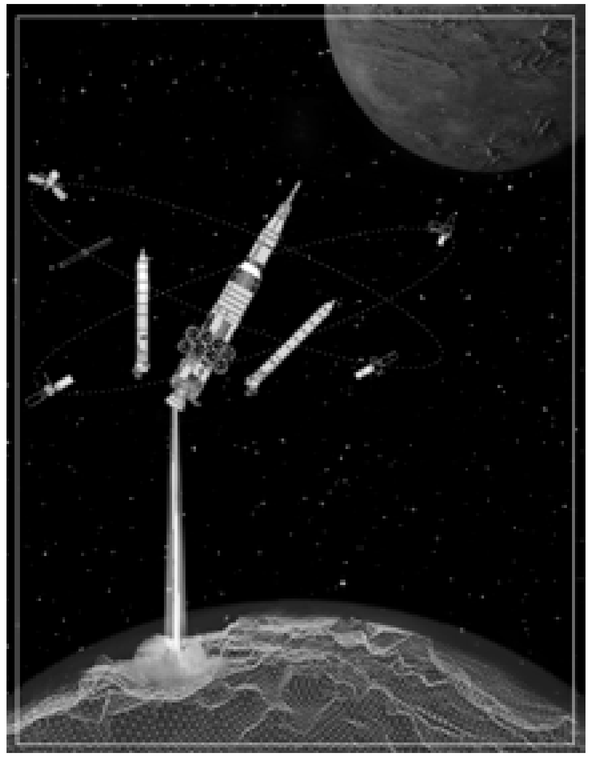
EXTREME HABITATION: ON THE HIGHER FRONTIER

A Guide on Symbiotic Habitat with Regenerative Life Support System



Mankind is by nature inquisitive and driven to explore the unknown, expand new frontiers, and advance scientific and technical limits through our own ingenuity. We belong to a long continuum of human progress perpetuated by the desire to innovate and adapt to changing habitats. In anticipation of making humanity multi-planetary, NASA has been challenged to develop infrastructure and technology that supports human habitation beyond Earth's protective atmosphere and resources. NASA's ARTEMIS mission and the Mars 2020 Perseverance Rover were tasked to survey the climate and geology on Mars in preparation for the next great leap in human space exploration, the Martian habitat. Yet, the current design for space colonization is confined to prioritizing practical needs with maximum efficiency while lacking consideration for spatial experiences. In search of an opportunity for the long-term survival of human civilization, habitation on the higher frontier demands a critical re-evaluation of existing standards for extraterrestrial living.

The development of space colonization could lead to advancements in architectural design, discovering alternative integration of ecology into the regenerative life support system, and furthermore developing technocentric resiliency strategies that are essential for human survival. To say mankind will one day inhabit Mars is to challenge architecture's ability to contend with extreme surface conditions like oxygen-less air, extreme cold, and high radiation levels. This thesis reimagines the Mars habitat through the design of mobile architecture, which resembles the human drive for exploration while allowing architects to explore new potentials of enclosed habitable spaces, supporting mankind's survival in the most hostile conditions of space.

EXTREME HABITATION: ON THE HIGHER FRONTIER

A Guide on Symbiotic Habitat with Regenerative Life Support System

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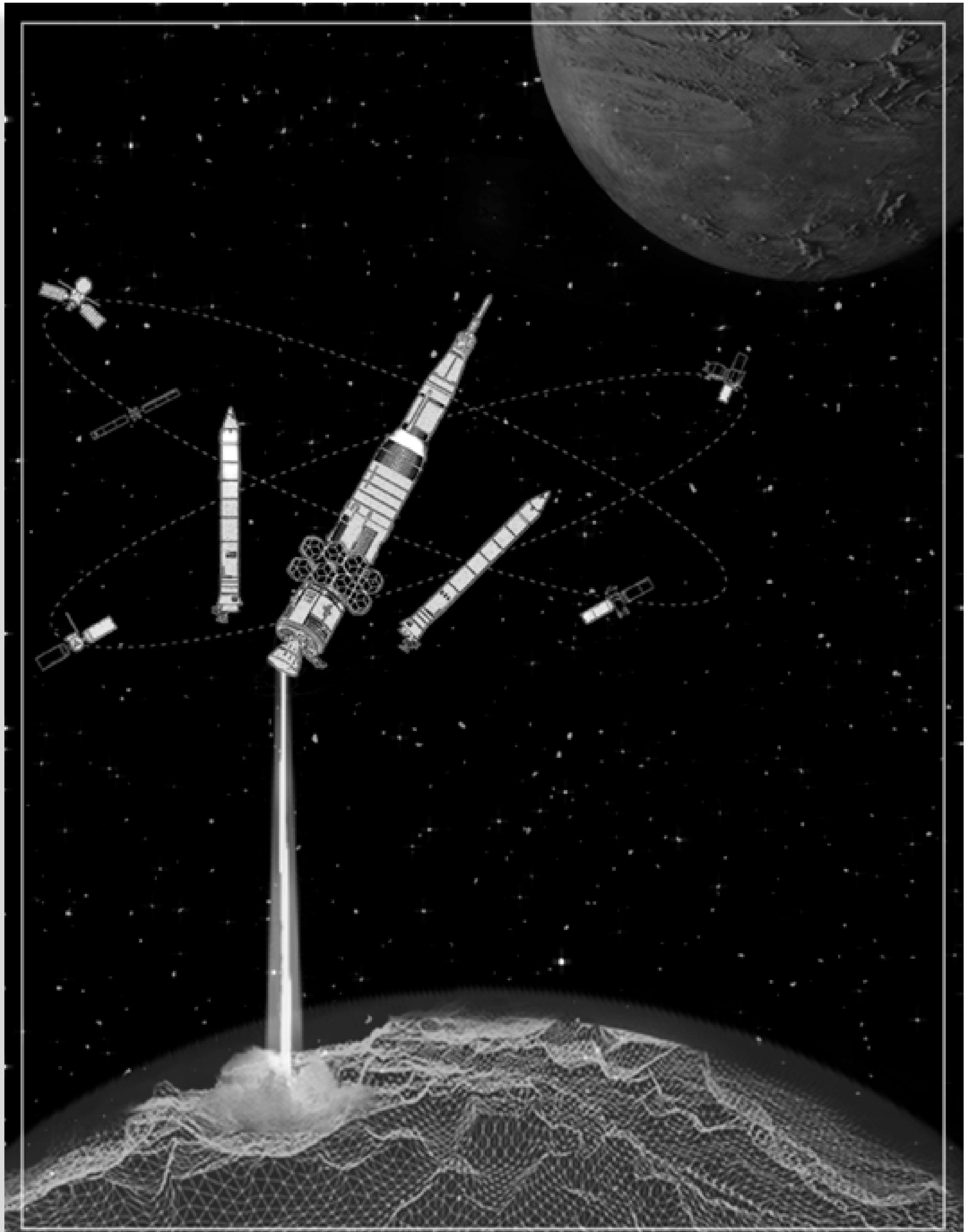
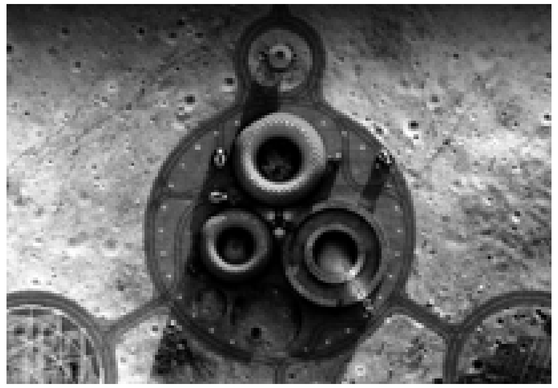
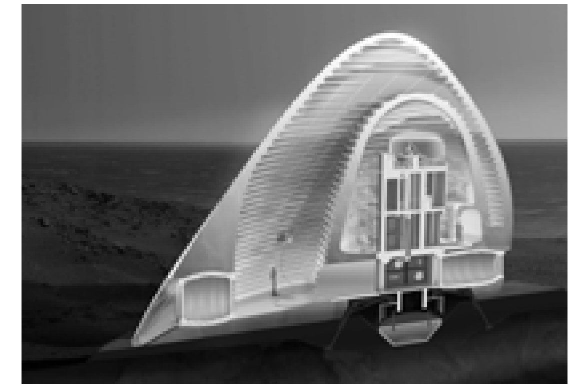
CONTENTS

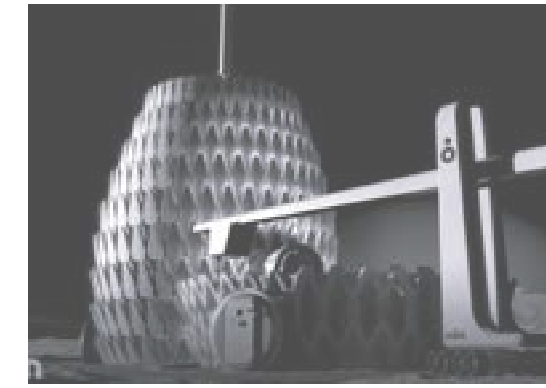


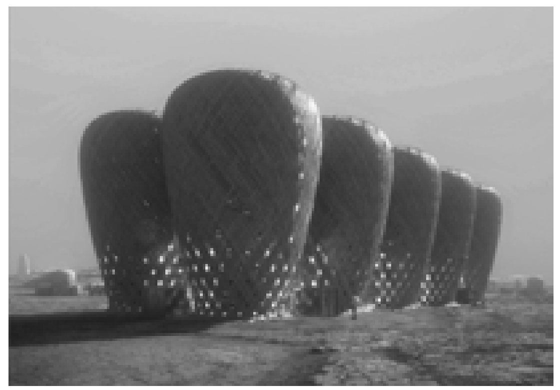
01 LIVING IN THE FUTURE:

Why the Higher Frontier?
Why Mars?



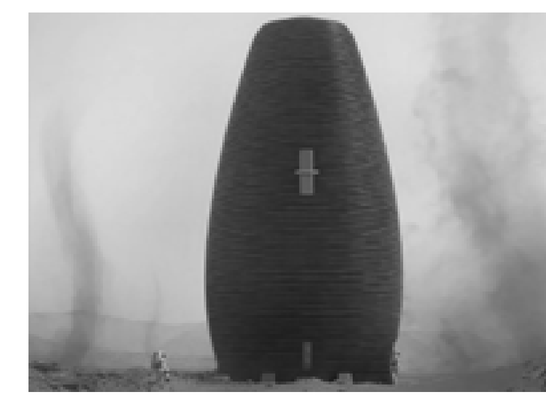


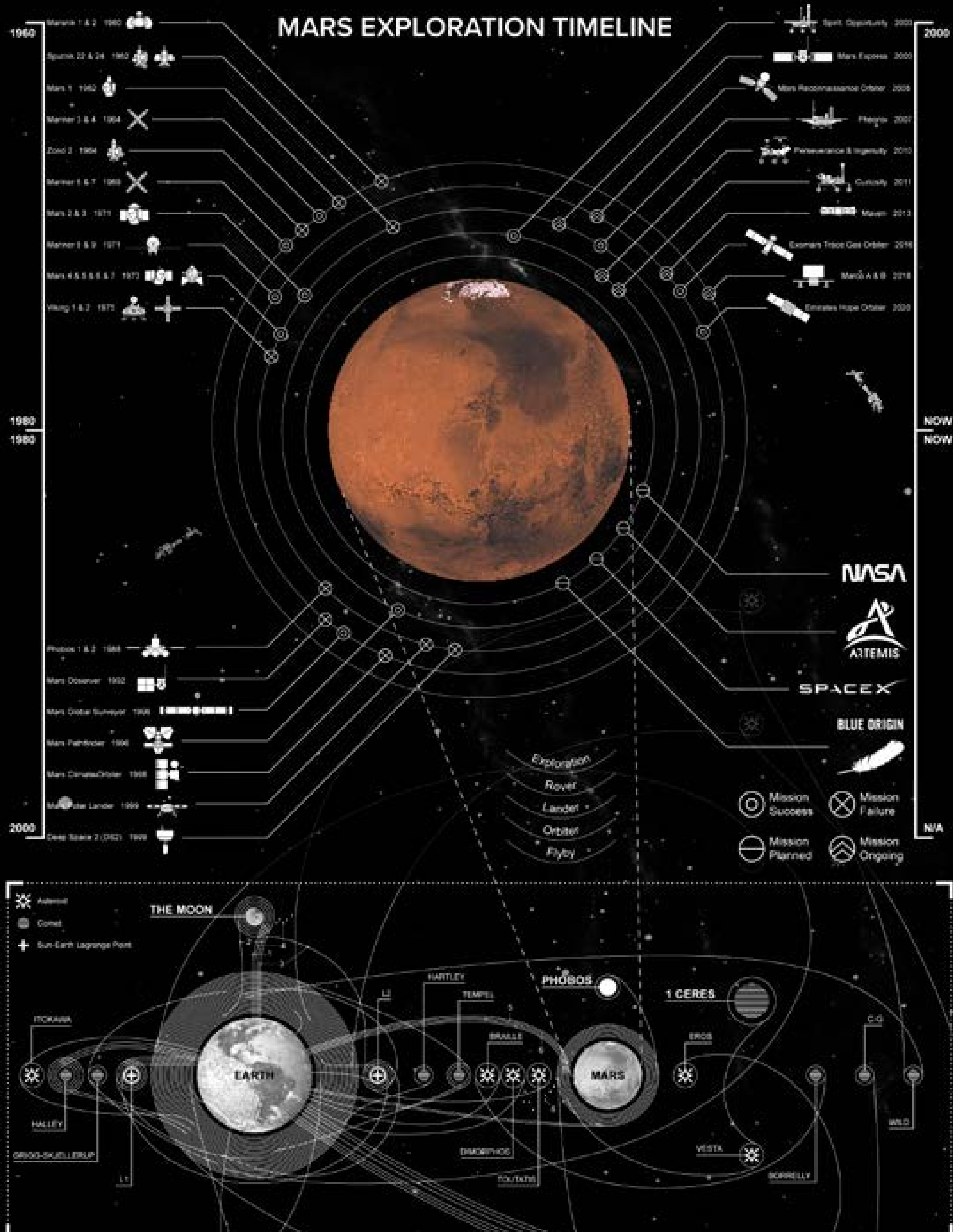


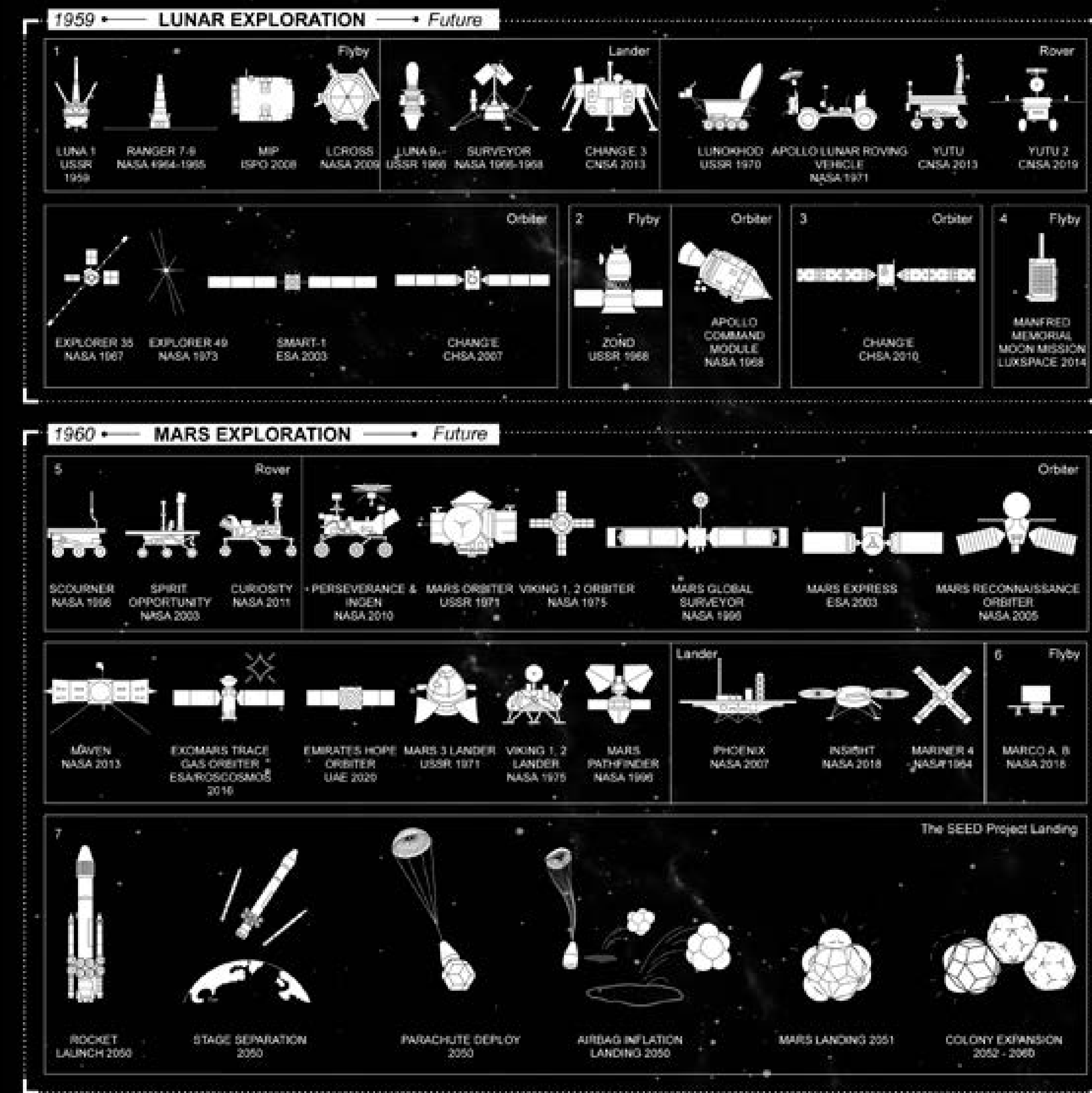


"LIFE CAN'T JUST BE ABOUT SOLVING PROBLEMS, THERE HAVE TO BE THINGS THAT INSPIRE YOU, THAT MOVE YOUR HEART. WHEN YOU WAKE UP IN THE MORNING, YOU'RE EXCITED ABOUT THE FUTURE."

- ELON MUSK







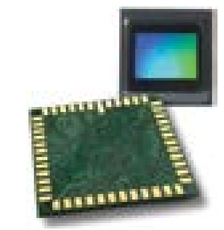
"The goal of the Mars Exploration Program is to explore Mars and to provide a continuous flow of scientific information and discovery through a carefully selected series of robotic orbiters, landers and mobile laboratories interconnected by a high-bandwidth Mars/Earth communications network."

- NASA Mars Exploration

Space Race & Benefits :

Given the unique site we are designing on, the unfamiliar conditions challenge us to conduct extensive background research regarding its condition and the existing aerospace technologies in practice. Currently, there is plenty of news on the ongoing reheated space race. From the initiative of Jeff Bezo's Blue Origins, which was founded with a vision of millions of people living and working in space to extract unlimited resources for Earth, or the revolutionary breakthroughs of Elon Musk's SpaceX, which focuses on making humanity multi-planetary. Space colonization has been a heated topic more than before. Musks declared his vision for a self-sustained city on Mars during the International Astronautical Congress presentation in 2017. For interplanetary civilization to thrive, energy must become regenerative to lower the transportation costs and labor in resource mining. Our thesis will build on the existing premise of technology but furthermore extend on the research of a self-regenerative system. In other words, we will design a regenerative biosphere that can be applied on human habitation scale to aid mankind's survival in extreme conditions.

Keywords: space architecture, extreme environment, sustainable structure



Microchips

Portable Computer

Photocatalytic Oxidation Chamber

Vibration Dampening Tool

Biomass Production Chamber

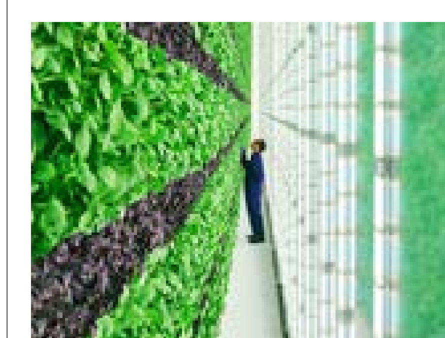
NASA's Technology

Mobile Devices / Cell Phone

Laptop

Air Purifier

Base Vibration Isolator



Vertical Farm / Green Wall

Earth's Technology

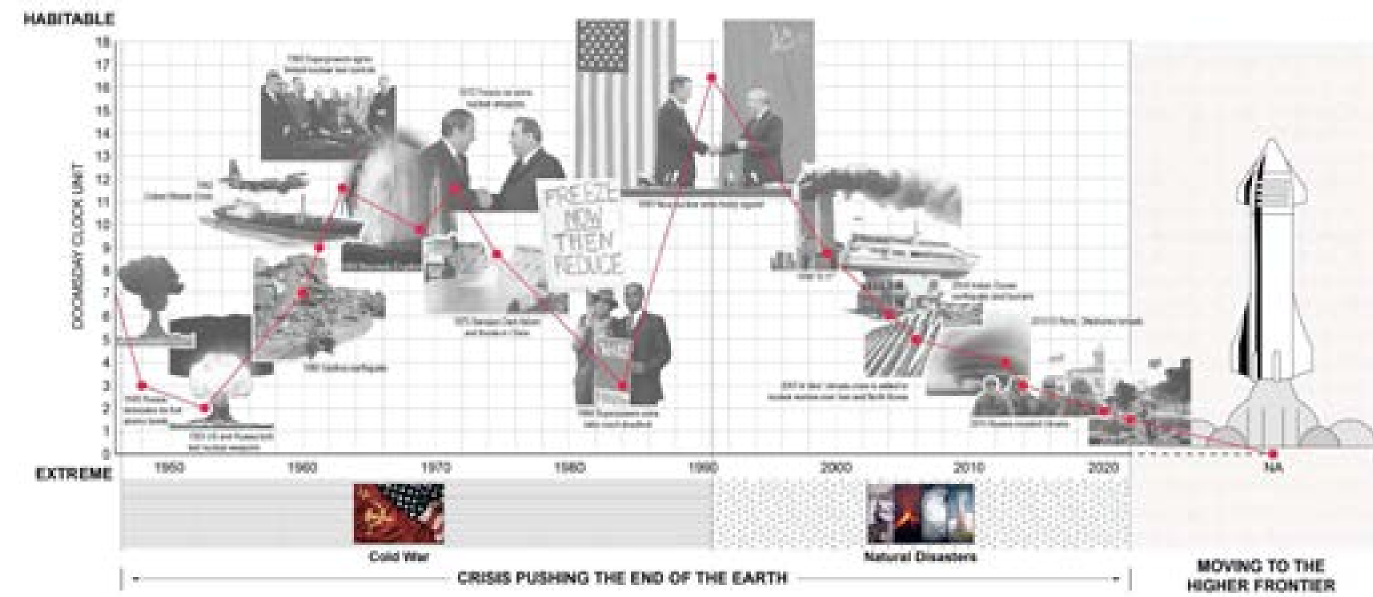
Deep Space Depression:

Yet, the current design for space colonization is confined to prioritizing practical needs with maximum efficiency while lacking consideration for spatial experiences. The prioritization of function often led the astronauts to challenges like deep space depression and lack of resources. In search of an opportunity for the long-term survival of human civilization, habitation on the higher frontier demands a critical re-evaluation of existing standards for extraterrestrial living.

Why the Higher Frontier ?

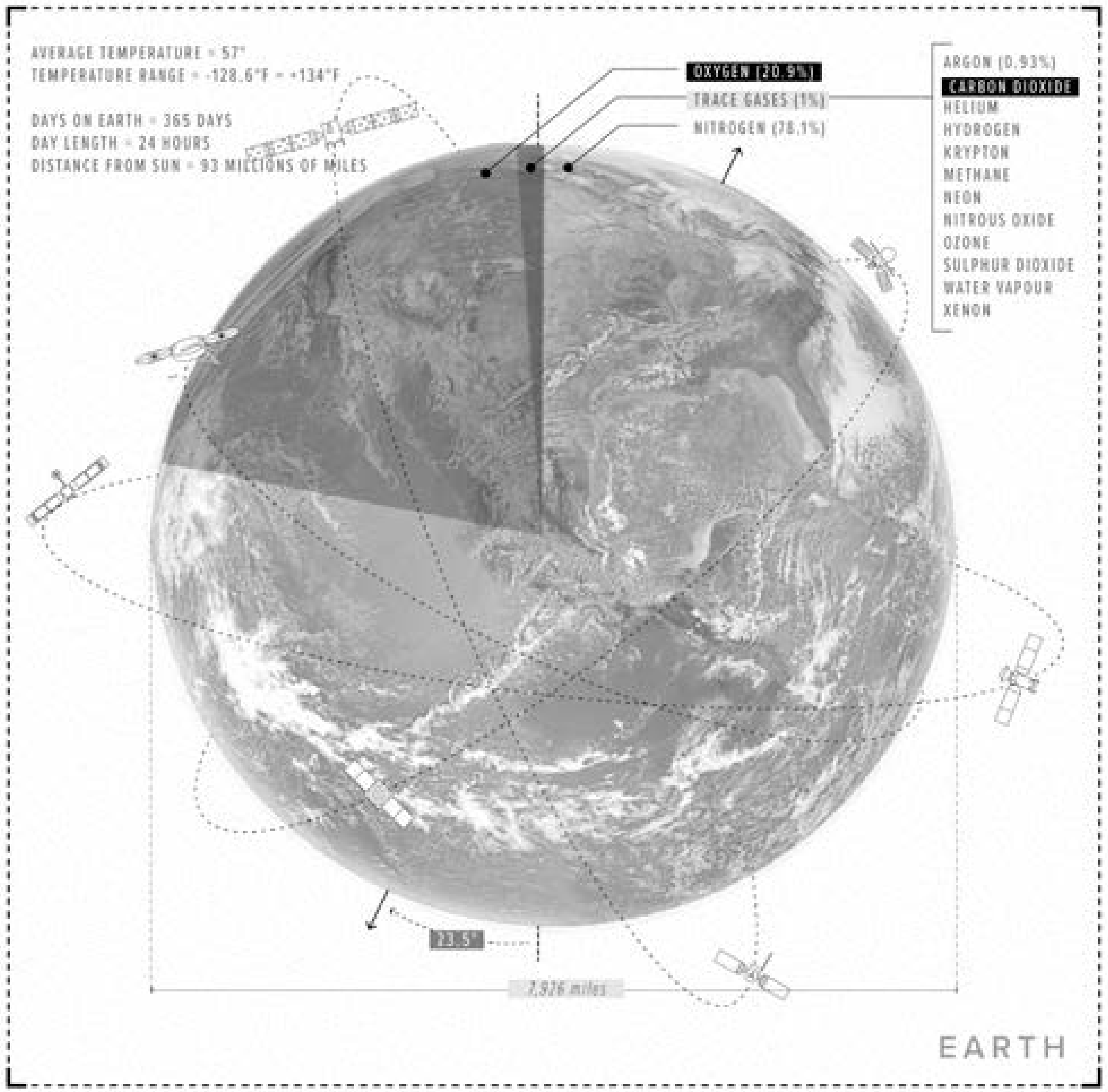
Research shows that 85% of the world's population lives in areas affected by climate change. The escalating level of warming would lead to deadly weather disasters, food scarcity, water shortages, and eventually catastrophic ecosystem collapse. Therefore, it is urgent for mankind to live with less dependence on the surrounding environment and be more reliant on oneself and technology for survival. Given the numerous extreme sites where human survival has been challenged, the more ambitious testing ground lies above and beyond in outer space.

