LEAP

TO ARCHITECTURAL THESIS PROJECT & BEYOND

"The future is in the skies."
M. Kemal Atatürk

SILA ÇELİK
submitted MAY.2020

CONTENT

ACKNOWLEDGEMENTS

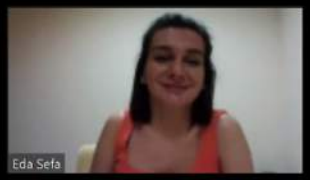
I'am extremely grateful to Professor Mark Frederickson for his invaluable contribution, unparalleled support, and guidance. I have learned the power of being a team from his experience and valuable participation.

I would also like to extend my deepest gratitude to my dear colleagues. They provided me with encouragement and patience throughout the duration of this project. I appreciate their valuable critisisms and help.

I'am deeply indebted to my mom who always supported and nurtured me throughout the whole journey. It would be tougher without your existence. And special thanks to my boyfriend who never let me down from thousands of kilometers far away.

Sıla Çelik

Dr. Mark Frederickson
Fulbright Professor of Architecture



Mom
Fulltime Supporter

[02]

WHY DO WE GO BACK TO THE MOON ?

The United States' Apollo 11 was the first crewed mission to land on the Moon, on 20 July 1969. There were crewed landings between 1969 and 1972, and numerous uncrewed landings.

NASA is going to the Moon with commercial and international partners to explore faster and explore more together.

This work will bring new knowledge and opportunities and inspire the next generation. In going to the Moon, NASA is laying the foundation that will eventually enable human exploration of Mars.

The Moon will provide a proving ground to test technologies and resources that will take humans to Mars and beyond, including building a sustainable, reusable architecture.

MOON

The Moon makes Earth a livable planet by moderating our home planet's wobble on its axis, leading to a relatively stable climate, and creating a tidal rhythm that has guided humans for thousands of years.

It is the only celestial a body beyond Earth that has been visited by human beings.

NASA's work at the Moon, which is pressing forward right now, is preparing us for the next giant leap: challenging missions to Mars and other deep-space destinations.

[0 3]

FACTS ABOUT THE MOON

TEMPERATURE

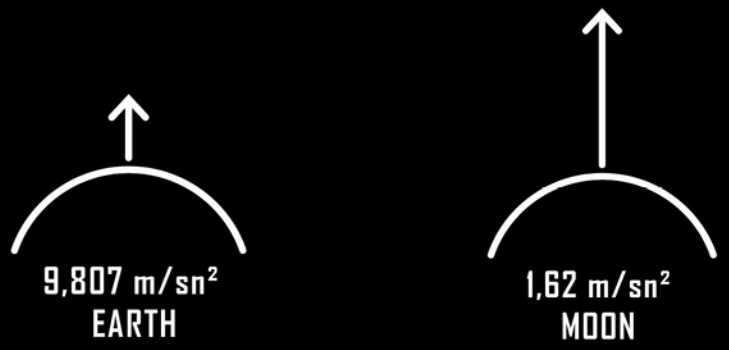
When illuminated by the sun, the surface of the moon can reach up to 127 degrees Celsius .When the illuminated side moves into darkness, the temperature falls significantly. Since the sun no longer heats the surface, the moon's surface can drop to -150 Celsius.

TEMPERATURE

However, underground studies shows that the temperature is constant. Therefore, initial habitations may be located underground and benefit from constant temperature to optimize the interior temperature to livable degrees for humans.

GRAVITY

Lunar gravity is one-sixth of Earth's gravity. The ease of physical movement for humans may provide recreational applications on the Moon such as development of games that are unique in the lunar environment.

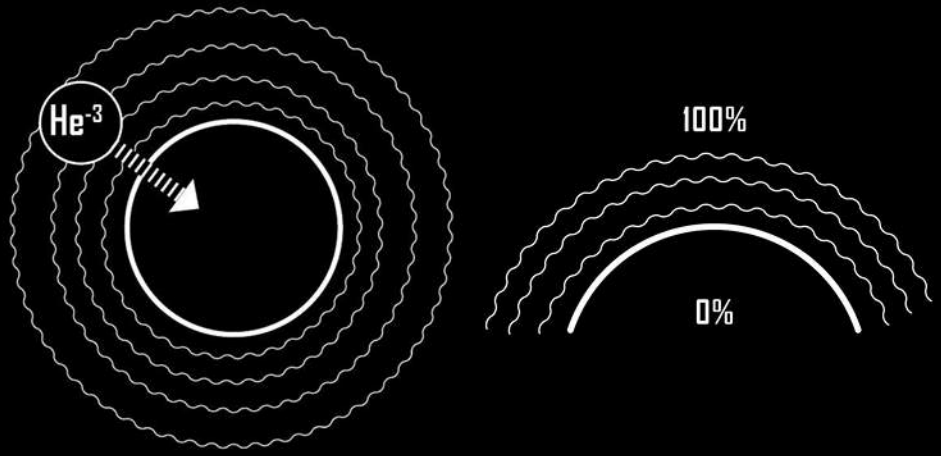


GRAVITY

However, lunar gravity affects the Achilles tendon and may result bone and muscle loss. It is required to do regular exercises during the time of mission.

SOLAR AND GALACTIC RADIATION

The surface of the Moon is baldly exposed to cosmic rays and solar flares, and some of that radiation is very hard to stop with shielding. Furthermore, when cosmic rays hit the ground, they produce a dangerous spray of secondary particles right at your feet. All this radiation penetrating human flesh can damage DNA, boosting the risk of cancer and other maladies. However, a constant depth of undergound does not exposed to these dangerous rays and flares.



The idea of harvesting a clean and efficient form of energy from the Moon has stimulated science fiction and fact in recent decades. Unlike Earth, which is protected by its magnetic field, the Moon has been bombarded with large quantities of Helium-3 by the solar wind. It is thought that this isotope could provide safer nuclear energy in a fusion reactor, since it is not radioactive and would not produce dangerous waste products.

REGOLITH AND ATMOSPHERE

The regolith has several metal alloys and high amount of oxygen that can be harvested during the mission. These metals may be used as resources for in-situ constructions, which decreases the cost, energy, and work time. Studies show that creaters sustain high amount of platinum, gold, and titanium resources. Mountanious areas have mostly glass resources and iron. The dark looking soils on near side of the Moon includes high amount of metal alloys on regolith.

^{8}O oxygen	^{14}Si silicon	^{26}Fe iron	^{20}Ca calcium	^{13}Al aluminum	^{12}Mg magnesium
^{18}Ar argon	^{2}He helium	^{10}Ne neon	^{11}Na sodium	^{19}K potassium	^{1}H hydrogen

Scientists found that the Moon has an insignificant atmospheric thickness infact. The gases that found mainly are inert gases, which may be extract with scientists on duration of the mission and may be used as lighting or thermal insulation resources.

[0 4]

LOCATION

PRIMARY SITE: HADLEY RILLE

Hadley Rille (on the left figure) is choosen for inital habitat experiment on Moon. The rille is a collapsed lava tube. For the project it is assumed that the lava tube (expamples from Moon and Mars on the right) is not collapsed since there are several advantages to settle on a lava tube on Moon and Mars.

It can be a protection against solar and galactic radiation. Also, underground habitation can provide heat insulation since the temperature underground is constant unlike the surface.

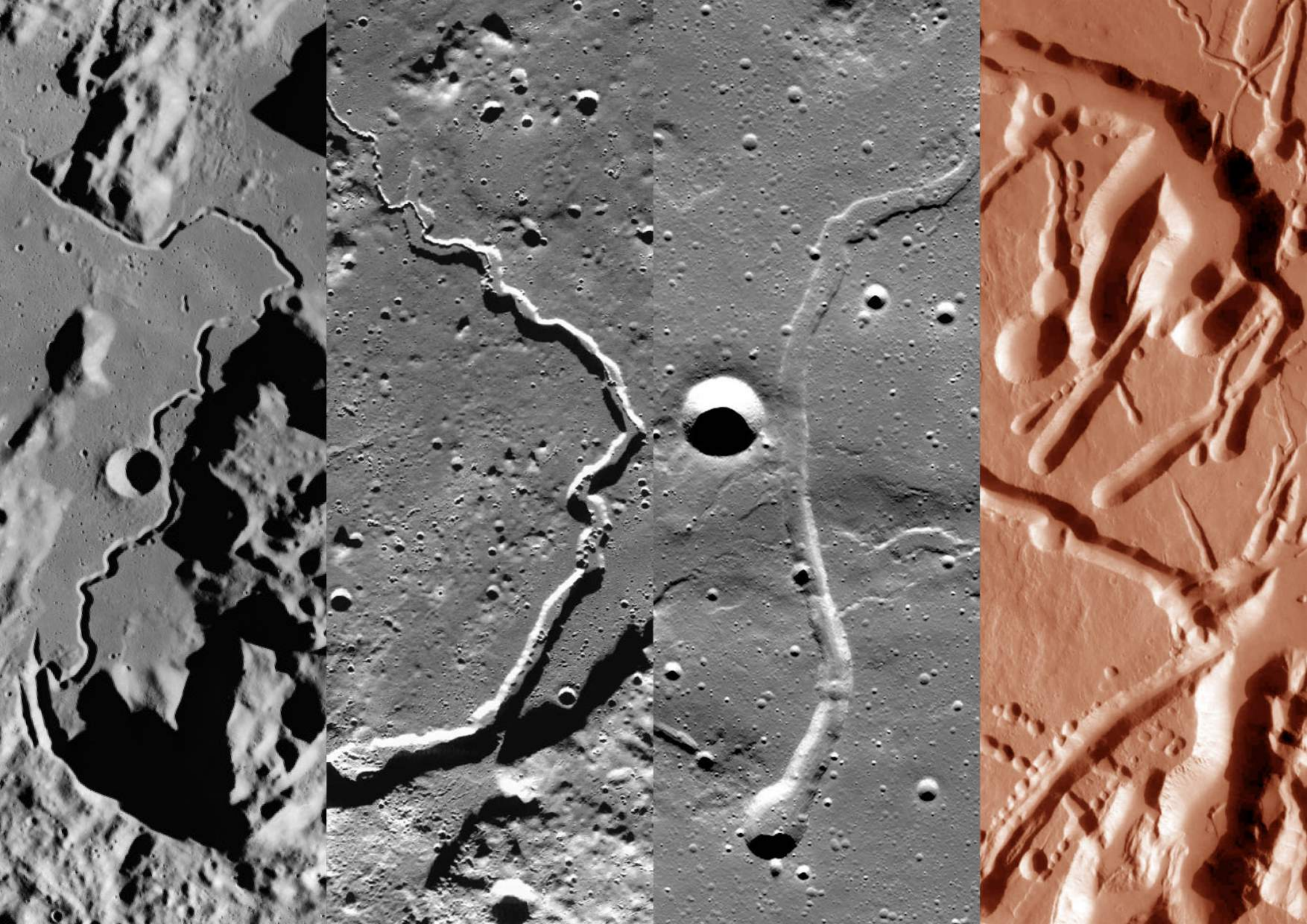
The rille is located on the mid-lattitude on near side of the Moon. Therefore, the location has the opportunity to have a Earth view while the surrounding provides flat and wide landing and launch spots. Also, various valuable local resources are valid in the site for construction.

TYPOLOGY: Research and Tourism Center

Space was only accessible for astronauts for the past space missions. This project will create a new bond between space and humanity. The Moon and deeper space will be accesible for people who are willing to discover, learn, and experience out of Earth.

Space tourism will create a sustainable economy for further space missions while enabling people to have a wider perspective to our home planet.

The mission will force our limits to develop sustainable technologies out of Earth to survive and we will access to valuable resources that might open gates for new sustainable ways of living here on Earth.



[0 5]

FUTURE MISSIONS

NASA ARTEMIS MISSION 2024

MARS ONE FOUNDATION MARS ONE 2025

SPACEX MARS MISSION 2030

[0 6]
KEY PROPERTIES

[CONSTRUCTION]

The best way to construct would be to use local materials on Moon. Because building materials will increase the payload therefore the will increase costs getting to Moon. Moon regolith has a huge potential as a local construction material. ESA has tested moon dust concrete and detected that moon dust concrete is more durable than ours on Earth. 3D printing in-situ construction would decrease work-load, cost, and construction time.

[WATER]

Scientists detected ice water reserves on North and South Poles. However, these regions are not preferable yet to be settled since poles have rough topograhy and it may cause problems during landings/launches. Recently it is detected that moon regolith has water in it, and it is released by micro-meteor rains to the vacuum of space. Therefore, water may be initially harvested from the regolith in mid-lattitudes where the topography is suitable for landings/launches.

[ENERGY]

Sustainable energy in the form of solar, fusion, waste, algae

[FOOD]

Methods might be used for food production on the Moon

[TRANSPORTATION]

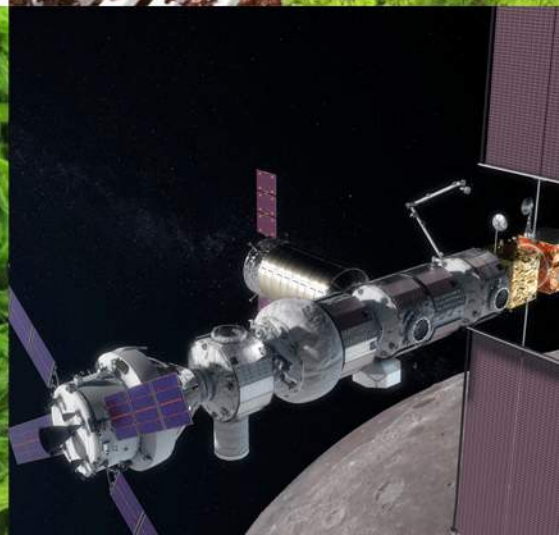
NASA is working with its partners to design and develop a small spaceship that will orbit the Moon called the Gateway. NASA believes the Gateway will be the key to a new era of lunar exploration – both in orbit and on the surface of the Moon. Also, it will provide sustainable transportation ways to deeper space missions like Mars.

[RADIATION SHIELD]

NASA is working with its partners to design and develop a small spaceship that will orbit the Moon called the Gateway. NASA believes the Gateway will be the key to a new era of lunar exploration – both in orbit and on the surface of the Moon. Also, it will provide sustainable transportation ways to deeper space missions like Mars.





[CONSTRUCTION]

LOCAL RESOURCES

Future settlements on the Moon or planetary bodies may utilize in-situ materials for a variety of applications:

• Volatiles such as oxygen obtained from the lunar "soil" (regolith) might be used to replenish atmosphere supplies and as a component of cryogenic rocket fuel.
• Silicates, metals, glass and basalt obtained from regolith might be used in the construction of space structures.

