Bounce on the moon

movement-driven habitat design

AR4ETA010 - Extra-/Terrestrial Architecture Graduation Studio

7 December 2025 Peixing Yang

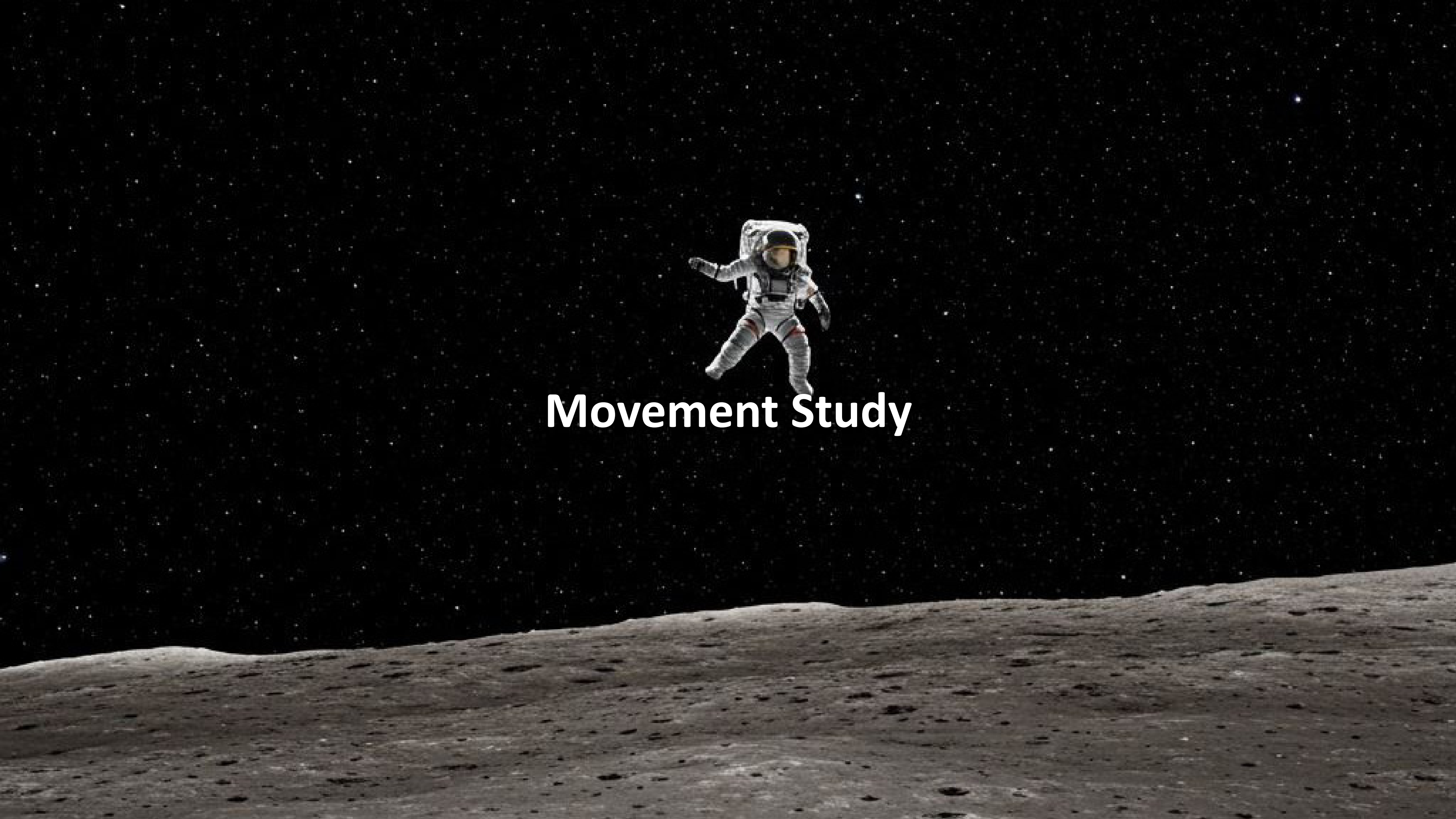
CONTEXT