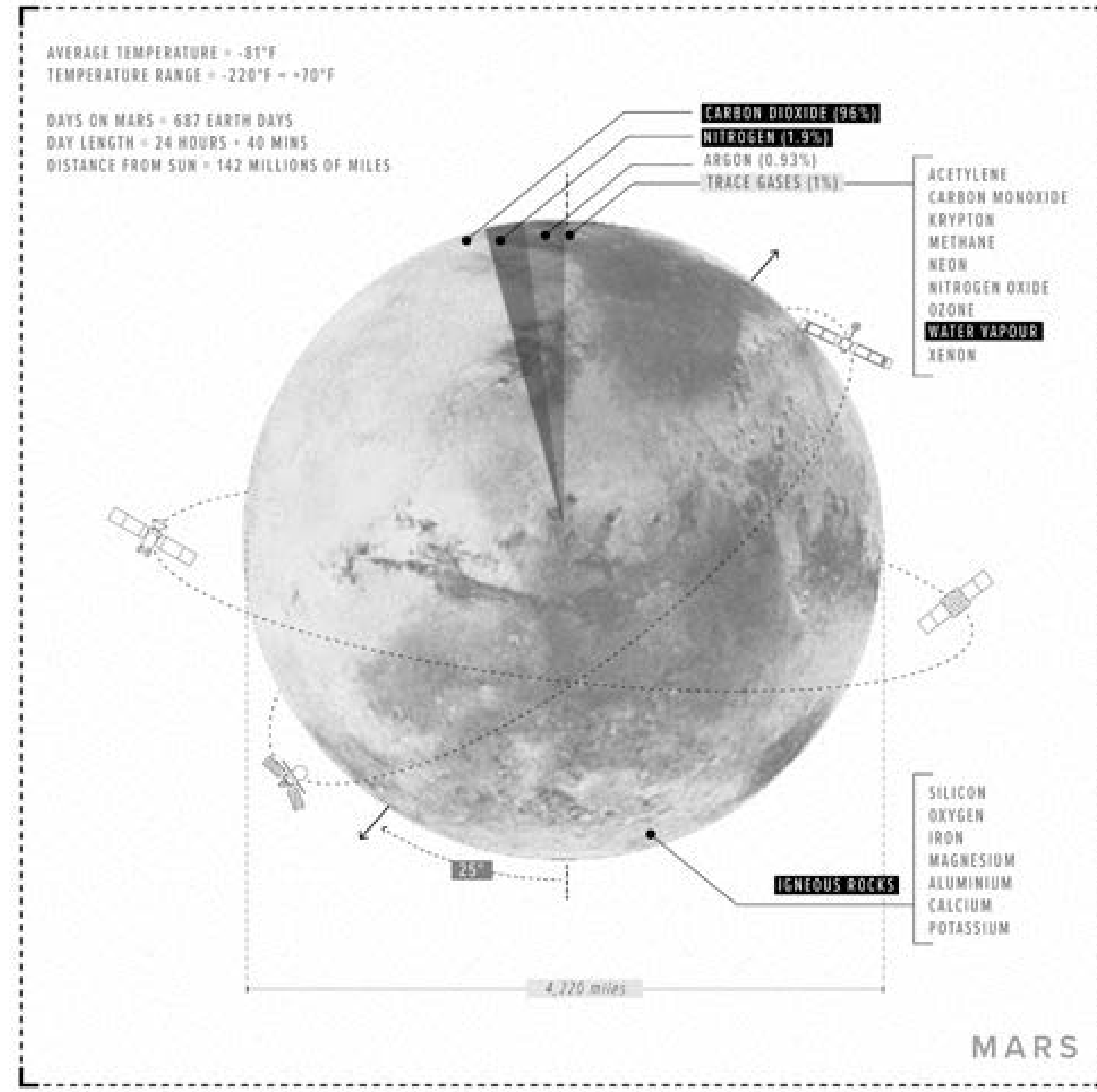
By selecting Mars to be our intervention site, we value its naturally inhabitable environment as an opportunity to best challenge mankind's ability to survive independently from extreme restriction of resources. By establishing a prototype of the "machine of living", it is foreseeable that it can be deployed to conquer any extreme environment on Earth.

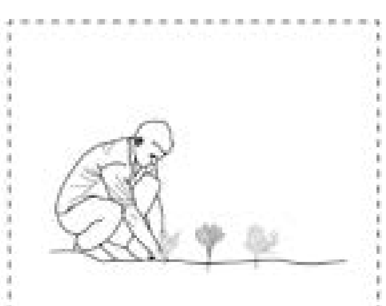


The Doomsday Countdown Clock

EARTH vs. MARS

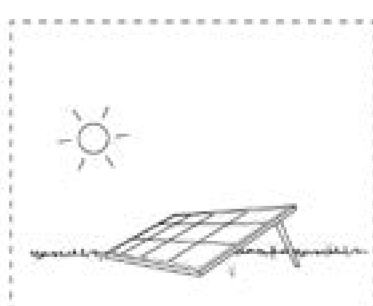






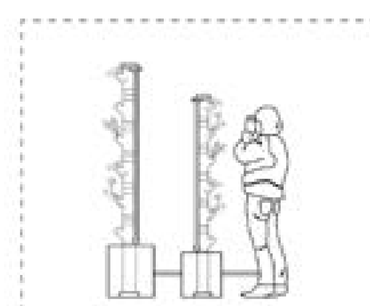
TRADITIONAL FARMING

- LABOUR INTENSIVE
- TRADITIONAL TOOLS
- WEATHER DEPENDENCY
- ORGANIC FERTILIZER



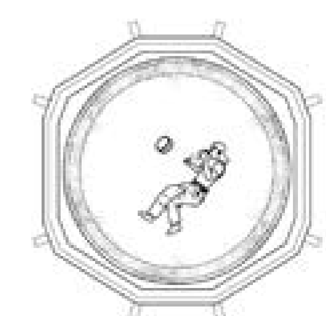
PHOTOVOLTAIC FARMS

- SOLAR POWER STATION
- ELECTRICITY MINING
- LARGE PRODUCTION
- CLEAN ENERGY SOURCE
- NO POLLUTION
- NO WEATHER DEPENDENCY



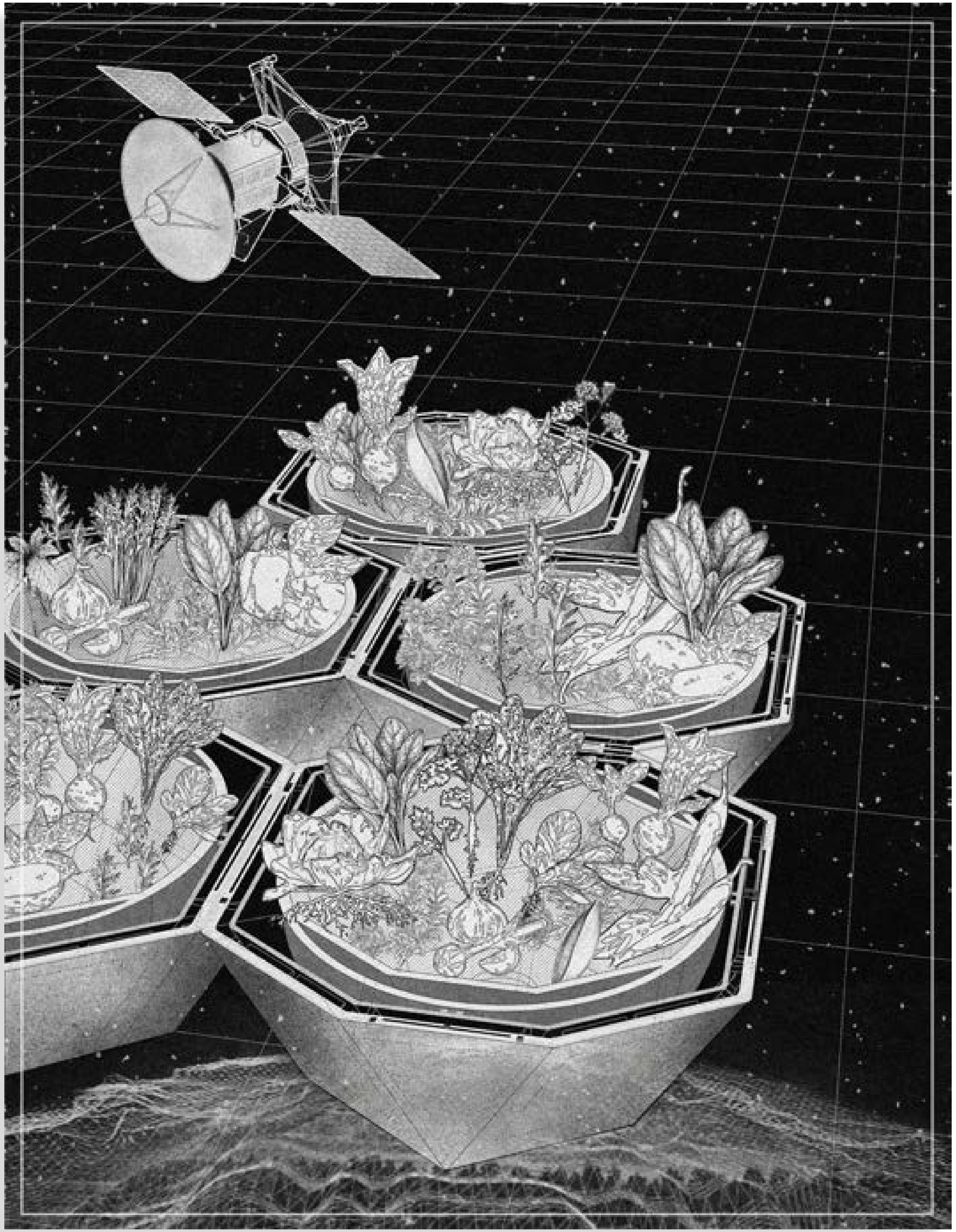
AEROPONIC PLANTING

- 98% LESS LANDUSE
- YEAR-ROUND PRODUCTION
- 95% LESS WATER
- CLOSED-LOOP SYSTEM
- AUTONOMOUS
- SCALABLE SYSTEMS



INTEGRATED FARMING

- AUTONOMOUS
- SEMI-CLOSED LOOP
- REGENERATIVE SYSTEM
- OXYGEN/FOOD SOURCE
- ENHANCED PRODUCTION
- FILTRATION SYSTEM

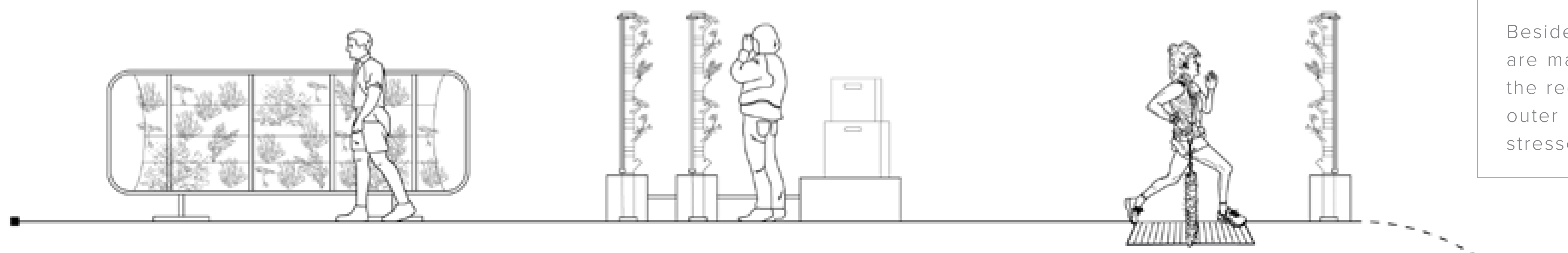


02 INTEGRATED ECOLOGY SYSTEM

Earthly Aesthetic, Nurturing & Psychological Impact, Air Quality: Photosynthesis, Food Source and Consumption, Biological study, Experiment: Interactive Plants, Biofilters: Filtration & Purification, **Growing Green on the Red Planet**

What are plants' role in space ecology?

Besides from consuming plants as food, there are many other ways for plants to contribute to the regenerative life cycle system. Especially in outer space, plants can leviate psychological stresses.



A. AESTHETIC

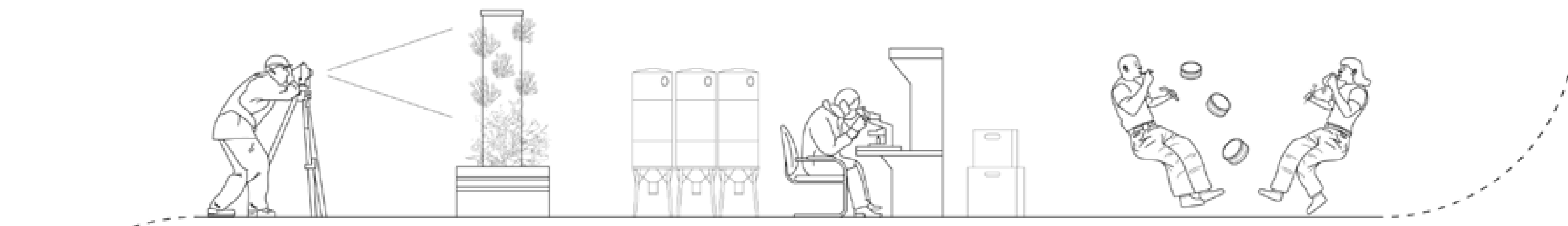
Green wall can mitigate air pollution levels by lowering extreme solar radiation and temperature through photosynthesis, trapping particulate matter, and capturing gases.

B. NURTURING

Aeroponic planting maximizes nutrient absorption while putting less stress on the plant, leading to healthier produce and with higher nutritional value.

C. AIR QUALITY

Plants can absorbs sunlight, water, and carbon dioxide to produce oxygen as a byproduct, which can enhance indoor air quality.



F. EXPERIMENT

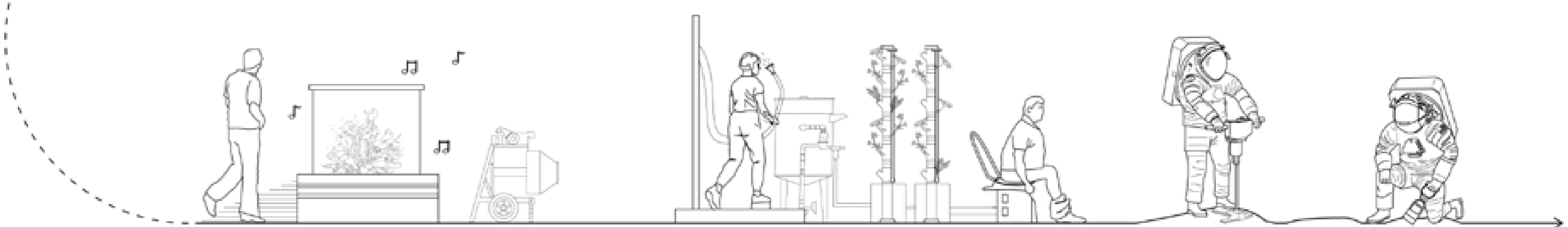
Scientists can experiment with plants through different lighting vs. growth.

E. EXAMINE

Astronaut can study the leaves, roots, soil, and associated microorganisms of plants to contribute on-going aerospace research.

D. CONSUME

Plants are major contributors for regenerative life system as food and nutrient intake.



G. ENTERTAINMENT

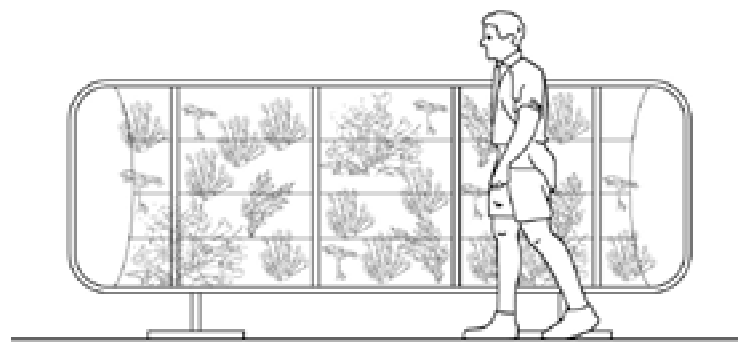
Plants can be further designed to interact with humans through different senses like touch, hear, and smell.

H. FILTRATION

Water can be recycled from shower/kitchen and be filtered and be used for irrigation and then be re-used in toilet as graywater.

I. FERTILIZING MARS

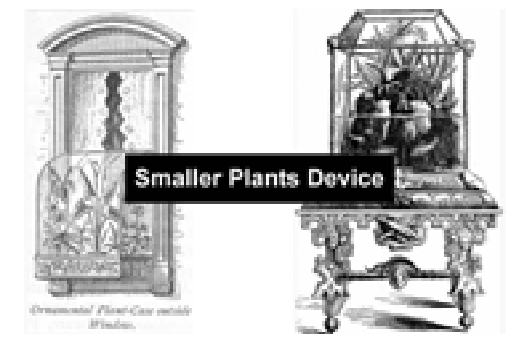
Scientists can monitor the growth of aeroponic plants for better usage in a regenerative life support system.

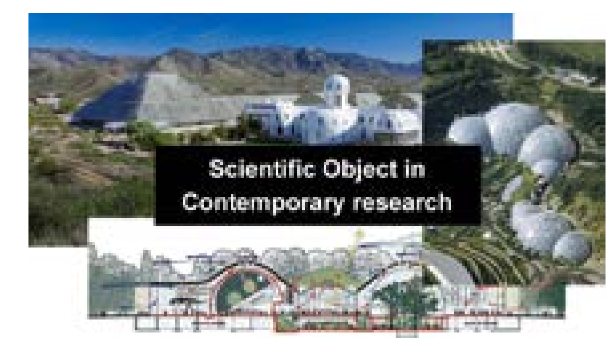


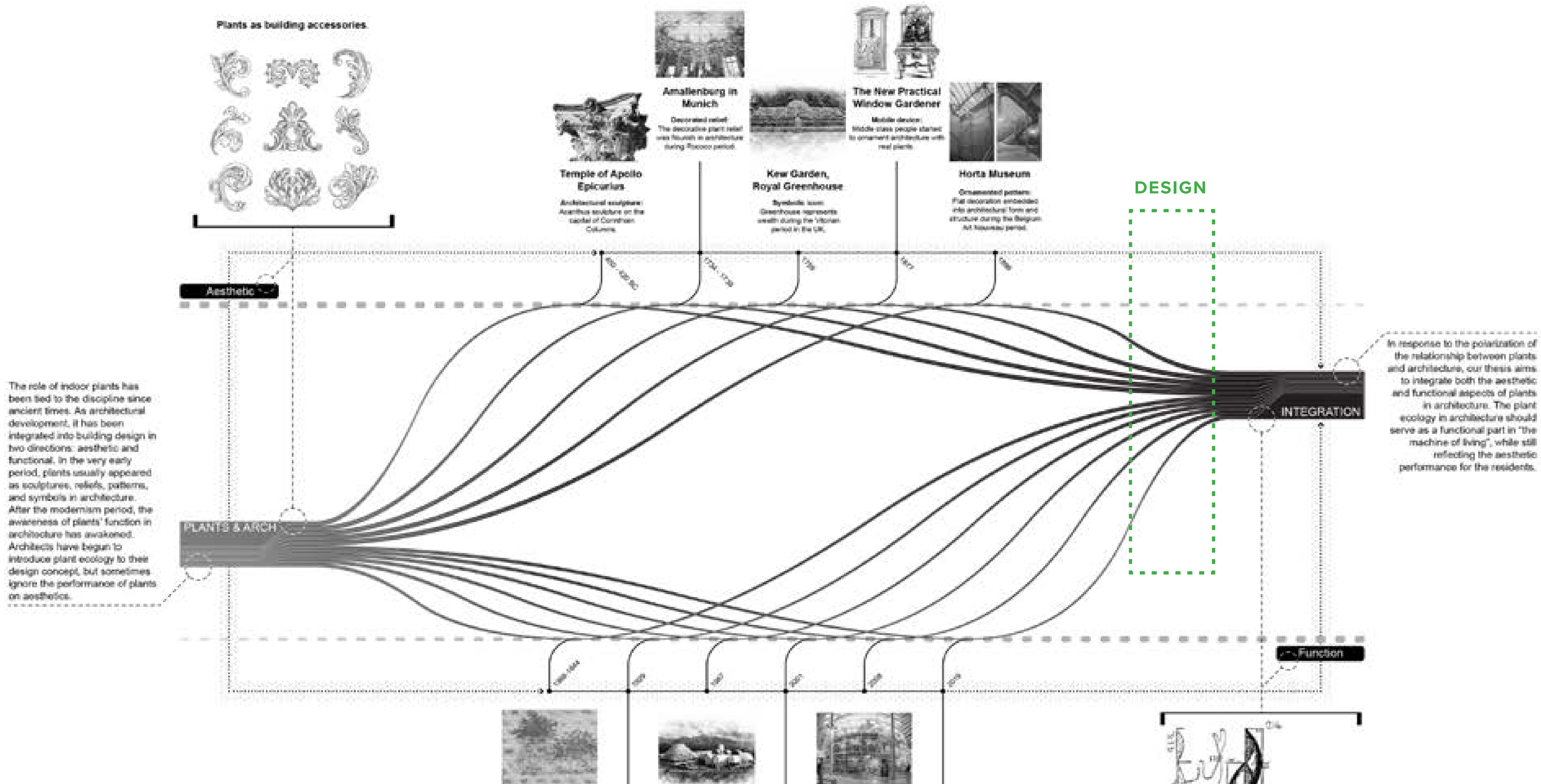
A. EARTHLY AESTHETIC

HISTORY OF PLANTS IN ARCHITECTURE

The role of indoor plants has been tied to the discipline since ancient times. The role has been transformed from an architectural pattern like the acanthus on the Corinthian column to a symbolic icon in the greenhouse representing wealth during the Victorian period in the UK. It was later applied as an ornament embedded into architectural form and structure during the Belgian Art Nouveau in the early modern period, but it has been utilized as a performative character to enrich the interior space since modern architecture. With the imagination for plants to actively interact with humans through the advanced technological mechanism, in this thesis we are extending the role of indoor plants to a technological device that produces an adjustable relationship with humans.

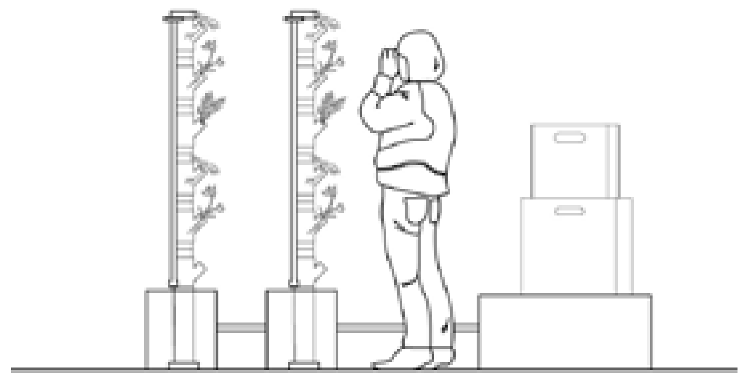






Unifying Aesthetics and Function: The Role of Plants in Space Architecture

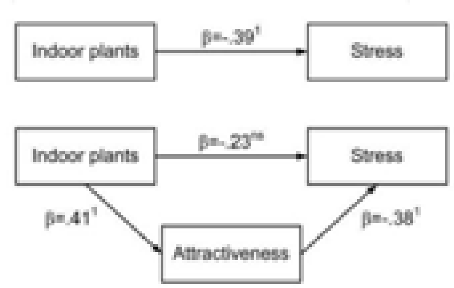
Throughout history, plants have played a significant role in architecture, often serving two distinct purposes: aesthetic and functional. As an aesthetic element, plants have been used as building accessories to enhance the visual appeal of structures. On the other hand, plants have also been utilized as experimental subjects due to their ability to produce oxygen, contributing to the function of a building's natural ventilation system. This bifurcation between the two roles has resulted in plants being viewed as either ornamental or practical, depending on their use within the context of a particular architectural design. This thesis seeks to unify the split between the two roles while integrating plants as a cohesive element that simultaneously serves both functions in the space.

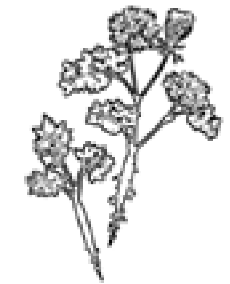


B. NURTURING & PSYCHOLOGICAL IMPACT

Plant As Psychological Needs

For another reason, plants can also act as a psychological mitigation for people during the long-term space traveling. In our experience and scientific reports, enclosed interior such as office and space capsule would cause potential mental stress for people who are inhabiting inside. Introducing plant ecology to such an environment can benefit to stress releasing and provide an Earthly presence for the space crews. In consequence, their efficiency and productivity would be drastically enhanced in the environment with well-integrated plant ecology.



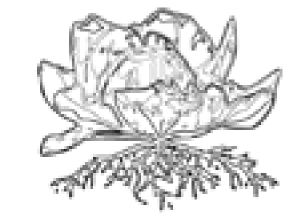


1. CARROT

Prevent oxidative damage in the brain, which slow the onset of various mental disorders.

2. HEBE

Help reduce depression, anxiety and stress, and improves mood.

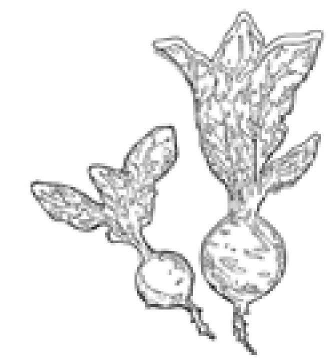


3. LETTUCE

The anxiolytic properties that help to control anxiety and depression.

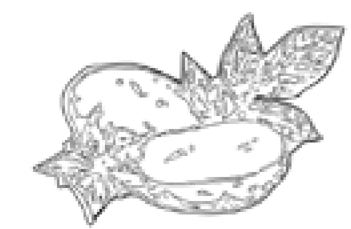
4. PAPRIKA

It produces melatonin and enhances the body's serotonin and norepinephrine.



5. RADISH

Radishes are rich in antioxidants and help reduce blood pressure and anxiety

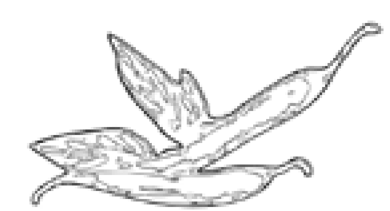


6. POTATO

"mood-boosting comfort food"/ It can help the brain to rebuild and restore serotonin levels.

7. GARLIC

They can ward off symptoms associated with insomnia, fatigue, and anxiety.

