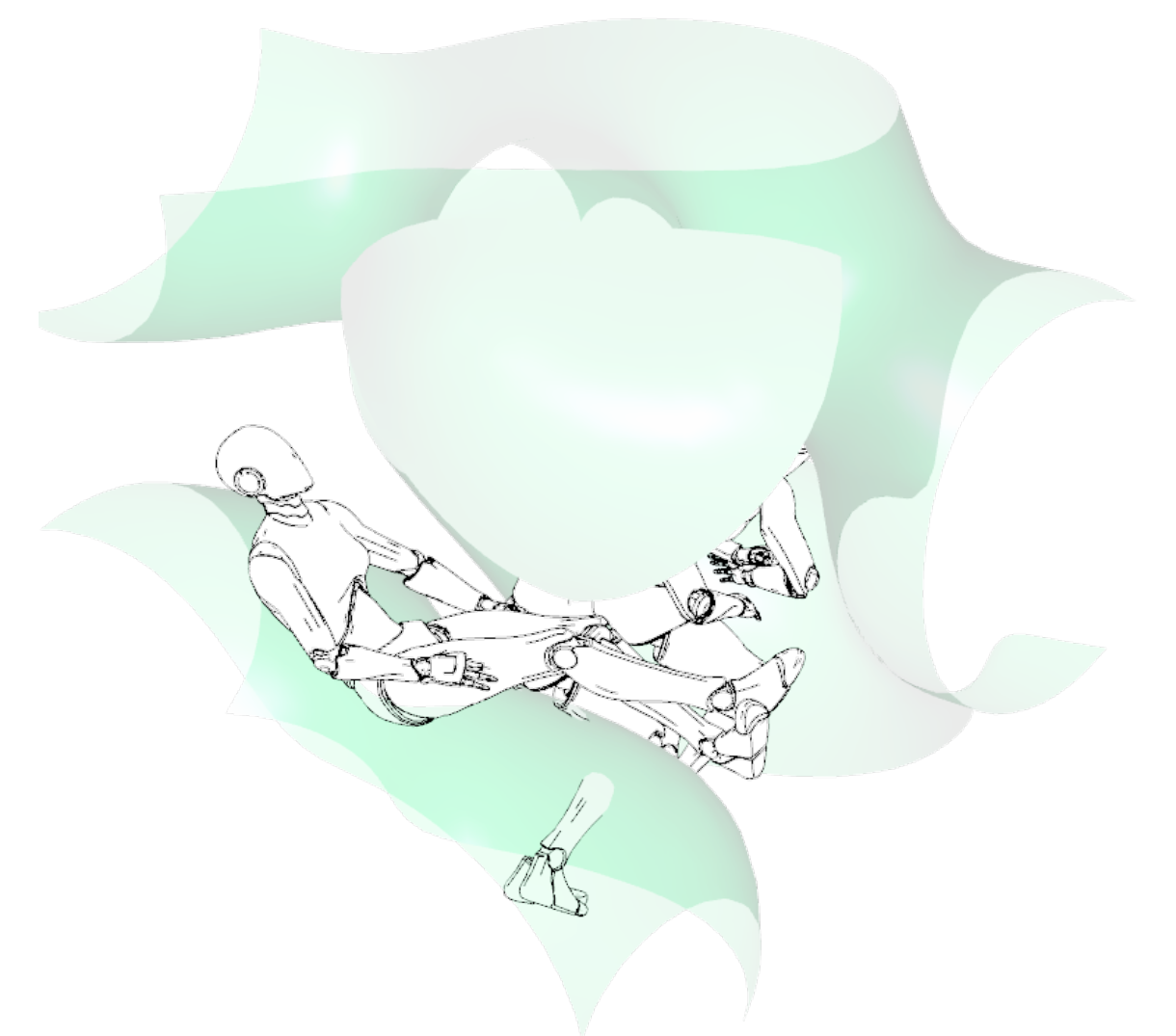
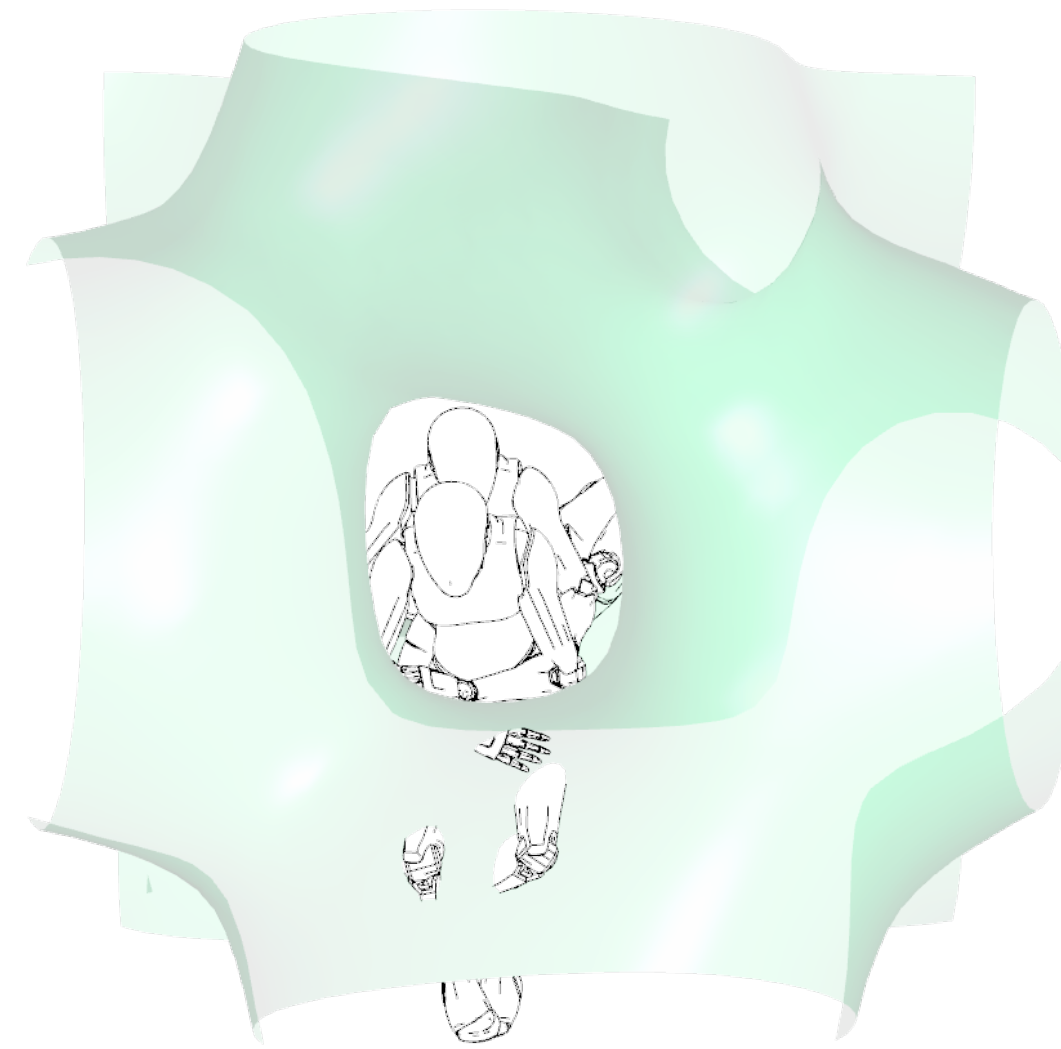