Moon contains abundant materials that might possibly be used for construction:

• Dark maria plains have basalts that are rich in iron, magnesium, and often, titanium.
• Highly cratered highland areas contain substantial quantities of aluminum and calcium-rich rocks.
• Oxygen is also plentiful in lunar regolith, affording many beneficial uses.

Lunar metals might be applied for beneficial construction uses provided that they can be mined, processed and formed in a practical manner:

• Highland soils are believed to contain significant amounts of aluminum, and mare soils contain some aluminum, much iron and small amounts of titanium.
• Purity levels of lunar regolith minerals are low compared with Earth soils, but iron-rich meteoroid fragments might be harvested by drawing a magnet along the surface.

LUNARCRETE

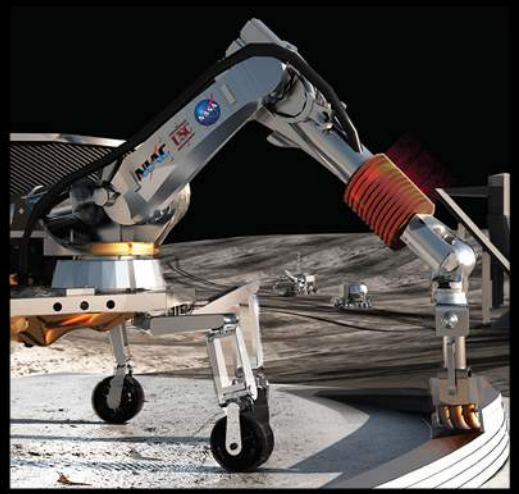
Lunarcrete shares the same lack of tensile strength as terrestrial concrete. One suggested lunar equivalent tensioning material for creating pre-stressed concrete is lunar glass, also formed from regolith, much as fibreglass is already sometimes used as a terrestrial concrete reinforcement material.

	EARTH	MOON
TIME TO SET	24-48 hours	3-4 hours
COST	very expensive	very cheap
STRENGTH	20 - 40 MPa	144 - 292 MPa

This proposal is based on the observation that water is likely to be a precious commodity on the Moon. Also sulfur gains strength in a very short time and doesn't need any period of cooling, unlike hydraulic cement. This would reduce the time that human astronauts would need to be exposed to the surface lunar environment.

3D ADDITTIVES AND ROBOTICS

The NASA Vision for Space Exploration calls for the return of humans to the Moon, and the eventual human exploration of Mars; the complexity of this range of missions will require an unprecedented use of automation and robotics in support of human crews. The challenges of human Mars missions, including roundtrip communications time delays of 6 to 40 minutes, interplanetary transit times of many months, and the need to manage lifecycle costs, will require the evolution of a new mission operations paradigm far less dependent on real-time monitoring and response by an Earthbound operations team.



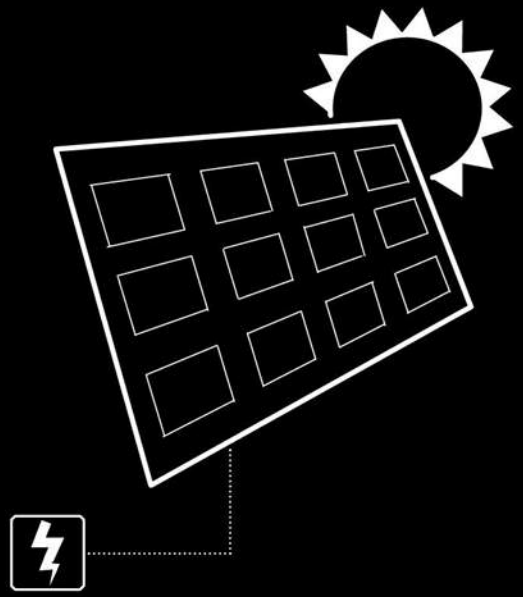
Robotic systems and automation will augment human capability, increase human safety by providing means to perform many tasks without requiring immediate human presence, and enable the transfer of traditional mission control tasks from the ground to crews.

Developing and validating the new paradigm and its associated infrastructure may place requirements on operations design for nearer-term lunar missions. The authors, representing both the human and robotic mission operations communities, assess human lunar and Mars mission challenges, and consider how human-robot operations may be integrated to enable efficient joint operations, with the eventual emergence of a unified exploration operations culture.

[ENERGY]

SOLAR ENERGY

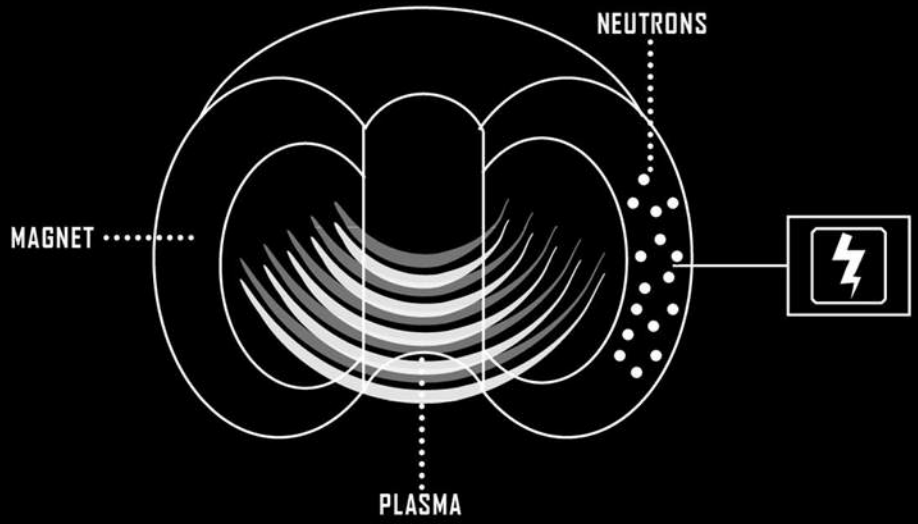
Research from the Qian Xuesen Laboratory of Space Technology in China shows that solar power generated on the Moon can supply future lunar bases, with plenty of energy to spare. Silicon dioxide, comprising a large component of the lunar rocks and dust, can be turned into glass for such a solar thermal system. The same lunar materials can also be converted into photovoltaic (PV) cells.



Another benefit is there is no weather or wind on the Moon. Consequently, PV cells could be constructed from lunar dust fairly easily, making it possible to build lunar-based solar power (LSP), not merely to support a few dozen people in a lunar base but to support the entire Earth. And how would we transfer the power from the Moon to Earth? Microwave beams – the old, well-developed technology that underlies radar, and is in your trusty microwave oven.

FUSION POWER

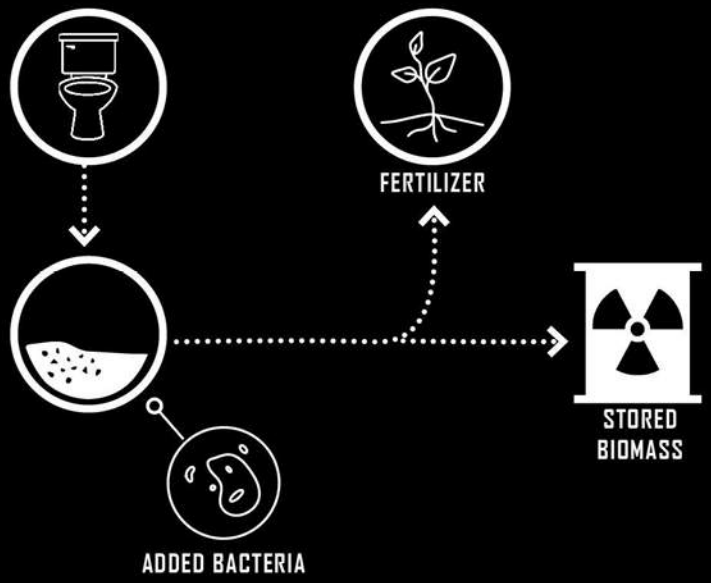
Unlike Earth, which is protected by its magnetic field, the Moon has been bombarded with large quantities of Helium-3 by the solar wind. It is thought that this isotope could provide safer nuclear energy in a fusion reactor, since it is not radioactive and would not produce dangerous waste products.



The isotop resources could be harvested from lunar dust and after laboratory processes the resource could be sent to Earth as a green energy resource. Since the mechanism requires high temperatures it may not be a suitable way to produce energy on Moon.

WASTE ENERGY

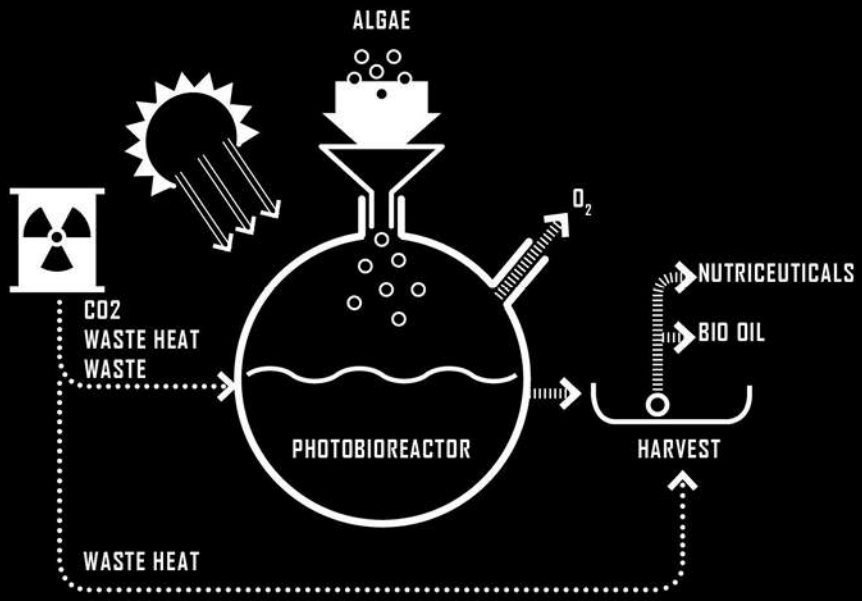
The ultimate in closed cycle resource is using biodigestor. By placing waste in one end you can get out usable cooking gas and fertilizer. The liquid fertilizer is rich in nutrients to boost crop production. By cycling human poop and other wastes on a closed loop system may develop the sustainability.



Anaerobic digestion is a well-established process based on the degradation of biomass by selected bacteria in an oxygen-free environment. It occurs naturally wherever high concentrations of wet organic matter accumulate in the absence of dissolved oxygen. Biogas production from human waste can represent a viable option as source of electrical power for small fuel cell systems during human planetary exploration missions.

PHOTOBIOREACTOR

The algae-powered bioreactor, called the Photobioreactor, represents a major step toward creating a closed-loop life-support system, which could one day sustain astronauts without cargo resupply missions from Earth. This will be particularly important for future long-duration missions to the moon or Mars, which require more supplies than a spacecraft can carry.

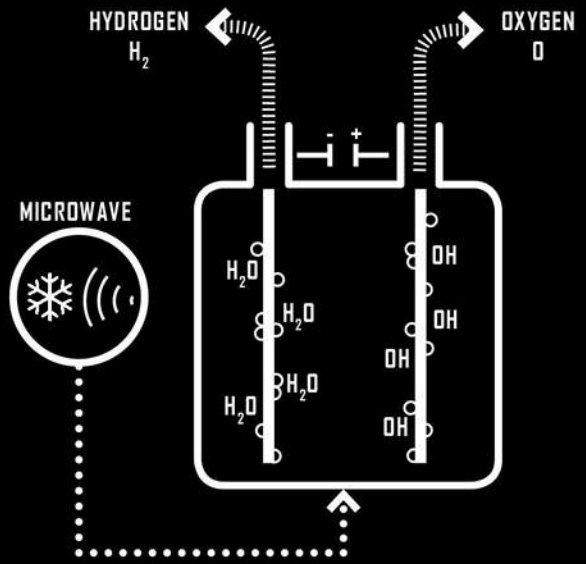


The photobioeactor is designed to use algae to convert the carbon dioxide exhaled by astronauts into oxygen and edible biomass through photosynthesis. What is more the algae is capable to produce bio oil which might be used as energy resource. The advantage of is bio oils are carbon neutral.

[WATER]

REGOLITH

Whatever its form, water is critical. People will need it for drinking and for its components, oxygen and hydrogen, which will be used for breathing and for making rocket fuel for deep space travel. Studies shows that regolith has water in it. And it may be possible to extract it by microwaves.



After reaching water resource it will also allow us to produce oxygen by electrolysis process. The initial step of Moon Mission may just begin with the harvest of water from moon dust, which may allow the crew settle there without the Earth support.

ICE WATER

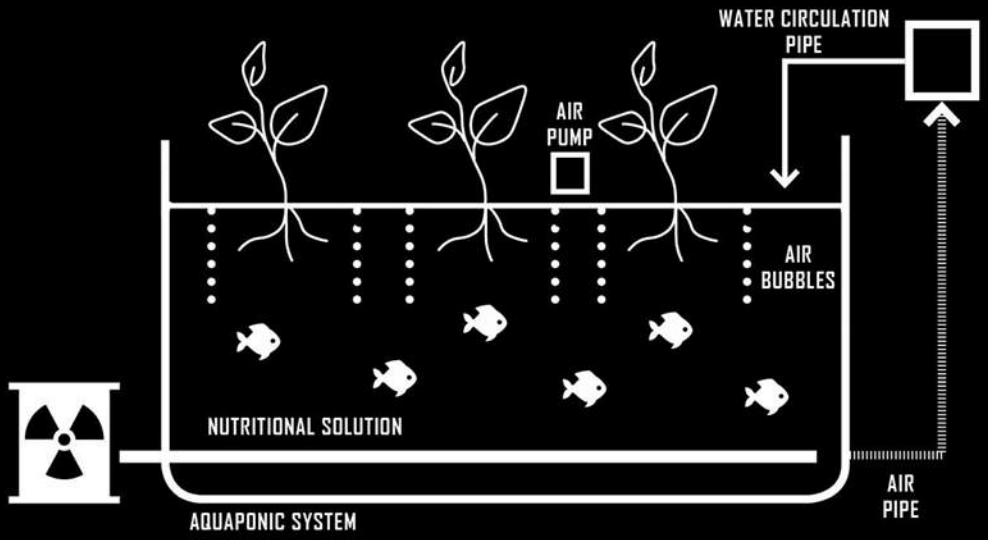
The most promising lunar water reserves appear to be in the permanently shadowed craters at the poles, which are among the coldest places in the solar system and, thus, good at preserving things like water, scientists expect. This, in addition to the abundant sunlight, is why the Moon's South Pole is the target region for an Artemis human mission. However, for initial steps the poles might not be good places to settle down because of their harsh topographic conditions for landing and launches. w

The challenge is that, for the most part, remote sensing instruments can detect water, or its chemical components, in a relatively shallow layer of the surface. This raises the question of whether that's all the water available for humans to use or whether it's merely the tip of the iceberg. Artemis astronauts will need to dig below the surface to find out.