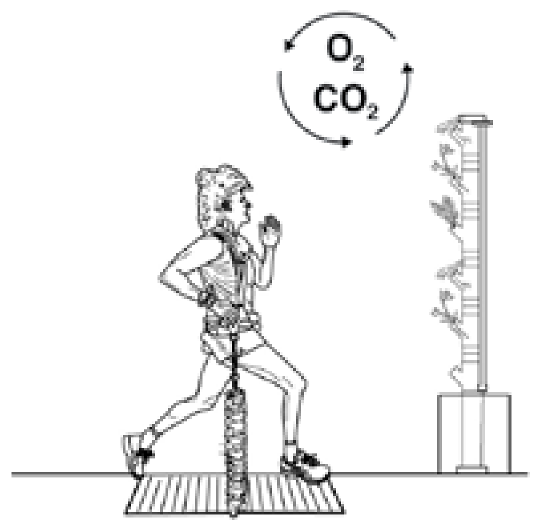


8. CHILI

Spice may boost the level of two chemicals endorphins, which can become painkillers, serotinin.

9. SPINACH

It is rich in folate and magnesium, which help reduce stress and increase focus.



C. AIR QUALITY: MAXIMIZE PHOTOSYNTHESIS

The goal for high oxygen productivity is to maximize photosynthesis while minimizing respiration. The process of photosynthesis occurs when plants use the energy from light to convert CO2 and water into sugars and oxygen. To increase photosynthesis means to increase plant's growth, leading to thicker stems, faster rooting, and more productivity with flowers and fruits. Photosynthesis activate radiation occurs with wavelengths between 400 and 700 nm. For many plants, for every 10% increase in light, there is a 7 to 10% increase in growth. More carbon dioxide (to 800- to 1,000-ppm) also increases photosynthesis, thus growth.

01 LIGHT

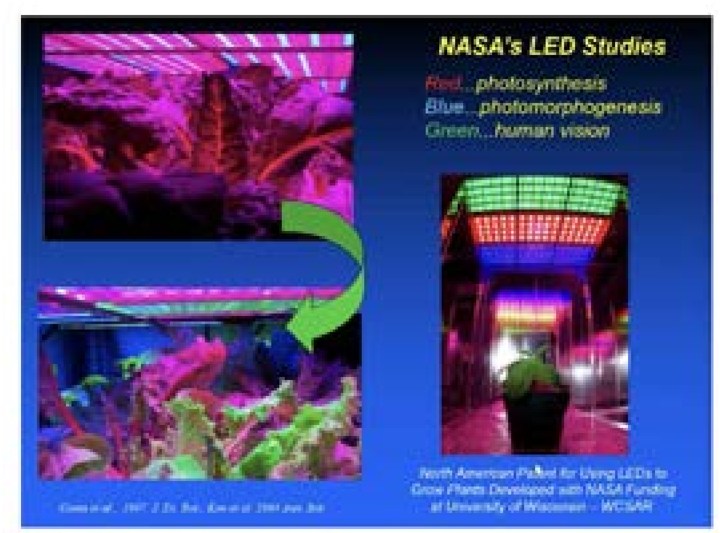
02 CARBON DIOXIDE

03 OXYGEN

04 WATER

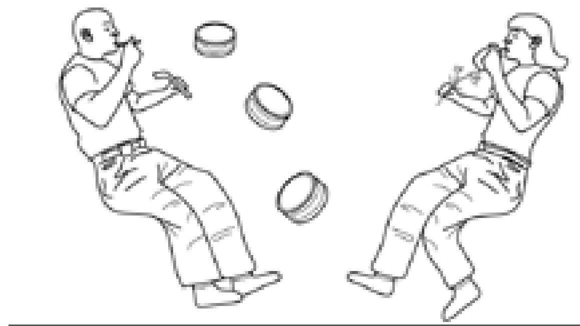
05 TEMPERATURE

06 NUTRIENTS



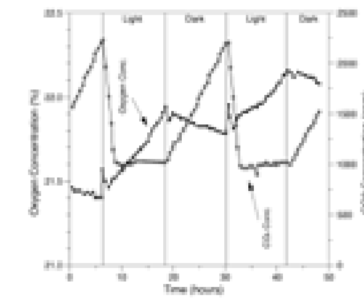
HIGH YIELDS FROM DIFFERENT LIGHT COLORS

HIGH YIELDS FROM HIGH LIGHT AND CO2 ENRICHEMENT



D. FOOD SOURCE AND CONSUMPTION

One of the inherent functions of plants is their ability to produce energy needed to survive. Since the Bion satellites, Launched in 1973 by NASA, s series of scientific research has been done in outer space, proving the possibility and advantage to cultivate plants for food resource with low gravity and artificial environmental setting. There is also an envision to achieve self-supplement in space habitat with aerospace cultivation of specific plants species by valuing their nutrition containment.

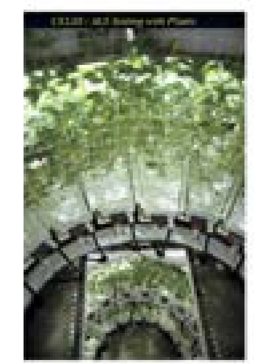


Plants Production Equation

How many sqft of plants are needed for two people?

How many panels needed?

= 100-200 sqft
= 200-400 sqft
= 40 sqft
= * 5-10

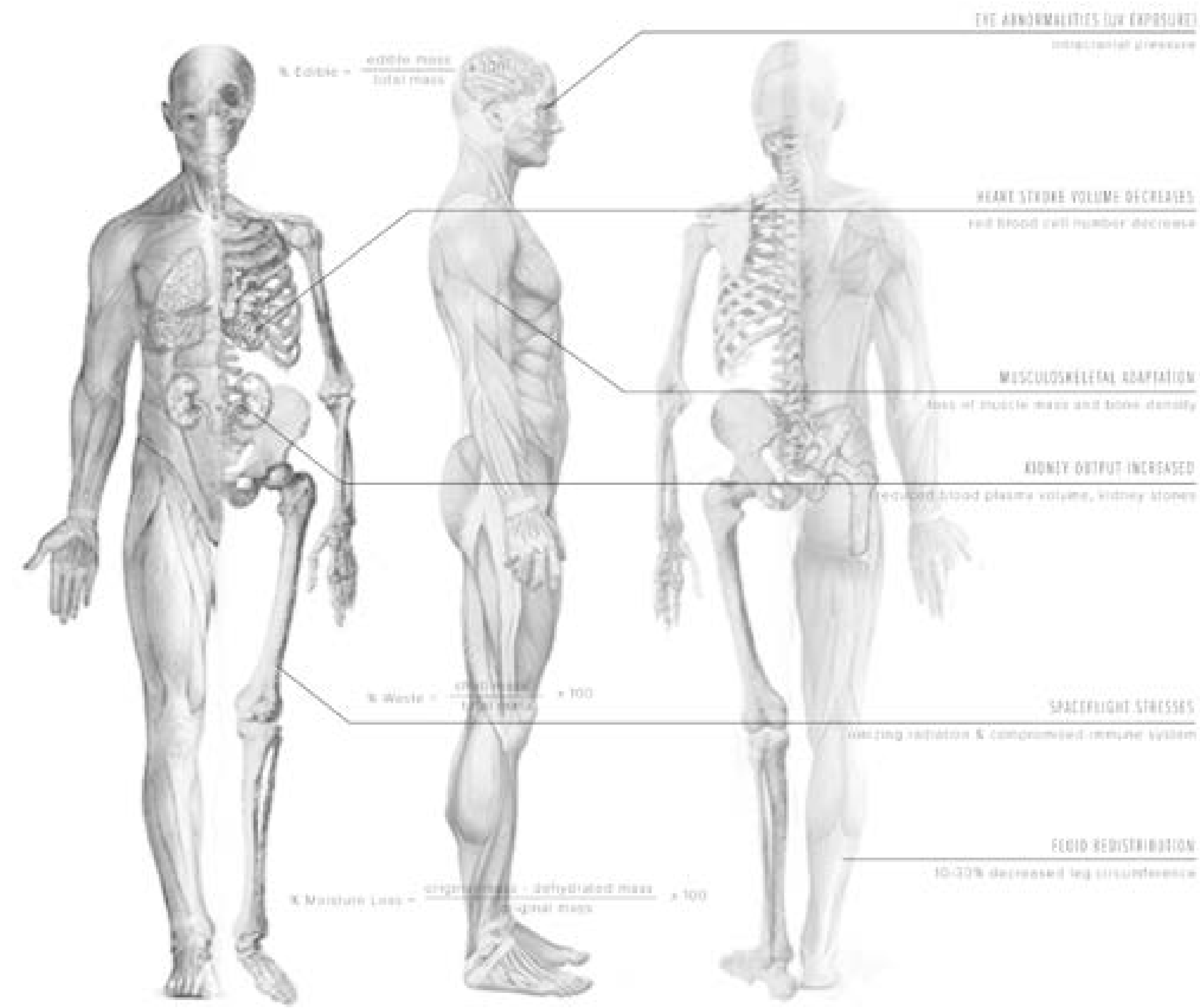


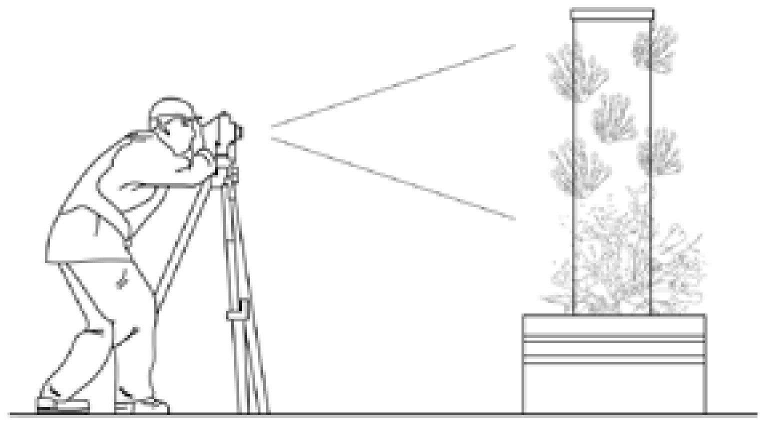
Plant As Food Source

One of the inherent functions of plants is their ability to produce energy needed to survive. Since the Bion satellites, Launched in 1973 by NASA, s series of scientific research has been done in outer space, proving the possibility and advantage to cultivate plants for food resource with low gravity and artificial environmental setting. There is also an envision to achieve self-supplement in space habitat with aerospace cultivation of specific plants species by valuing their nutrition containment.

E. EXAMINATION: SPACE BIOLOGY

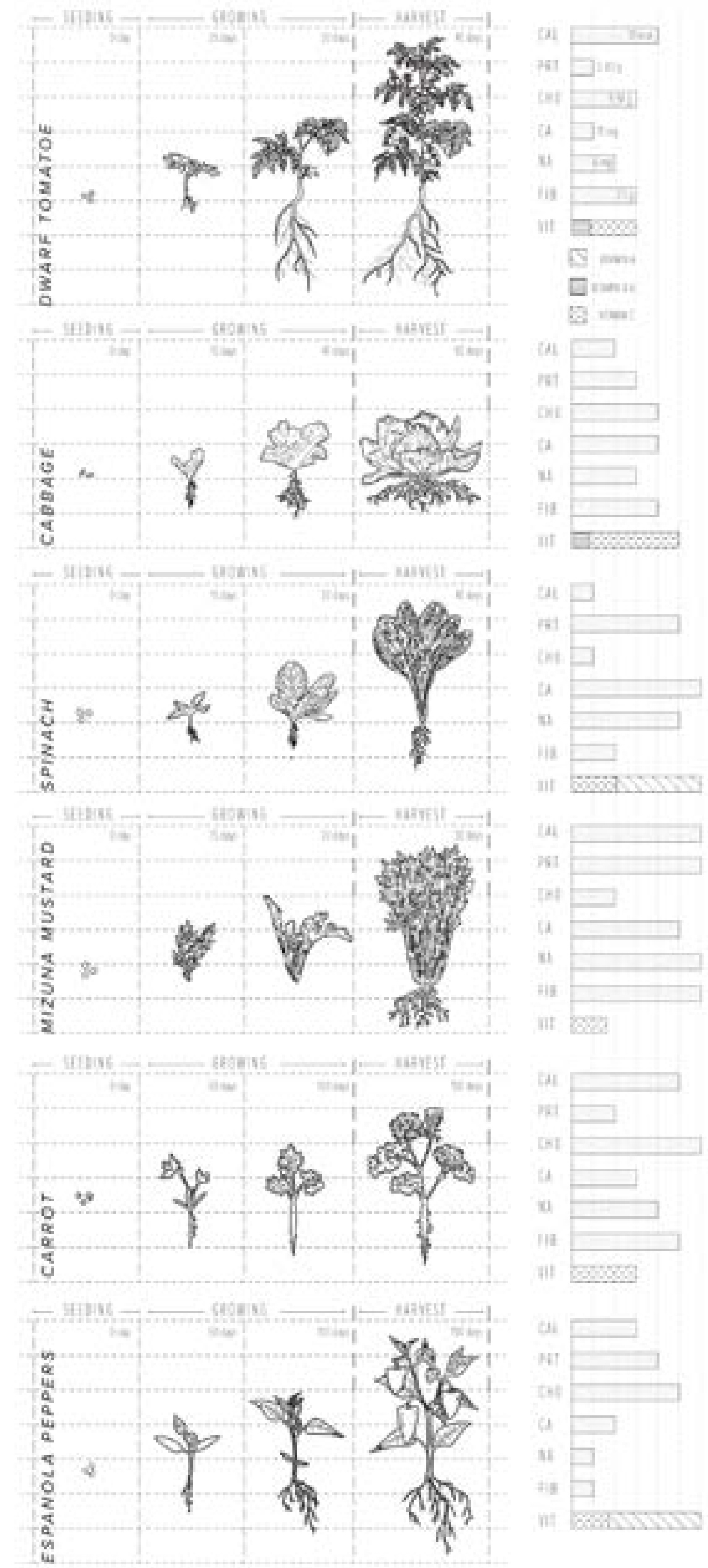
Human body are often challenged with deformation and loss of bone density in long-term deep space travel, the consumption of selected plants in addition to vitamins may potentially lighten the impact.

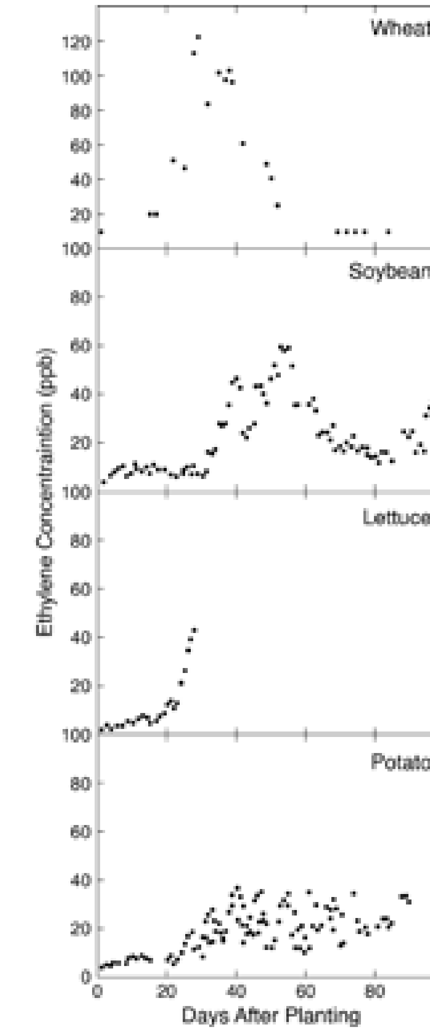


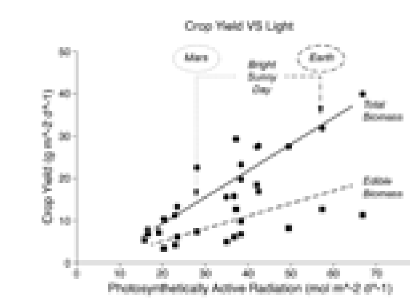


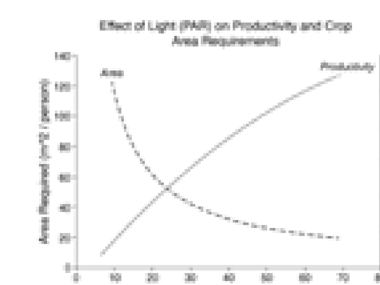
F. EXPERIMENT: LIGHT? AREA? PRODUCTIVITY?

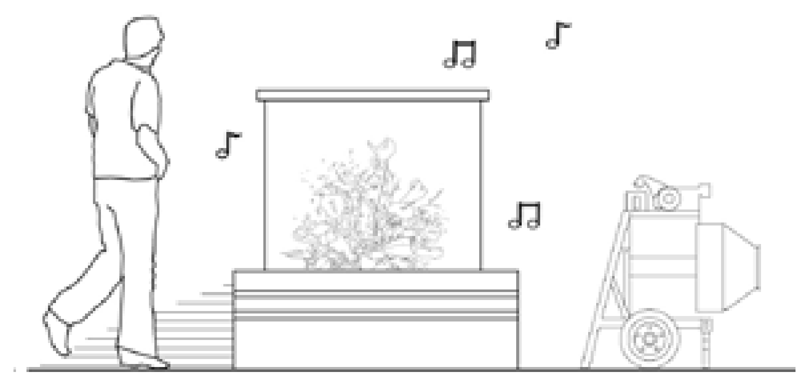
These are the selection of plants that are currently suitable for aeroponic planting and many of them are already put to experiment at NASA. We have also found a scientific report that proves plants yield more production with more light exposure. This has become an important element in our design phase later.





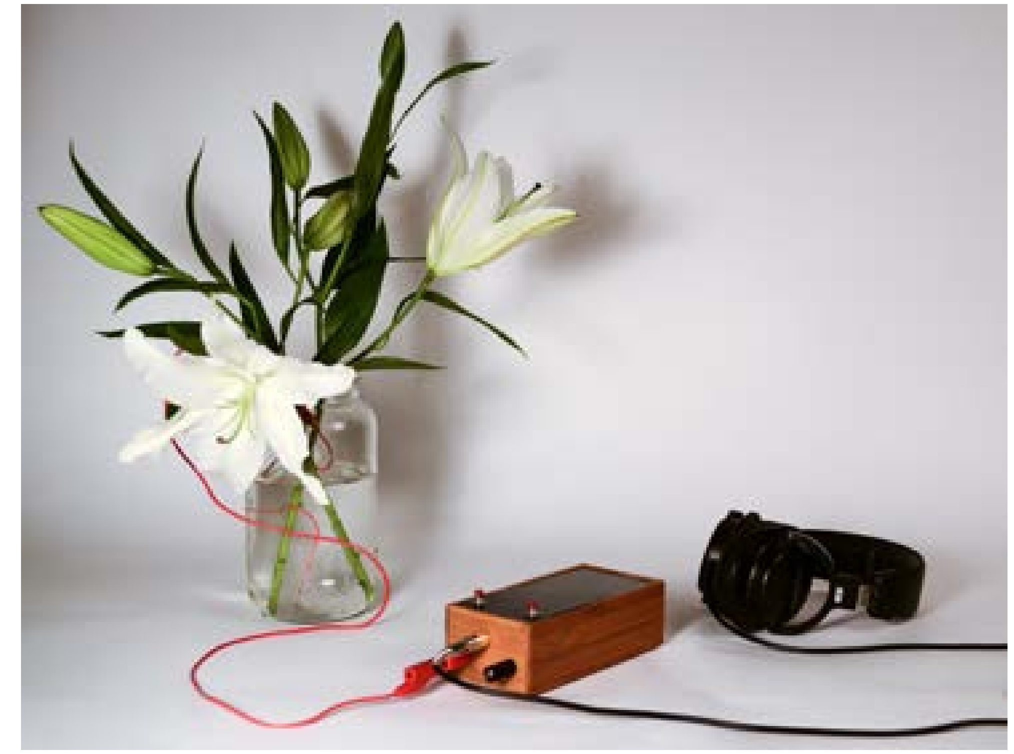


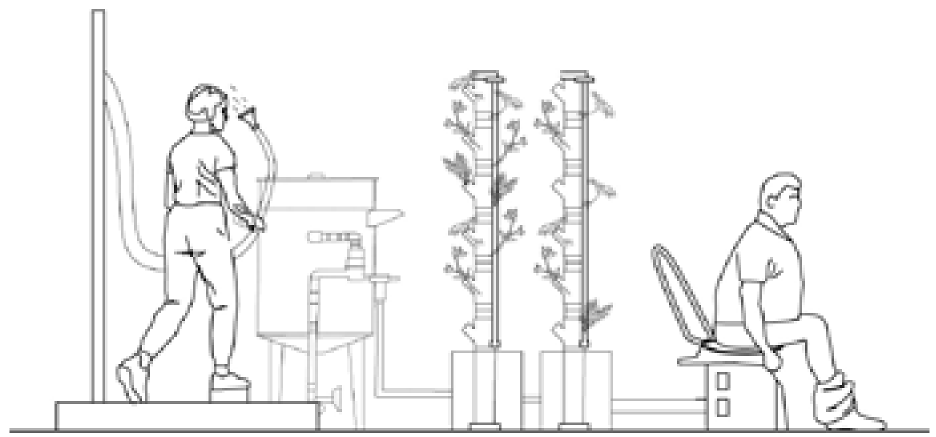




G. ENTERTAINMENT: INTERACTIVE PLANTS

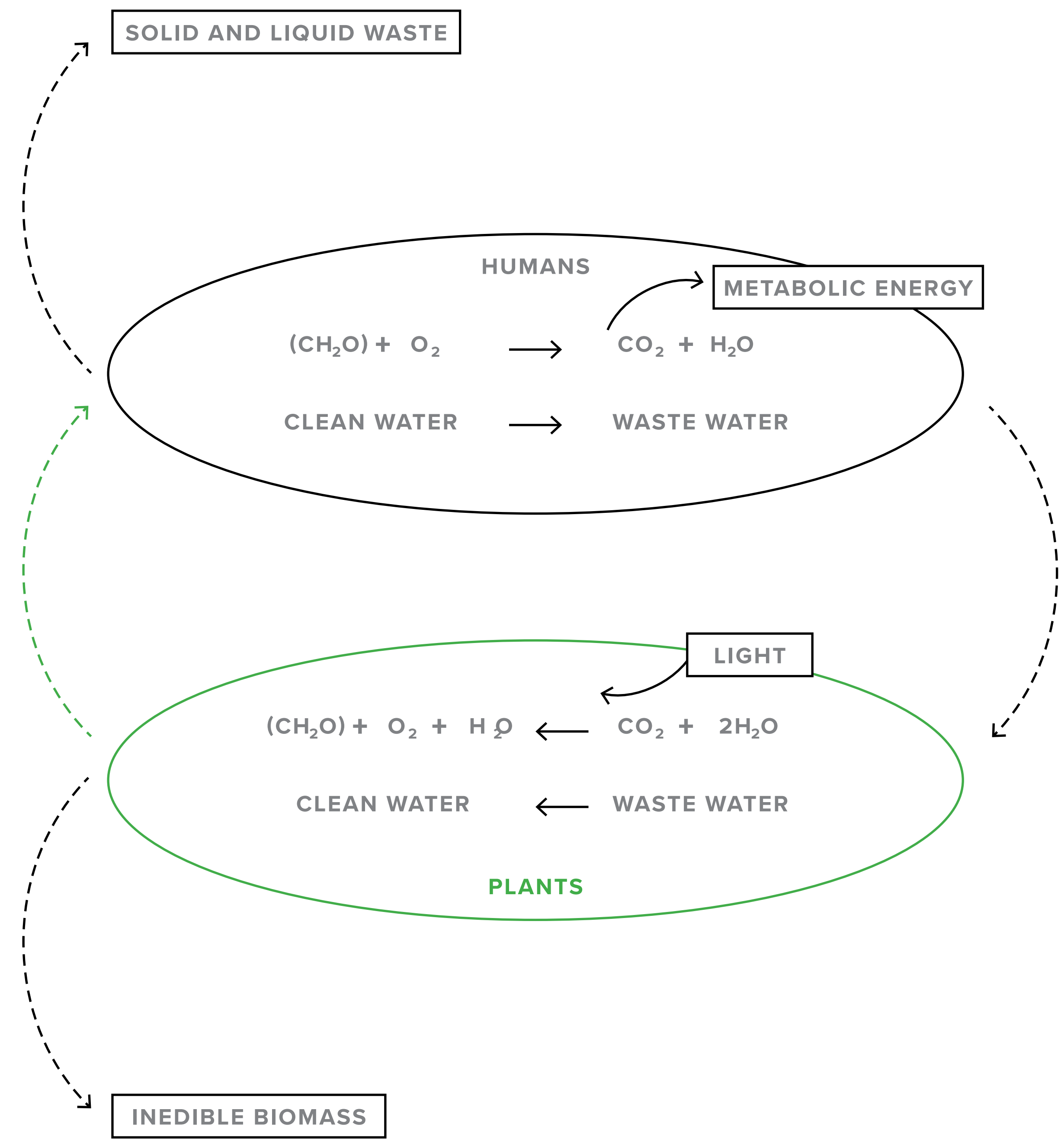
Plants may also be designed to have interactive elements with humans, for example transforming touching to sound, potentially giving a life-like presence and the ability to communicate.

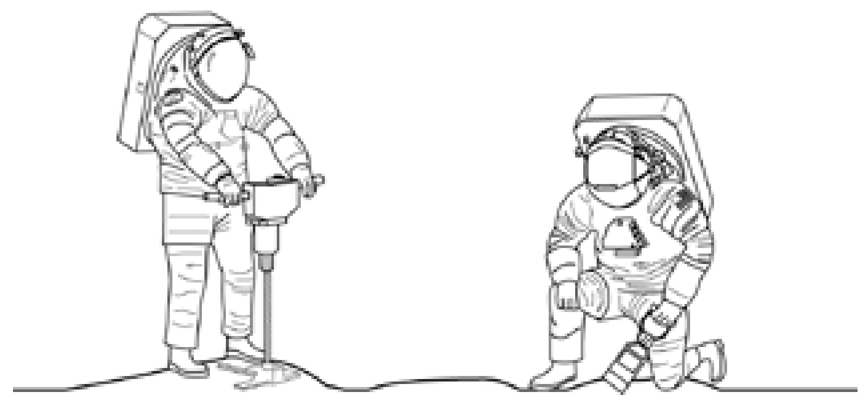




H. BIOFILTERS: FILTRATION & PURIFICATION

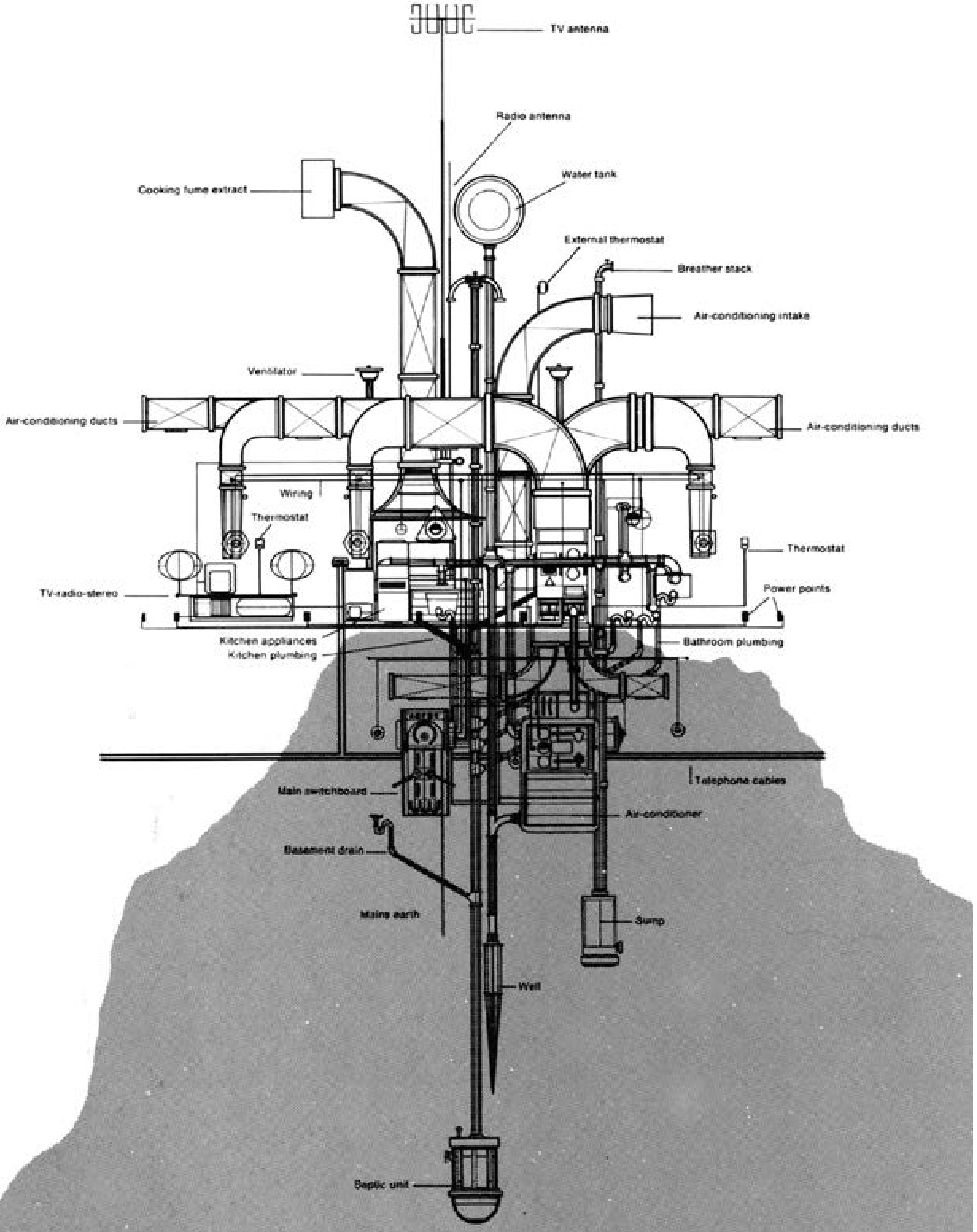
More importantly, plants may be used to remove common household pollutants from water. Many substances harmful to people and animals are conducive to plant growth. Human wastes are also a good source of nutrients for plants and it may then regenerate other resources, creating a semi-closed loop.