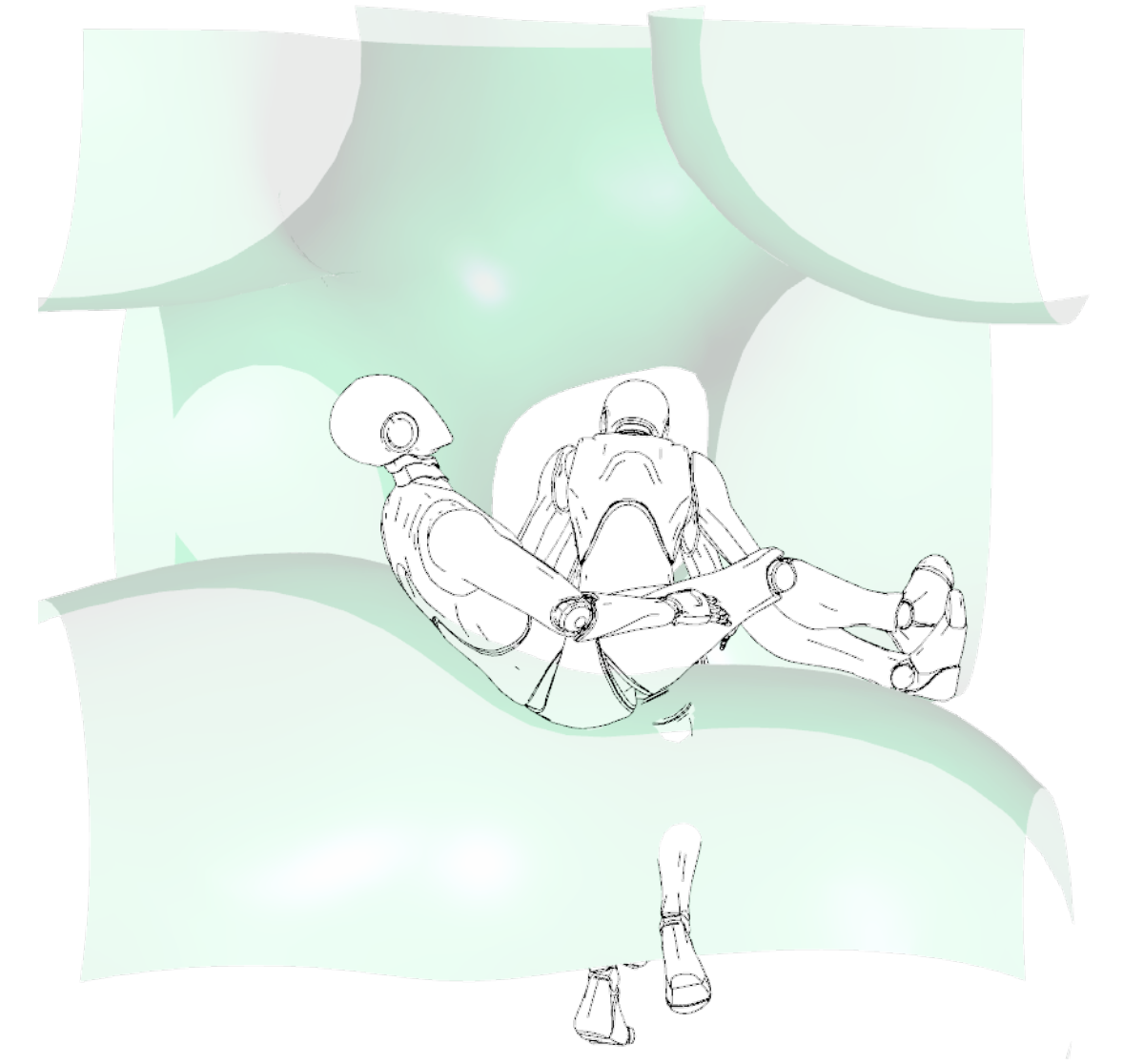
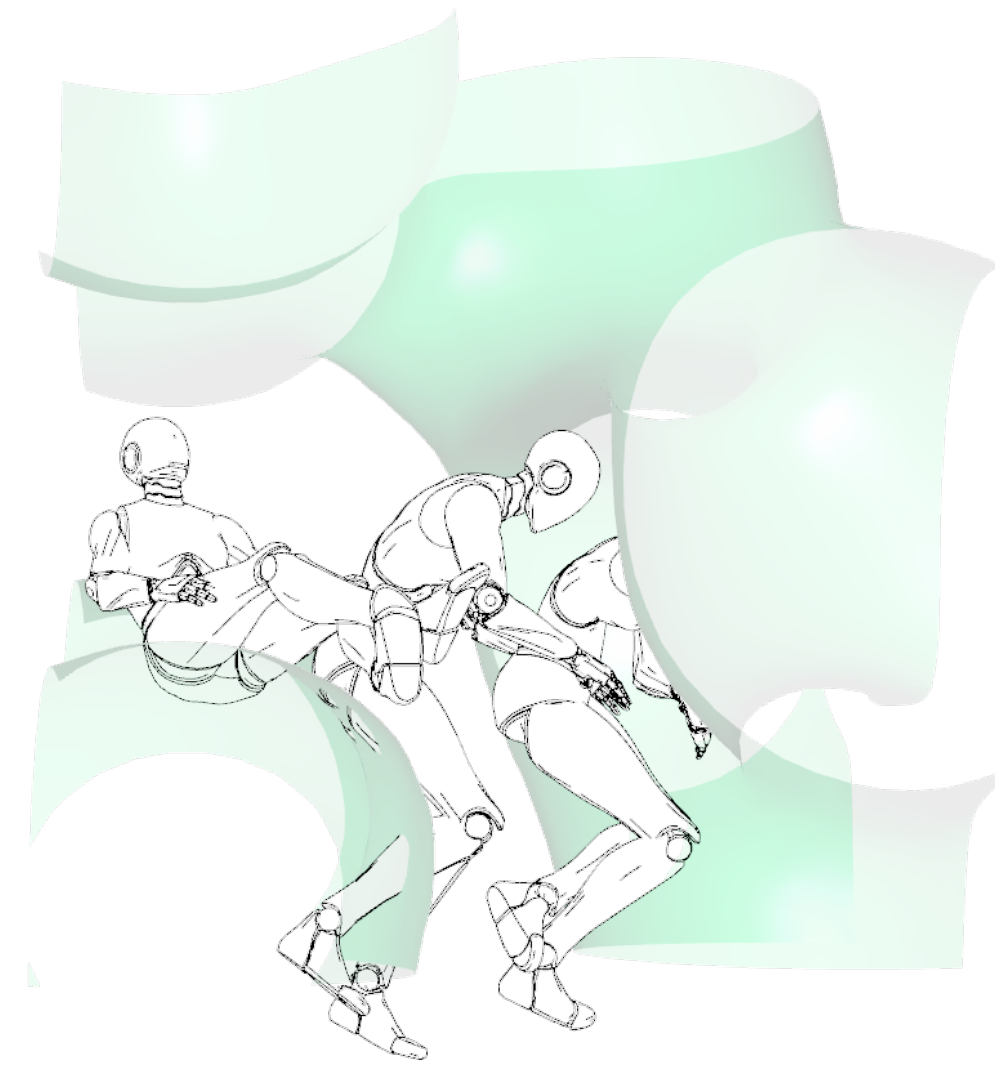