[FOOD]

FOOD TO GROW

One ways to generate food on Moon might be to use LED technology. There are advantages by using LEDs to optimize plant growth. You get huge amount of photons for relativeley little power where the resources are lacking. LEDs can also be made a specific wavelength of light for targeting just what a plant needs.



Studies have suggested that plants can grow faster than normal since they may exposed to light 24 hours per day. No soil is necessary, as the plants hangs in the air and their roots are sprayed with nutrients. The LED energy is produced one of previosly mentioned methods.

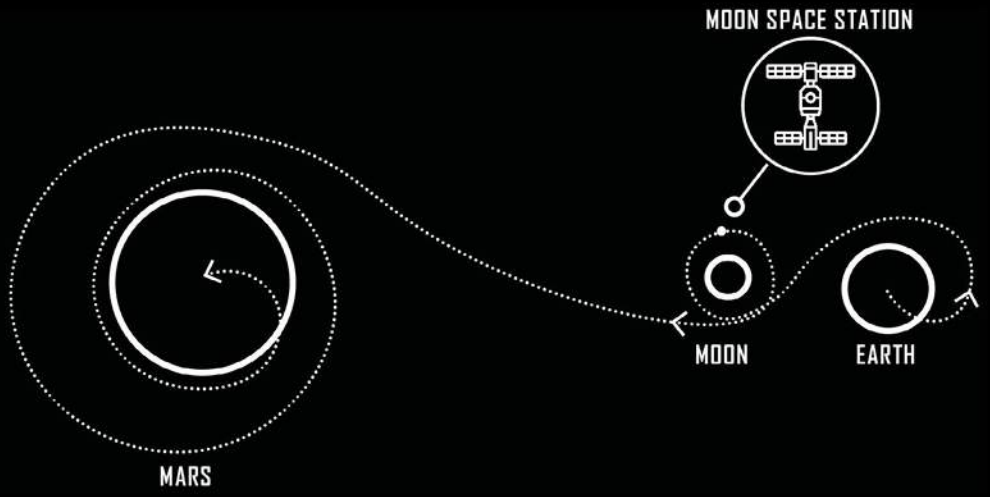
ALGAE AND TILAPIA

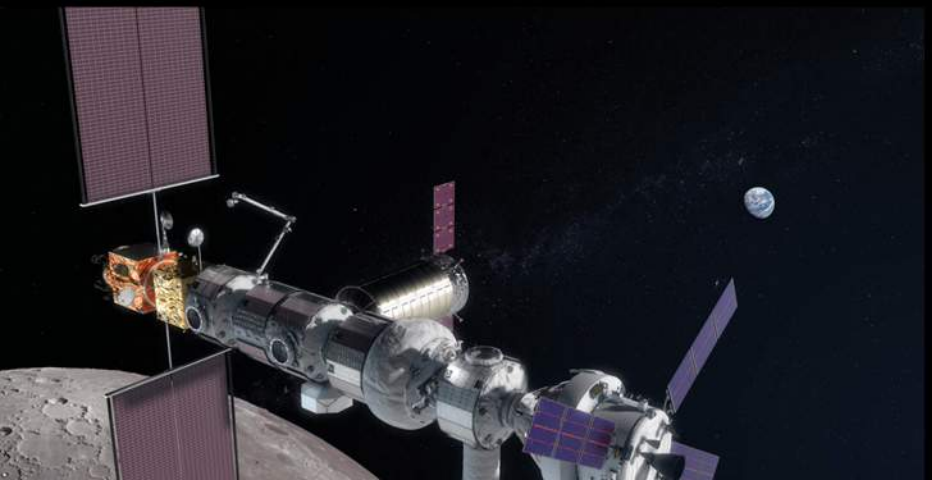
Other ways of food generation on Moon might be algae production and specifically tilapia fish as a part of aquaponic system. Microalgal biomass, which is rich in micronutrients, is already used for dietary supplements to advance human health. The richness of algae, combined with its minimal resource requirements, makes it a promising and sustainable nutrition solution.

Maintenance of crew health is of paramount importance for long duration space missions. Weight loss, bone and calcium loss, increased exposure to radiation and oxidative stress are critical concerns that need to be alleviated. Tilapia are currently under evaluation as a source of food and their contribution to reducing waste in advanced life support systems (ALSS). The nutritional composition of tilapia whole bodies, fillet, and carcass residues were quantitatively determined.

[TRANSPORTATION]

NASA is working with its partners to design and develop a small spaceship that will orbit the Moon called the Gateway. NASA believes the Gateway will be the key to a new era of lunar exploration – both in orbit and on the surface of the Moon. Also, it will provide sustainable transportation ways to deeper space missions like Mars.



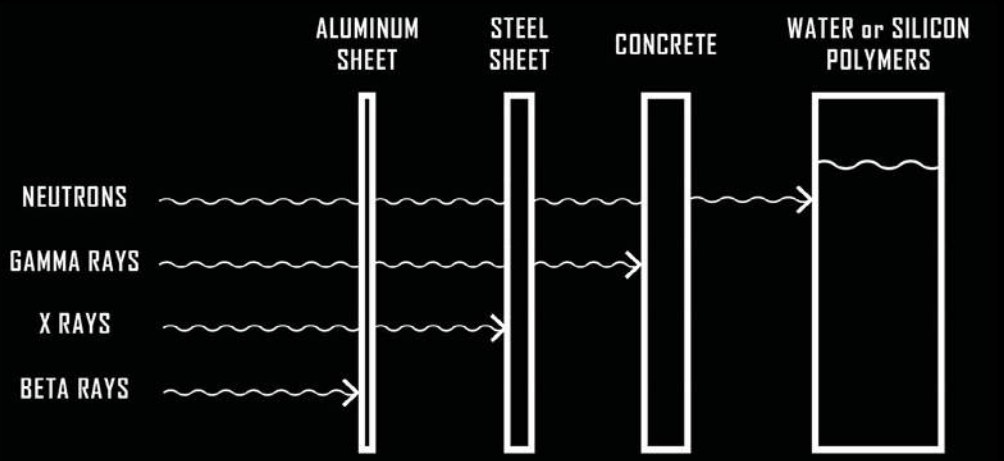


The Dragon spacecraft is capable of carrying up to 7 passengers to and from Earth orbit, and beyond. The pressurized section of the capsule is designed to carry both people and environmentally sensitive cargo. Towards the base of the capsule and contained within the nose cone are the Draco thrusters, which allow for orbital maneuvering.

Falcon 9 is a two-stage rocket designed and manufactured by SpaceX for the reliable and safe transport of satellites and the Dragon spacecraft into orbit. Falcon 9 is the first orbital class rocket capable of reflight. SpaceX believes rocket reusability is the key breakthrough needed to reduce the cost of access to space and enable people to live on other planets.

SpaceX's Starship spacecraft and Super Heavy rocket (collectively referred to as Starship) represent a fully reusable transportation system designed to carry both crew and cargo to Earth orbit, the Moon, Mars and beyond. Starship will be the world's most powerful launch vehicle ever developed, with the ability to carry in excess of 100 metric tonnes to Earth orbit.

[RADIATION SHIELD]



Unwanted exposures to high-energy or ionizing radiation can be hazardous to health. Prolonged or accumulated radiation dosage from either particle-emissions such as alpha/beta, proton, electron, neutron emissions, or high-energy electromagnetic waves such as X-rays/γ rays, may result in carcinogenesis, cell mutations, organ failure, etc. Significant research efforts have been focused toward designing efficient, lightweight, cost-effective, and flexible shielding materials for protection against radiation encountered in various industries (aerospace, hospitals, and nuclear reactors). In this regard, polymer composites have become attractive candidates for developing materials that can be designed to effectively attenuate photon or particle radiation.

Water is another hydrogen-rich molecule that can absorb
radiation. However, the oxygen content in water makes it a lot heavier than polyethylene, and therefore is much more expensive
to launch. Generally, lighter shields can greatly reduce the harmful effects of incoming space radiation particles, but they cannot completely stop them. On long duration manned missions, advantage can be taken of the good shielding characteristics of liquid hydrogen fuel and water.

[0 6]

CASE STUDIES

BIOSPHERE 2

Biosphere 2 is an American Earth system science research facility located in Oracle, Arizona. It was originally constructed between 1987 and 1991, and has been owned by the University of Arizona since 2011.

Its mission is to serve as a center for research, outreach, teaching, and lifelong learning about Earth, its living systems, and its place in the universe. It is originally built to be an artificial, materially closed ecological system, or vivarium. It remains the largest closed system ever created.

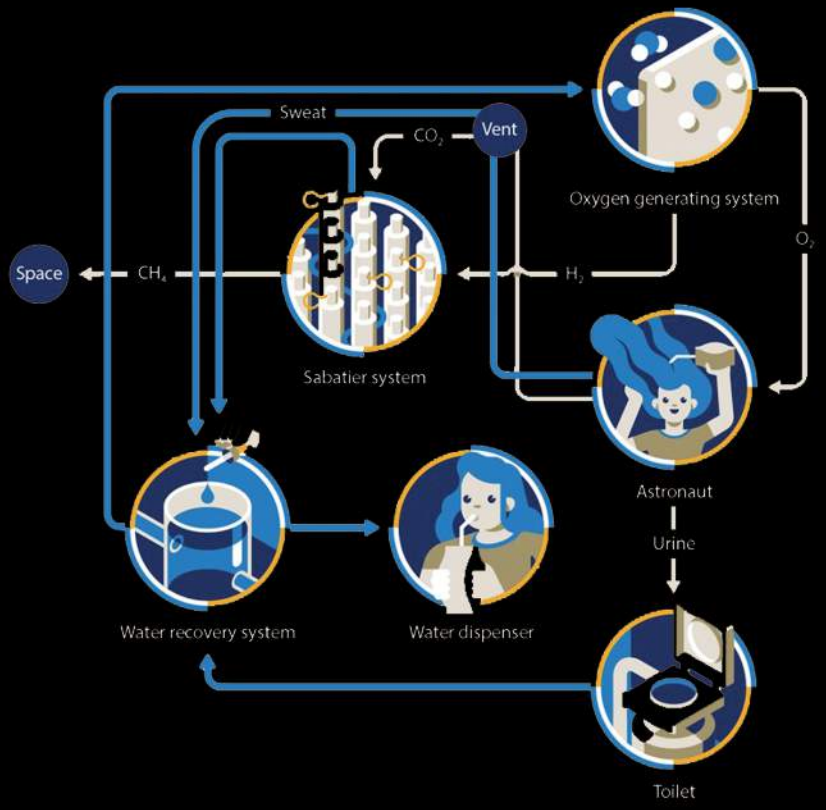
Biosphere 2 was originally meant to demonstrate the viability of closed ecological systems to support and maintain human life in Outer Space. It was designed to explore the web of interactions within life systems in a structure with different areas based on various biological biomes.

Its mission was a two-year closure experiment with a crew of eight humans ("biospherians"). Long-term it was seen as a precursor to gain knowledge about the use of closed biospheres in space colonization. As an experimental ecological facility it allowed the study and manipulation of a mini biospheric system without harming Earth's biosphere.

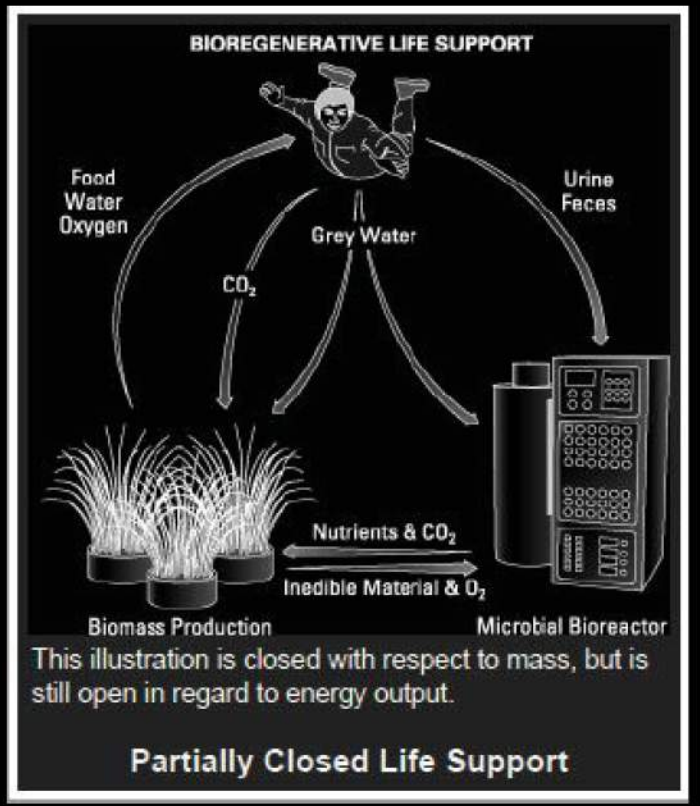
CASE STUDIES

LIFE SUPPORT SYSTEMS

INTERNATIONAL SPACE STATION LIFE SUPPORT SYSTEM



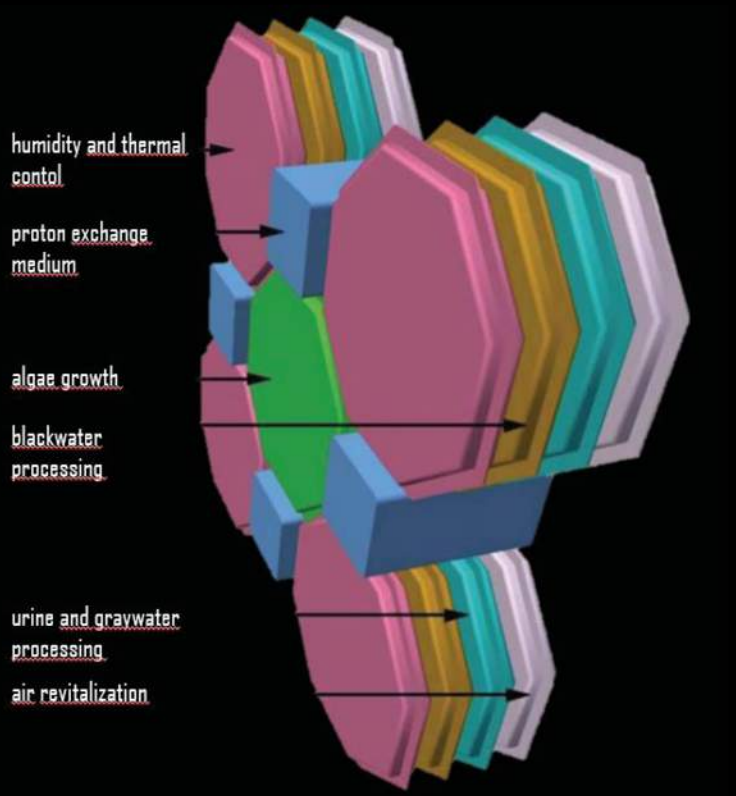
NASA PARTIALLY CLOSED LIFE SUPPORT SYSTEM