I. GROWING GREEN ON THE RED PLANET

Research suggests Martian soil has some of the nutrients plants need to grow and survive. The atmosphere on Mars has about 95% carbon dioxide, but it may in turn be great resources for plants growth. Scientists have conducted plant experiments simulating Martian conditions using volcanic soil in Hawaii, which is known for its similarity to Martian soil. These experiments found that plants can actually grow in these soils. However, we cannot predict what we will be able to do once we land on mars. However, we are proposing our design as a SEED prototype that may contribute to the fertilization of Mars.



03 THE ANATOMY OF NEO-DWELLING

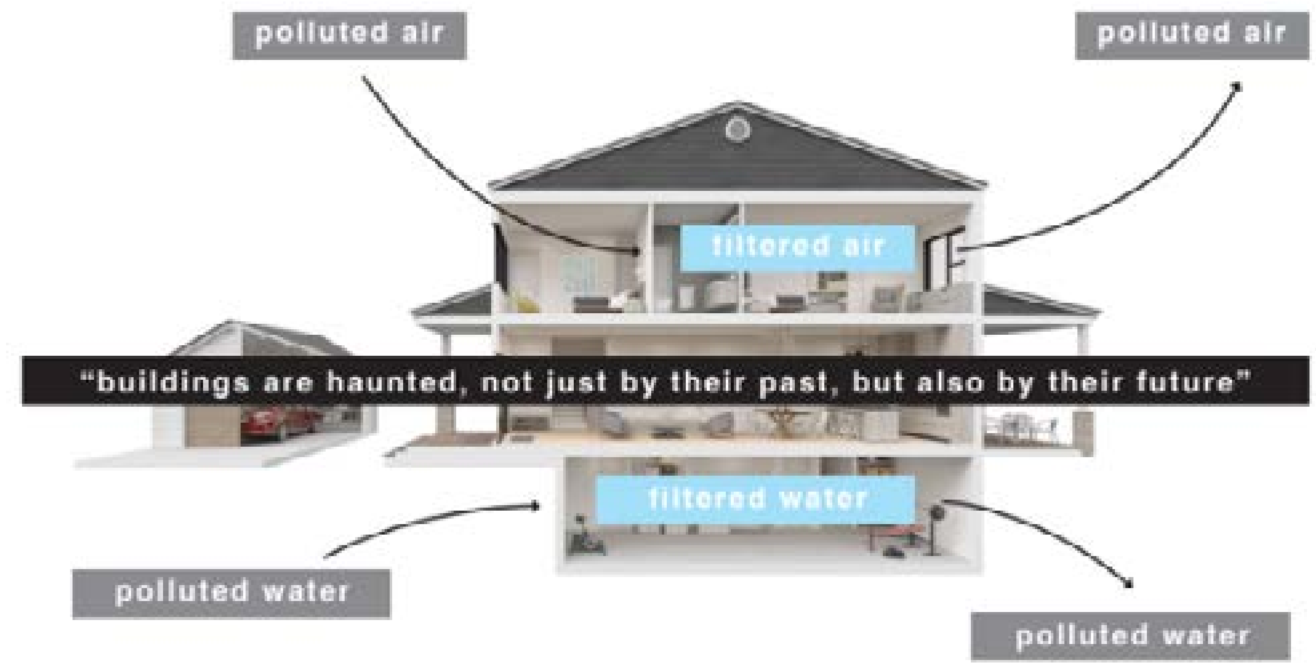
The Toxic Ecology
The Well-tempered Enviornment
What is a Regenerative System?
The Loop Ecology

The Toxic Ecology

"...[The] term hyperobjects ... refers to things that are massively distributed in time and space relative to humans. ... A hyperobject could be the very long-lasting product of direct human manufacture, such as styrofoam or plastic bags, or the sum of all the whirring machinery of capitalism."
- Timothy Morton

Looping of hyperobjects are then perpetuated by the obsession to the creation of a well-tempered interior, leading to endlessly extracting exterior resources to serve the inside while neglecting the output of the materials. We unconsciously create the toxic ecology then consumes its toxicity, leading to an endless cycle of self-destructive behavior and environmental degradation.

Keywords: space architecture, extreme environment, sustainable structure



Creation of Tempered Enviornment

The creation of a tempered environment in space architecture involves the development of sustainable and environmentally friendly structures and habitats that can protect humans from extreme environments. One possible aspect of this development is the creation of smart environments that are designed to regulate temperature, humidity, and other environmental factors in a controlled manner.

Smart environments may involve the use of advanced sensors and control systems that allow for real-time monitoring and adjustment of environmental factors to optimize human comfort and well-being. These systems may also be designed to be energy-efficient, using renewable energy sources such as solar power to minimize environmental impact and reduce the need for resupply missions.

The creation of a tempered environment in space architecture requires a multidisciplinary approach that integrates knowledge from various fields such as engineering, materials science, biology, and psychology. By developing sustainable and smart environments in space, humans can sustain long-duration missions and establish a permanent human presence beyond Earth.

Keywords: space architecture, extreme environment, sustainable structure

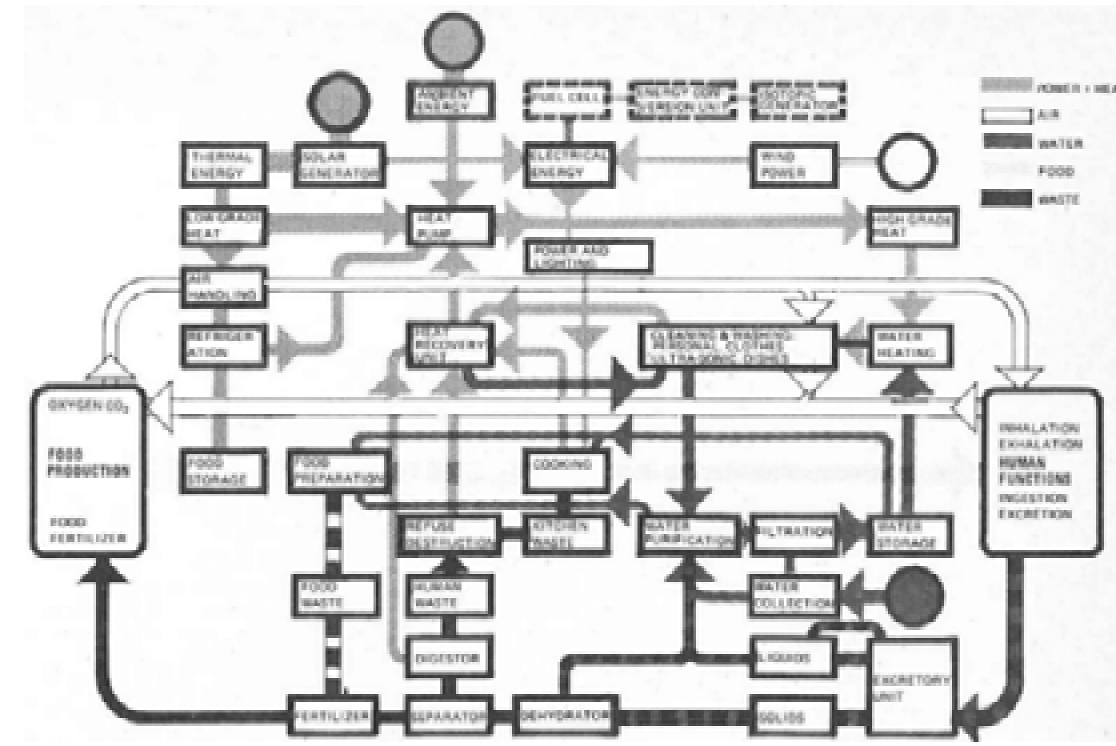
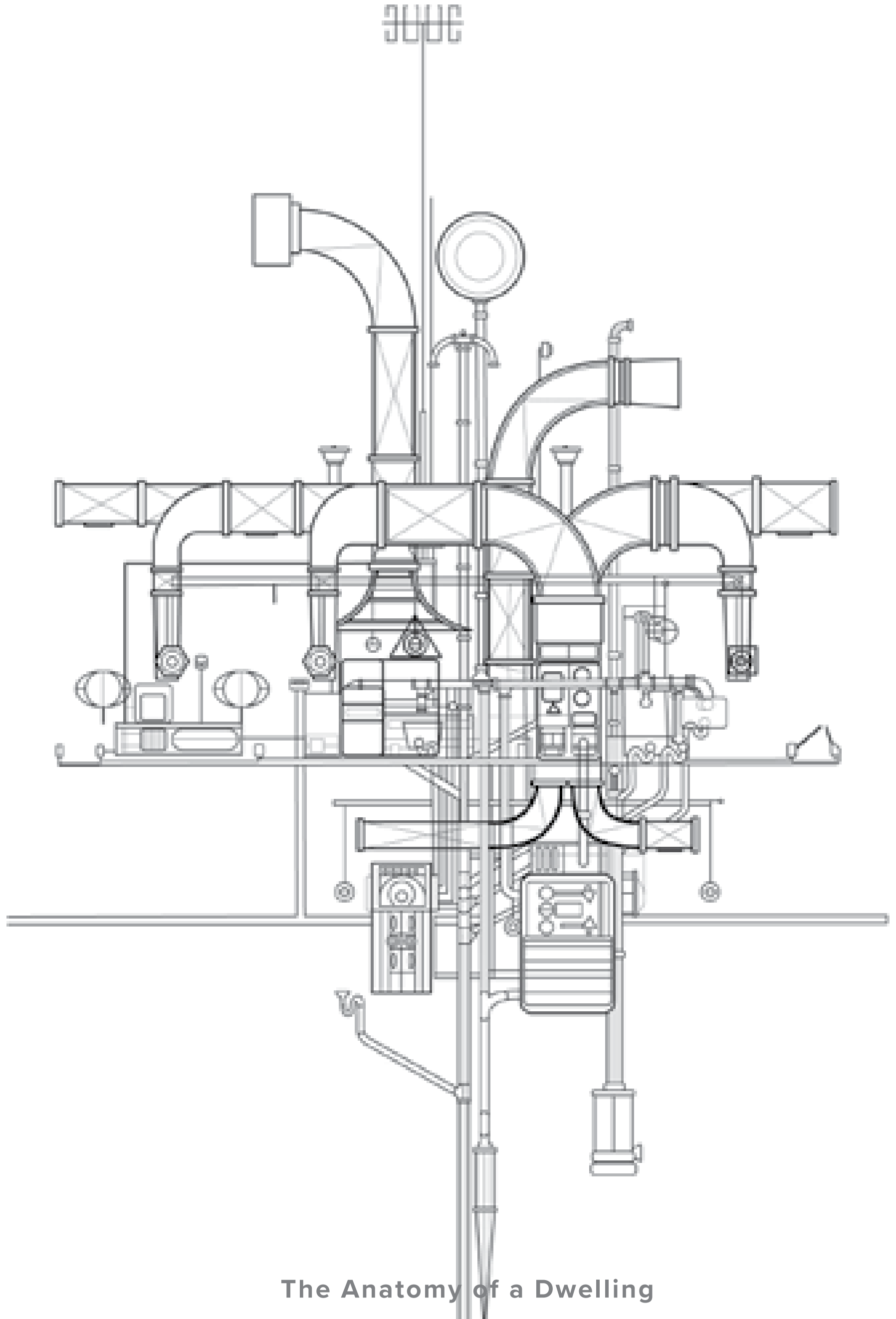
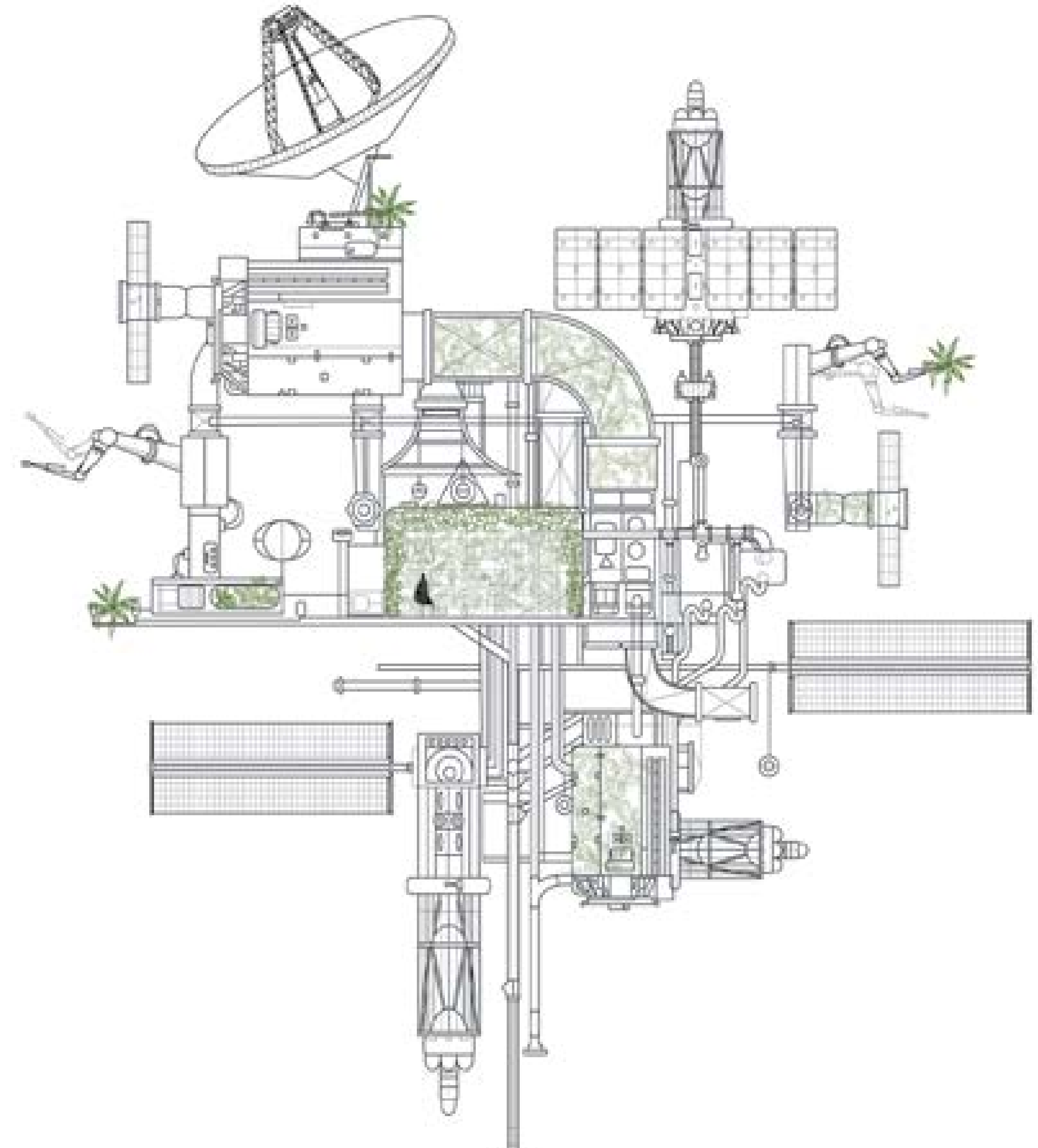


Figure 11. Alexander Pike, basic diagram for a hypothetical service unit (*Architectural Design*, 1972).



The Anatomy of a Dwelling

Since modernism, the theory of “A house is a machine for living“ has deeply rooted in the architectural discipline, further splitting the artificial construction from the existing nature. Each machinery in the architectural system serves as a part of the integrated mechanism to detach the interior environment from exterior nature. As the building technology progressed, architecture became more reliant on these machineries, which have generated today’s living machines. As an entirety. they extract the resource from the exterior nature to maintain the interior living condition while emitting the pollution to the existing outside environment.



The Anatomy of a Neo-Dwelling

In response to the growing environmental issues, the future architecture system should develop from the established robotic mechanism to an advanced organic or bionic mechanism. This new proposed system integrates natural entities such as plant ecology as a machinery within the architectural mechanism, bridging resource exchange between interior and exterior. It helps the architectural system evolved from a dissipative object to a regenerative pivot. This means it can also produce positive interaction such as energy flows to the exterior environment, and could be deployed under any circumstance.

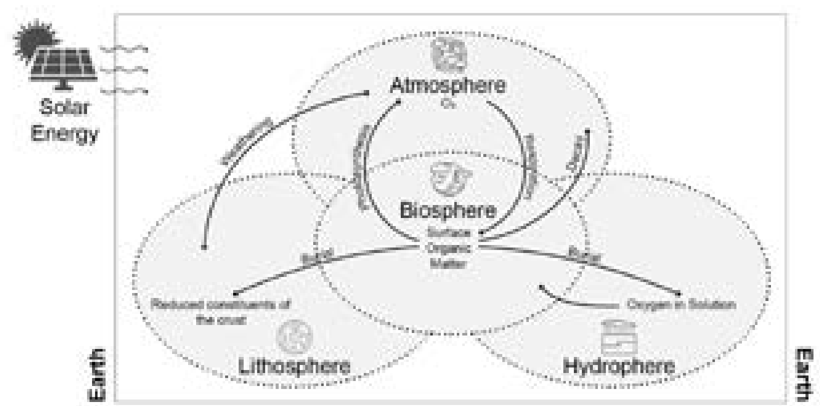
Regenerative Life Support Systems:

Artwork by Angelina Zhang and Junye Zhong

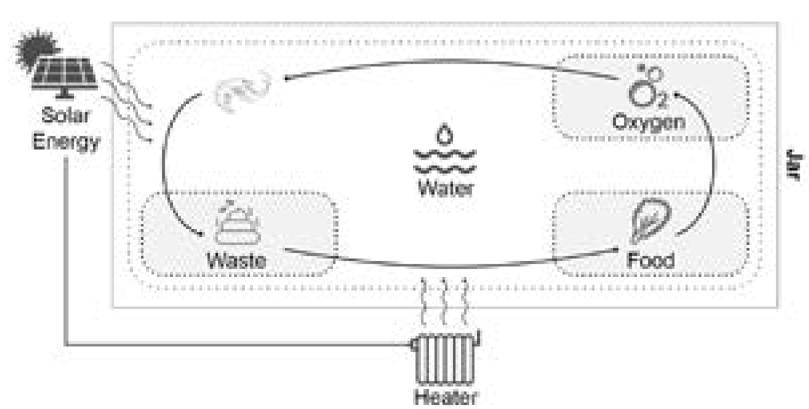
WASTE = FOOD

The regenerative life support systems (closed loop) listed below are arranged based on the duration. While Earth being the most complex system and has the most developed regenerative system, an ecosystem jar is also a successful simplified replica that capsulates the regenerable system. Other man-made systems like the NASA Habitat, Space Station, and Space Suit are more complex but with limited duration, with spacesuit lasting only 10 hours in space. The preliminary study on the regenerative life support systems guide this thesis to explore the role of plants as an integral element in these loops.

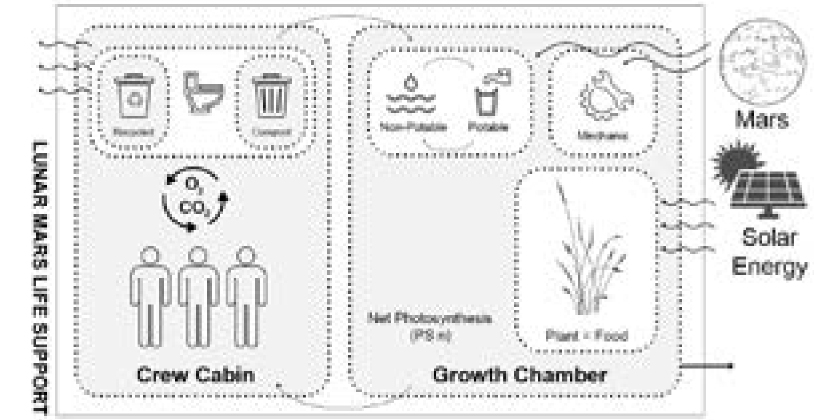
EARTH



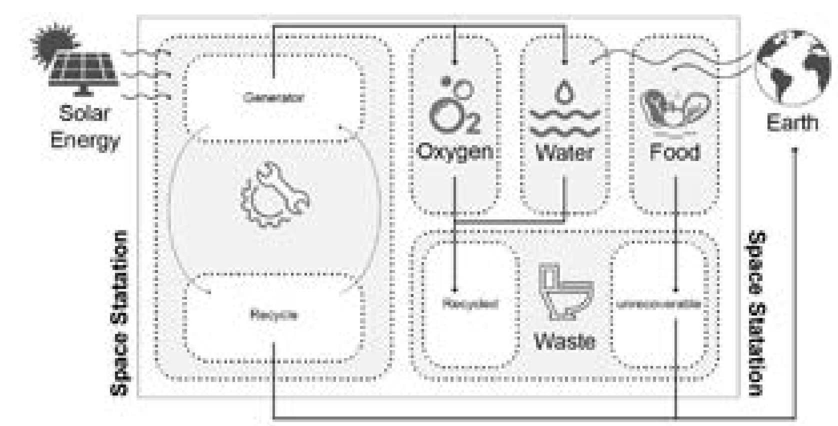
ECOSYSTEM JAR



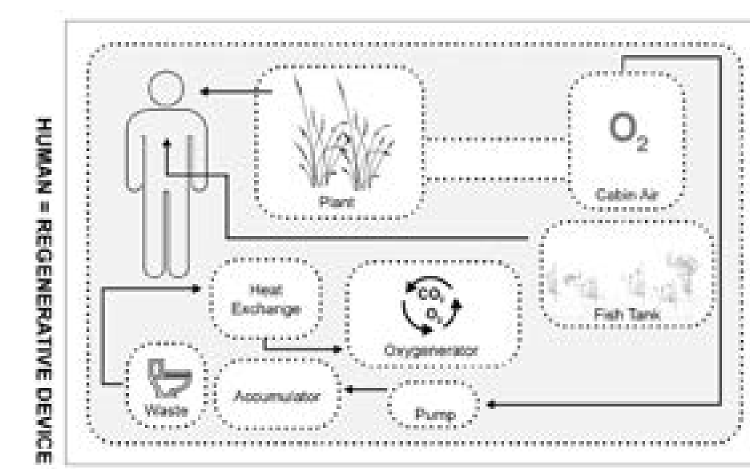
NASA HABITAT



SPACE STATION



SPACE SUIT



Regenerative Life Support Systems:

Regenerative Architectural System (RAS):

Artwork by Angelina Zhang and Junye Zhong

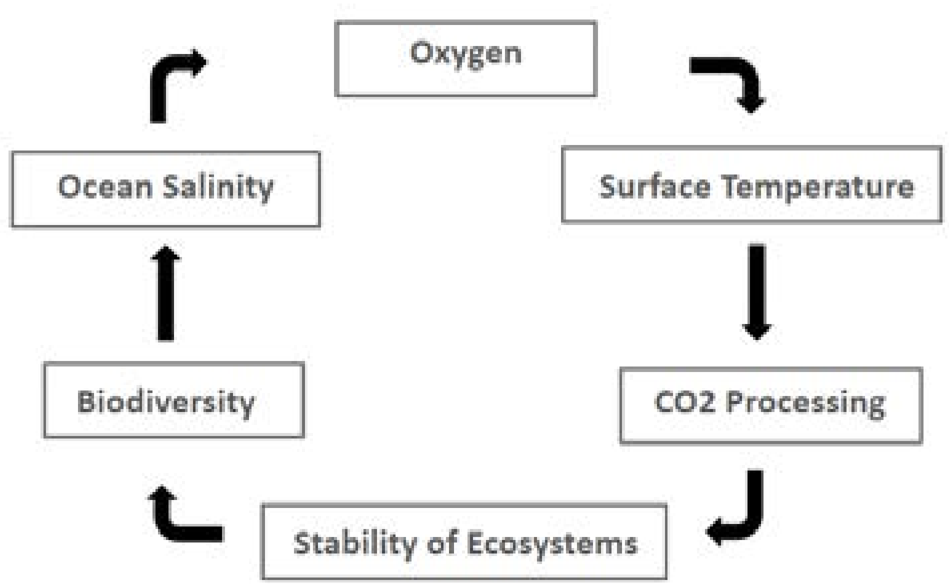
BUILDING = ECOSYSTEM

By research and observation, there is similarity in operating mechanism between human life support system and aquatic ecosystem. This has provided inspiration to integrate natural entities in contemporary architectural system and develop an idea of regenerative architectural system. The natural entities would work as a part of the operating mechanism in the RAS, contributing to the living condition within the architectural envelope. Unlike the machinery in conventional architectural system that only consume the outer resource, the inherent functionality of natural entities to produce resource can bridge the two-way connection by balancing the resource intake and output.