Design approach

Evaluate output



Dummy shown as time-lapse positions

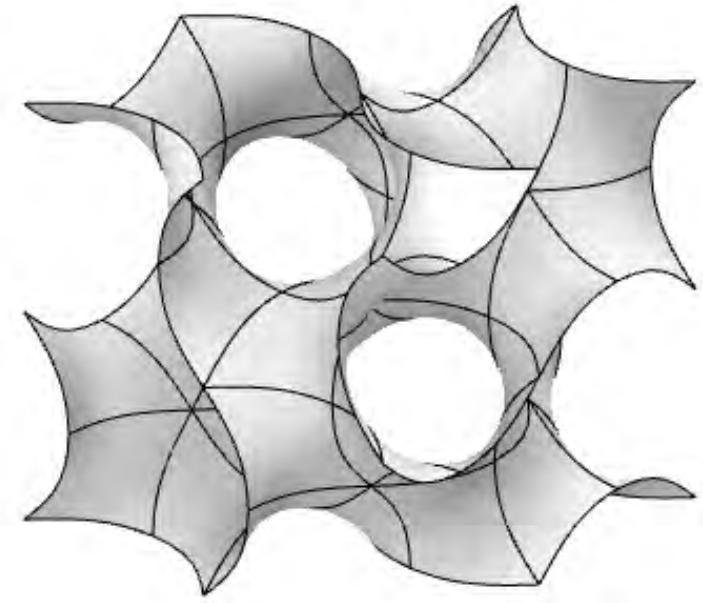


Case studies

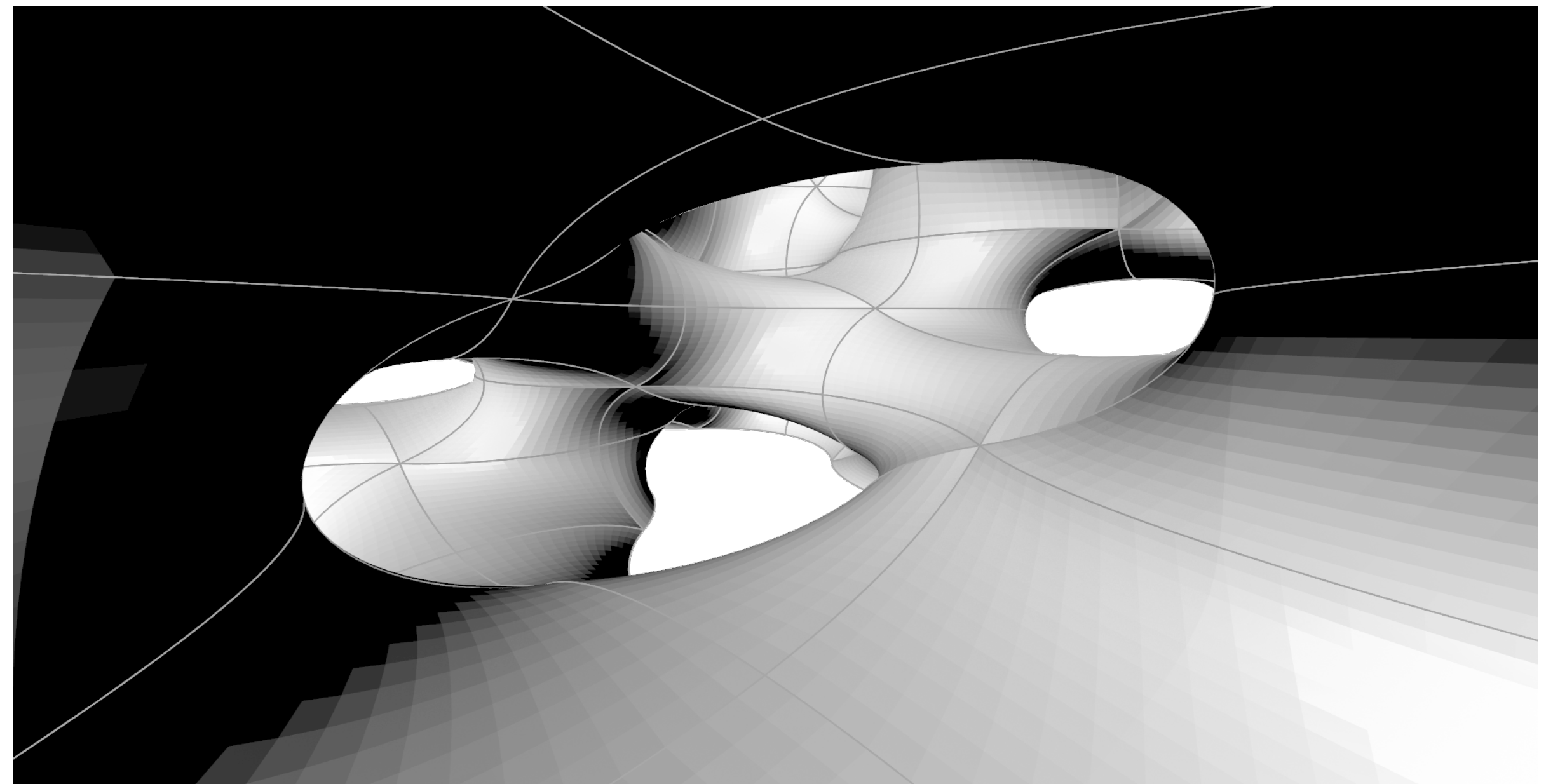
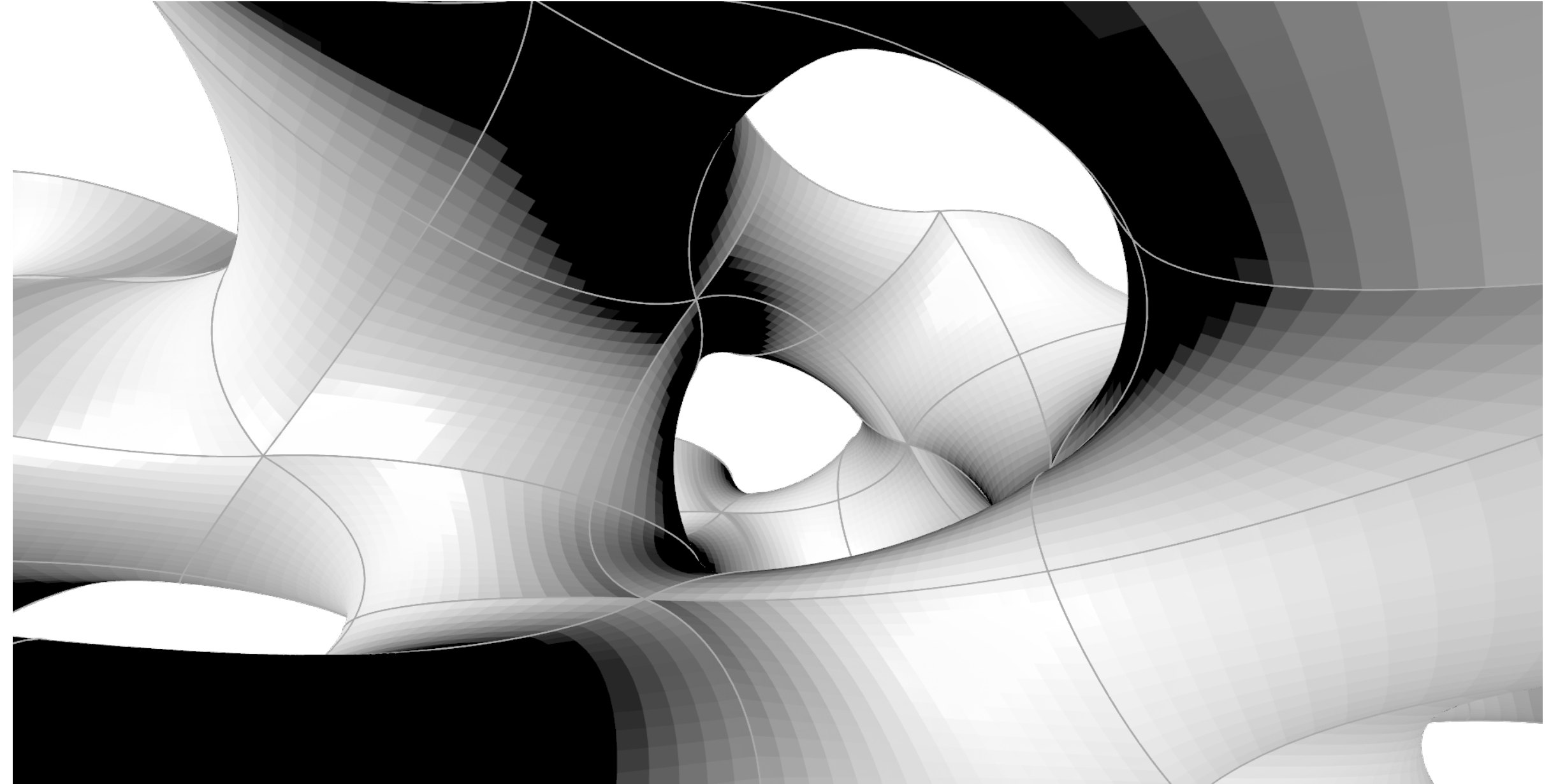
Urban Furniture
Gyroid Climber
2013
Exploratorium, San Francisco