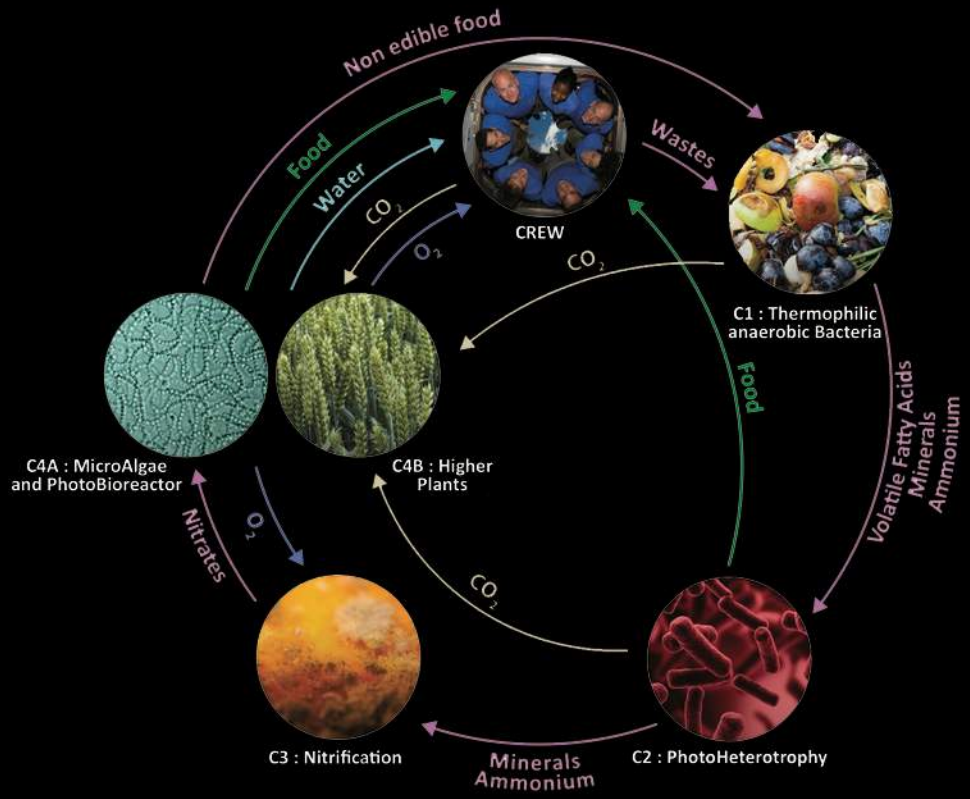
CASE STUDIES

LIFE SUPPORT SYSTEMS

NASA
WATER WALL SYSTEM

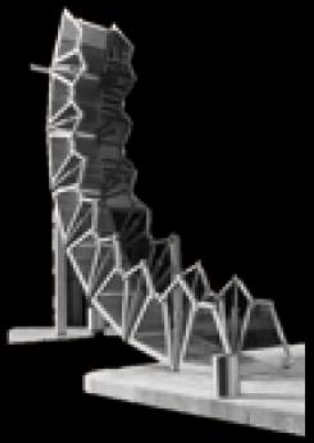


MELISSA FOUNDATION
MICO ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE



CASE STUDIES

FOLDABLE STRUCTURES



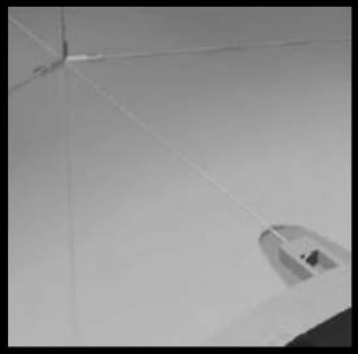
Origami, the Japanese tradition of paper-folding, has inspired a number of unique spacecraft designs. It's little wonder that it fascinates NASA engineers: origami can seem deceptively simple, hiding complex math within its creases.

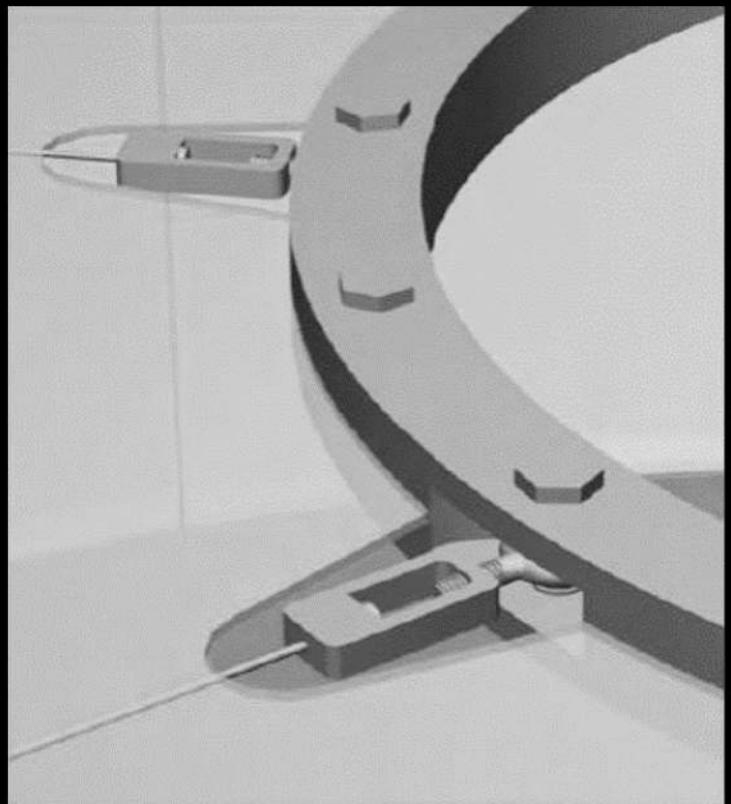
Deployable structures are structures that can be easily reduced in size for transportation or storage. A number of everyday structures could be classed as deployable; tents and umbrellas are two simple examples. Current interest in deployable structures arises mainly from their potential in space.

A useful characteristic of deployable structures is rigid foldability or the ability to fold without requiring any members to warp or stretch. This characteristic allows a folding structure to be manufactured out of inflexible materials such as steels or glasses.

CASE STUDIES

POP-OUT INTERIOR STRUCTURE



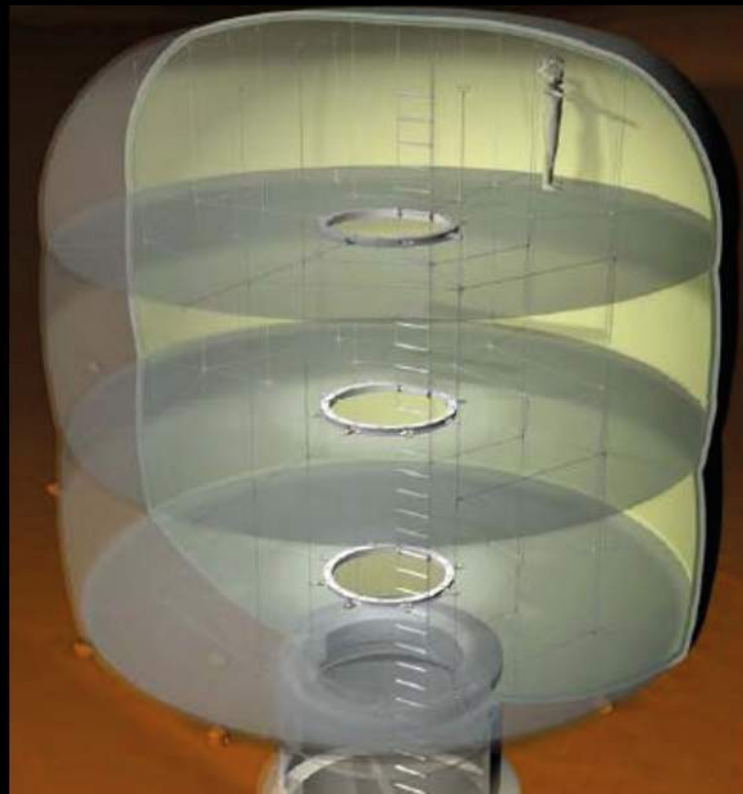


SICSA "Pop-Out" Interior Concept

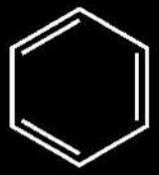
SICSA has studied and conceptualize inflatable space structures over a period of more than two decades. One proposed design deploys interior floors automatically:

• An axial "web" of tension cables support floor membranes that are integrated and folded within the inflatable enclosure package prior to launch.

• Vertical cables, in combination with the horizontal web, restrain the deployed envelope shape and provide attachment points for utility systems and equipment.

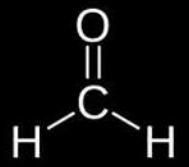


NASA CLEAN AIR STUDY



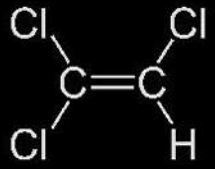
BENZENE

Eye irritation, drowsiness, dizziness, increase in the heart rate, headaches, confusion, unconsiousness



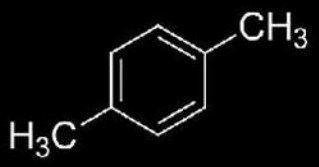
FORMALDEHYDE

Nose irritation, mouth and throat irritation, swelling in lungs



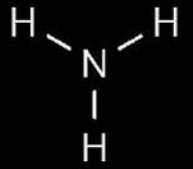
TRICHLOROETHYLENE

Excitement, drowsiness, headaches, nausea, dizziness, vomiting, coma



XYLENE

Confusion, headaches, drowsiness, heart problems, liver and kidney damage, coma,



AMMONIA

Eye irritation, coughing, sore throat

The first and most obvious step in reducing indoor air pollution is to reduce off-gassing from building materials and furnishings before they are allowed to be installed.

The National Aeronautics Space Administration (NASA) identified indoor air pollution problems associated with sealed space habitats .

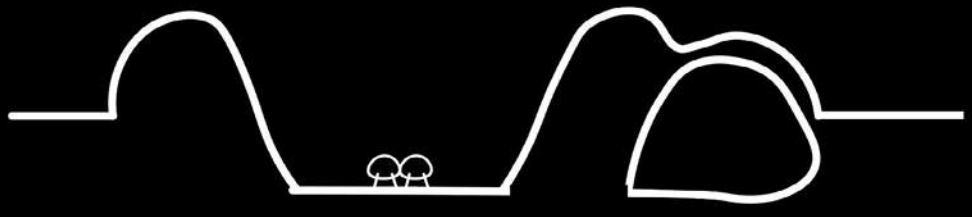
A promising approach to reducing trace levels of air pollutants inside future space habitats is the use of higher plants and their associated soil microorganisms.

	BENZENE	FORMALDEHYDE	TRICHLOROETHYLENE	XYLENE	AMMONIA
PEACE LILLY	✓	✓	✓	✓	✓
BROADLEAF LADY		✓		✓	✓
SNAKE PLANT	✓	✓	✓	✓	
ENGLISH IVY	✓	✓	✓	✓	
LILYTURF			✓	✓	✓
FLORIST'S CHRYSANTHEMUM	✓	✓	✓	✓	✓
RED EDGED DRACENA	✓	✓	✓	✓	
CORNSTALK DRACENA	✓	✓	✓		

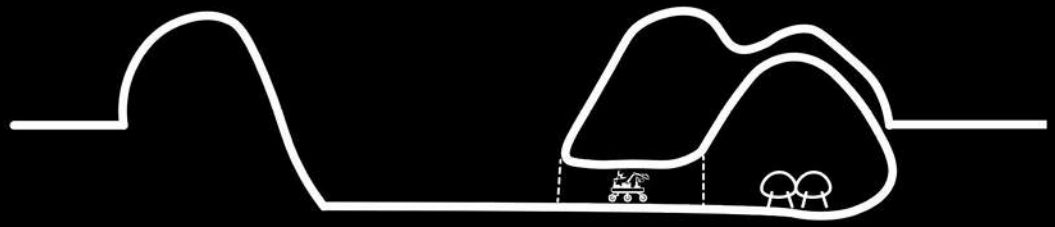
[08]

LEAP

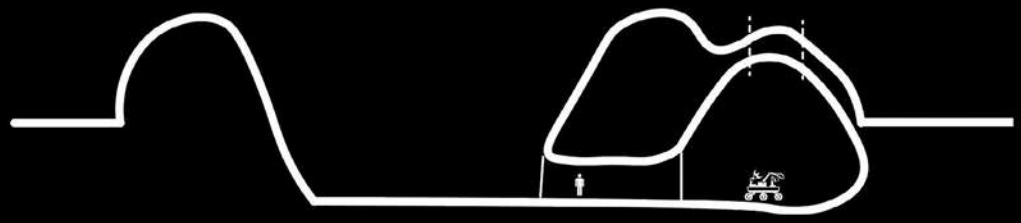
CONCEPT STAGES



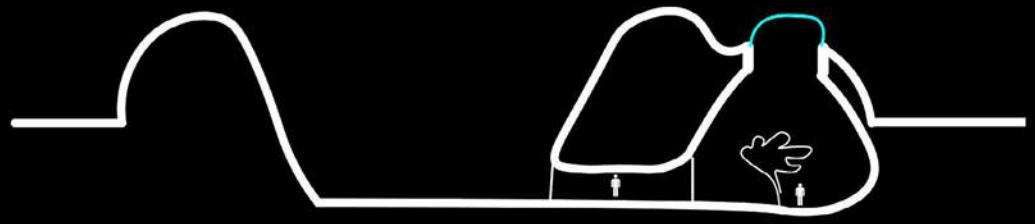
STAGE 1
only scientists with inflatable modules



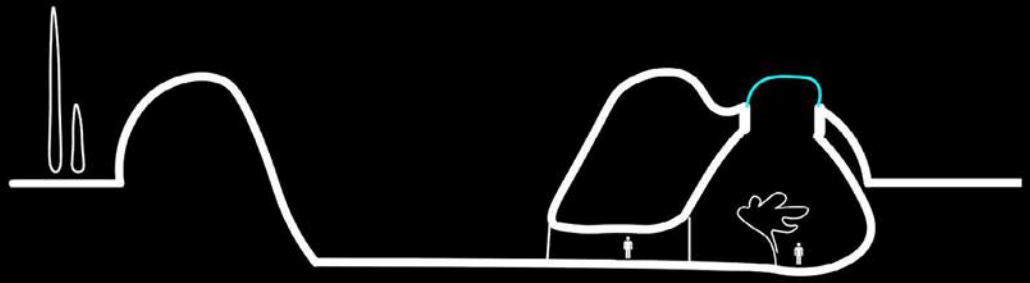
STAGE 2
construction equipment sent by earth