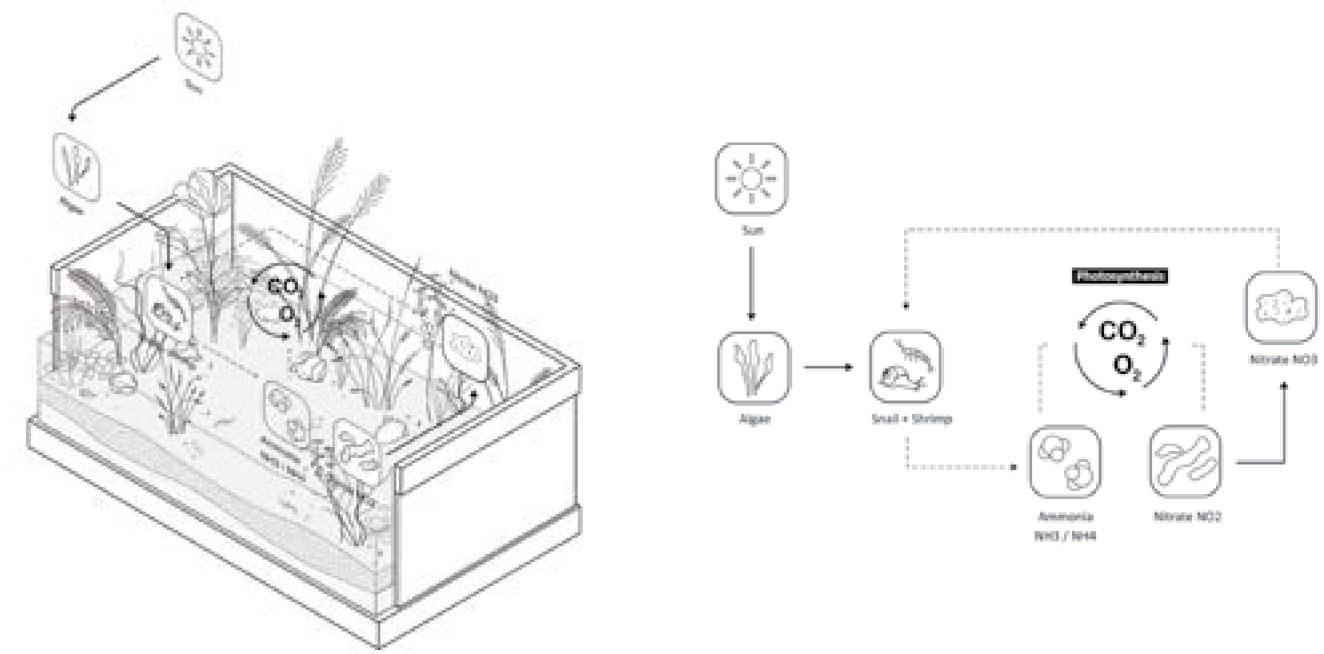
Gaia Theory

all organisms and their inorganic surroundings on Earth are closely integrated to form a single and self-regulating complex system, maintaining the conditions for life on the planet.

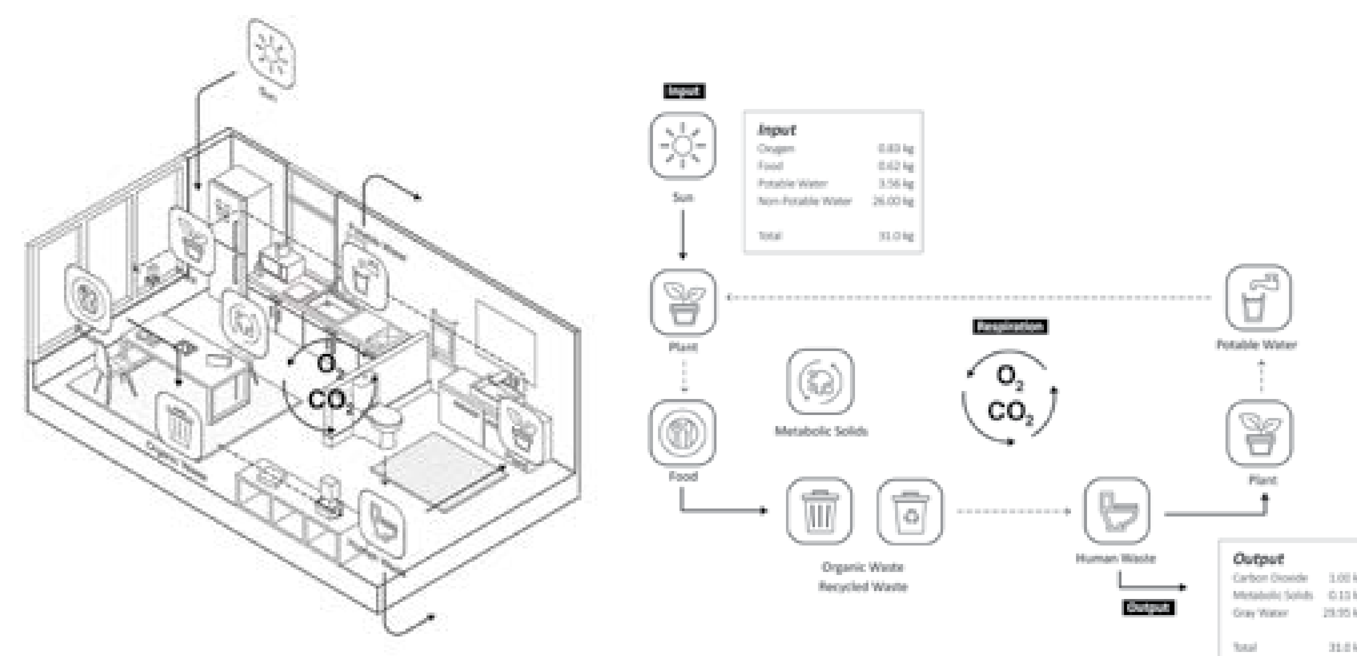
—James Lovelock & Lynn Margulis (1970s)



AQUATIC ECOSYSTEM



HUMAN LIFE SUPPORT

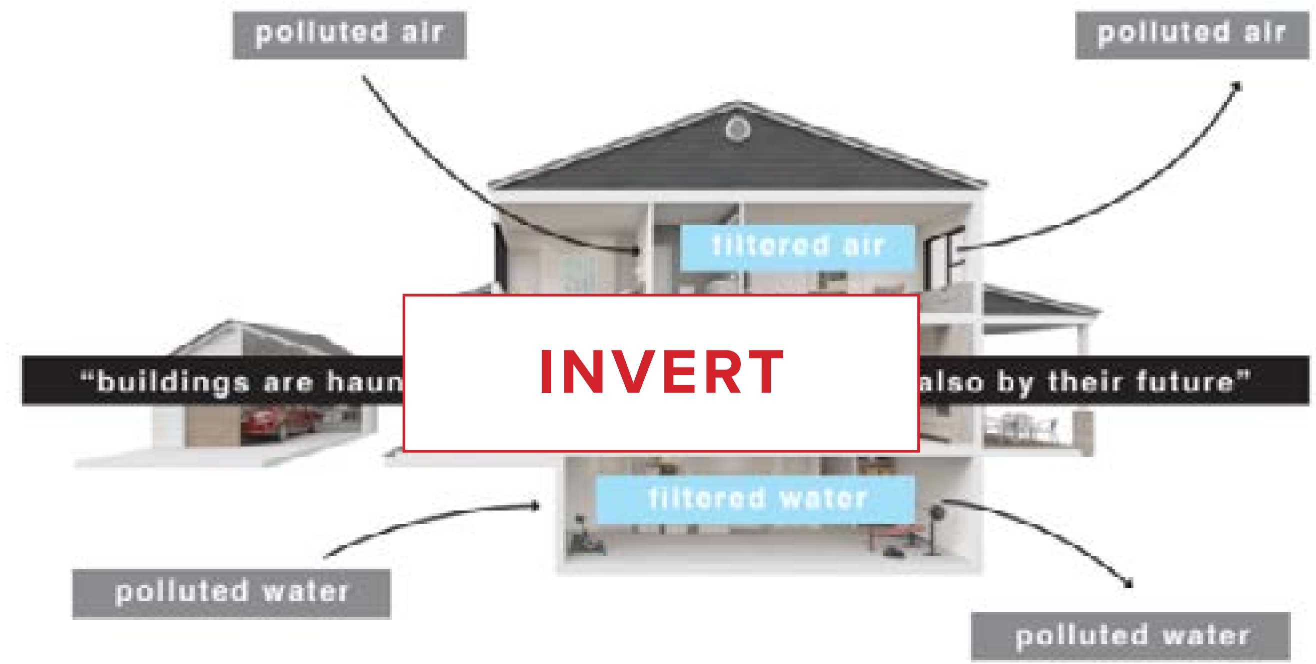


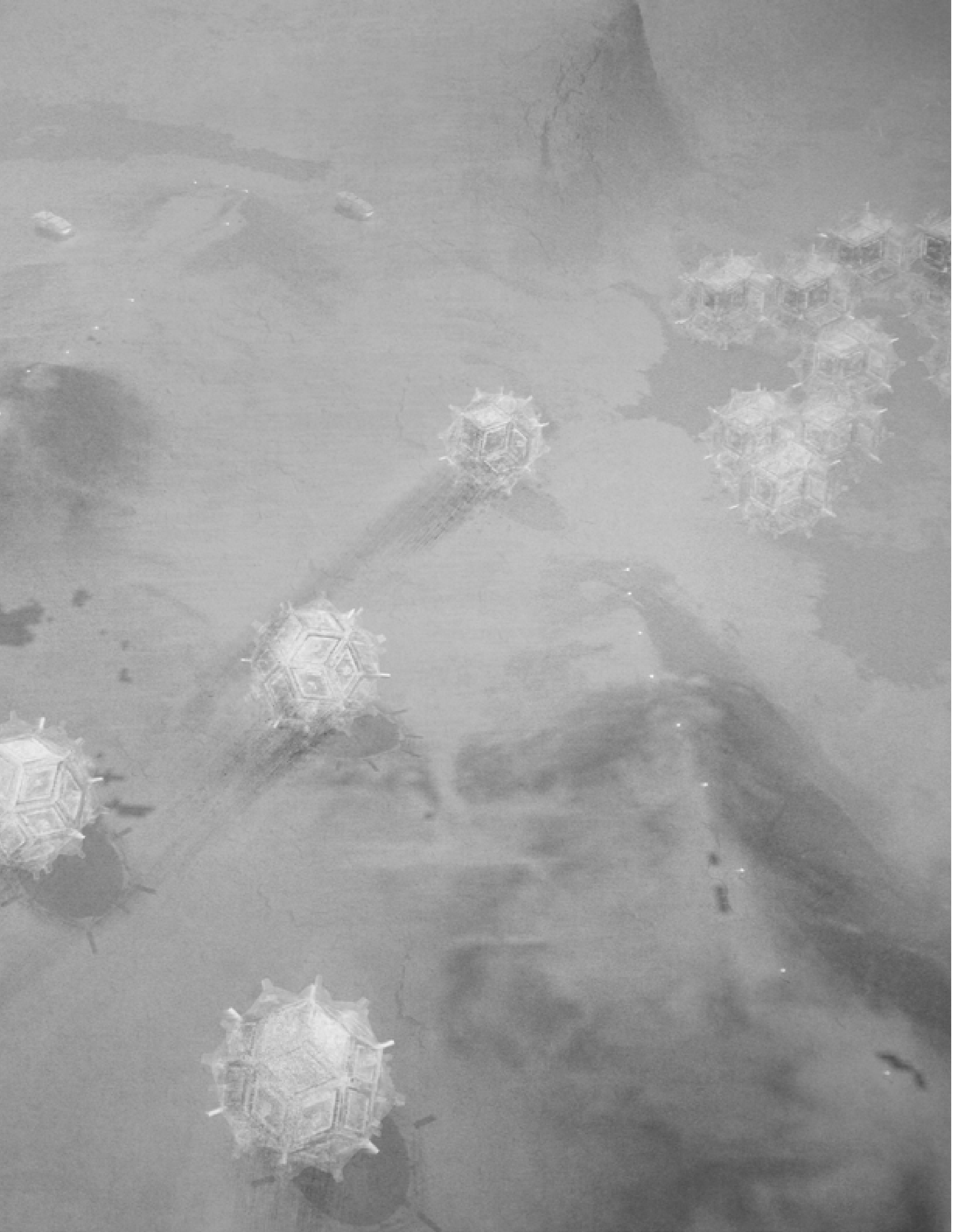
The Toxic Ecology

The Loop Ecology

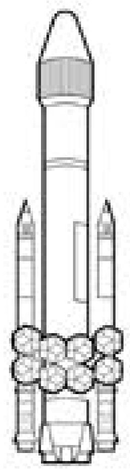
Artwork by Angelina Zhang and Junye Zhong

One potential solution for inverting the modern dwelling mode of extracting natural resources to maintain interior living conditions is to explore more sustainable and regenerative approaches to building and living. It could involve utilizing renewable energy sources like solar, wind, and geothermal power to power the home and reduce reliance on fossil fuels. Additionally, exploring regenerative agriculture and permaculture practices could allow for food to be grown on site, reducing the need for transportation and packaging of produce. Finally, implementing circular systems for waste management, water usage, and material sourcing could reduce the impact on natural resources and support a more sustainable and holistic approach to living. By prioritizing these approaches, we can begin to create homes that are not only comfortable and functional, but also in harmony with the natural systems around us.



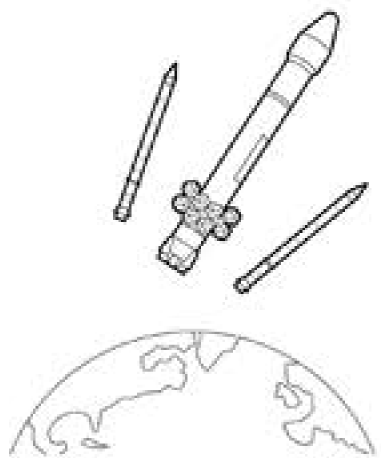


04 THE SEED HABITAT



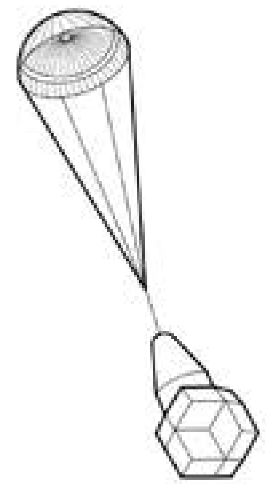
01

ROCKET LAUNCH



02

STAGE SEPARATION



03

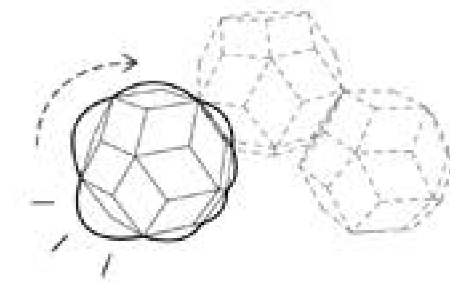
PARACHUTE DEPLOY

04

AIRBAG INFLATION LANDING

05

LANDING ON MARS



06

UNIT IN MOTION
MODULAR CONNECTION

Transport and Deployment Method

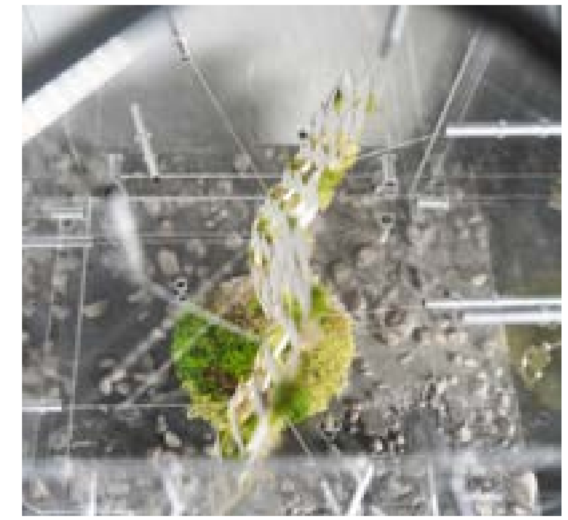
The modular units will land in similar methods as NASA's 2020 mission preseverance rover through the Entry, Descent, and Landing to reach the top of the Martian atmosphere, traveling approximately 12,500 miles per hour. The membrane inflation activated by the parachute deployment will allow the modular unit to be protected during the landing. After the landing, the unit will deflate each individual airbag unit to put the unit in motion.

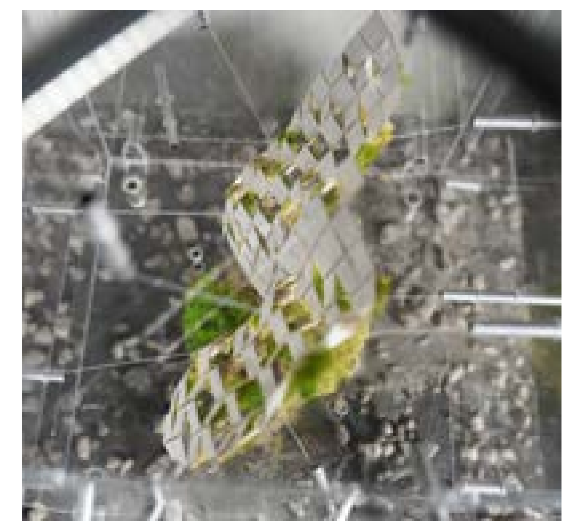
Switchable Interior Scene with Plants

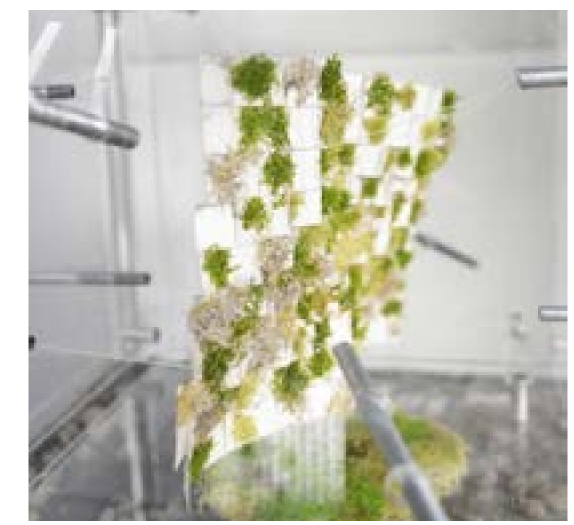
Reflected the progressive idea by the plant ecology in future dwelling, the interior space should be flexible in terms of form, furnishing, atmosphere, etc. The position of the plants is switchable by the application of mechanic equipments, allowing people to interact with plants as they need.

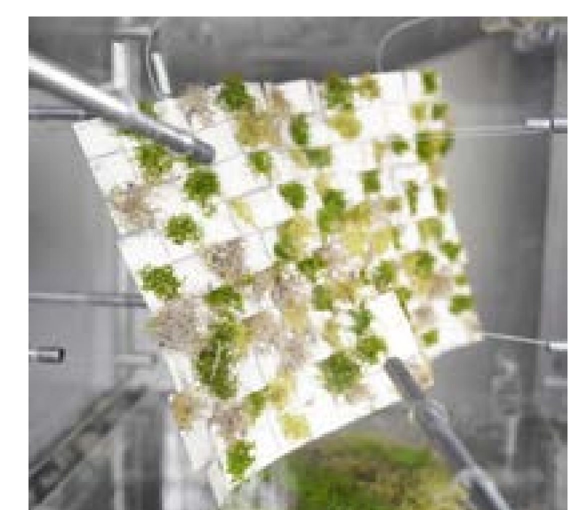
Conceptual Render of the Interior Space

As the benefit of machinery, the architectural system can achieve the ambition of integrating plant ecology with automation. This conceptual render illustrates the dynamic relationship between humans, plants, and architectural elements such as wall and furniture. The deformable envelop is consisted of adjustable panels to create furnitures and space in different form. Hidden plants would appear during the action of these panels, enriching the spatial atmosphere and interacting with people.



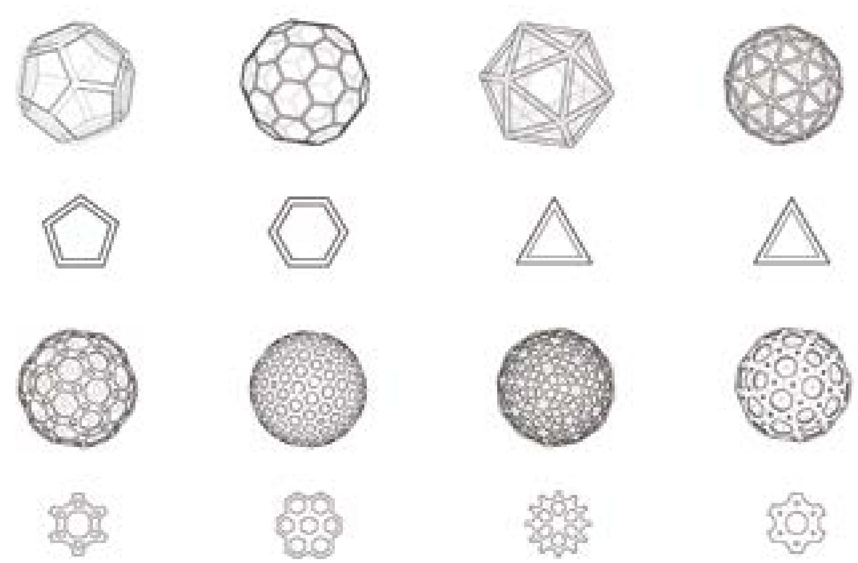




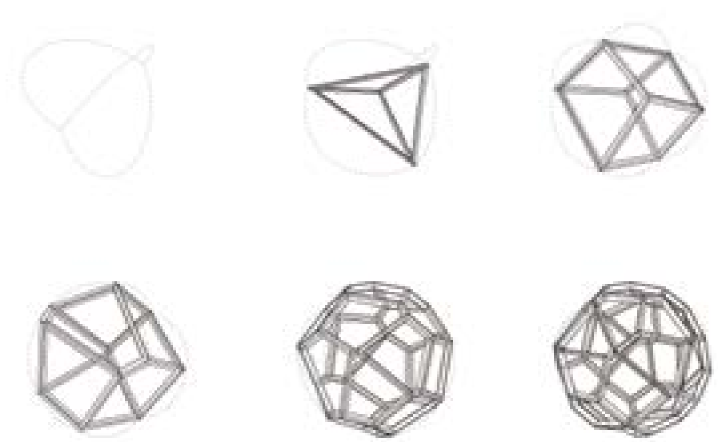


Geometric Pattern Thinking

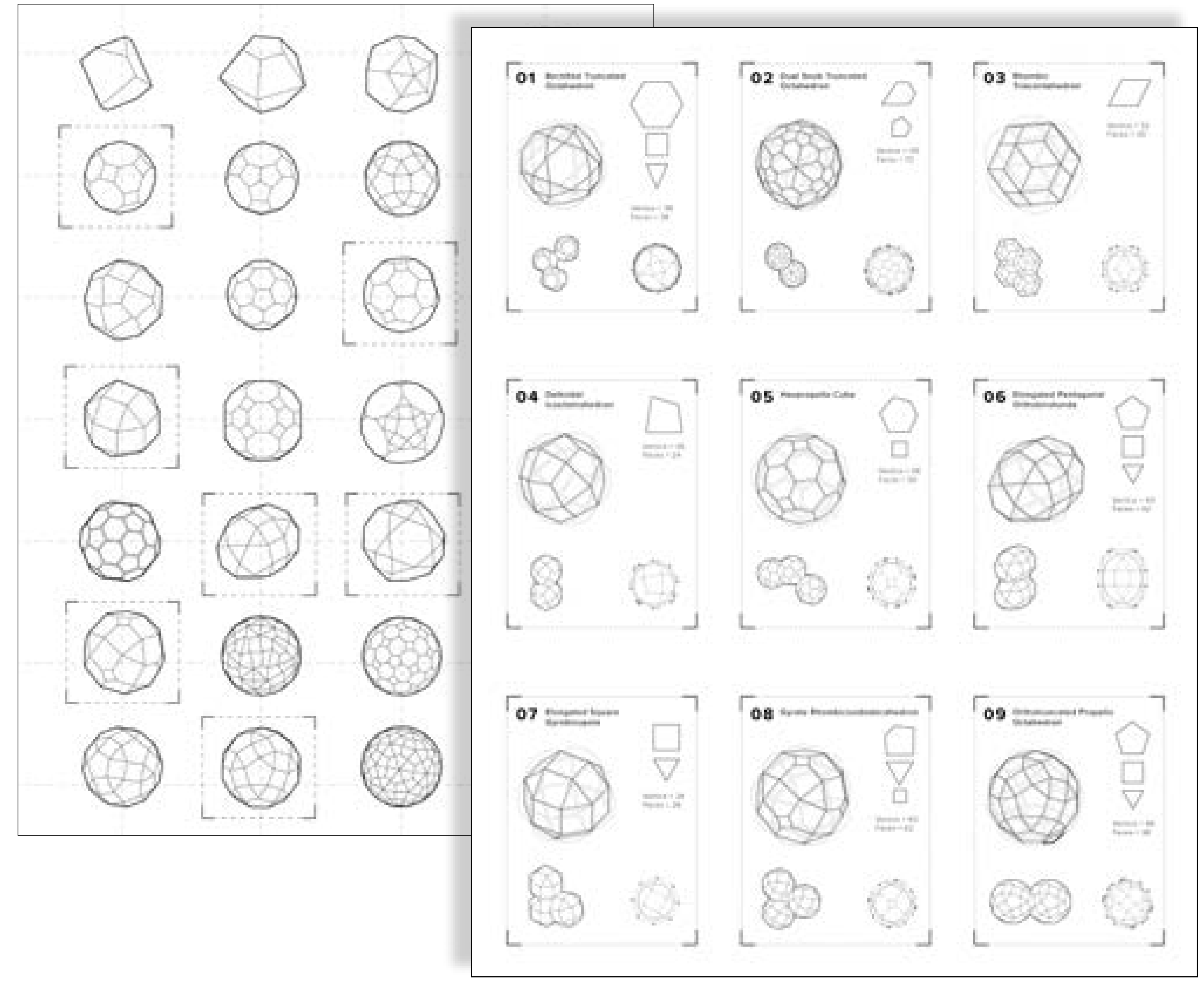
Developing from the idea of landing method, tessellation can be used in aerospace design for several reasons. One of the main advantages of tessellation is that it can create structures that are both lightweight and strong. This is particularly important in aerospace design, where weight is a critical factor in determining fuel efficiency and performance. By using tessellated structures, the building can be created with lightweight yet strong components that can withstand the stresses and strains during the mission.