Movement Study

Spatial Study

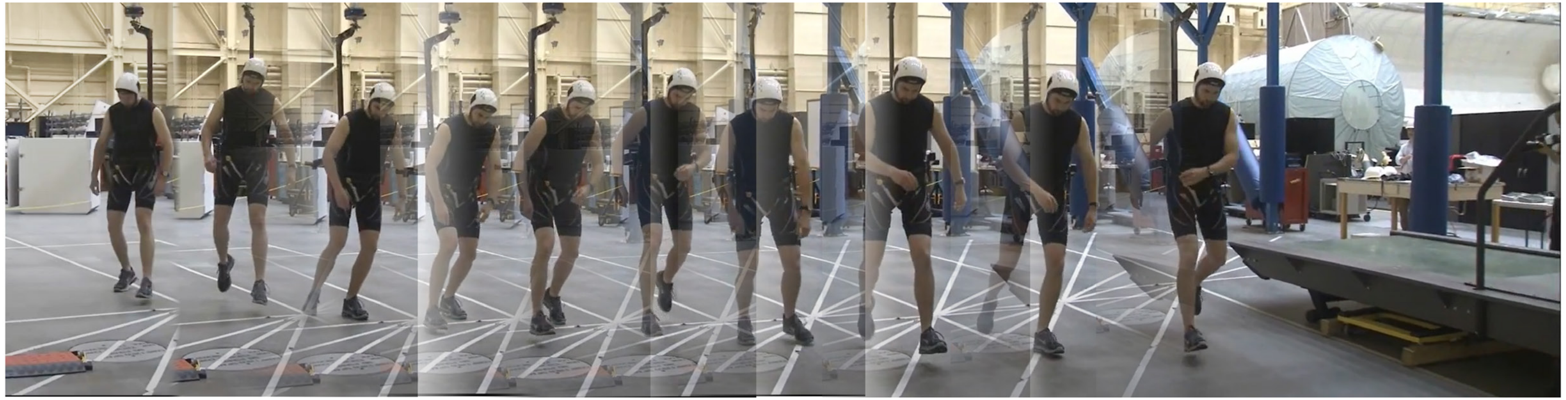
Programmatic Study

Material Study


Movement Study

Bounce

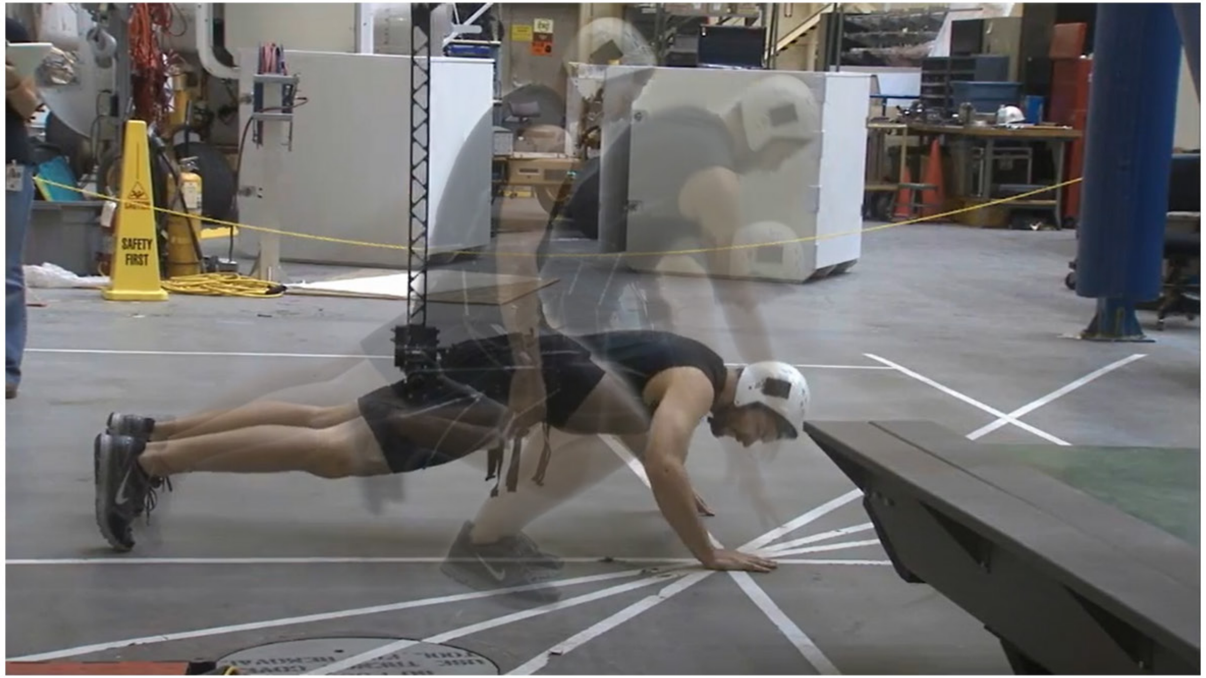
Every step:
Time:

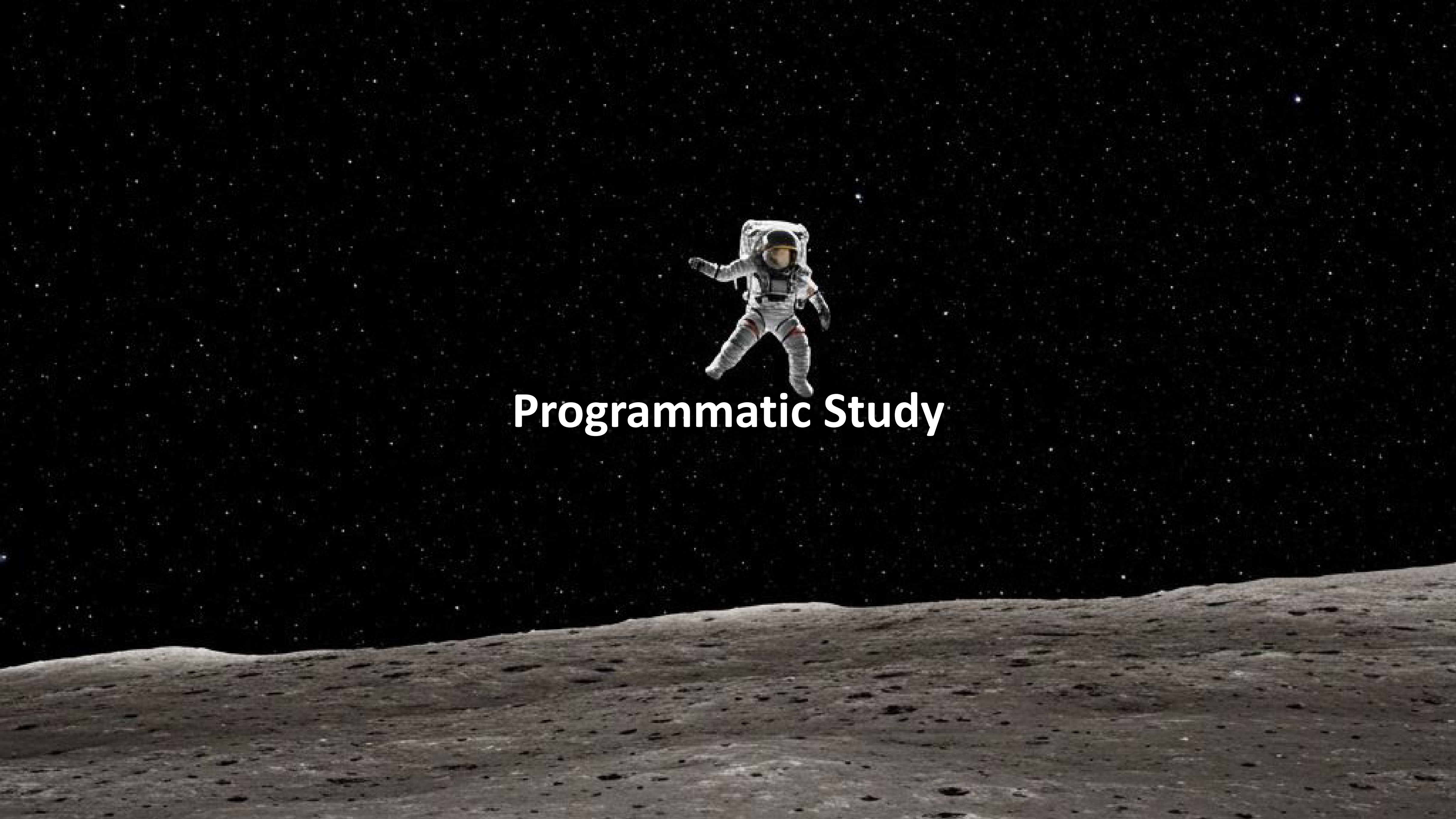


0s 2s 4s 6s 8s 10s 12s

Flip

Height:
Time:




Programmatic Study

45 Days Missions

NASA Artemis Surfacr Mission:4
Apollo Program:3
ESA Stimulation:4

Genaral function

Working Area	Living Area
Office	Recreation
Workshop	Restaurant/Bar
Laboratory	Exercise Facilities
Private quaters	Service
Hygiene	Water Storage
Sleeping	Waste
Indi-Recreation	Health

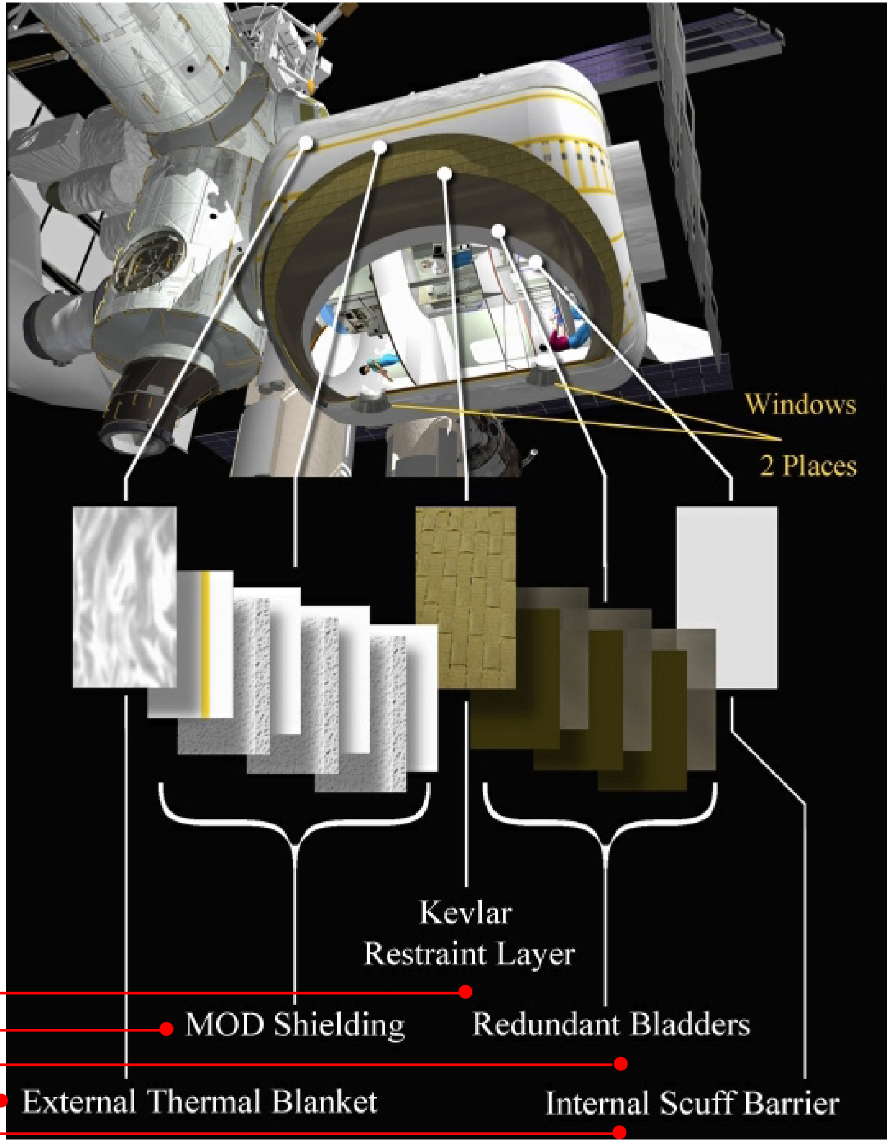
45 Days

Restaurant/Bar	20m^2
Exercise Facilities	XXm^2
Office	18m^2
Workshop	18m^2
Private quaters	12m^2
Hygiene	12m^2
Sleeping	24m^2
Indi-Recreation	XXm^2
Service	24m^2