First impressions



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.



Part.3

Proof of concept



Behind the film
2001: Space Odyssey
1968

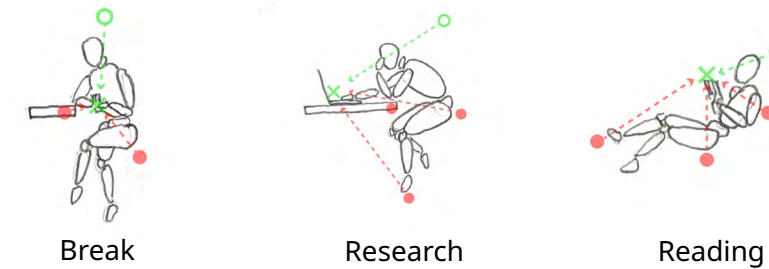
Proof of concept

Reflection

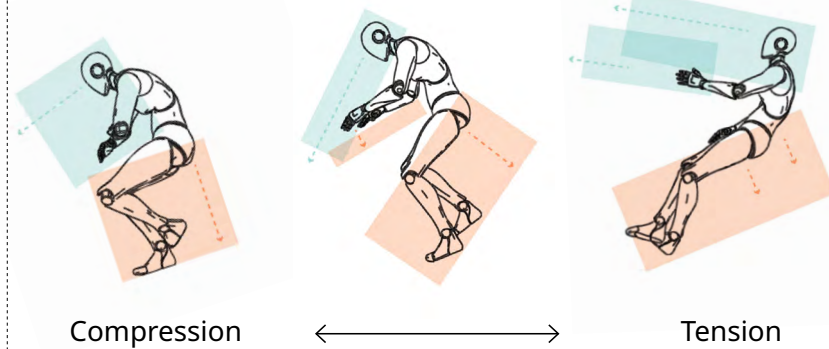
Analyse ambient

Identify room function

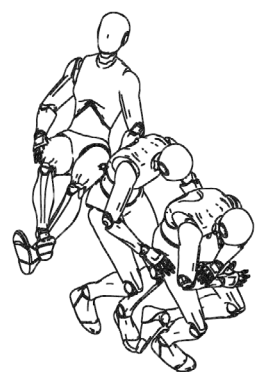
The case of workspace



Set anchors & sequence



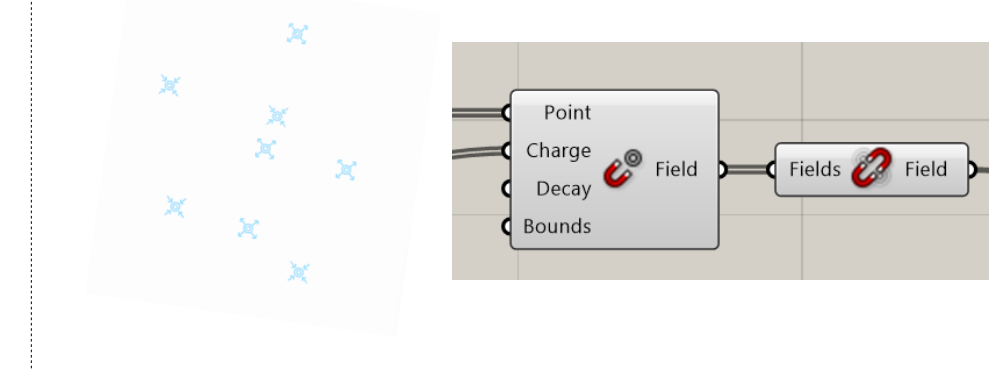
Trace movement



Boundary: 2x2x2 m³

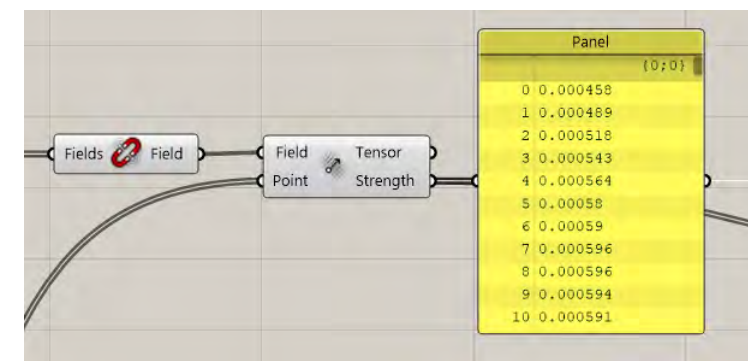
Merge multiple anchors

Charge anchor points

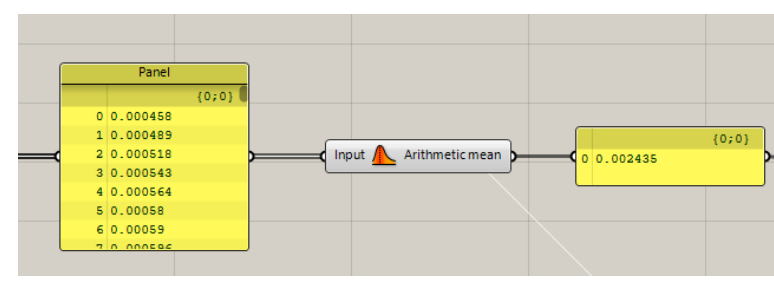


Spatial quality --> Vector Representation

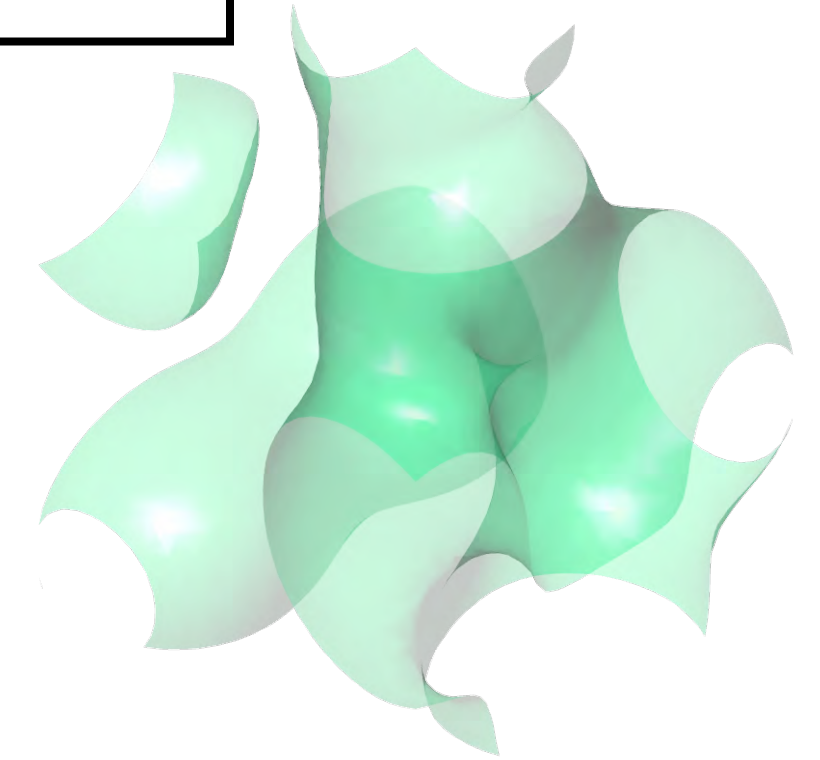
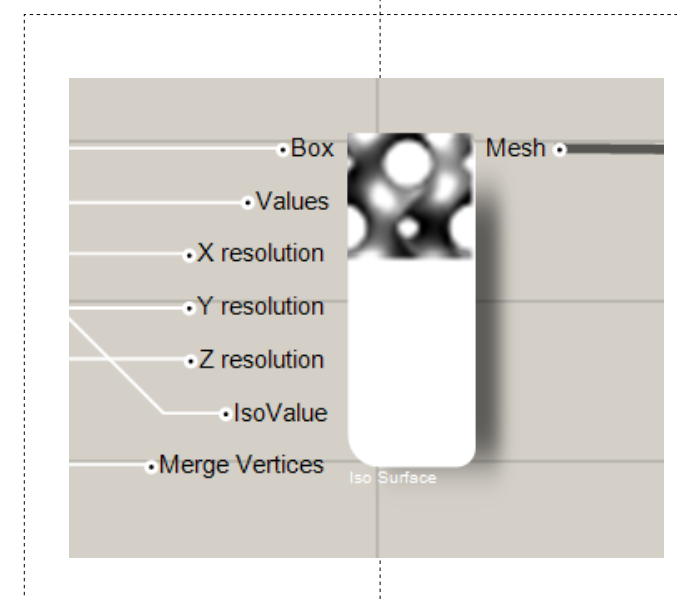
Evaluate strength