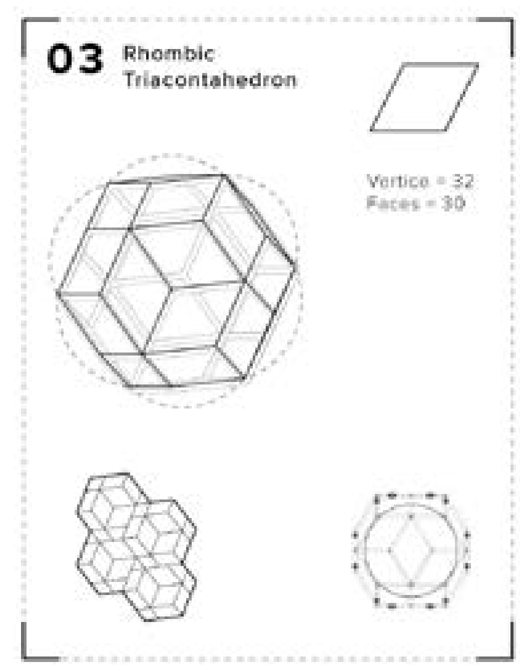


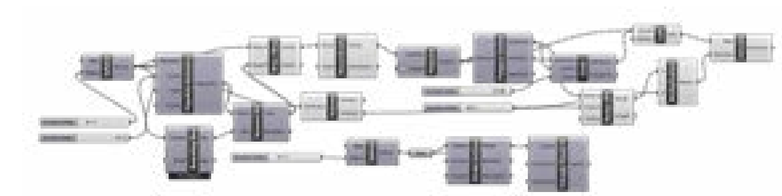
Equal Divisions



Random Divisions







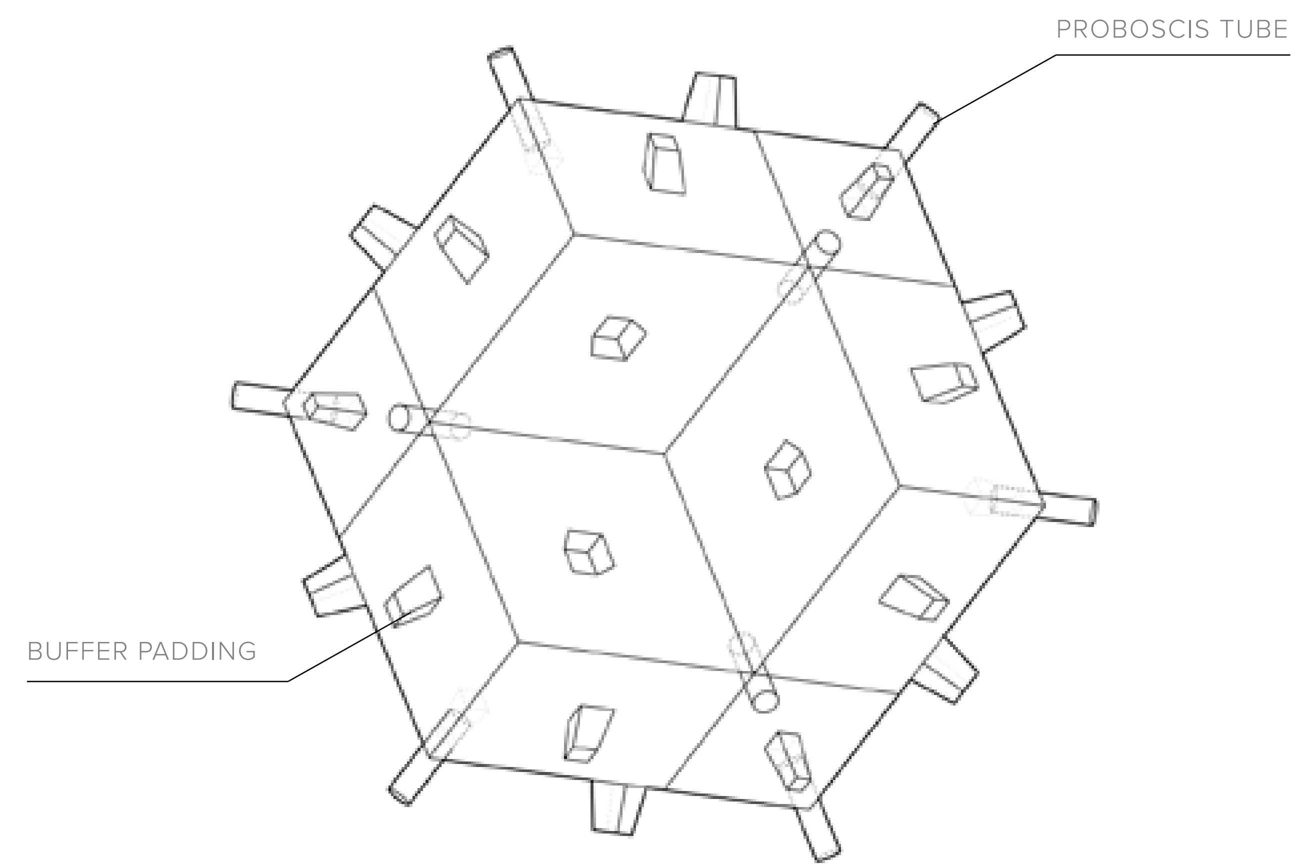
Voroni Sphere Division

Rhombic Triacontahedron

or triacontahedron, as the most common 30-faced polyhedron, a convex polyhedron with 30 rhombic faces. The ratio of the long diagonal to the short diagonal of each face is exactly equal to the golden ratio, φ. The acute angles on each face measures 2 tan−1(1/φ) = tan−1(2), or approximately 63.43°, also called a golden rhombus.

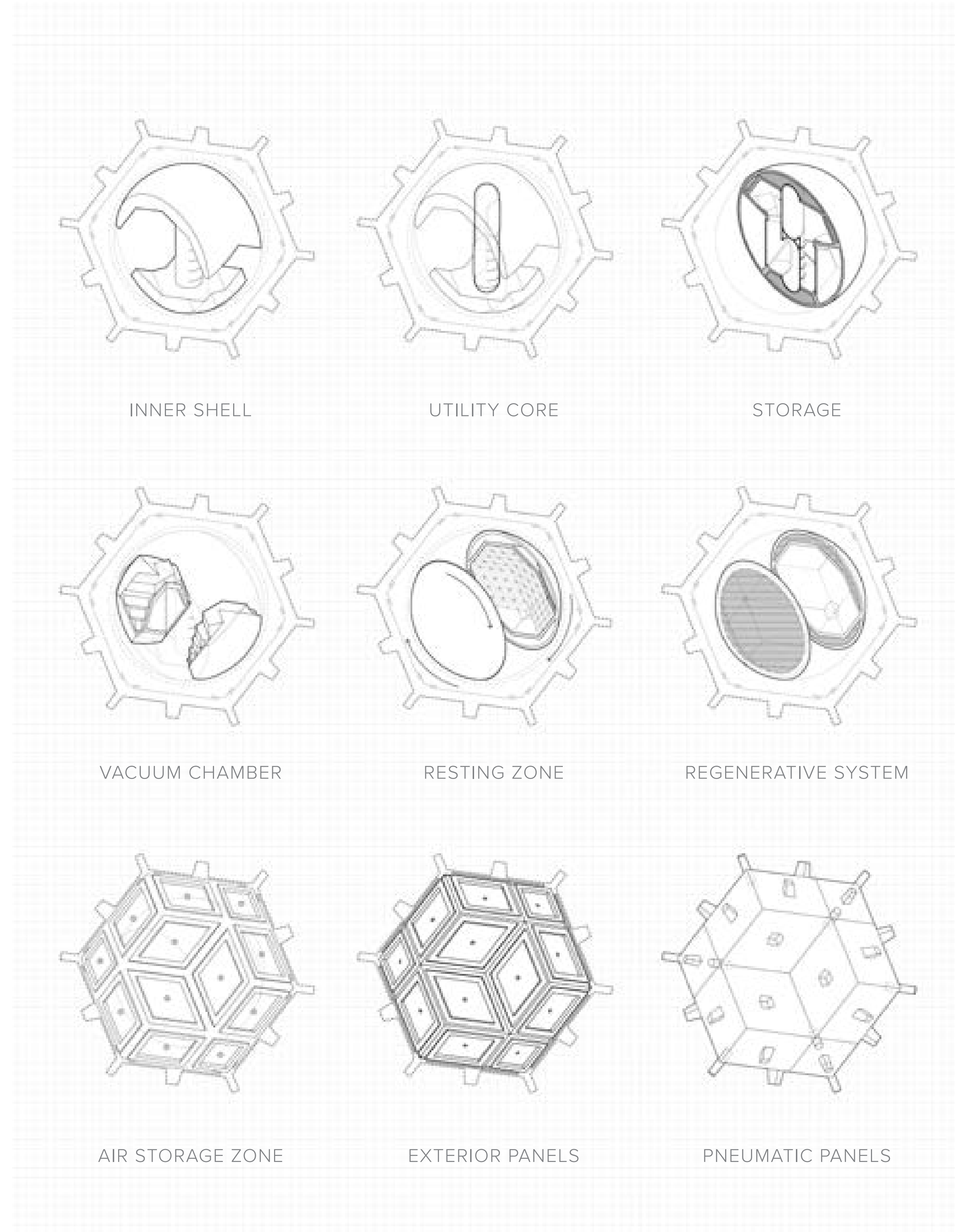
The SEED Habitat

The ambition is to create a semi-closed loop system on mars to provide comfortable working and living environment for two people during their Mars mission. NASA's original Martian exploration plan with two people will last 30 days after the landing on Mars. This semi-closed loop system aims to extend the duration as long as possible by integrating ideas of regenerative resources and mobile structures.



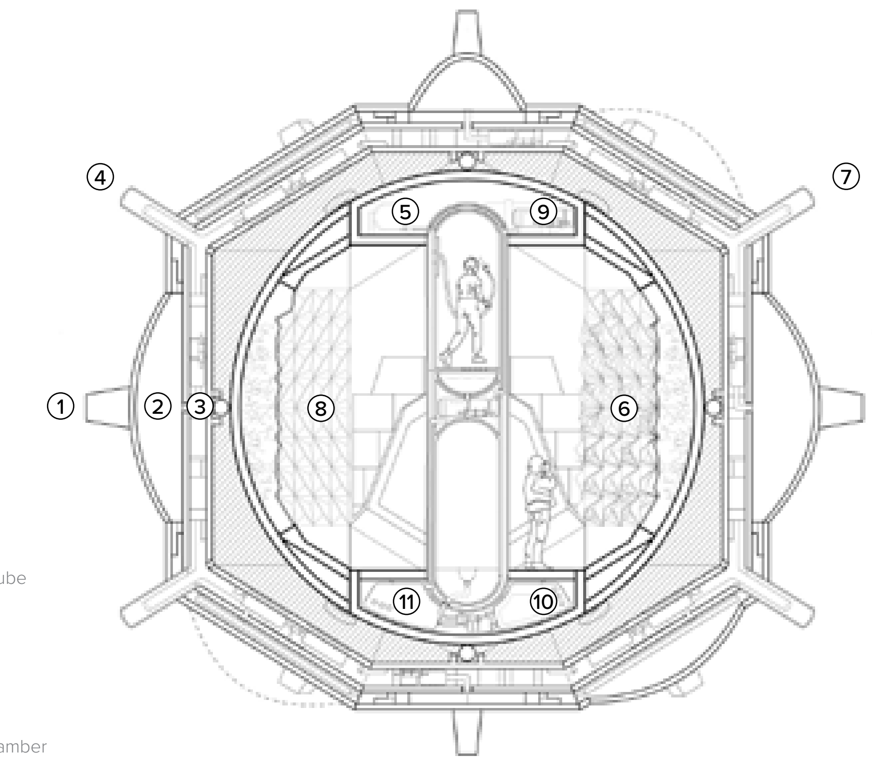
Structural Layer

Each subsystem is designed to maximize consumable mass closure. Resources can be extracted on Mars and be treated for consumption. For example, the water may be extracted beneath Mars surface and circulate through the pod for filtration, then to be used for shower, kitchen, irrigation, and then graywater. Similarly, CO_2 can be absorbed from the atmosphere to be used as part of the pneumatic system that enables movements of the building.

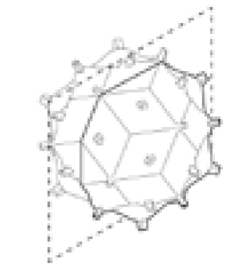


Sections

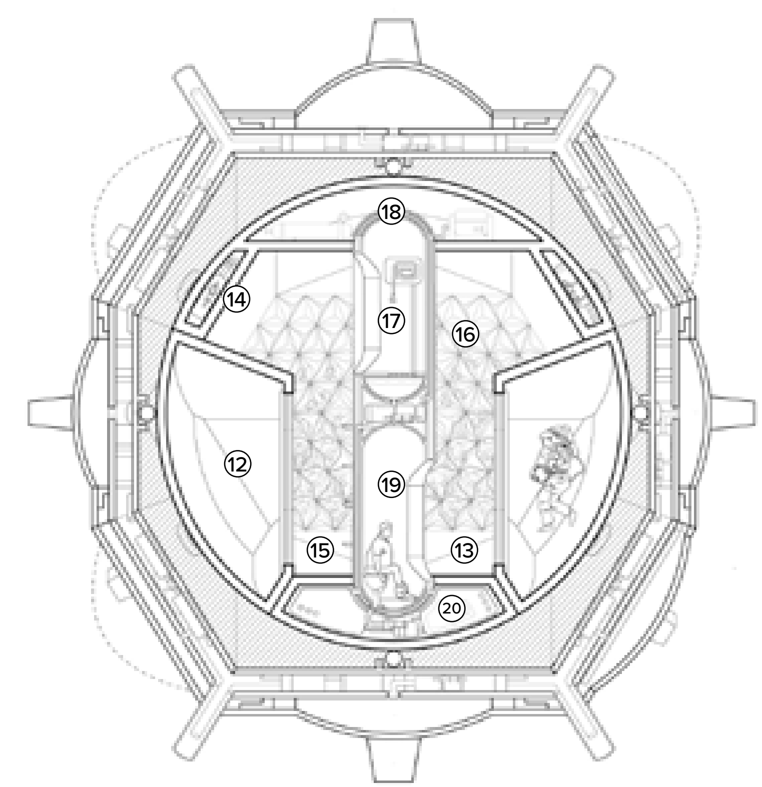
These complex layers enclose a space with 235 m³, which can transform between lab and living function. While the exterior envelop is inflating and rolling, the inner sphere will maintain its position due to the gravity. Between the exterior envelop and the inner sphere, there are bearing balls to allow position shifting and complex motion. Within the inner sphere, vacuum chamber and functional space surround the utility core at the center to support people’s work and lives.



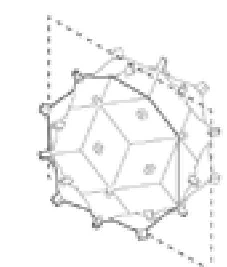
1. Buffer Padding
2. Pneumatic Skin
3. Air Pump Mechanics
4. Resource Extraction Tube
5. Filtration System
6. Aeroponic Chamber
7. Steam Outlet Tube
8. Oxygen Tank
9. Filtered Water
10. Gray Water
11. Resource Process Chamber



SECTION A-A



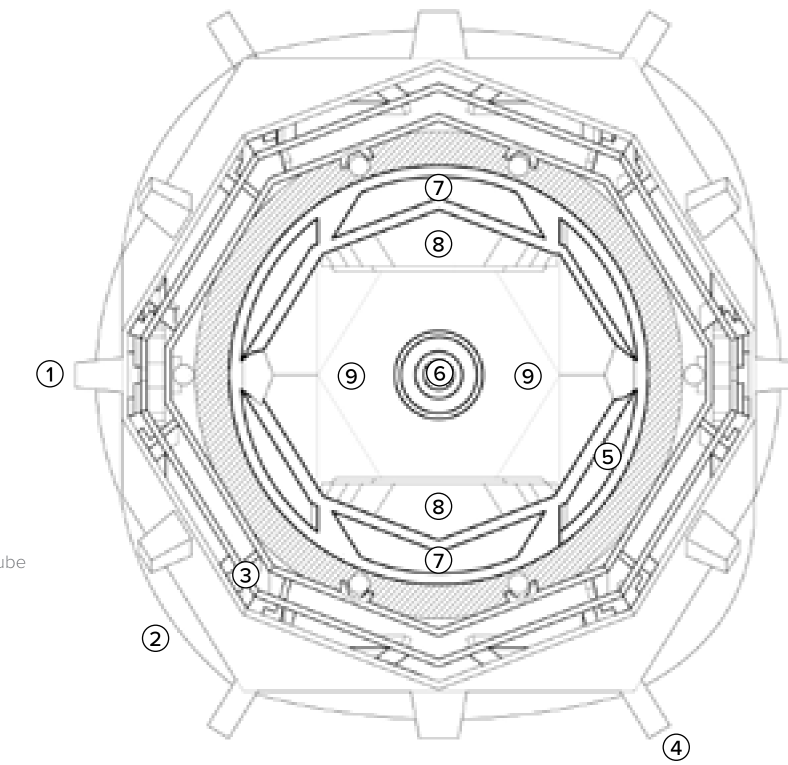
12. Vacuum Chamber
13. Personal Storage
14. Resource Storage
15. Research Platform
16. Sleeping Chamber
17. Shower
18. Clean Water System
19. Toilet
20. Gray Water System

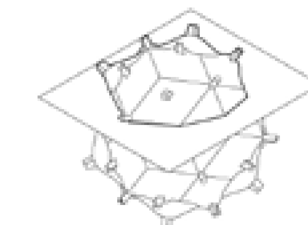


SECTION B-B

SPECS

DIAMETER	8.5 m
VOLUME	235 m³
STORAGE	50 m³
CAPACITY	2 people
DURACTION	80 Days +
PRESSURIZED	yes



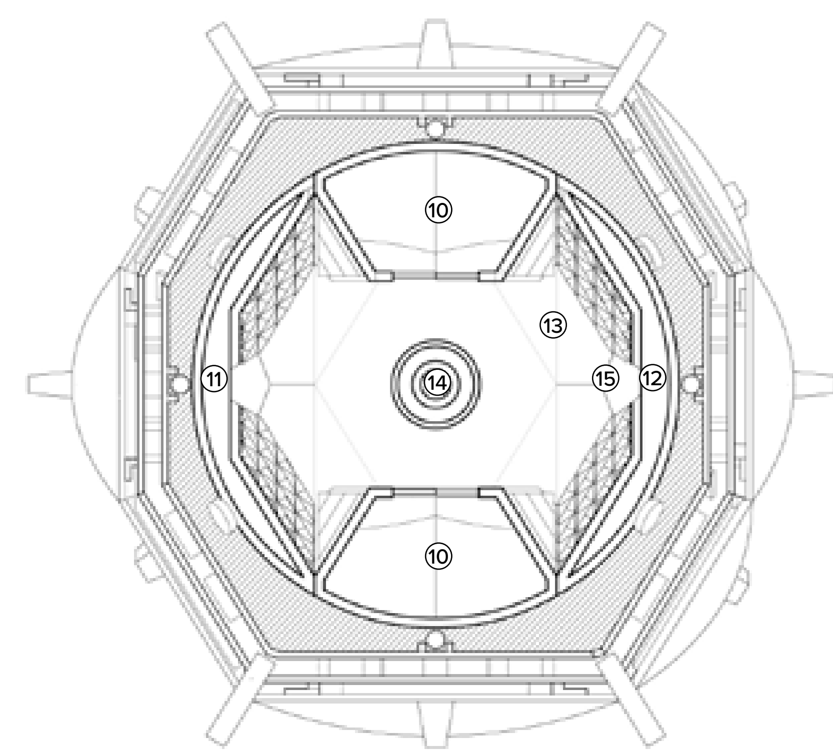


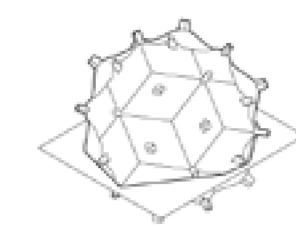
SECTION C-C

1. Buffer Padding
2. Pneumatic Skin
3. Air Pump Mechanics
4. Resource Extraction Tube
5. Filtration System
6. Toilet
7. Resource Storage
8. Personal Storage
9. Common

Plans

The inner core is split into different zones serving unique programs. The central core (fixed) will serve as kitchen and shower/toilet utilities as well as water filtration. The upper floor will be sleeping zone and when the sides rotate, it will serve as circulation for the office zone to access upper floor. The two vaccum chamber will be essential for de-contamination if the astronaut exists the capsule for on-site study and the panels will flip open to serve as joint connection with other capsules if necessary.





SECTION D-D

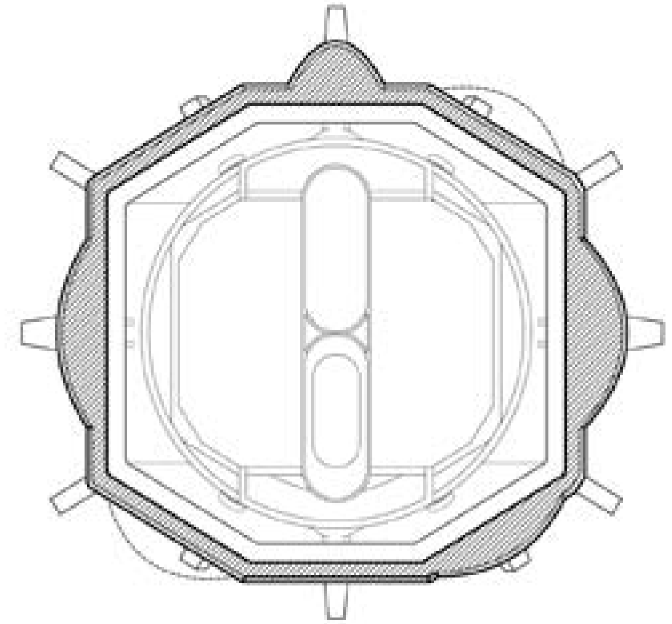
10. Vacuum Chamber
11. Aeroponic Chamber
12. Oxygen Tank
13. Sleeping Chamber
14. Shower
15. Lookout Window

SPECS

DIAMETER	8.5 m
VOLUME	235 m³
STORAGE	50 m³
CAPACITY	2 people
DURACTION	80 Days +
PRESSURIZED	yes

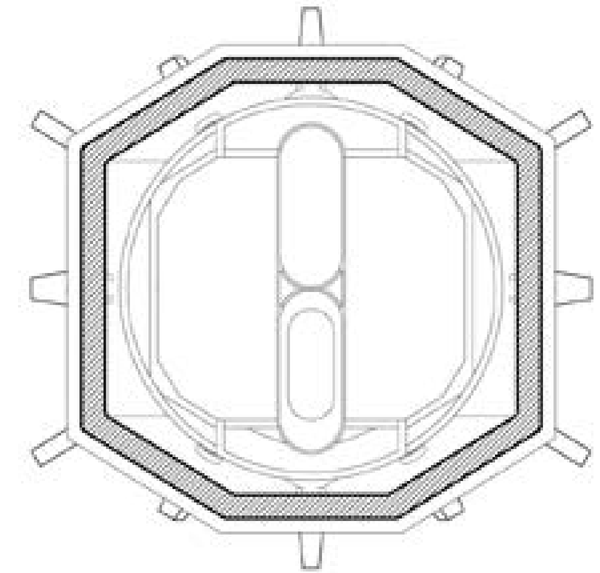
Multi-Layer System

The complex mechanic system between two envelopes manipulates the movement of both layers which also contains the required life support machinery within the gap. The outer layer is composed of inflatable silicones that can control the rods by changing the size of each unit. The inflatable silicones and rods control the size and mobility of the design, making it as a breathing organ at each time it deforms. Within the bigger respiratory form, the inner layer can also be transformed by a string system that is pushing and pulling to change the form of the interior space and the position of the plants. The overall design would be an alive architecture with a smaller organ within a bigger organ, which both can be bionically respiratory.



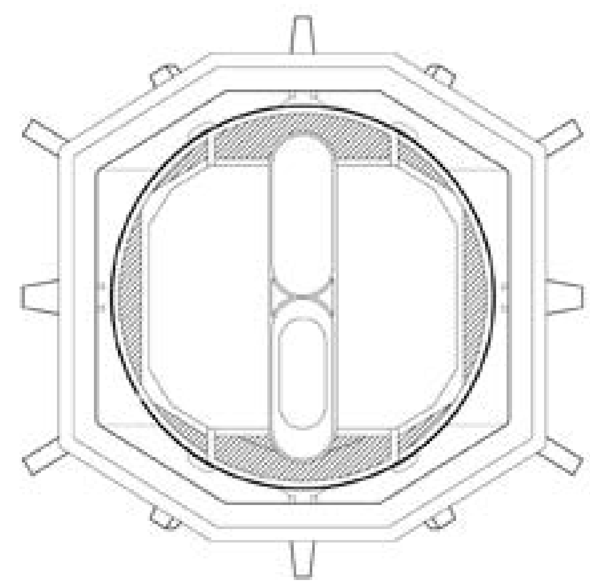
1. PNEUMATIC LAYER

The exterior layer of the module is composed of flexible silicon material, which serves as a protective layer during landing and can be individually controlled for movement.



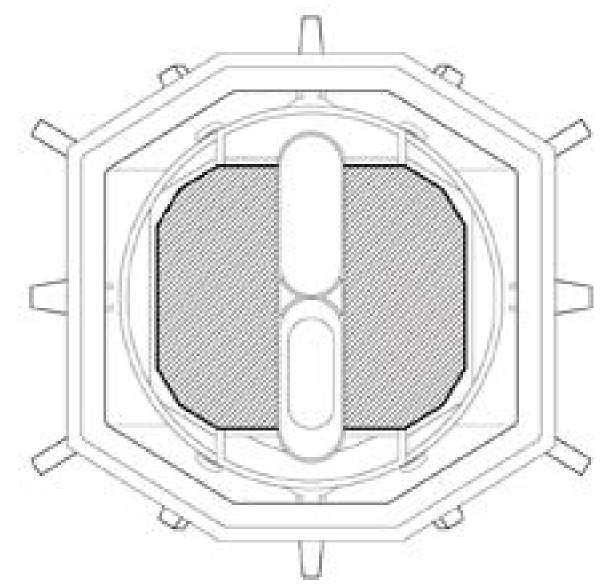
2. MECHANIC LAYER

The inner layer serves as the mechanic/equipment space to store resources and controls the exchange and filtration of exterior to interior resources.



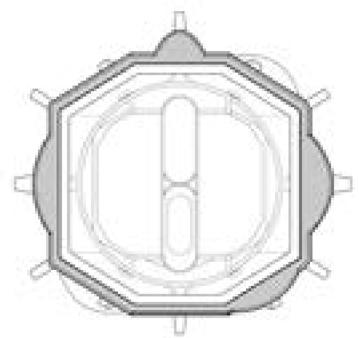
3. REGENERATIVE LAYER

This layer controls the regeneration of resources, including using aeroponic planting as food source and filtering exterior $CO2$ into usable $O2$.



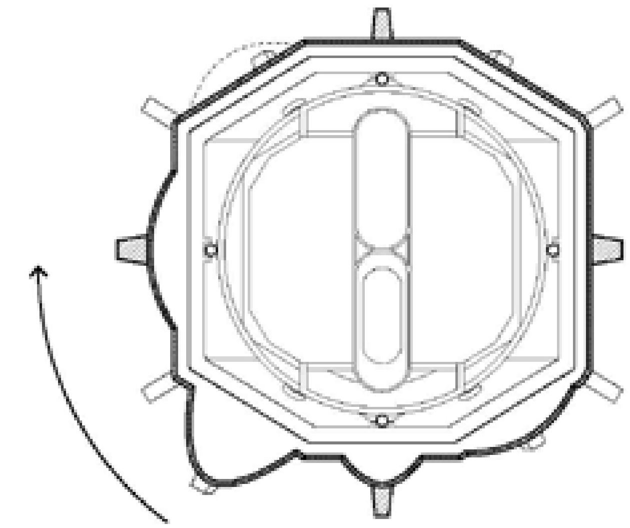
4. HABITATION LAYER

The inner most layer consists of living space which allows the astronaut to conduct research and basic living requirement in a convertible space.