Material Study

NASA TransitHub

Dimention:8.2 meters
Shell thick: one-foot-thivk
Layer:1.MMOD Shield
2.Multi-Layer Insulation
3.Intermediate Energy Absorber
4.Primary Restraint Layer
5.Bladder Layer
6.Internal Liner



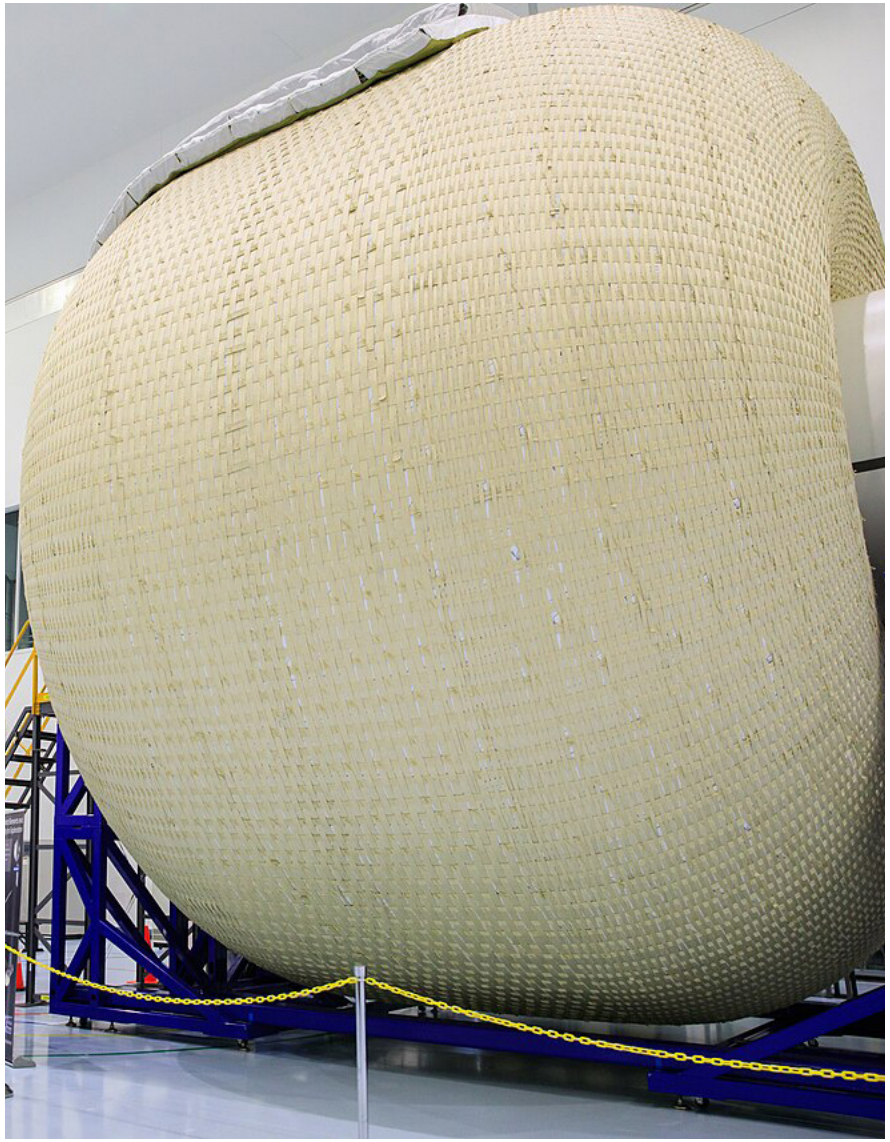
Structure layer
MMOD Shielding
Redundant Bladder
External Thermal Blanket
Internal Scuff Barrier