Test iso-values



Generate geometry

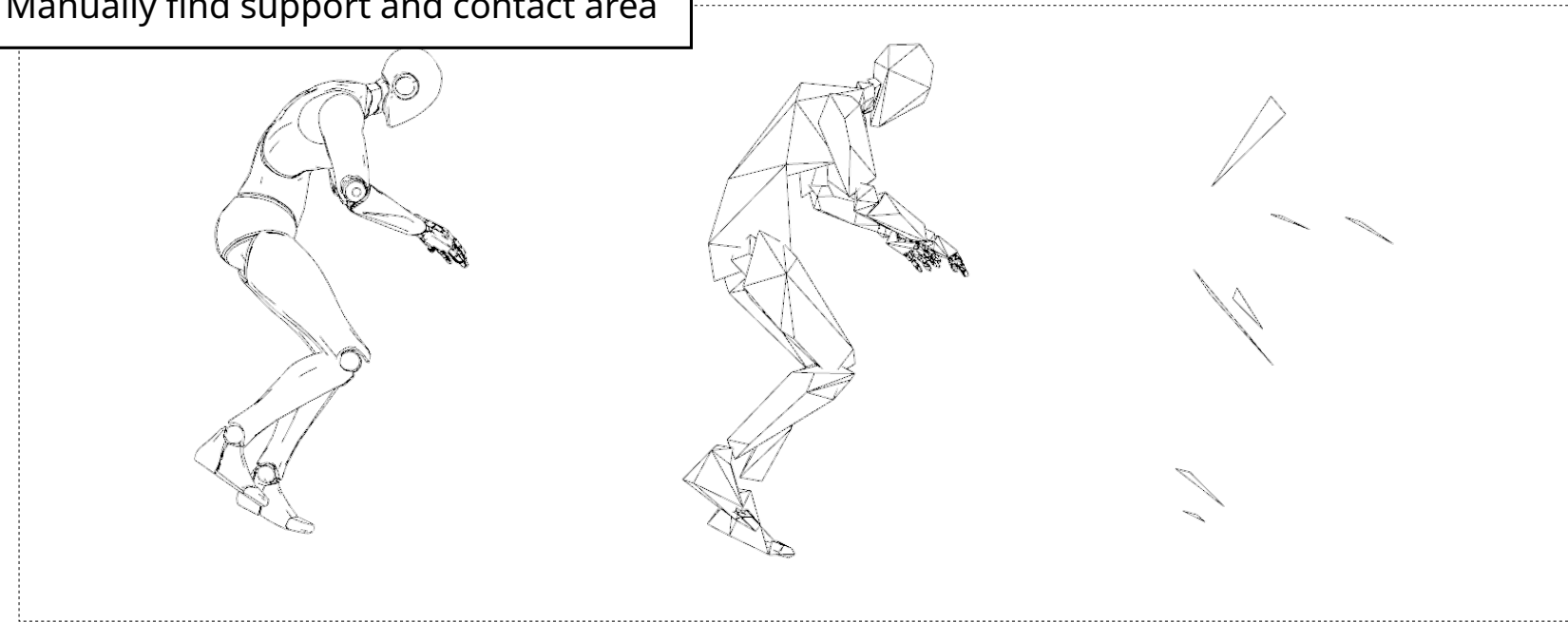


Spatial perception is gained through vectors, But directional property is lost as the list of vertices merged to one IsoValue, making future analysis impossible