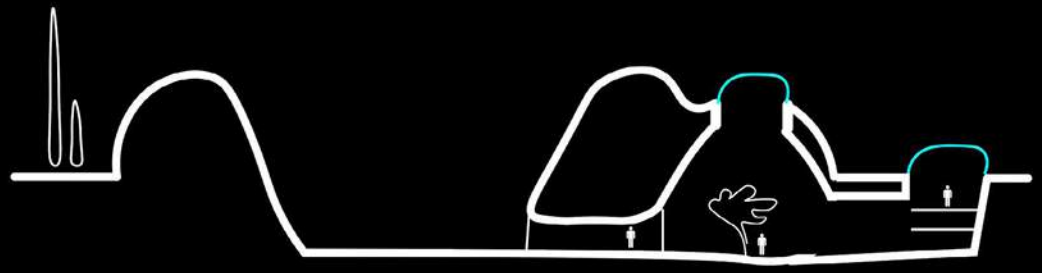
STAGE 3
permanent laboratories and construction on lava tube



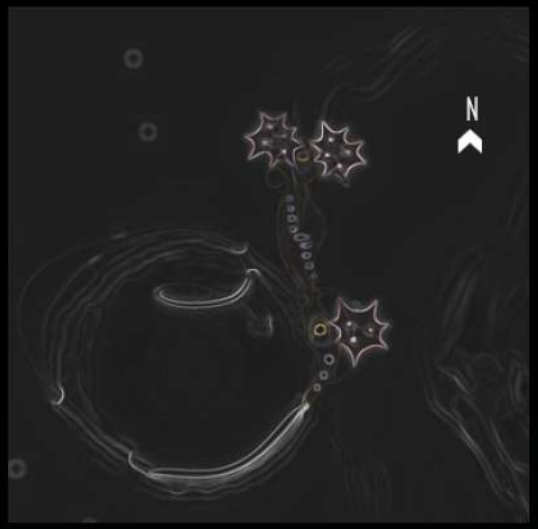
STAGE 4
lava tube used as production

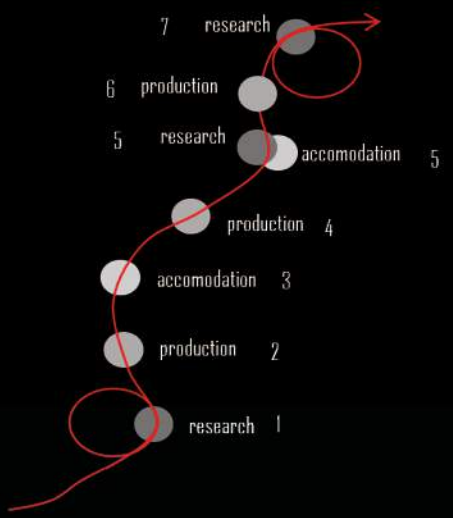


STAGE 5
exportation of moon resources to earth

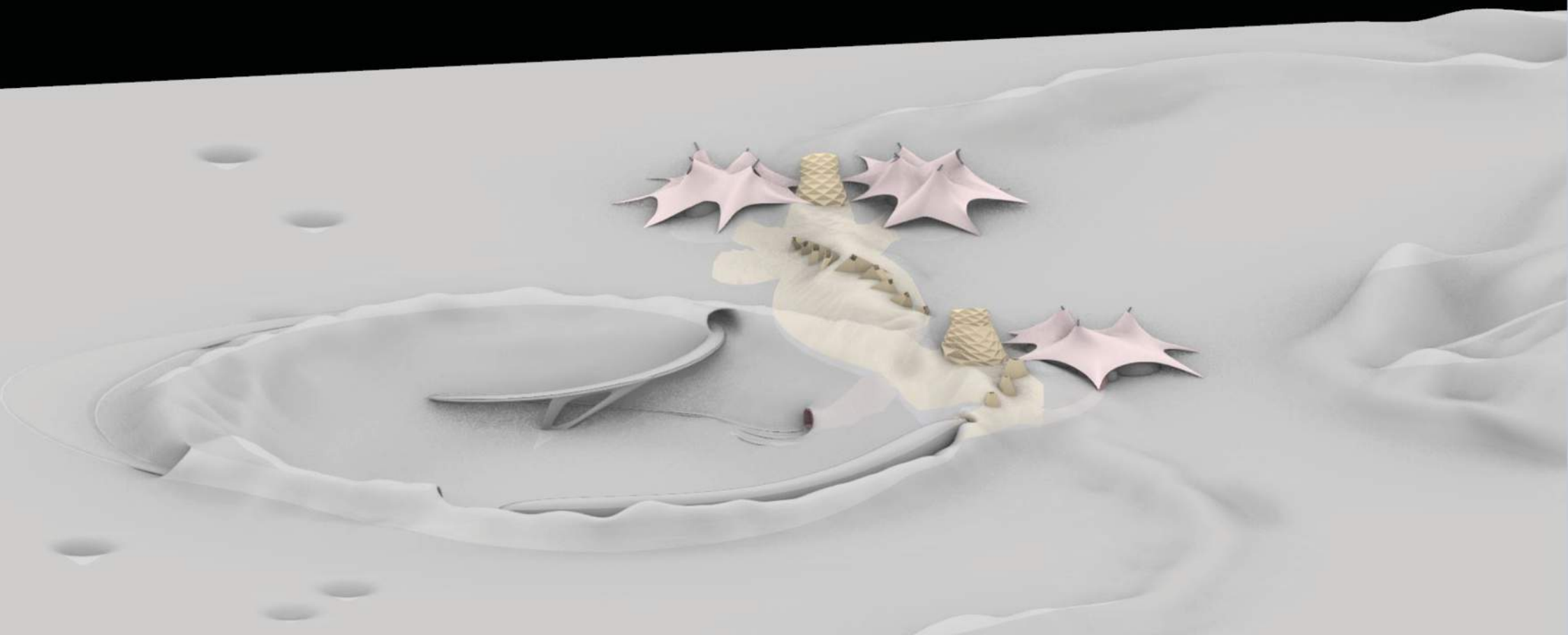


STAGE 6
further construction and space tourism





The site starts from a crater and lavatube tangency and it develops through the lavatube to the north pole direction since there are ice water resources detected. Research-production-accomodation units repeat along the lavatube according to the needs.

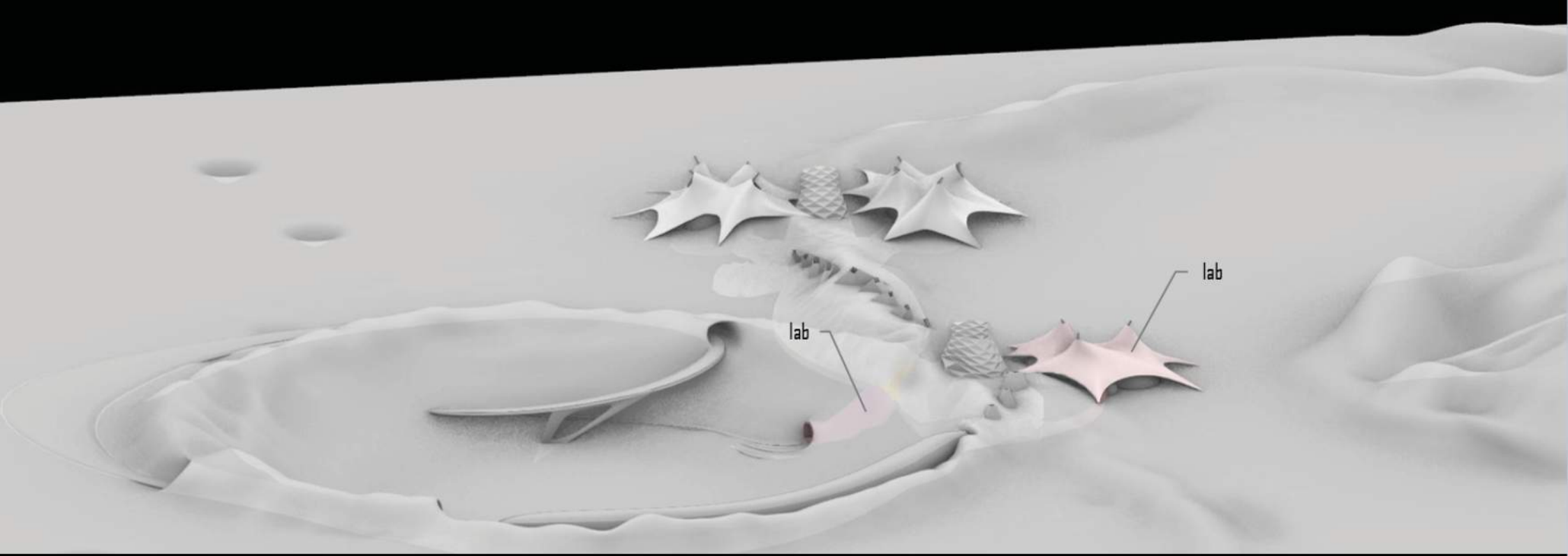


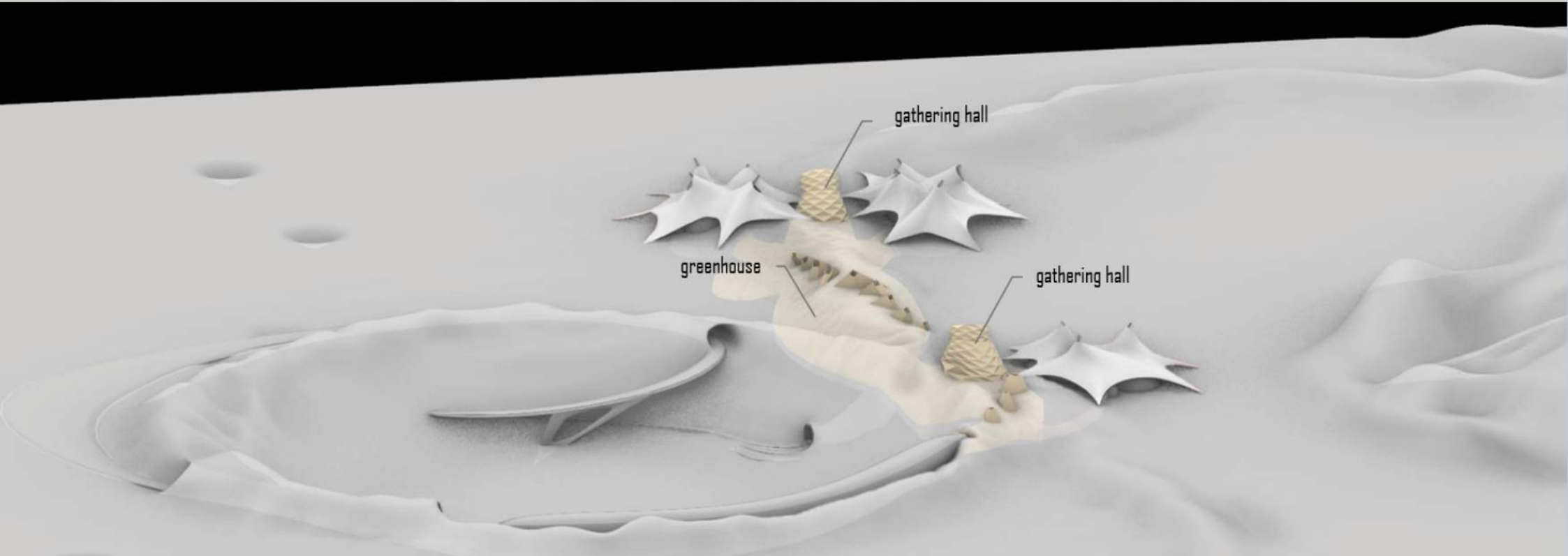
PHASE 1 : RESEARCH

This phase includes only scientists to search about the location and local resources and have further knowledge for the mission. They start to accomodate with inflatable nomadic structures on the base of crater. Later they are provided with rovers and robotics from Earth so they are able to start digging the wall of crater and reach to lavatube. They solidify the carved space with lunacrete and build their first permanent laboratories on the Moon. They also reach to the other side of the lavatube by digging the wall of lavatube. And they build their second pop out laboratory on surface to reach mountainous region for more resources.

PHASE 2 : PRODUCTION

This phase is focused for local production and in-situ construction. It still includes only scientists. They reached the row resources and processed them according to the material need. Lavatube is used for oxygen-water production units through pop-out facades. Greenhouse is built and Earth dependency gradually vanishes. They are able to produce oxygen-water-food and necessity robotics with local materials on site.


lab
lab


gathering hall
greenhouse
gathering hall

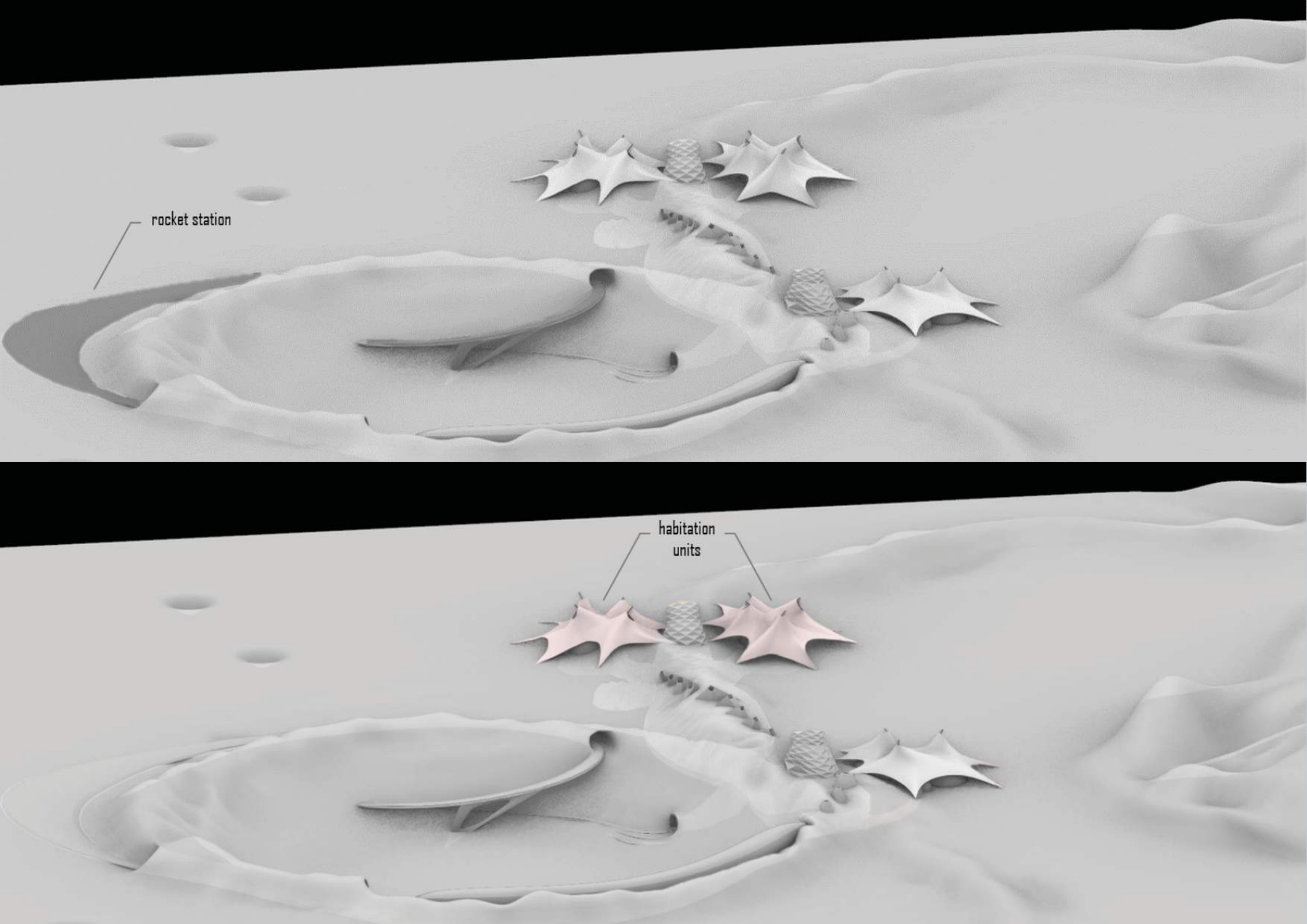
PHASE 3 : EXPORTATION

The processed resources are now ready to be exported back to the Earth. He^{-3} isotop is the main resource that is exported to the Earth since it may enable us to have fusion power on Earth. The exportation phase will increase the fund for this mission and the complex will develop further after this stage.