Bigelow Expandable Activity Module

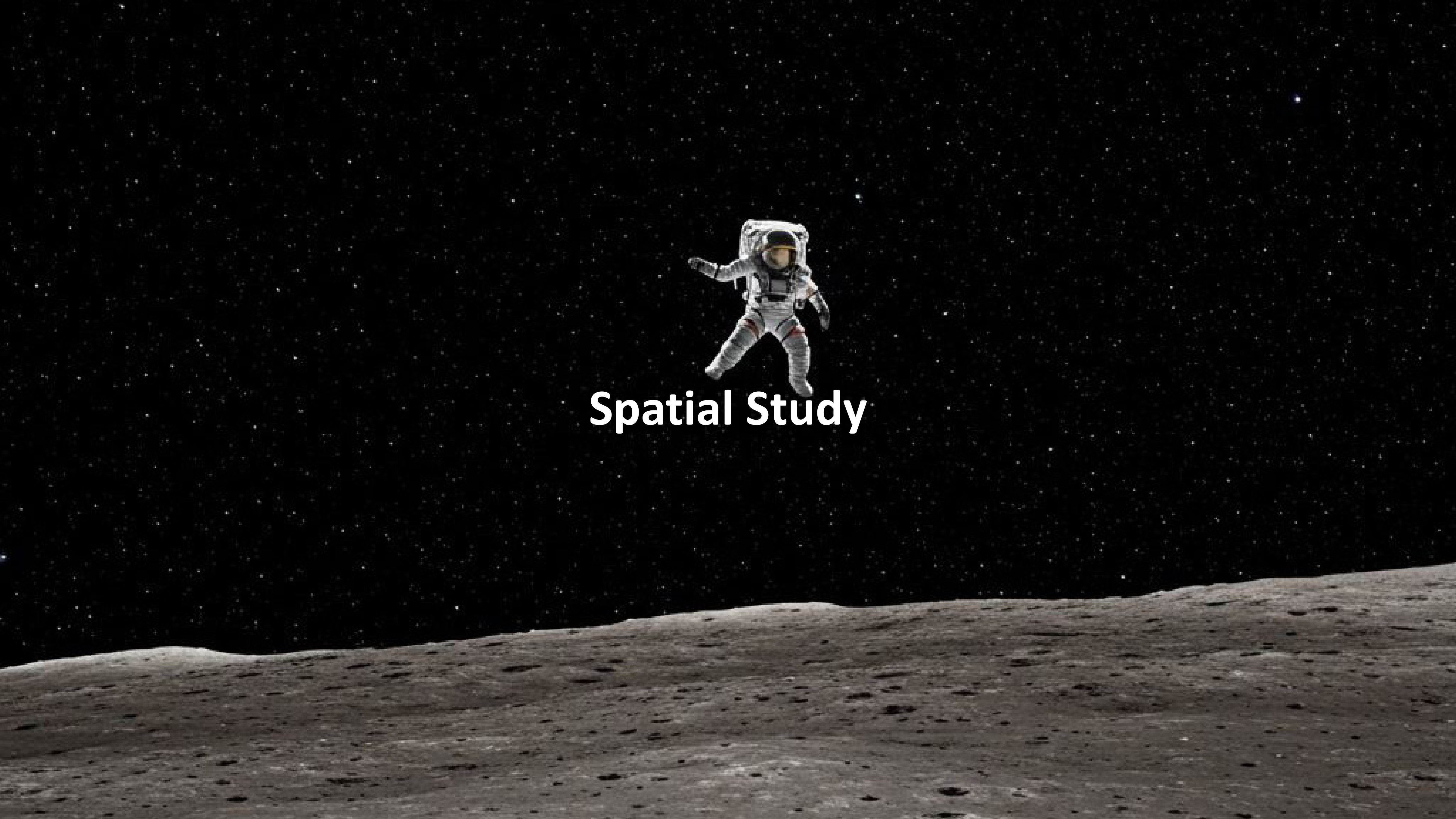
Dimention:4.01m long and 3.23m diameter
Shell thick: one-foot-thivk
Layer:1.MMOD Shield
2.Multi-Layer Insulation
3.Intermediate Energy Absorber
4.Primary Restraint Layer
5.Bladder Layer
6.Internal Liner

Large Integrated Flexible Environment

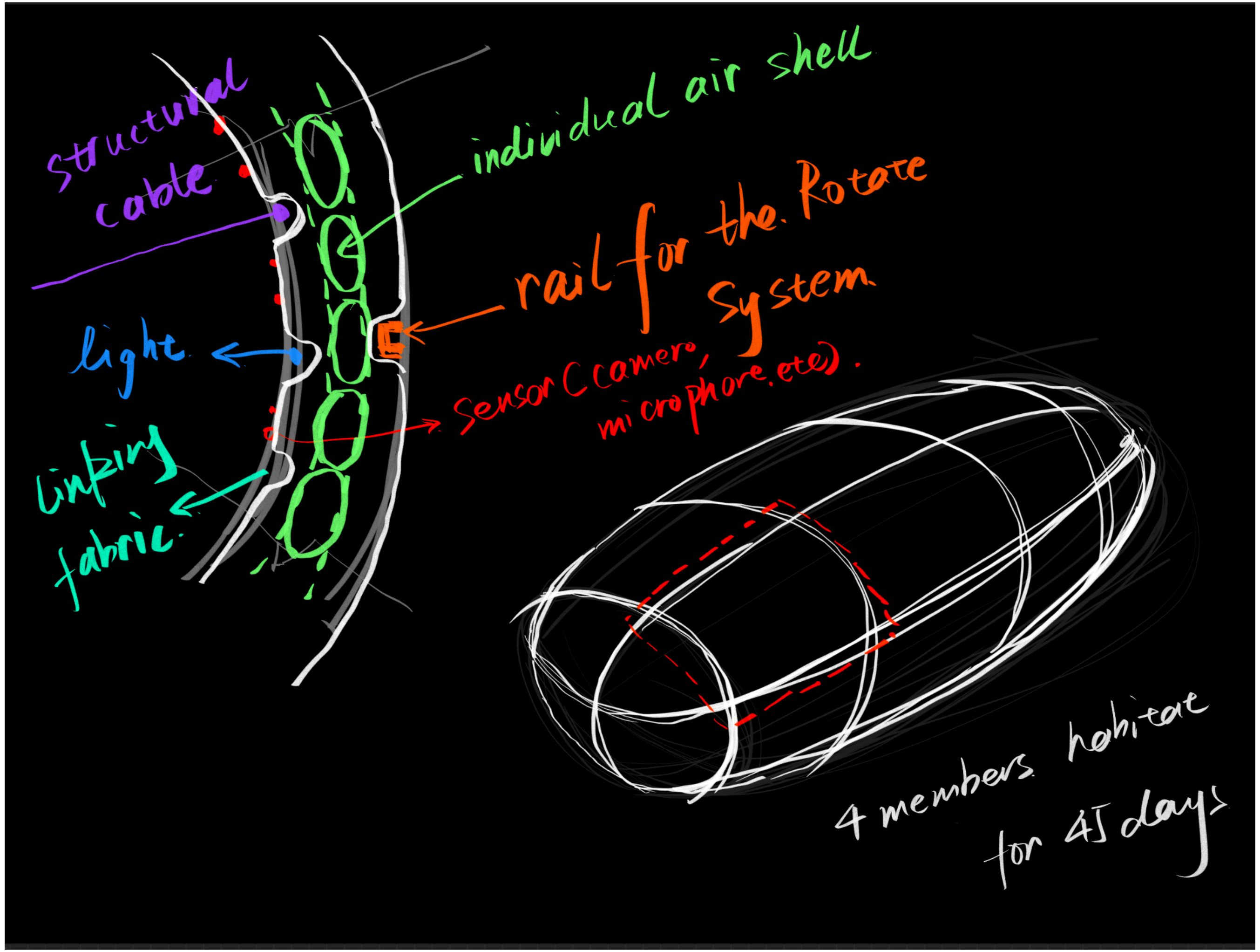
Dimention:6m long and 9m diameter
Crew Capacity: 4 astronouts
Layer:1.Thermal + MMOD
2.Structural Webbing
3.Bladder