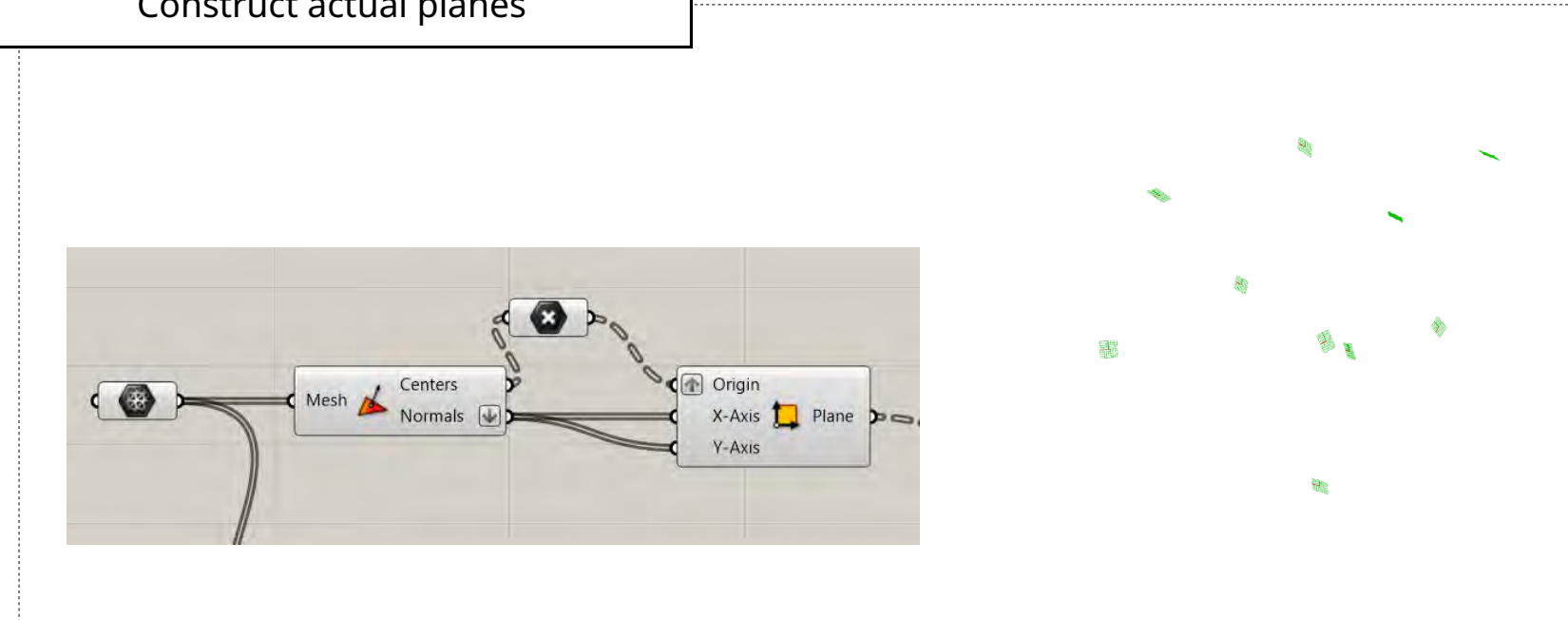
Proof of concept

Re-claim anchor strength

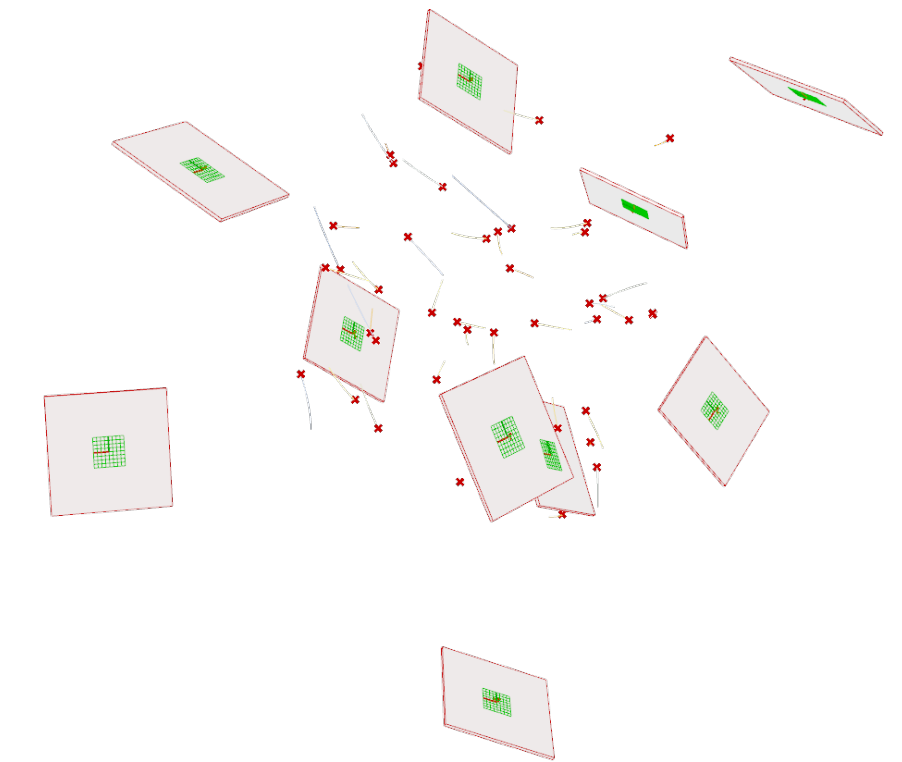
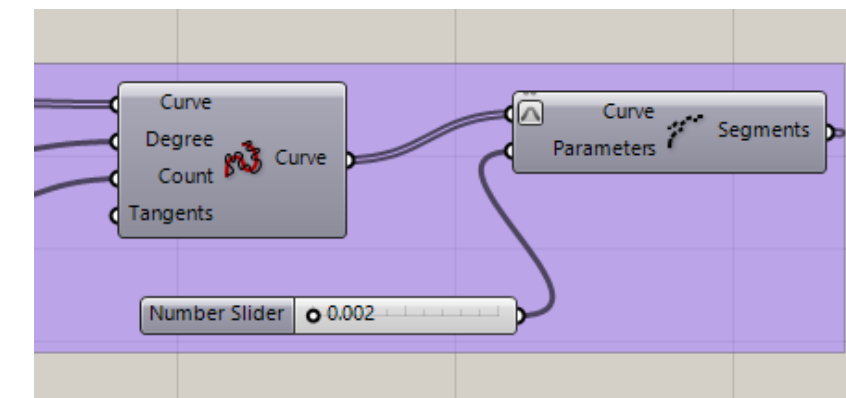
Manually find support and contact area