PHASE 4 : SPACE TOURISM

For this project the final phase is space tourism. The complex grows and accomodation units are built by digging the side walls of the lavatube. The units have direct acces to surface of the Moon for moonwalk and discovery for visitors.

Space tourism will be the breaking point for space missions to create sustainable economic structure. The fund will provide further developments on Moon mission but also help us to prepare for Mars mission.


rocket station
habitation
units

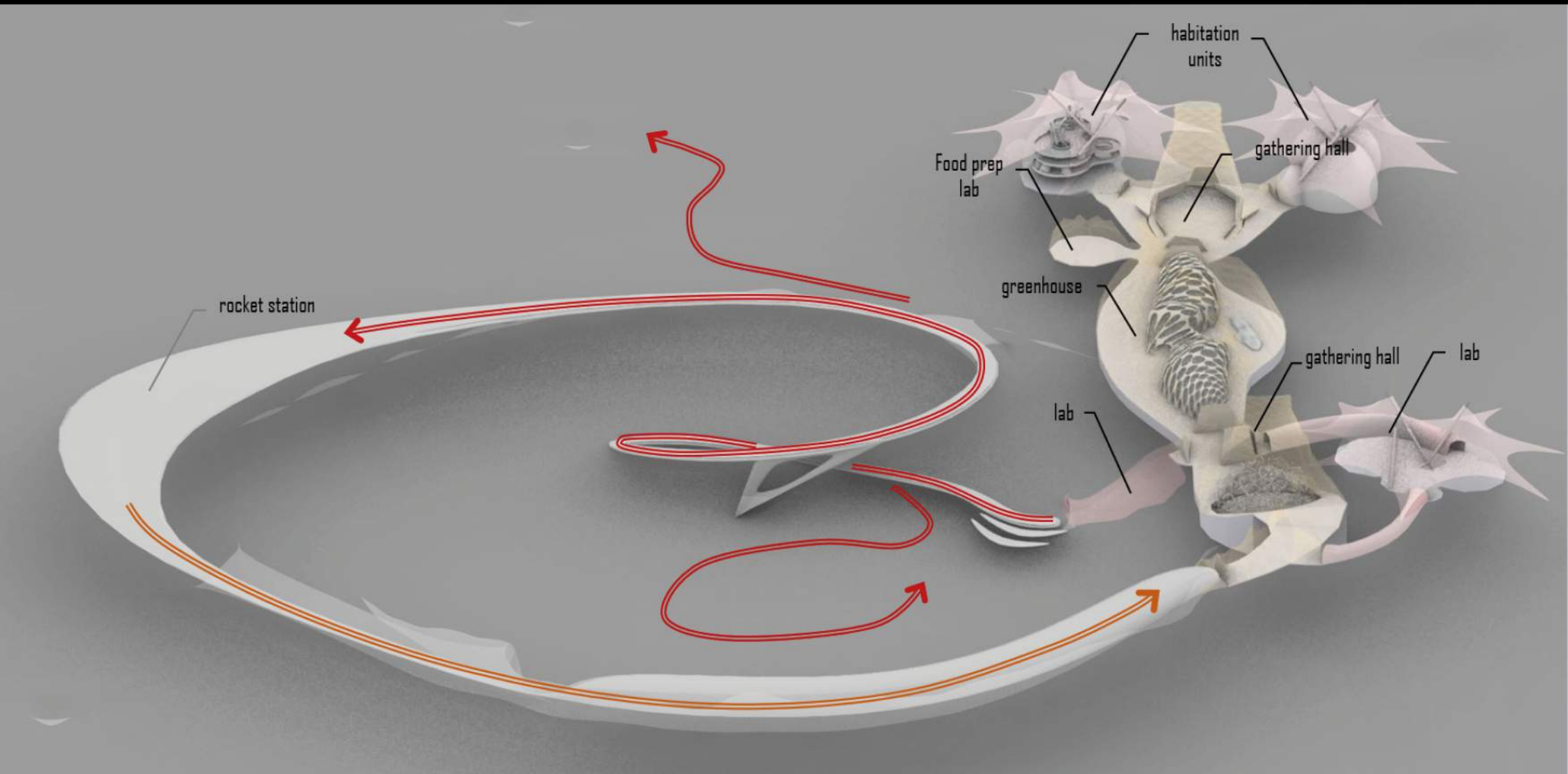
CIRCULATION

ROVER CIRCULATION

visitor

scientists

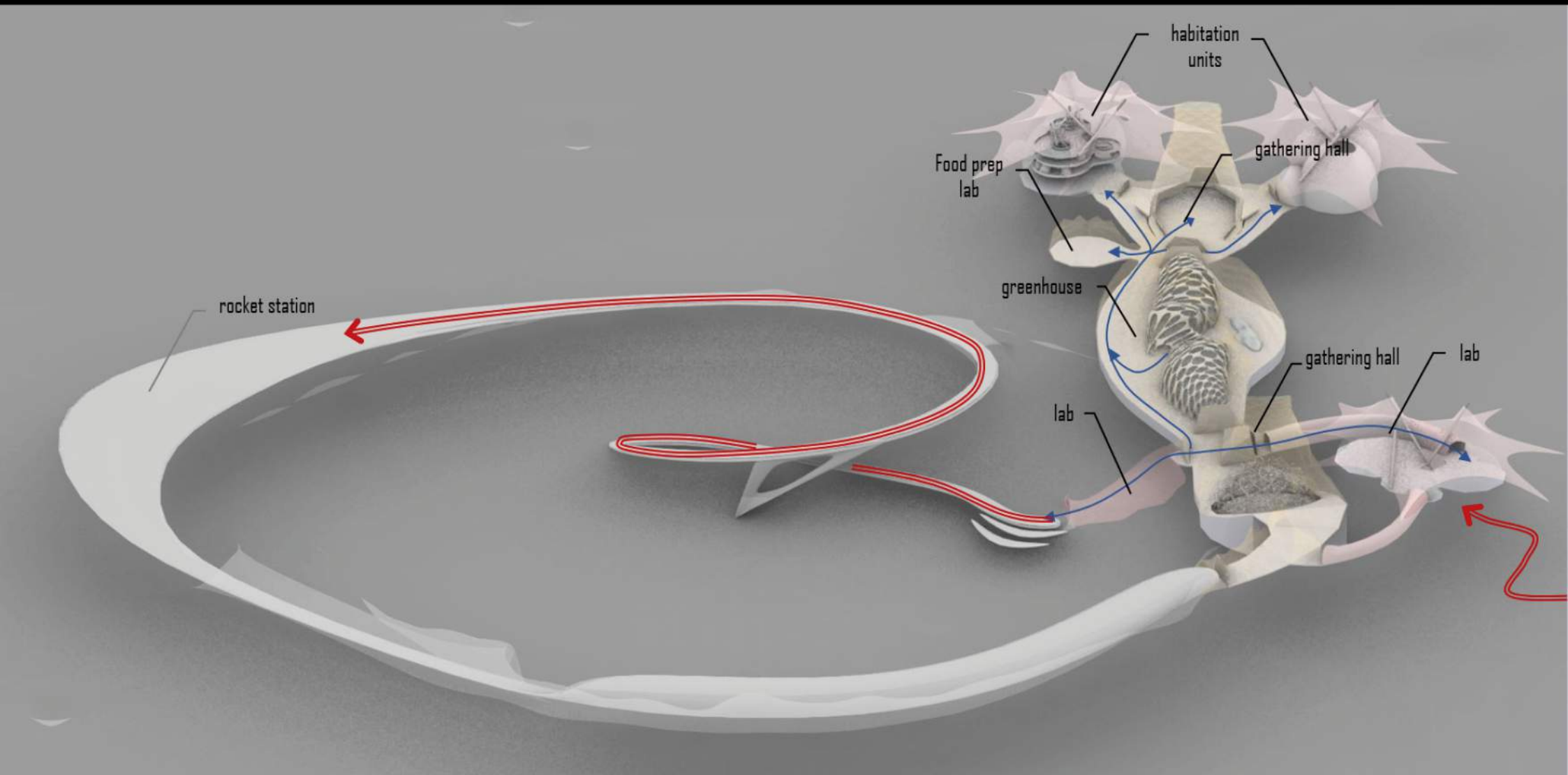
Visitor and scientists entrances ae located in different levels and this provides protection against any harmful contact between visitors and moondust.