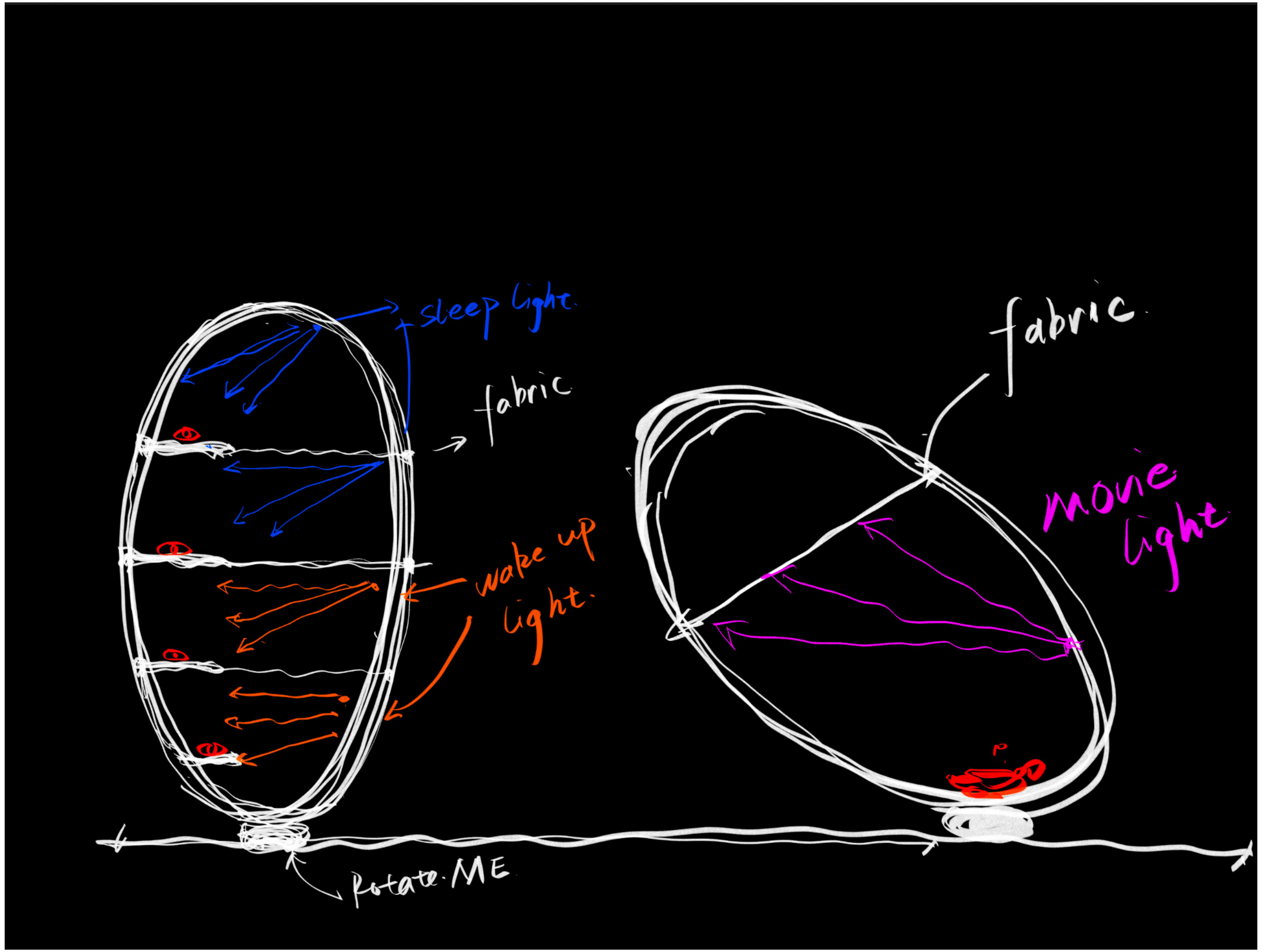
Spatial Study



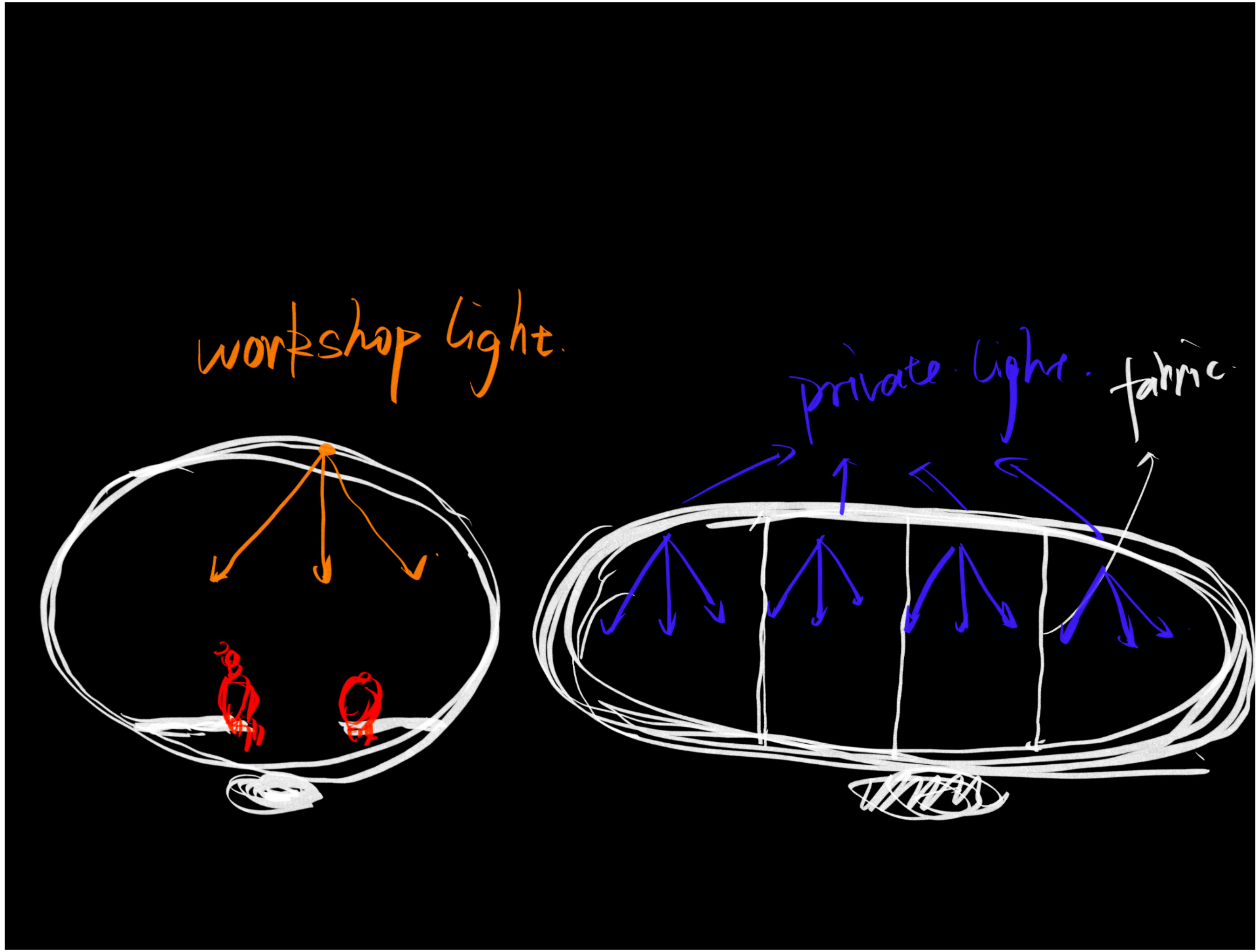
Prototype

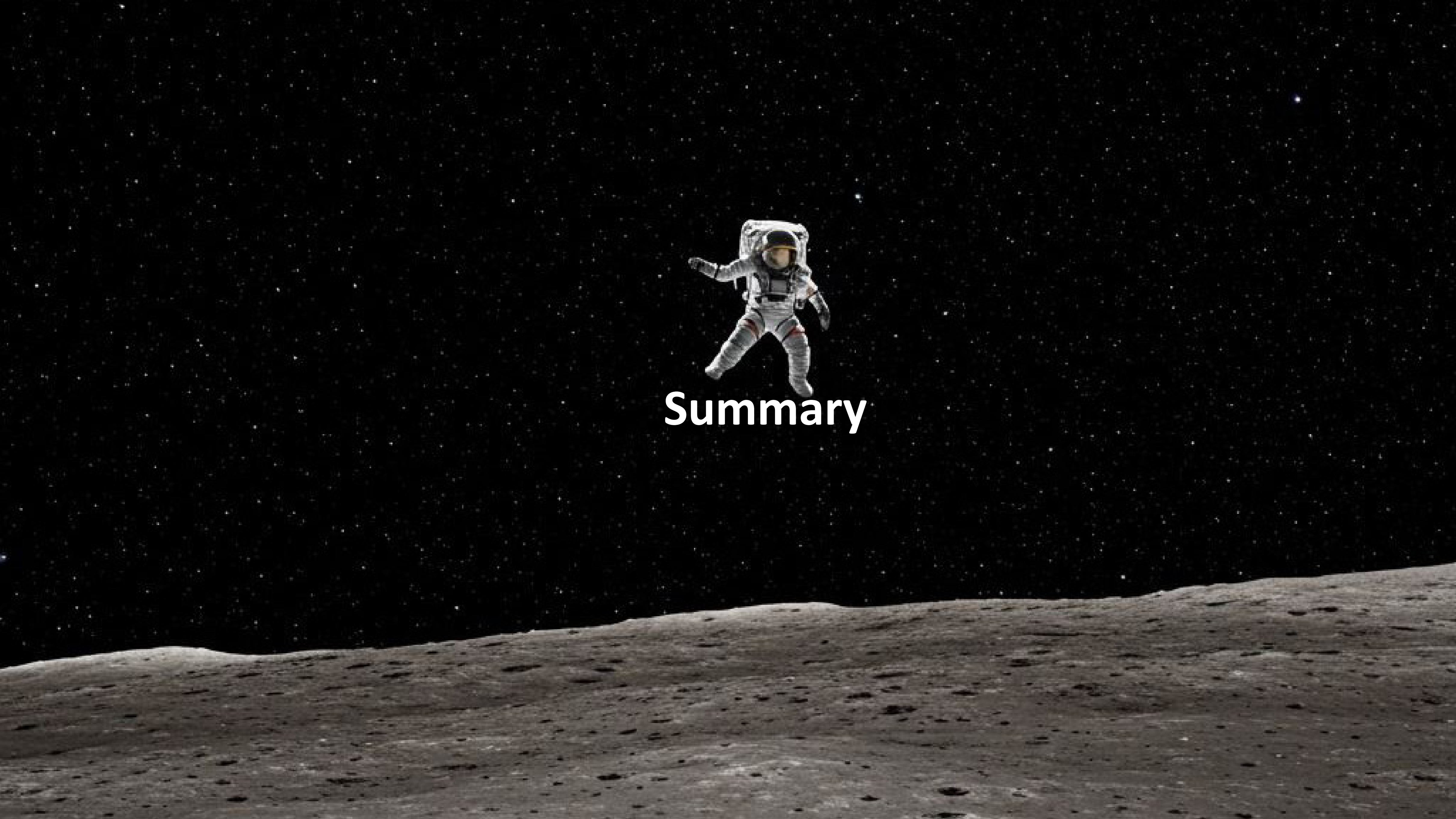

structural cable
individual air shell
rail for the Rotate System
light
sensor (camero, microphone. etc).
linking fabric
4 members habitate for 45 days

Scenerio


sleep light.
fabric
wake up light.
Rotate ME
fabric.
movie light.

Scenerio




Summary

Summary

Movement

Focused on lunar gravity movement, especially the bounce as a key spatial generator.

Identified how 1/6 g reshapes body posture, trajectory curves, and timing of motion.

Collected references from Apollo footage, parabolic flights, underwater neutral-buoyancy training, and animations to understand realistic movement patterns.

Defined the goal: map the jump arc to derive scalable spatial rules for movable architecture.

Material

Studied NASA and Bigelow inflatable habitat wall structures.

Broke down layers:

External protection (MMOD shielding, thermal blanket)

Attenuation layers (radiation, abrasion)

MLI insulation

Structural load layer (Kevlar restraint)

Internal bladders (air-holding membrane)

Clarified that air is held inside the bladder, while Kevlar restrains the pressure and defines form.

Space

Reviewed spatial requirement charts for lunar missions.

Understood the functional separation between working, living, private, and service zones.

Noted acoustic separation ("quiet / noisy") and circulation connections.

Considered 45-day mission scale, typically for 4–6 crew, requiring compact but adaptive spatial allocation.

Program

Mapped mission activities into four major categories:

Working → labs, workshop, EVA prep

Living → exercise, recreation, dining