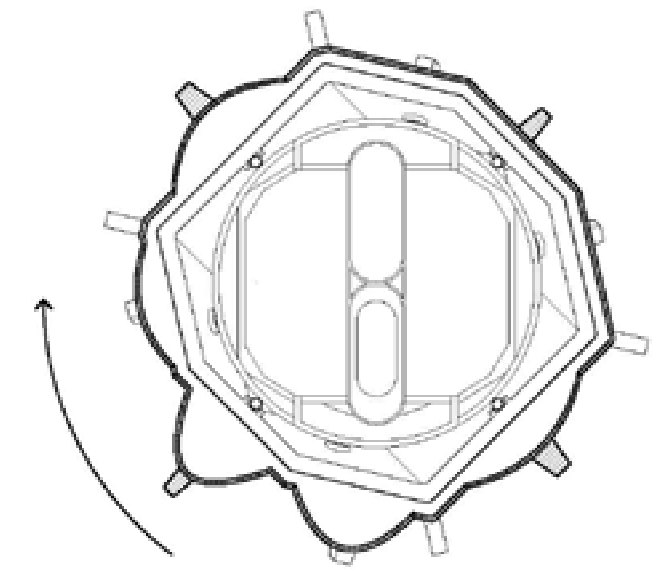


Object in Motion (Pneumatics Panels)

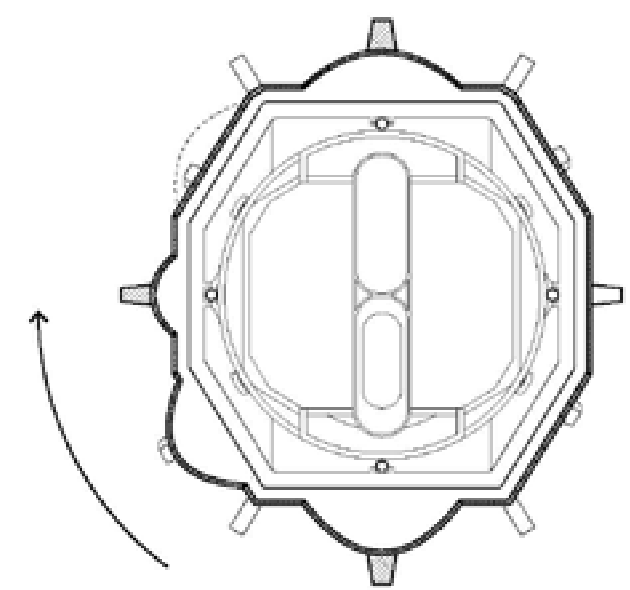
The complex mechanic system between two envelops manipulates the movement of both layers which also contains the required life support machinery within the gap. The entire habitat can be seen as a portable and mobile lab cabin that can move around on Mars for site research. While the exterior envelope is inflating and rolling, the cabin will move in any direction but the inner sphere will remain stable due to the bearing ball structure and gravity.



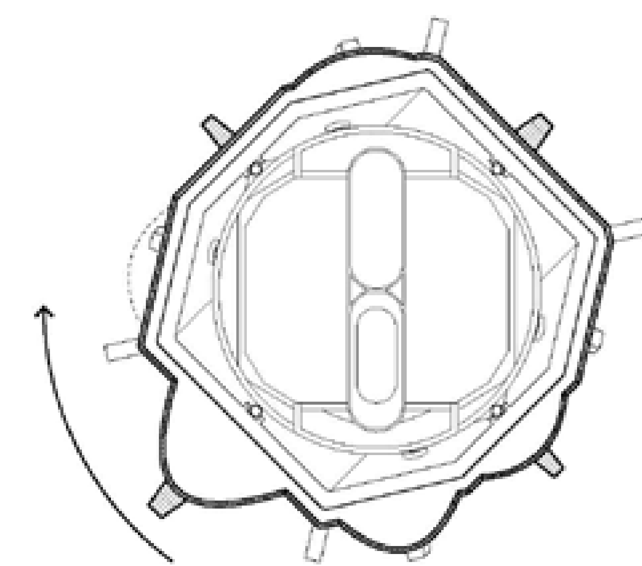
PHASE 1



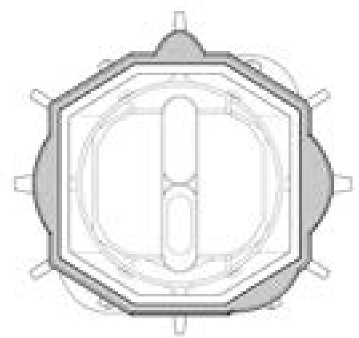
PHASE 2



PHASE 3

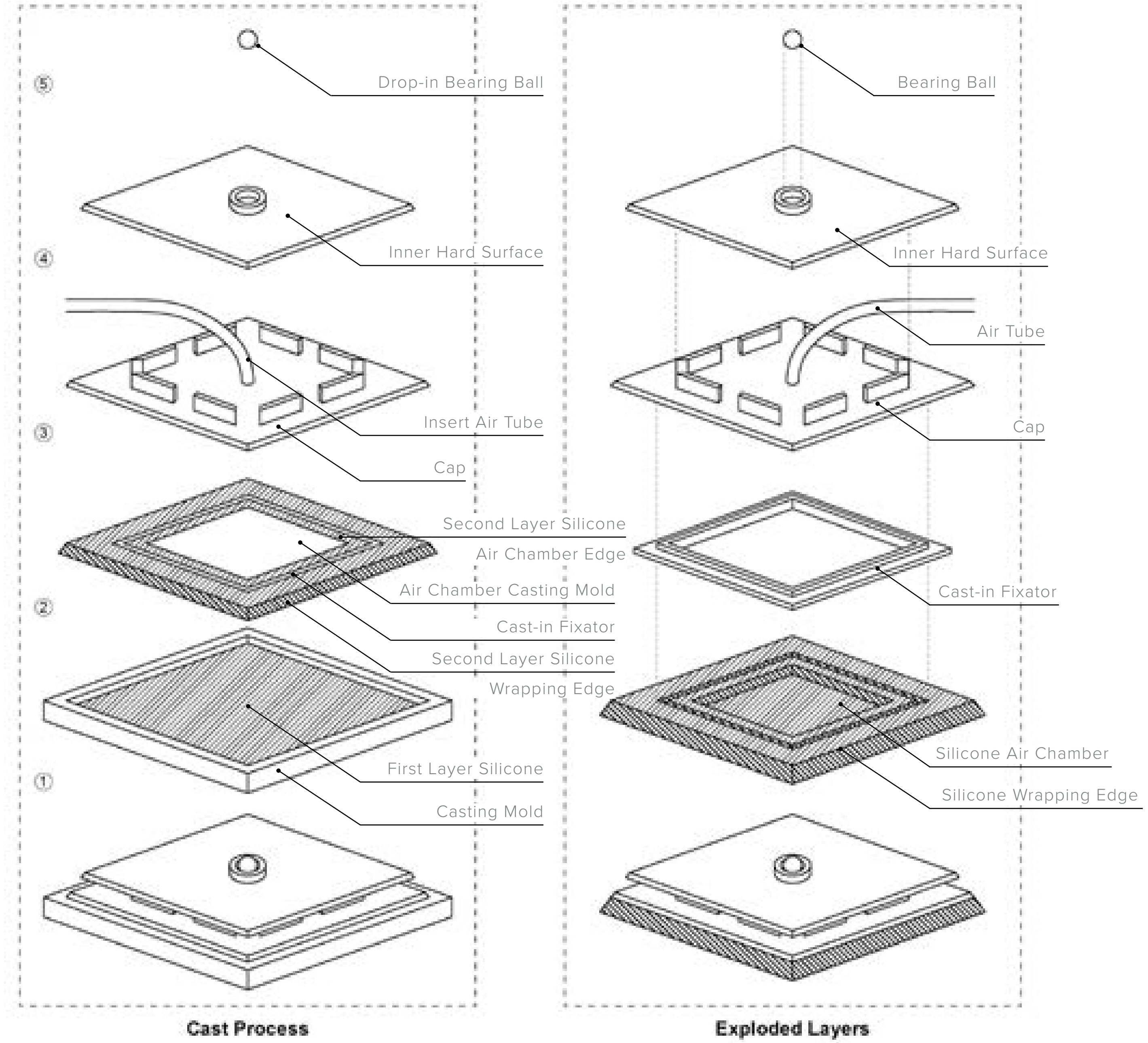


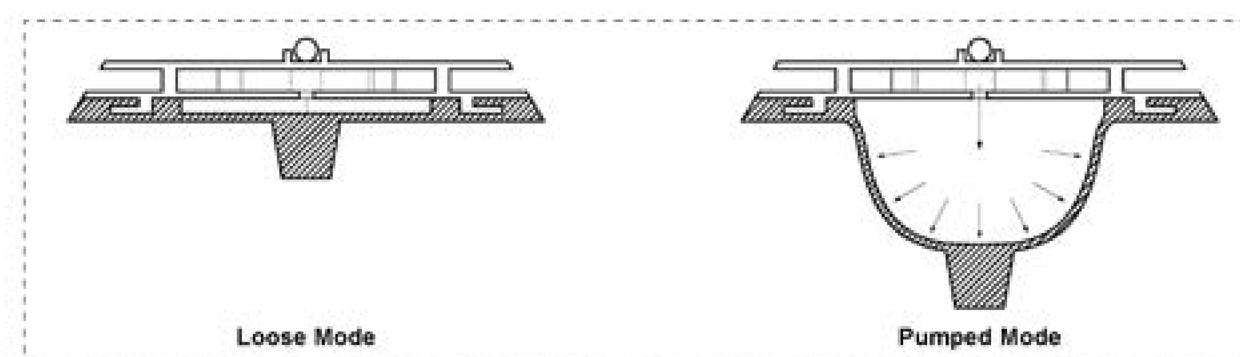
PHASE 4

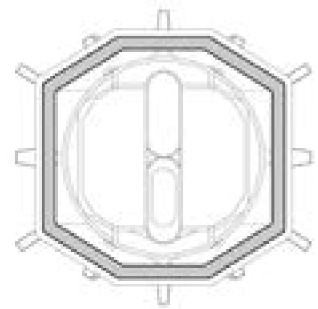


Panel

The exterior pneumatic envelop is consisted of 30 brick modules. Each one of them are made up of silicone skin and two layers of hard skeleton. There is also an air tube designed to place between these two layers to pump air into the air chamber covered by the silicone skin. The cast process starts from the silicone with buffer padding, then positioning a cast-in fixator with another layer of silicone to create an air chamber and reinforce the resistance to the air precure. Afterward, the two layers of hard skeleton will be capped onto the silicone.

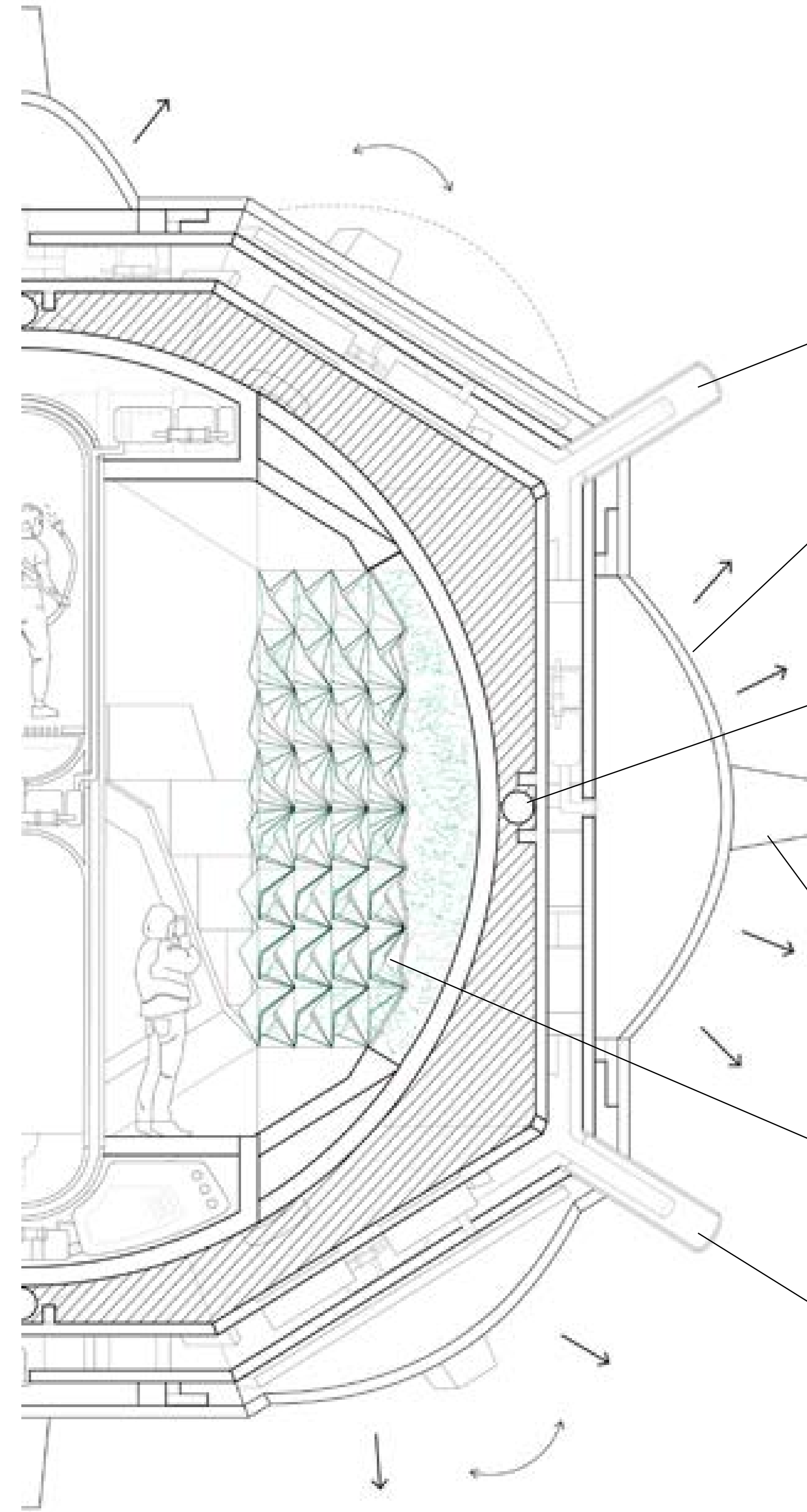


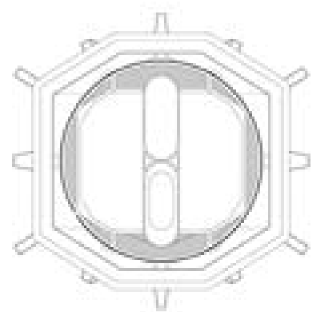




Systems In Details

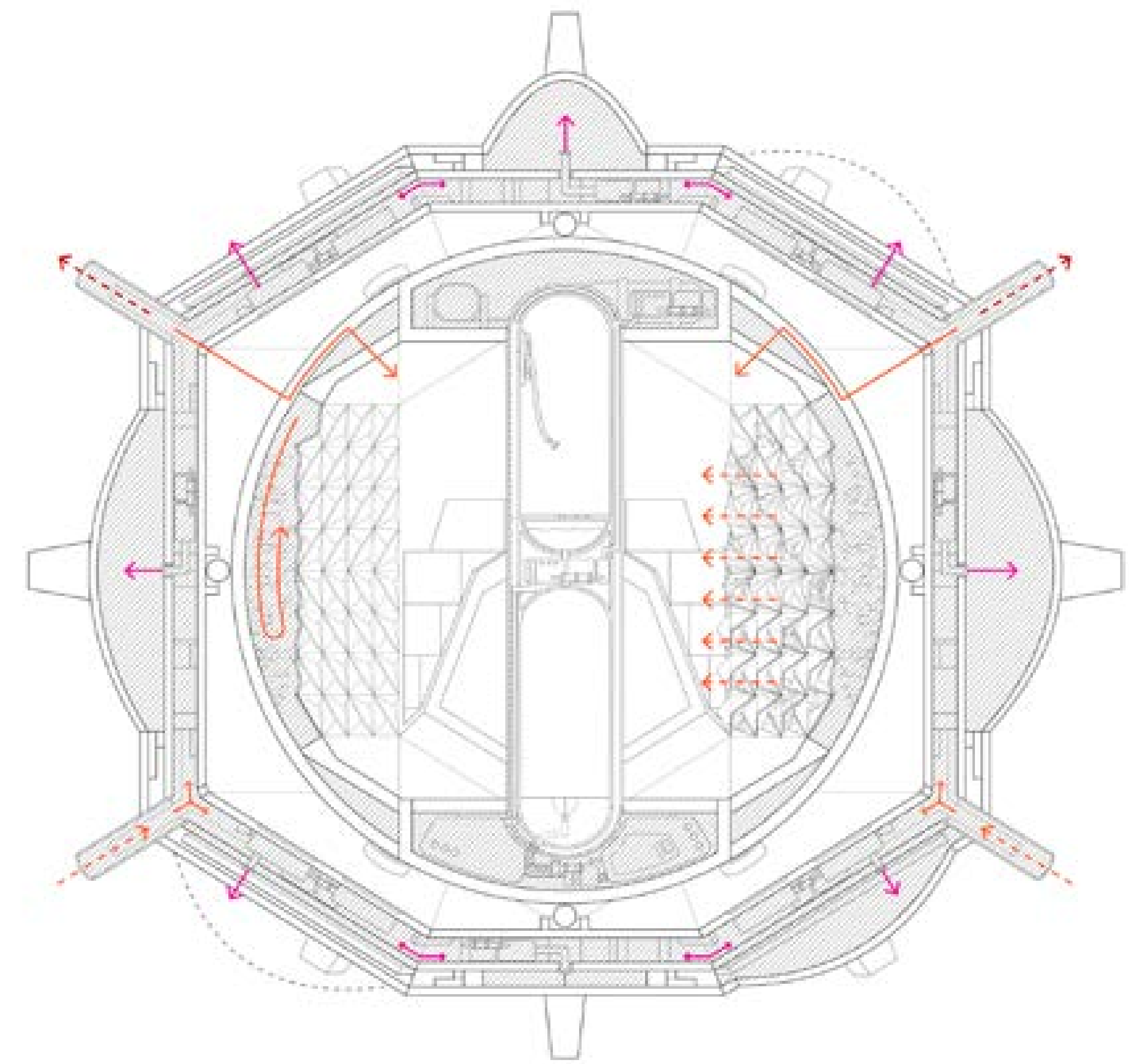
The integrated system together works as a network, from the extraction of external atmosphere and Martian ice to the internal process and circulation of usable air and potable water. Essential elements like the aeroponic wall and the dynamic pneumatic panels works together to facilitate the synchronization of movements, the production and re-production of life support system. The entire habitat works like a living organism to sustain the life within.



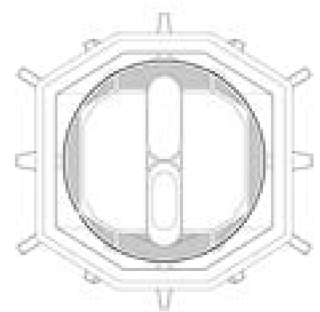


Air (O^2) Production through Photosynthesis

It is forseable for photosynthesis to occur on Mars, as it is primarily composed of CO2, therefore it may be possible to create a sustainable enviornment for photosynthesis through terraforming. With sufficient levels of CO2 on the Martian surface, they can be seen as valuable resources to support plant growth inside the SEED Habitat. The plant may then produce O^2 to support human survival within the sphere. Through maximizing light exposure and manipulating the LED color in between the layers, the plants can ensure maximum production. The panels inbetween can then be operated to release the production of oxygen into the living space to sustain the human.

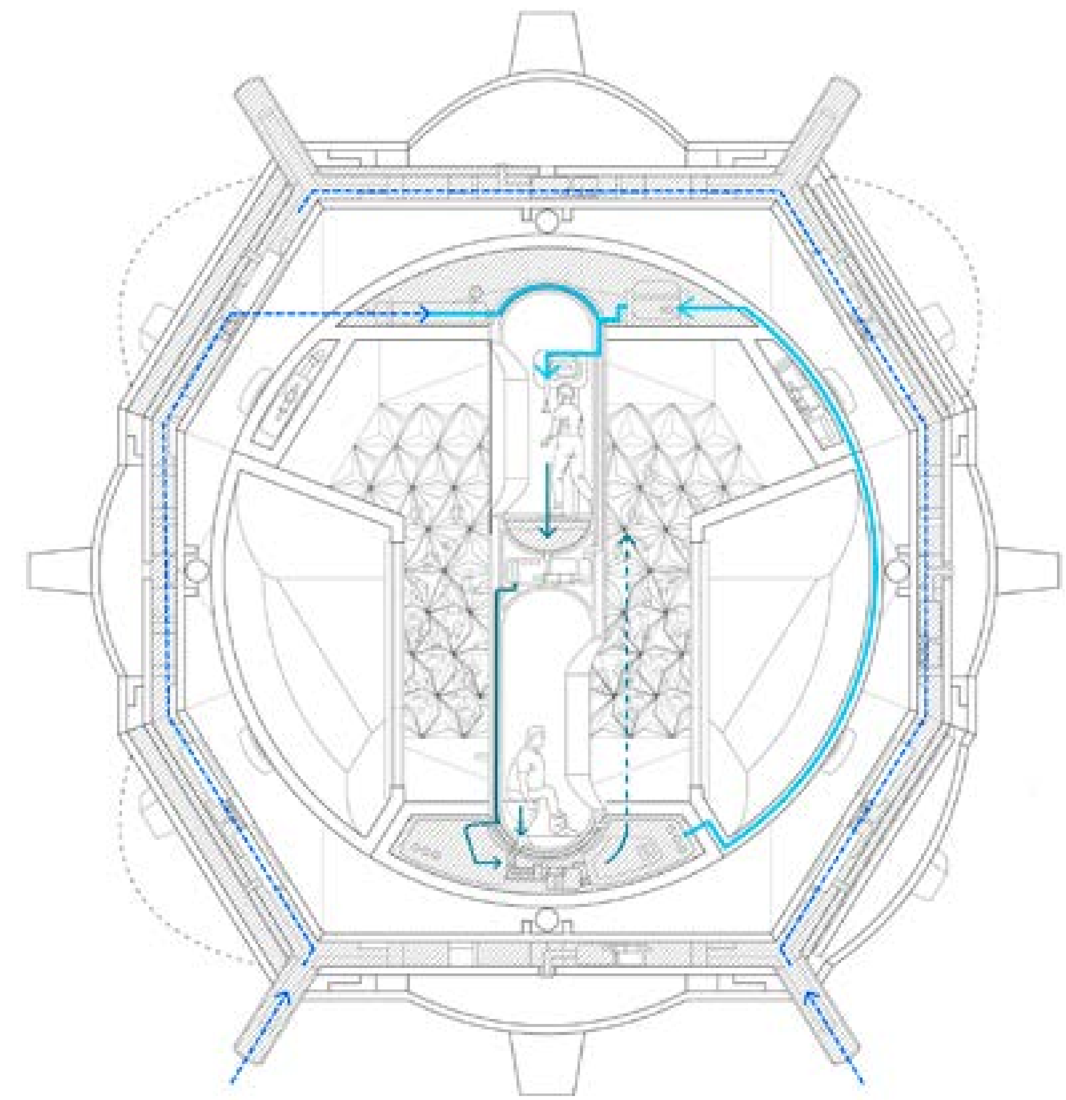


Air Circulation
Filtered Oxygen
Intake CO2
Exhaust Gas

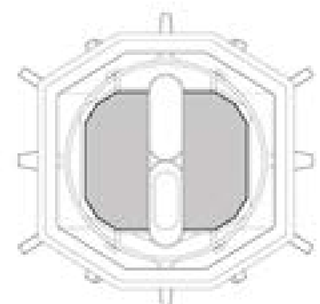


From Martian Polar Ice Caps to Potable Water

Recent studies and missions to Mars have provided evidence that the planet has significant amounts of water ice, particularly at its poles, which could be a valuable resource for future human exploration and settlement. With the extraction of ice, the liquid may be processed through the outer shell of the habitat and be circulated to the interior sphere to become usable water for shower and drinking. It can then be collected as gray water to be used for toilet flush and its waste can be extracted by the plants as nutrition and for filtration purposes.

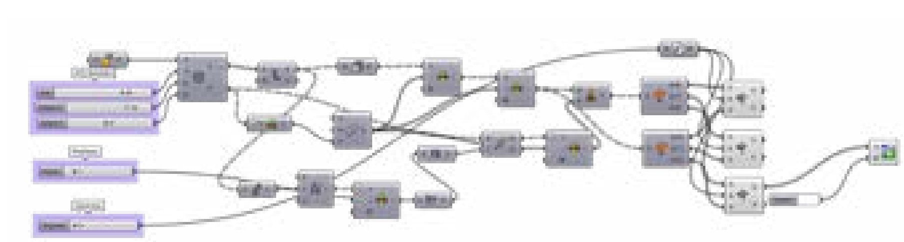


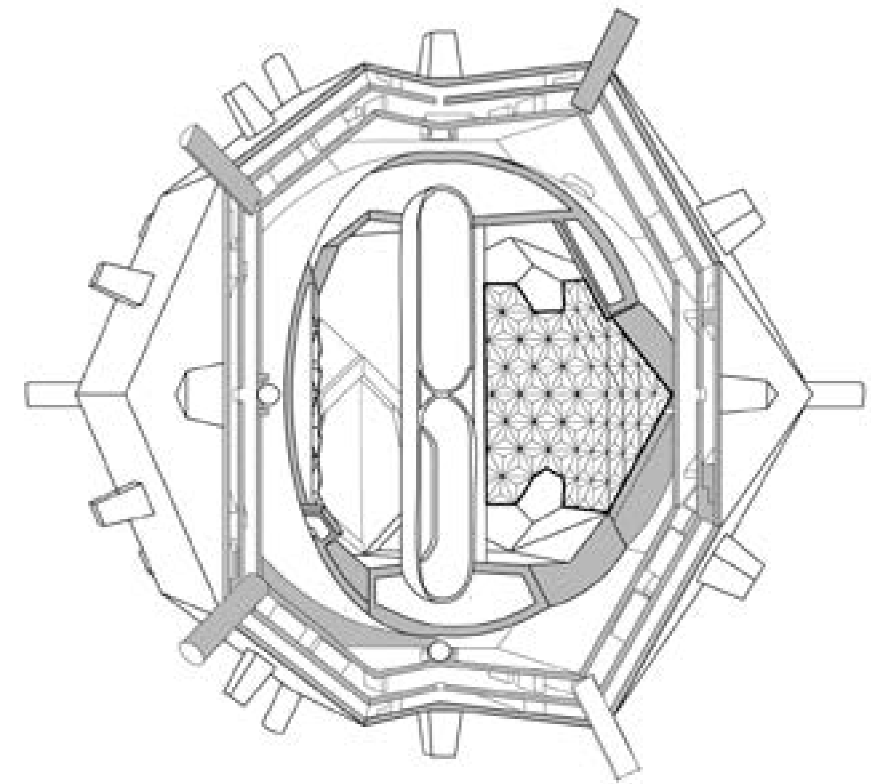
Clean Water
Gray Water
Mars Ice Caps (Harvestable Water)



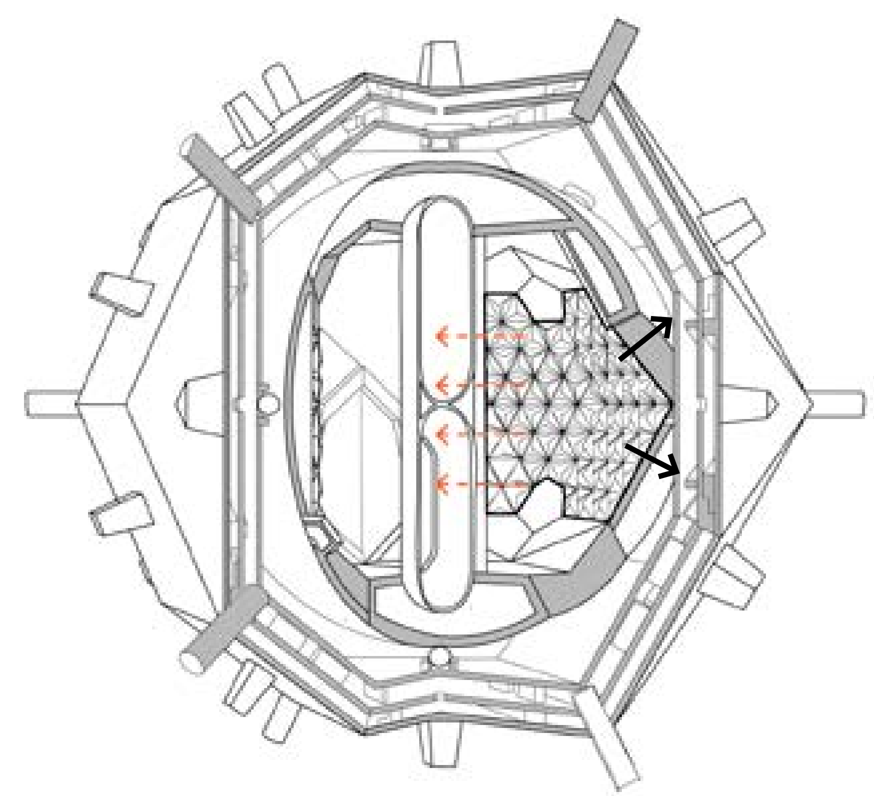
Kinetic Wall

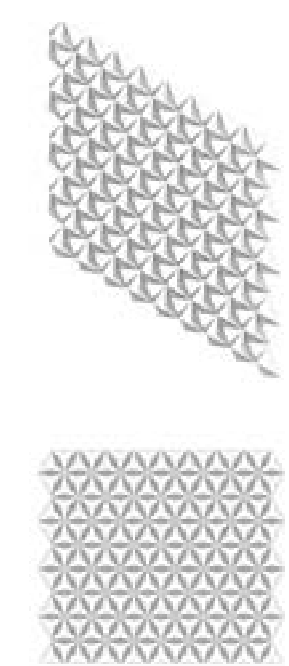
On two side of the interior space, ther are kinetic walls designed, and developed with detection system, which allows the kinetic wall to interact with people and truly makes this project unique. By integrating this sophisticated technology into the wall, they were able to create an interactive experience for users that truly sets this project apart from others. The detection system utilizes a series of sensors and cameras that detect the presence and movements of people in front of the wall, enabling the wall to respond and react to their movements in real-time. While the wall panels open, the plants behind will be shown to people who is interacting with the wall. This dynamic interaction between the wall and the user creates a sense of engagement and immersion, transforming the wall from a static object into a living, breathing entity that can adapt and respond to its environment.