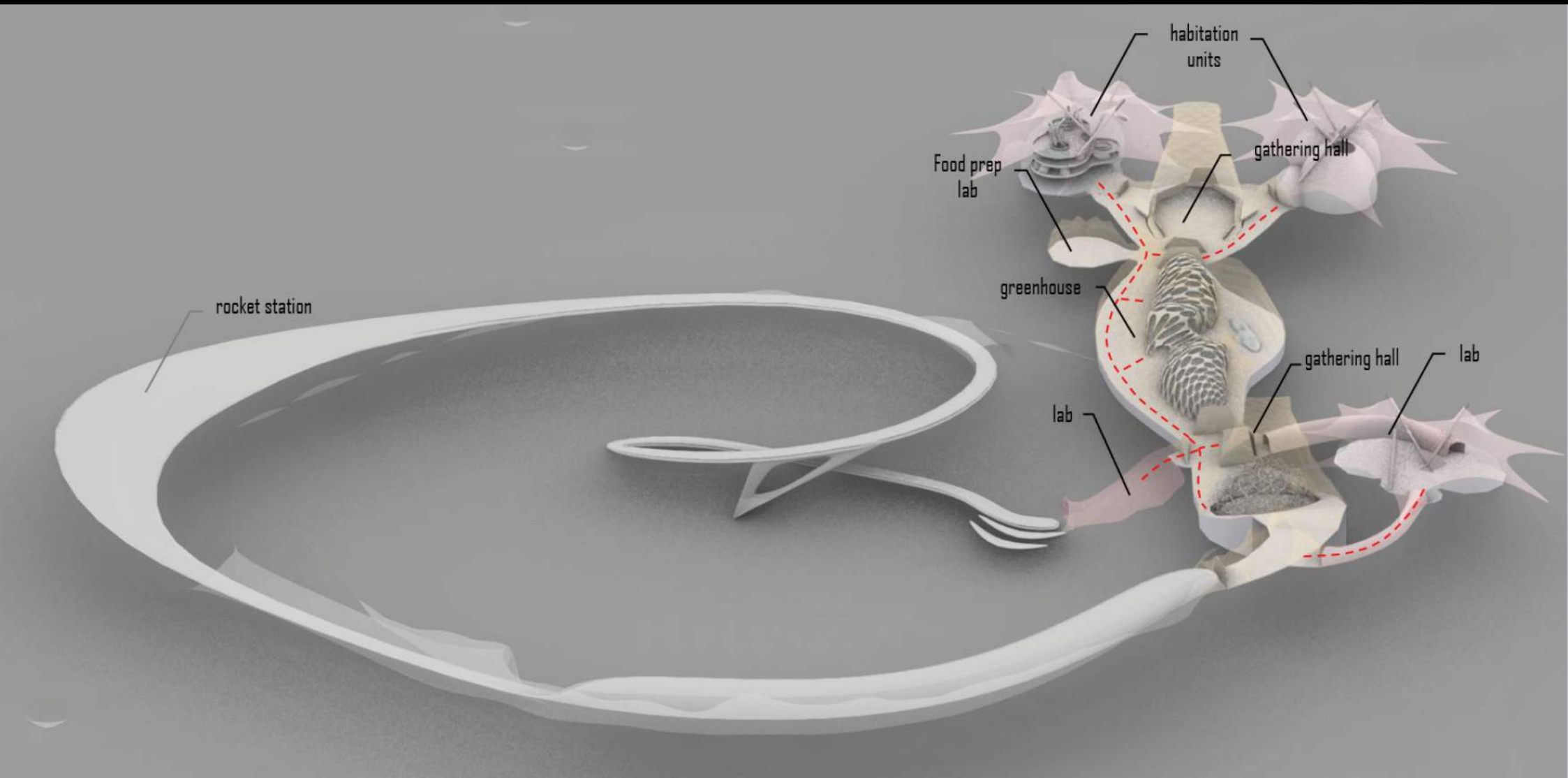
SERVICE CIRCULATION

interior service

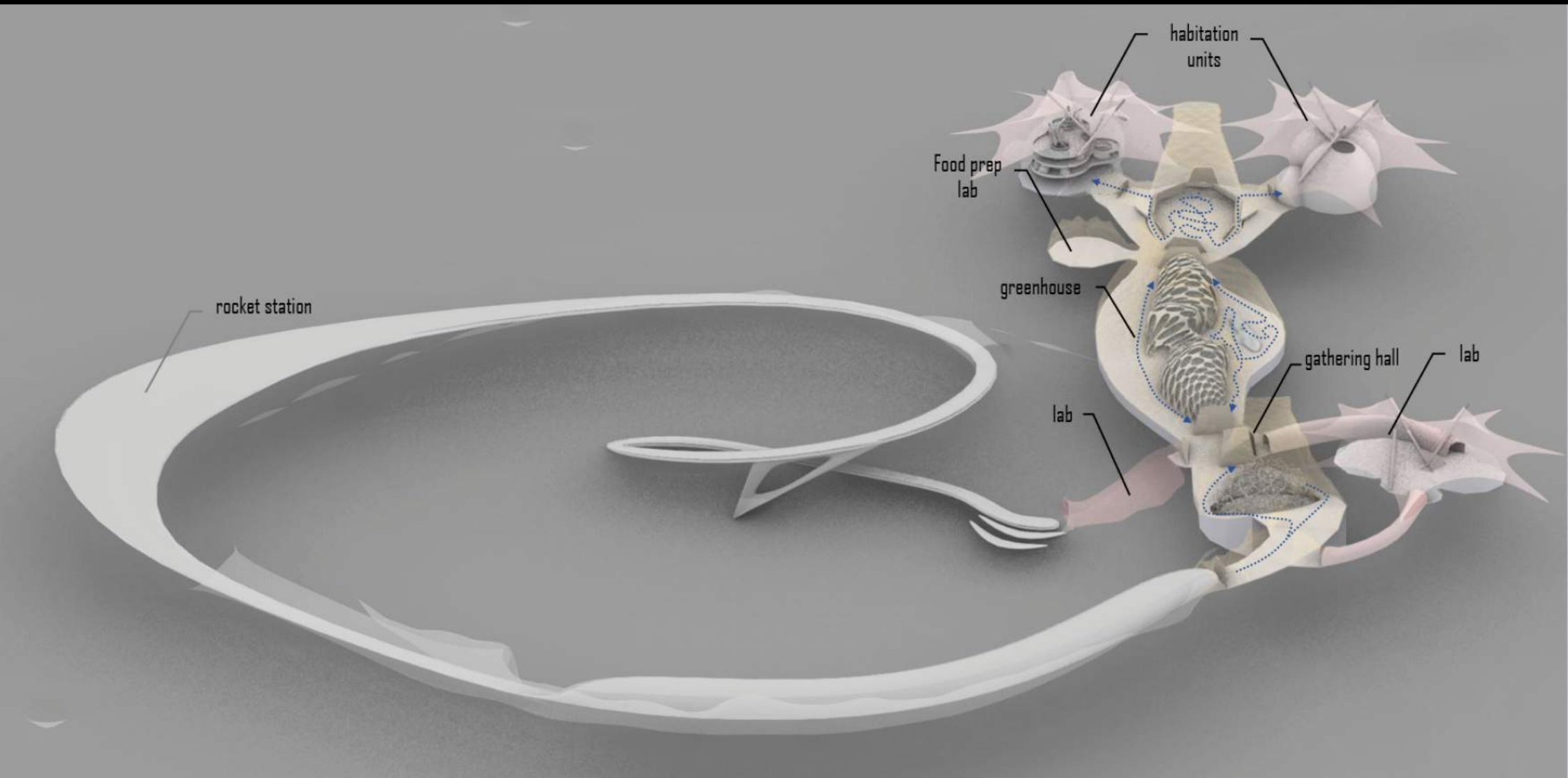
exportation



EMERGENCY CIRCULATION

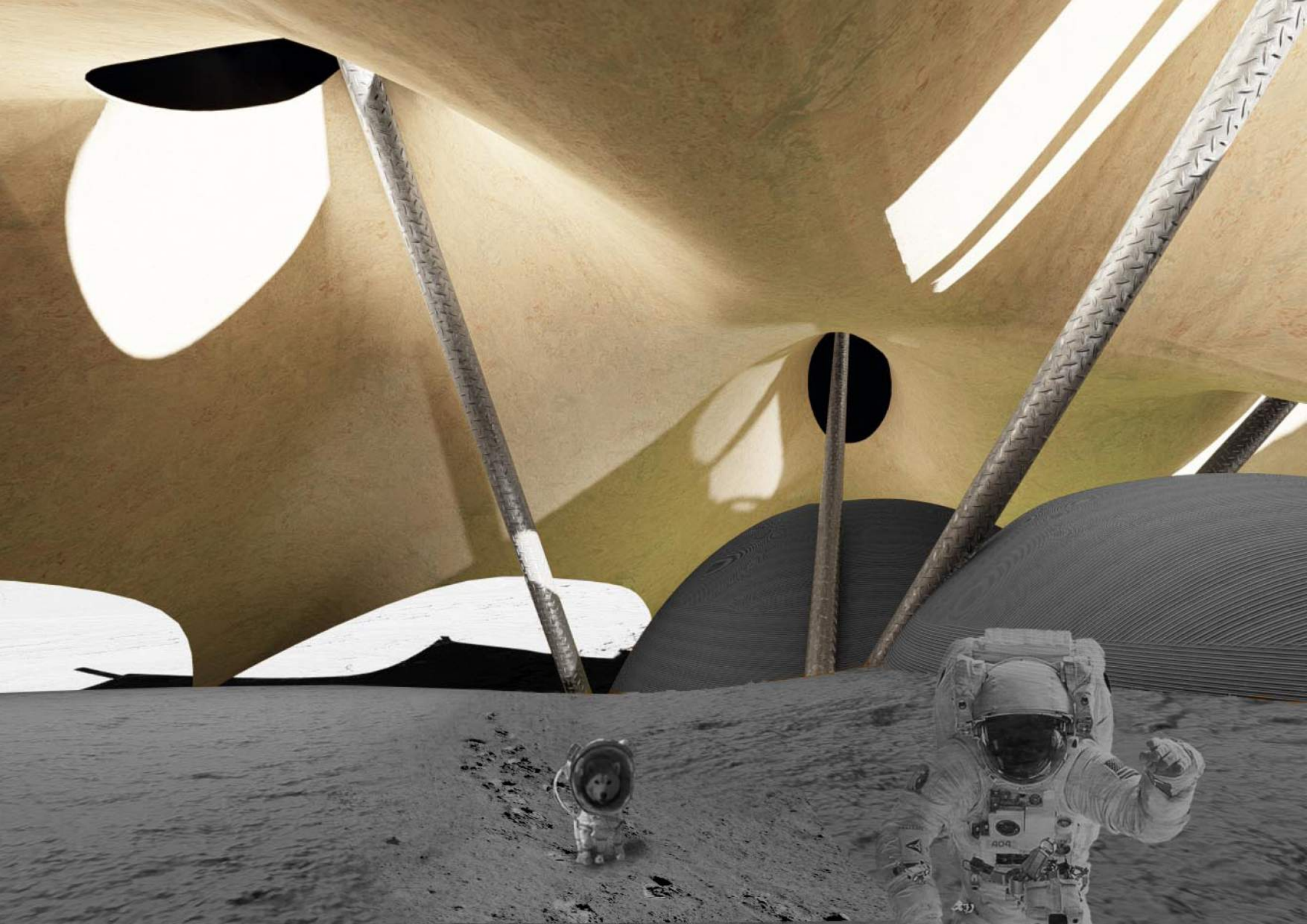


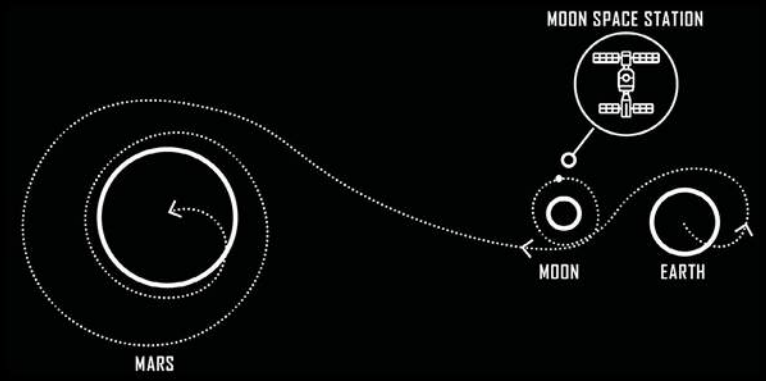
VISITOR CIRCULATION



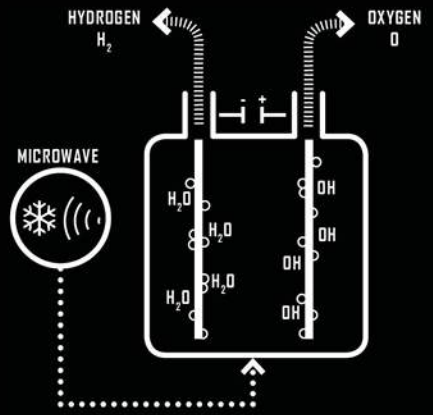
PHASE 01
RESEARCH

The semi-open space underneath the tent will allow scientists to have a safe moon-walk and sample data collection.

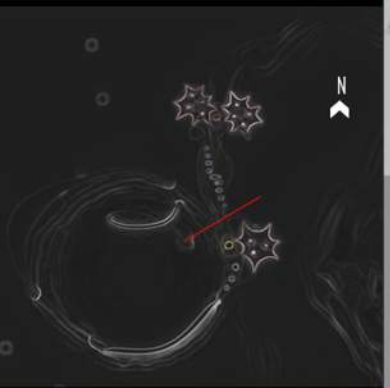


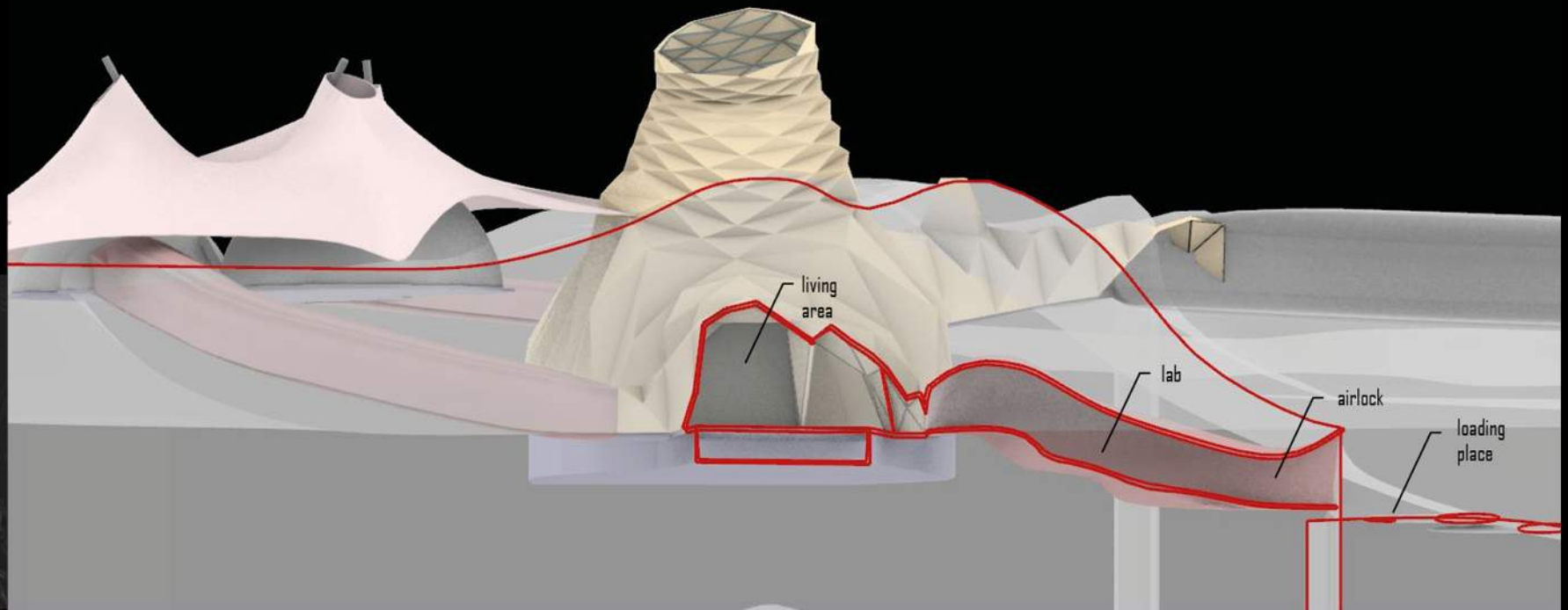


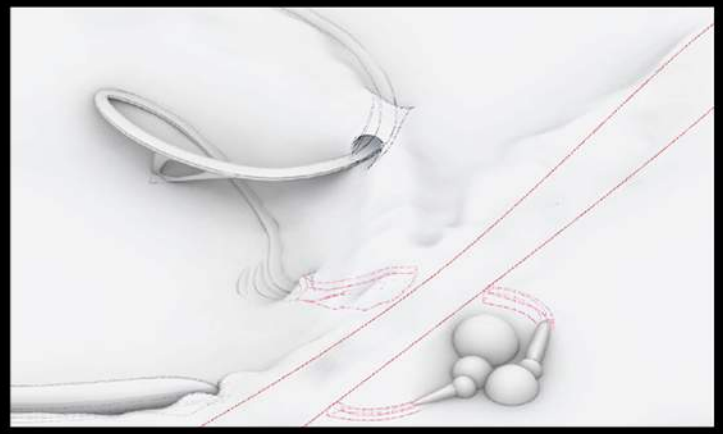
The food will be supplied from Earth for early stages.



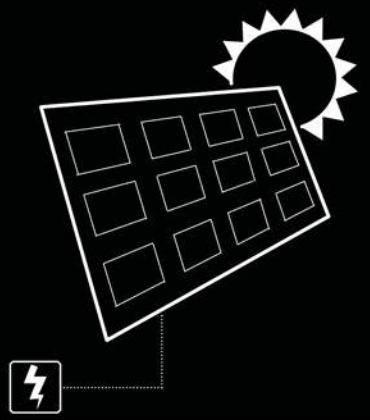
Regolith will be used for water harvest and electrolysis process will generate oxygen for early stages.