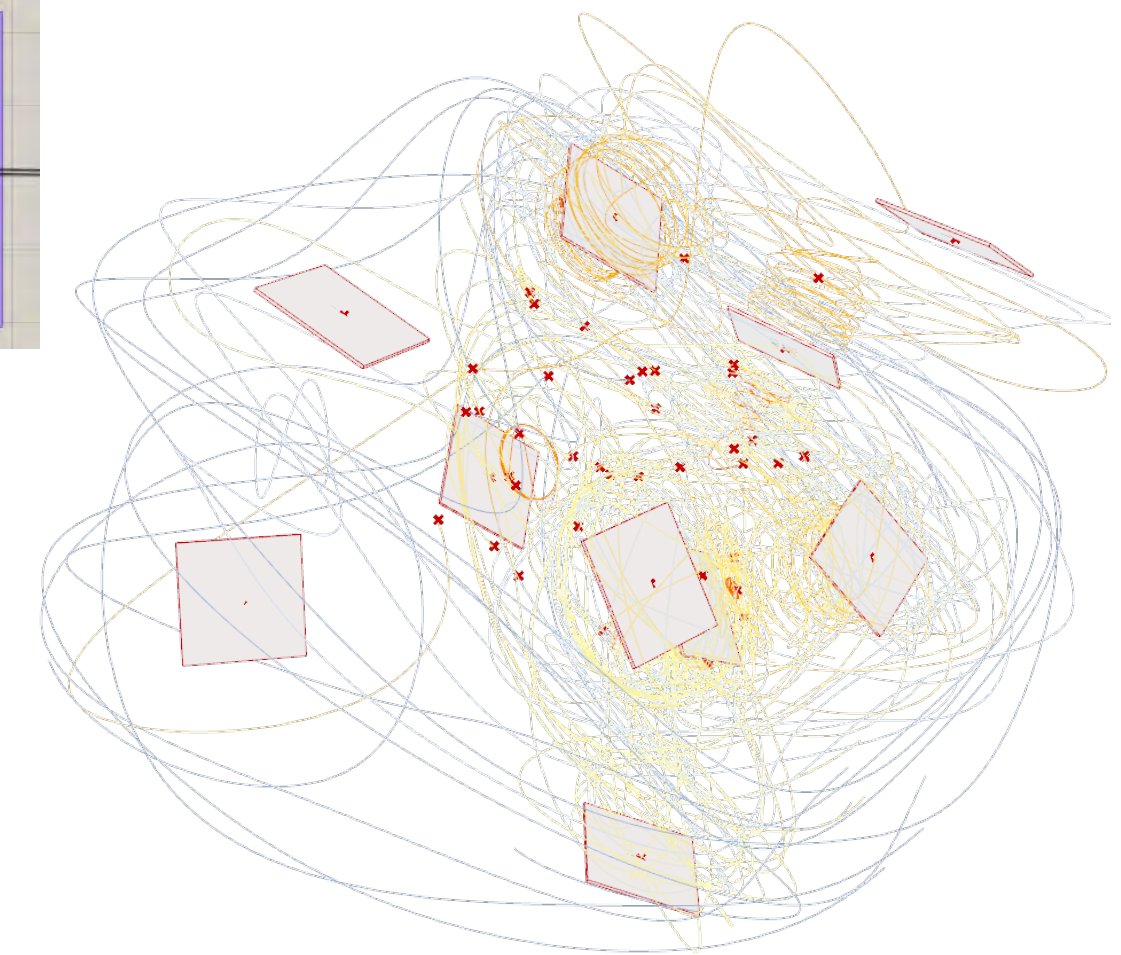
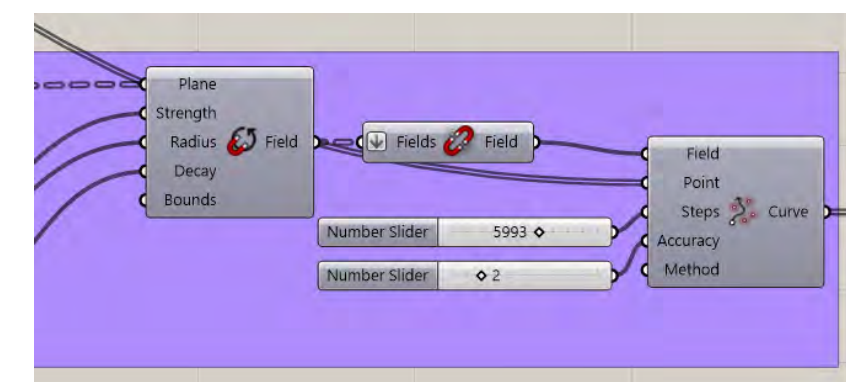
Construct actual planes