Private → crew quarters, hygiene

Service → storage, waste, maintenance


Report

Problem statement

Long-duration lunar missions intensify psychological stress caused by confined interiors and limited privacy.

Existing rigid habitat modules cannot adapt to changing spatial needs across working, living, private, and recreational phases.

Reduced gravity (1/6 g) fundamentally alters human movement—especially jumping, posture, and spatial occupation—creating a new architectural challenge

The project aims to address how lunar-specific bodily movement can inform spatial design.

Objective and Motivation

To map 1/6 g jump movement and translate its spatial logic into a transformable architectural system.

To develop mobile and reconfigurable interior configurations that shift between collective and private spatial modes.

Relevance

Lunar bases are essential for future deep-space exploration; environmental adaptability is crucial for crew well-being

Movement-informed design remains underexplored in space architecture, presenting significant potential for new spatial methodologies.

Mid-duration missions (≈45 days) reveal urgent needs for transformable, reconfigurable habitats.

The work contributes to both architectural innovation and knowledge production in extreme-environment design.

Research and Design question

Main question
How can 1/6 g human movement—particularly jumping trajectories—generate a transformable architectural system for mid-duration lunar missions?

Sub-questions
How can movement curves be transformed into architectural scales, deformation strategies, and spatial thresholds?

Method

Literature review: lunar biomechanics, reduced-gravity movement, inflatable habitat technologies, materials.