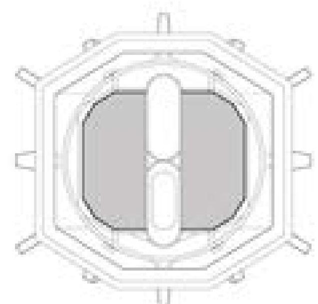


Closed Up Kinetic Wall



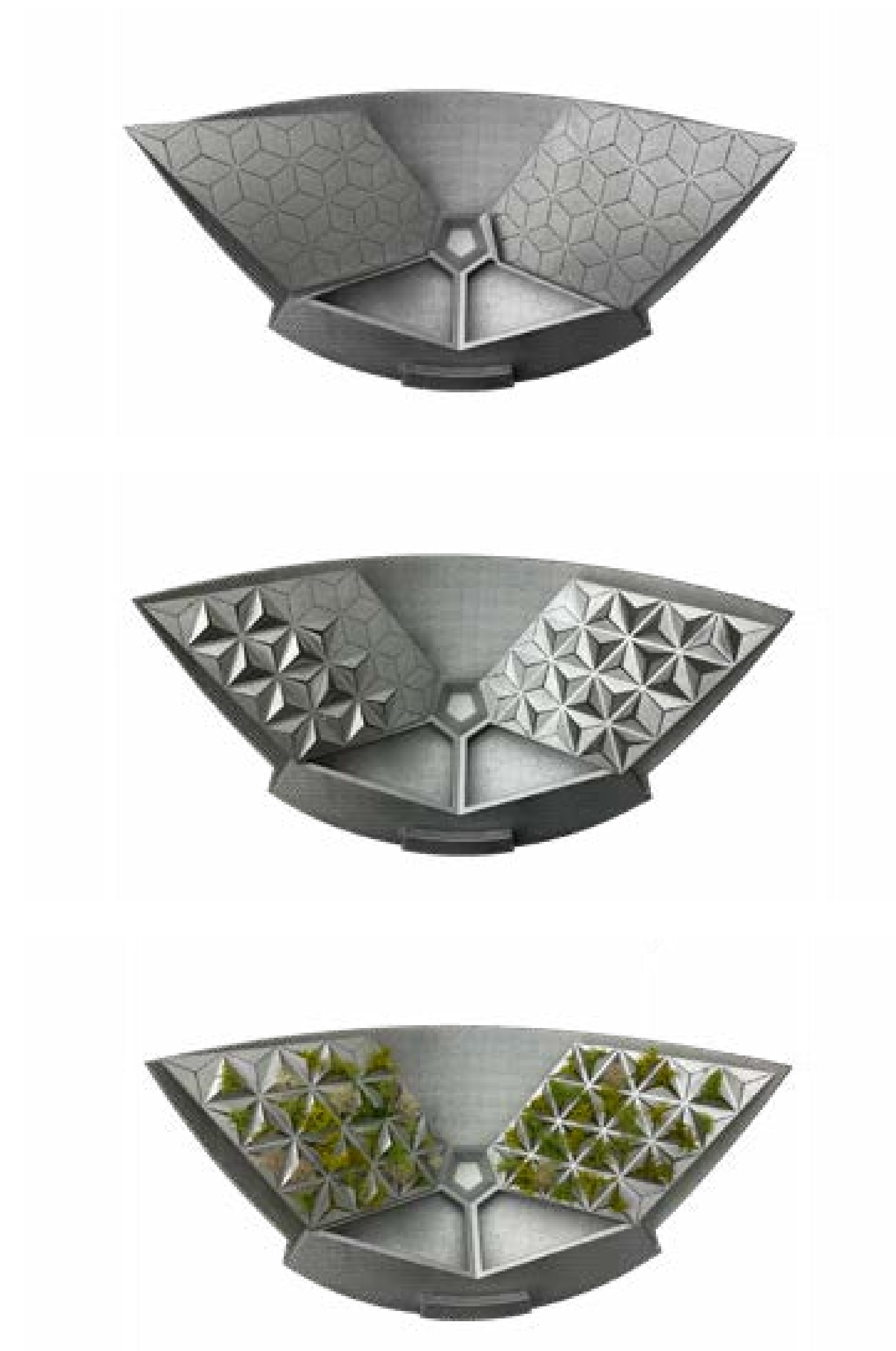


Opened Kinetic Wall

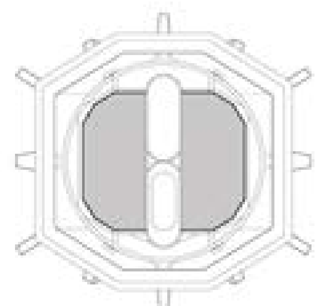


Oxygen Tank

The plants behind the kinetic wall are used to provide oxygen in conjunction with the oxygen generator This can help extend the duration of the mission by complementing air circulation and reducing mechanical burden. While the wall panels are closed, the plants will be in photosynthesis mode to convert the CO^2 to O^2 in-between the spheric shell and the kinetic wall. While the wall panels are opened, the plants behind will be shown to people who is interacting with the wall. Meanwhile, the oxygen produced by plants will be released between these openings.

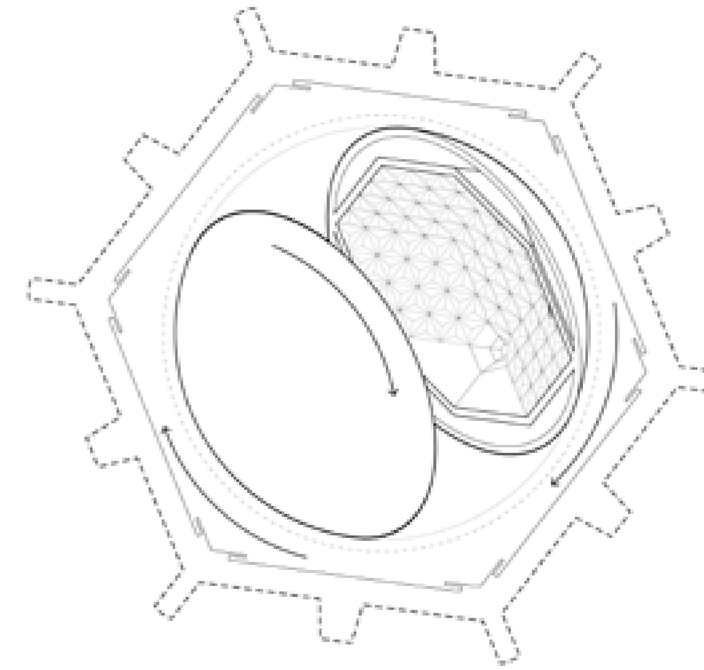


Kinetic Aeroponic Wall

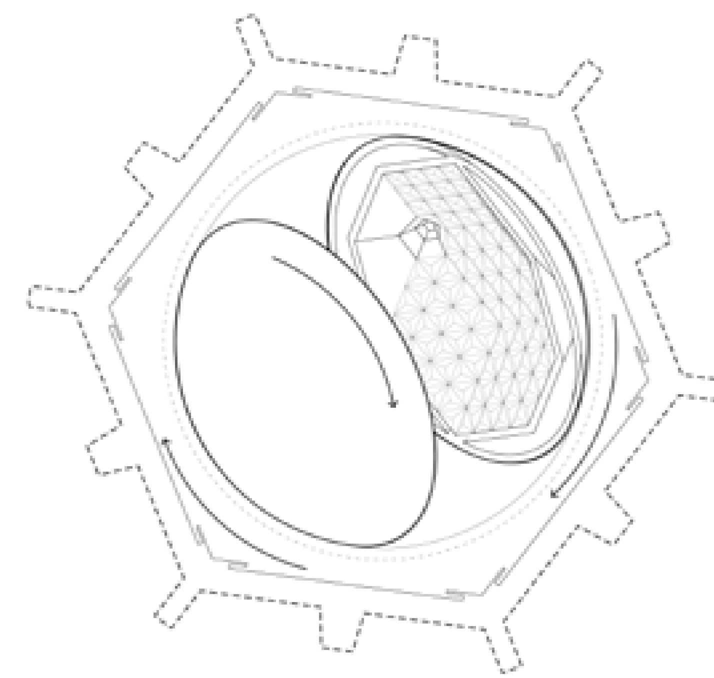


Inner Rotation Layer

The inner volume will be subdivised into three zones, the central will remain fixed while the two sides may be rotated to create different spatial experiences as well as differerent programs. When rotated 90 degrees, the zone is designated as work zone and the floor plate becomes ladder to access upper floor. When rotated 90 degrees again it creates a separate zone and an upper level for sleeping.

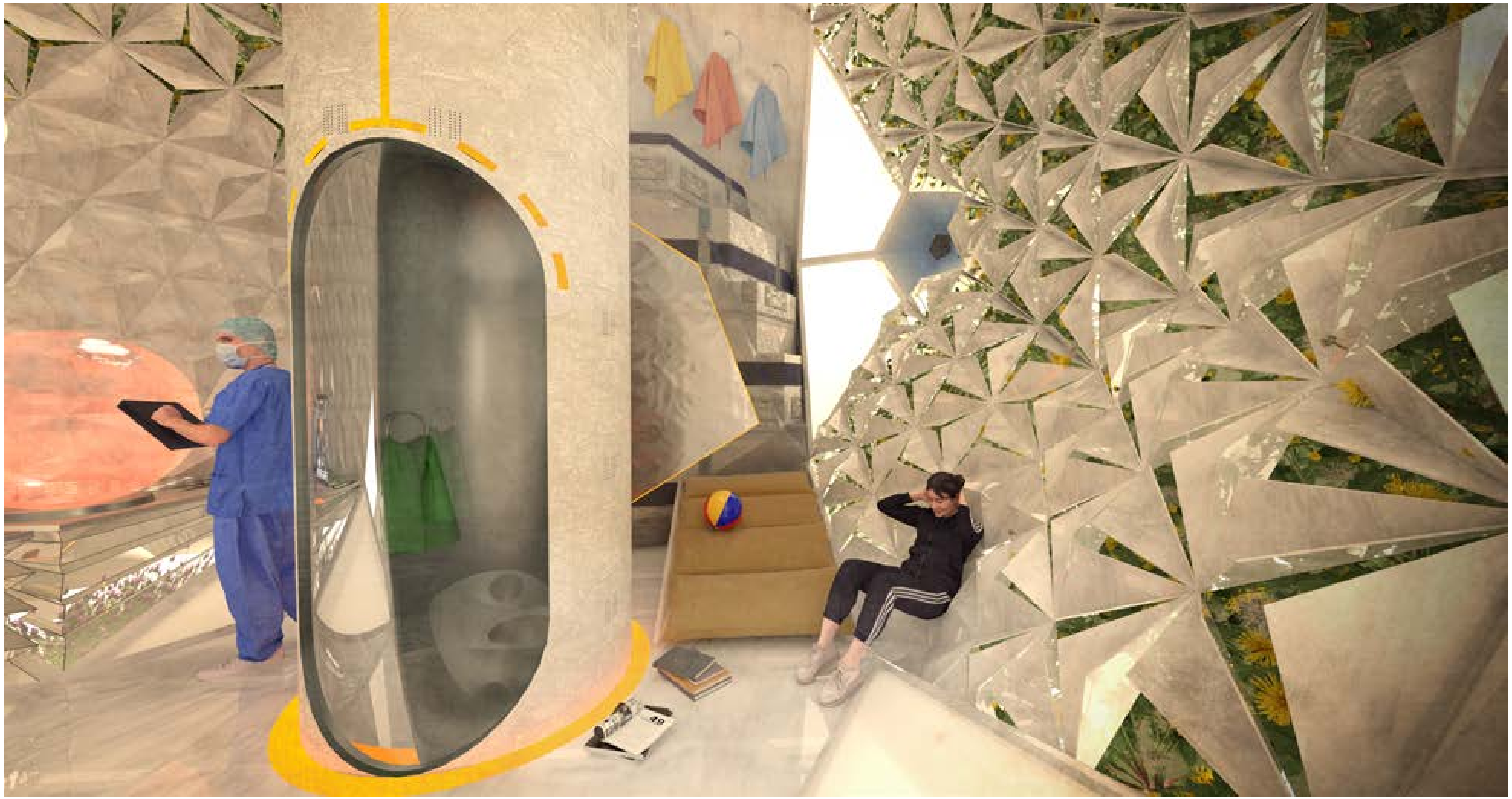


RESTING MODE

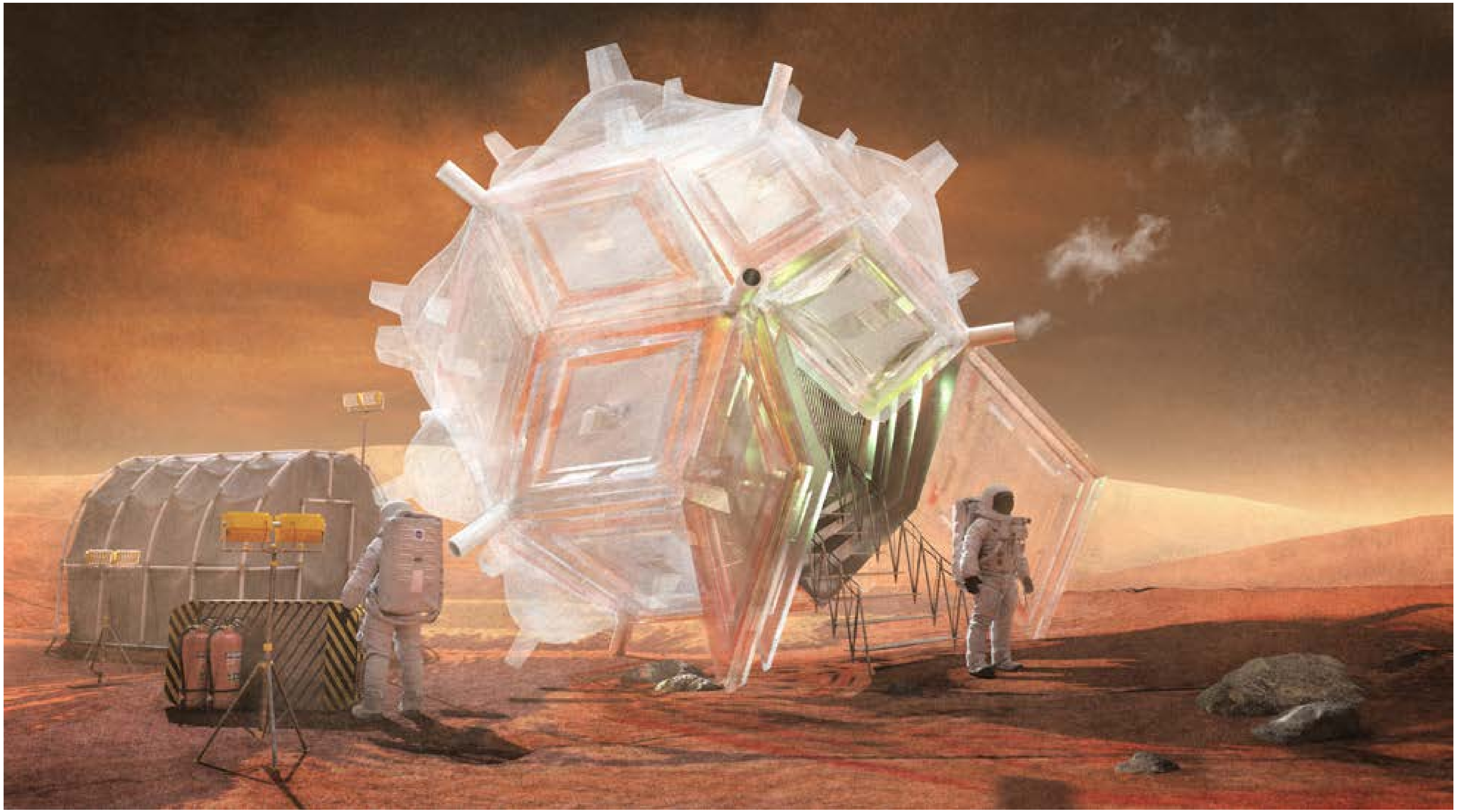


RESEARCH MODE

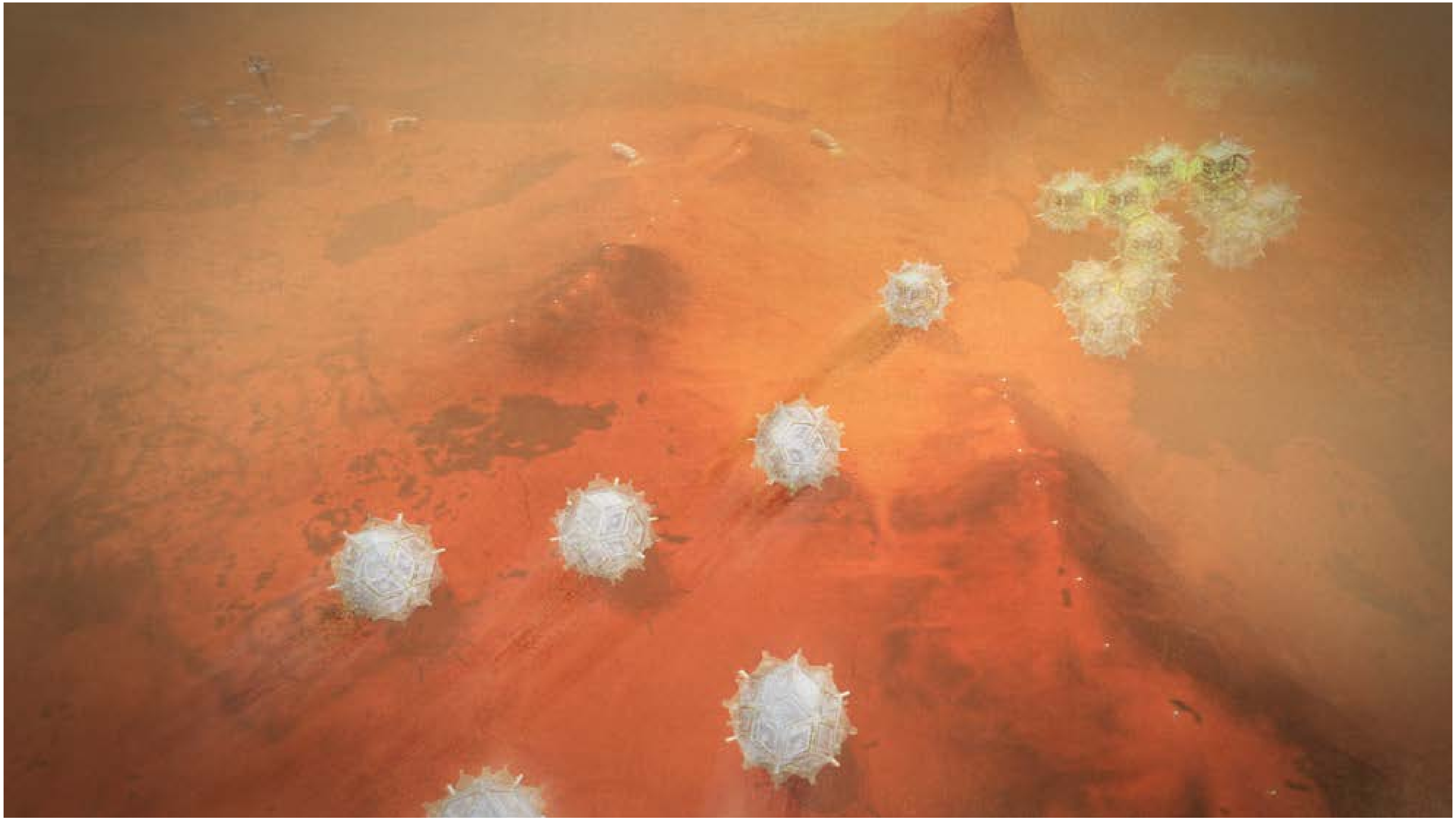
SEED Habitat Interior Scenarios (Working vs. Resting)



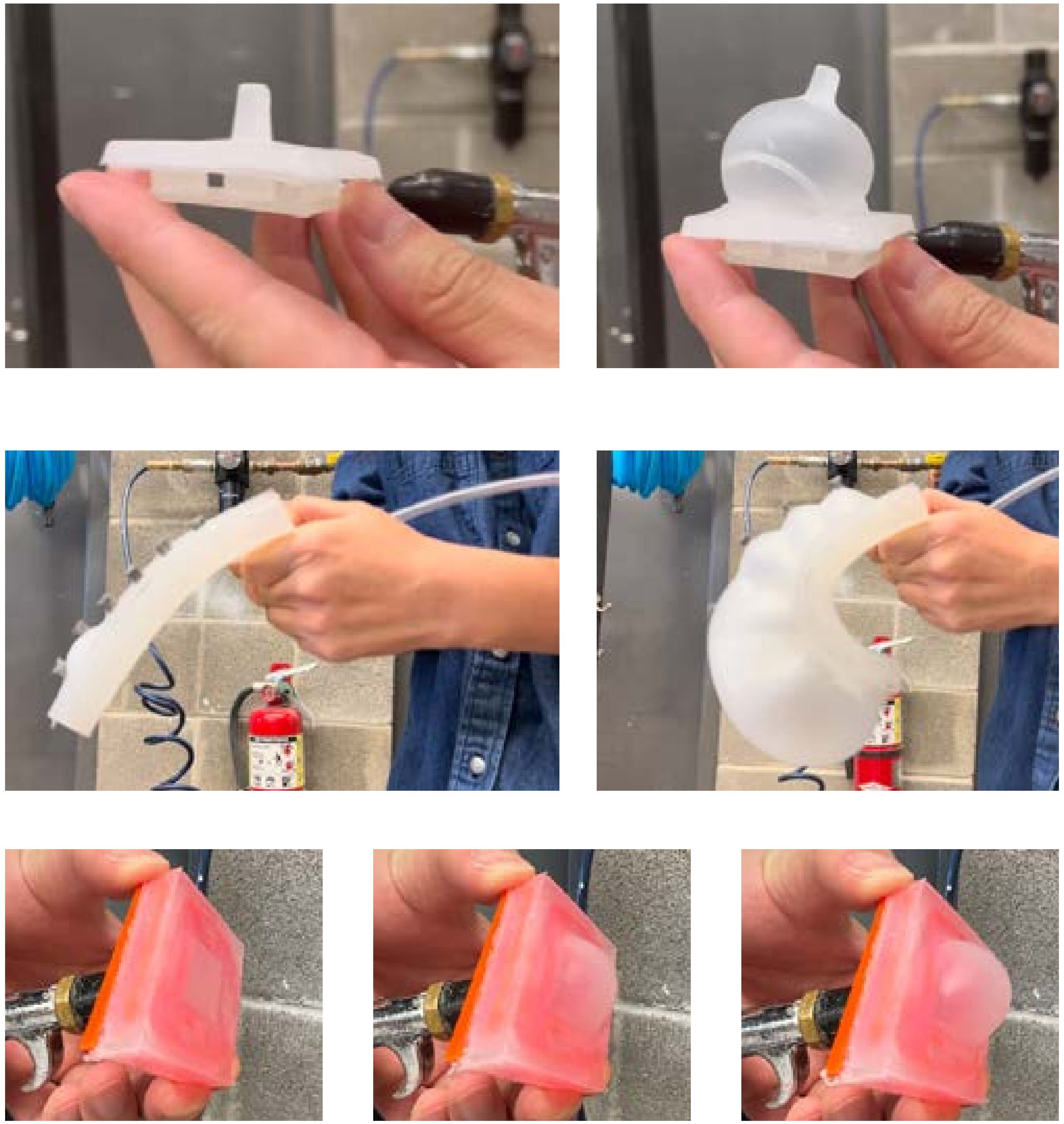
SEED Habitat Interior Scenarios (Adaptive Wall)



Research Station on Mars Surface



The Sixth Migration



Prototype Testing

Model Process

Contributions

Speculative designs for outer space habitat has been discussed as early as 1903, with the goal of human expansion without the exasperation of any ecosystems or the displacement of indigenous people. More recently, NASA announced design competitions in 3D-printed habitat for deep space exploration to advance the existing sustainable construction technology with long lasting benefits and applications. It is with similar interest for us to research and contribute our own ingenuity in the discourse of an innovative architectural system integrated with the regenerative life support system that enables mankind to explore and to survive in the most hostile conditions of space.

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