Analyse force anchors

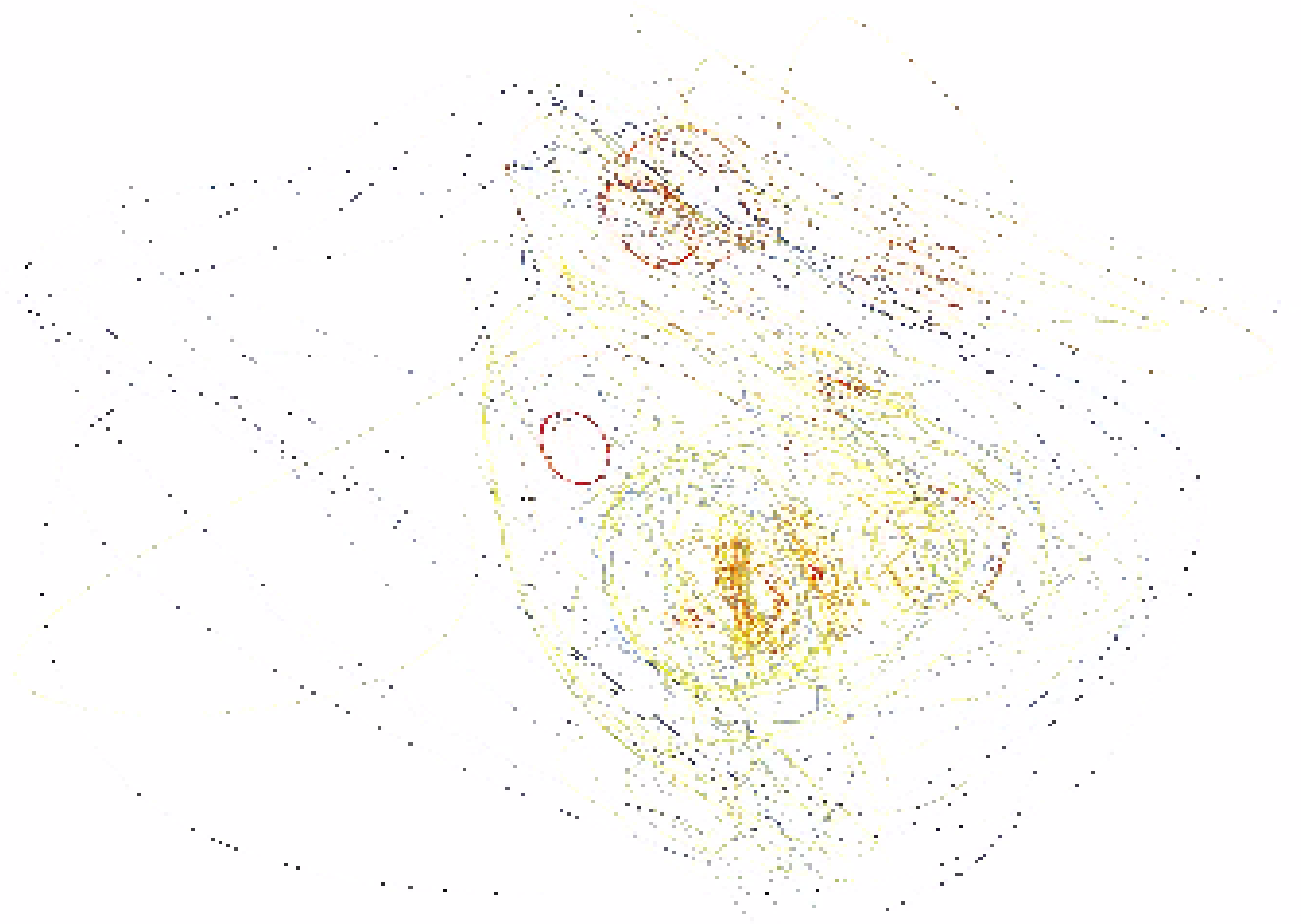
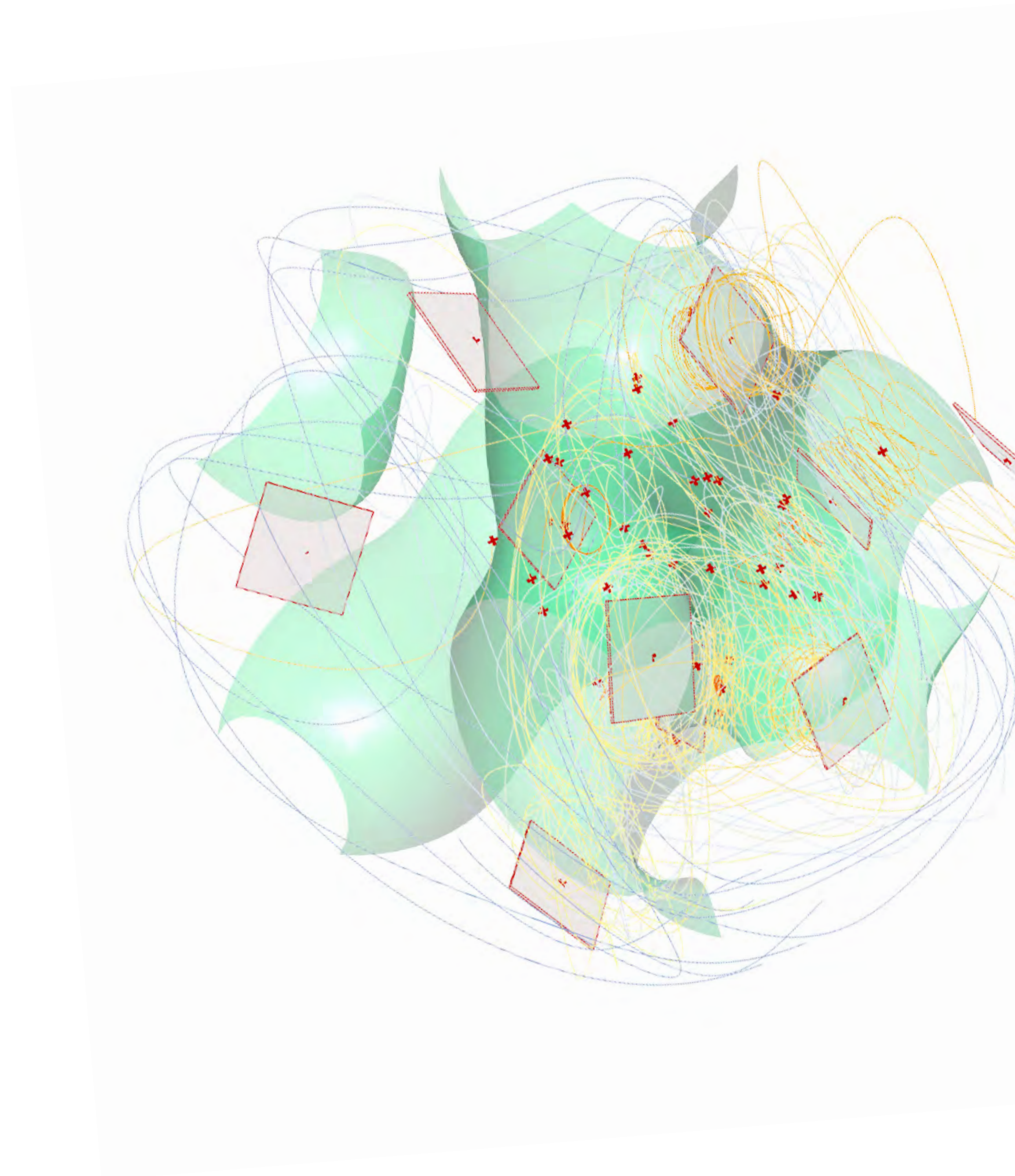


Analyse visual leading lines



Proof of concept

Mind-muscle simulation



Next step

Remaining for A2

Visualize first-person room ambient

Materialization

Integrate slicing and patterns for 3D printing

Lighting

Geometries that catch or reflect light
(part of visual perception but not yet presented)



Rabbit dens
Yu Lei