Video and motion analysis: Apollo EVA footage, NASA NBL underwater training, parabolic flight 1/6 g simulations.

Movement mapping: extracting jump trajectories (height, displacement, posture shifts).

Computational modeling: Grasshopper simulations for motion-based geometric generation.

Physical prototyping: foldable and inflatable structural models to test adaptability.

Theoretical framework

Lunar biomechanics: reduced-gravity locomotion, neutral body posture changes, load distribution.

Habitability psychology: privacy gradients, crowding, mission rhythm, shared-space stress.

Adaptive architecture: kinetic structures, mobile systems, reconfigurable envelopes.

Inflatable habitat precedent research: TransHab, BEAM, Sierra Space LIFE Habitat.

Scope

Location: Lunar surface (Artemis mission context).

Duration: 45-day mid-duration mission.

Crew size: 4–6 astronauts.

Programme: Working, living, private areas, service facilities, and movement-based recreational space.

Exclusions: Large-scale settlement planning, ISRU systems, energy and infrastructure engineering

Schematic planning

Space protoyope: Finalize the prototype untill 19 Dec

Computatioanal modeling: 26 Dec

Assumed Me system: Finalize the digital Me system 31 Dec

Reference

NASA. (2016). Extravehicular Activity (EVA) Overview. NASA Human Spaceflight Documentation. https://www.nasa.gov

NASA. (2020). Neutral Buoyancy Laboratory (NBL) operations overview. NASA Johnson Space Center.

Chiang, Y.-C., Bier, H., & Mostafavi, S. (2018). Design to robotic assembly: An exploration in stacking. Frontiers in Digital Humanities, 5, 23. https://doi.org/10.3389/fdigh.2018.00023

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