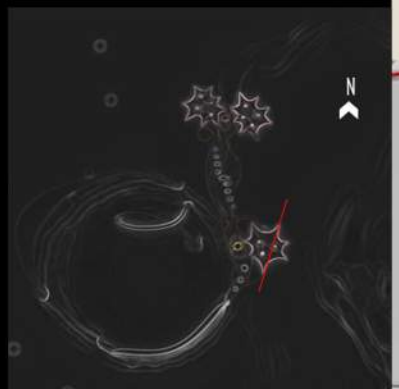


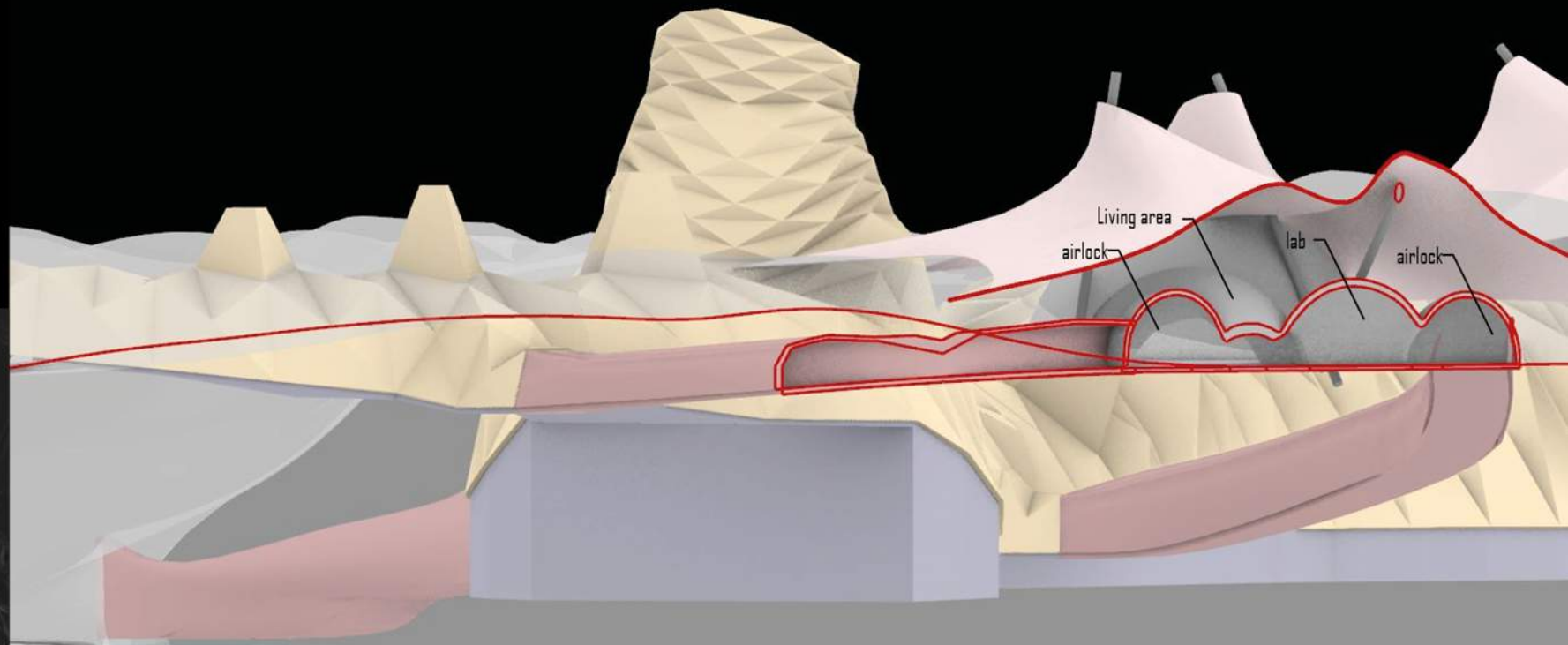


Early stage construction is only carved out and solidified structure to reach to lava-tube. Later pop-out lunacete structure will be consturcted by 3D printing robotics.



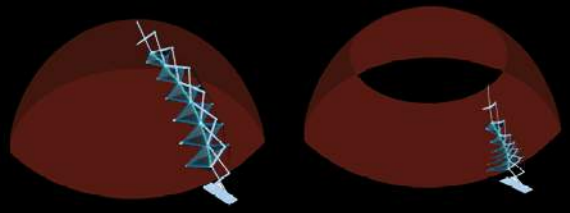
PV will be sent from Earth for early stages but after local production starts the PVs will be produced on site. The tents will be used for transparent PV application.



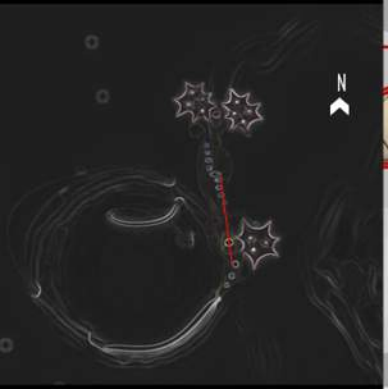


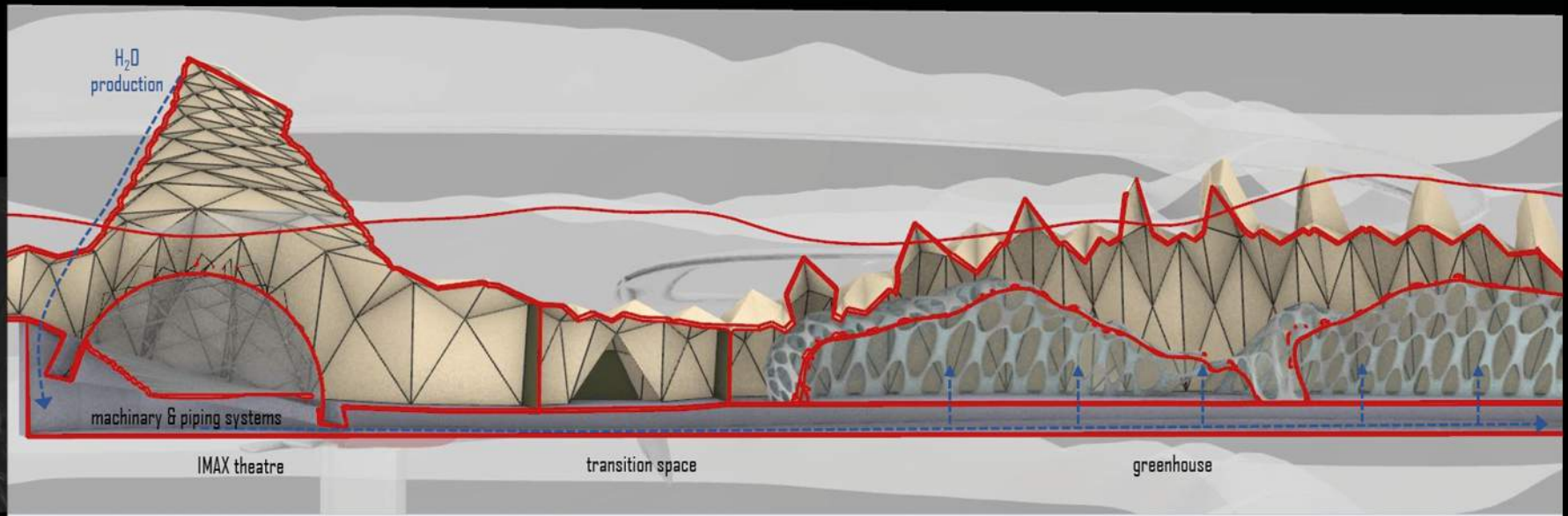
PHASE 02
PRODUCTION

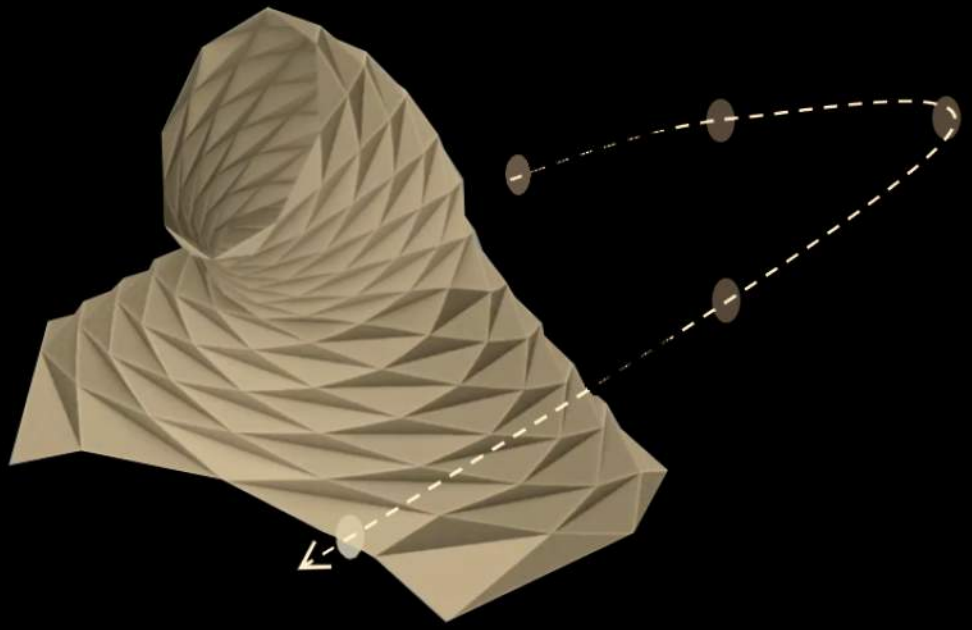
Pop-out facades are oxygen and water production units. Gathering points will be located underneath these facades. This perspective is from IMAX theatre. The recessed screen is mobile and it appears when there is a need. The skylight allows a view to Earth and creates a dramatic perspective for visitors.



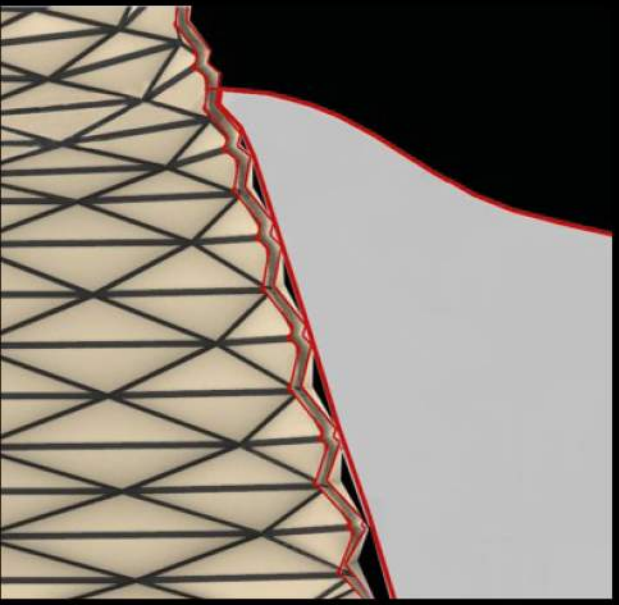
The IMAX screen is made of PTFE fabric and with the help of scissor structure it is mobile.





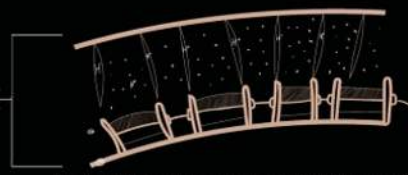


The pop-out facade is mobile and it rotates according to sun and solar wind direction. In between the panels chemical liquids flow. When solar wind occurs H+ isotops reacts with these liquids and produce oxygen and water. When there is no solar wind PVs are generating electricity with the optimize angle with sun.



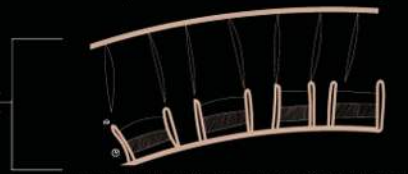
The air in between the folded structure and lavatube provide better thermal insulation for interior environment.

When the anode is initialized. $Fe(OH)_2$ groups split when Fe^+ anions are attracted towards them and as soon as H^+ cations reach the OH^- anions, H_2O groups are transported into growth vessels for water production.



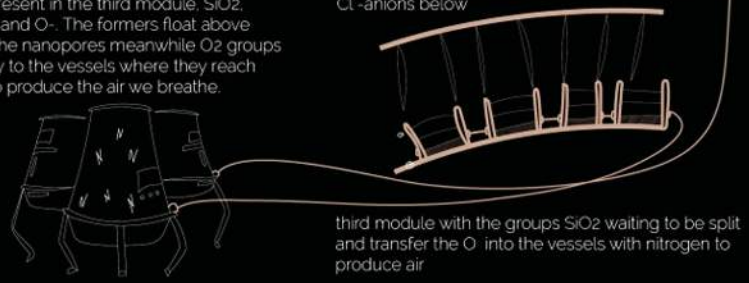
first module with the groups $Fe(OH)_2$ waiting for the hydrogen cations and transfer them into the vessels, once they reacted with OH anions creating water

The reversed dialysis causes the disassociation of $SiCl_4$ which lets the Si^+ anions float free above. where they are stopped from the nanopores of the membrane and Cl anions migrate to the catode reaching the module below.



second module with the groups $SiCl_4$ waiting to be split once the reactions started and transfer Cl^- anions below

Finally the groups present in the third module. SiO_2. disassociate into Si^+ and O^-. The formers float above where they stop at the nanopores meanwhile O_2 groups are led mechanically to the vessels where they reach nitrogen isotropes to produce the air we breathe.

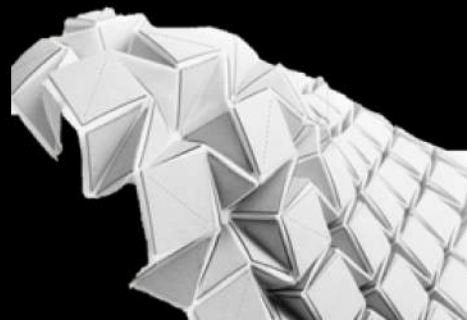


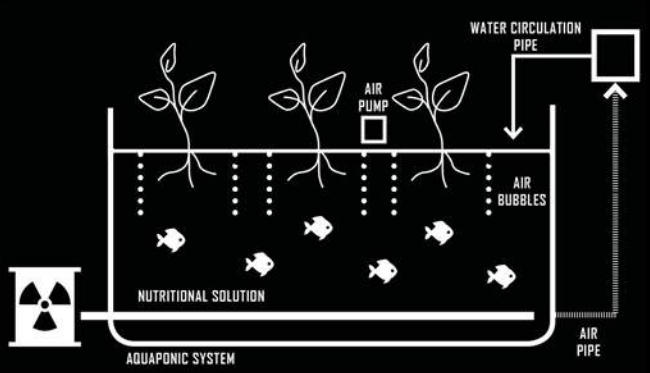
third module with the groups SiO_2 waiting to be split and transfer the O^- into the vessels with nitrogen to produce air

$$Fe(OH)_2 + H_2 \longrightarrow Fe + 2\,H_2O$$

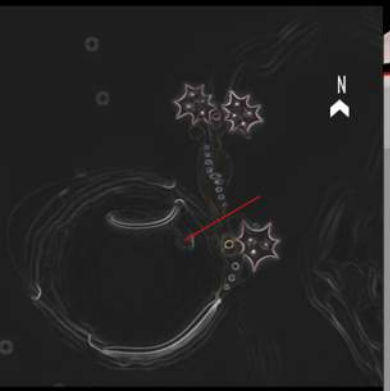
$$SiO_2 \qquad Si + O_2$$

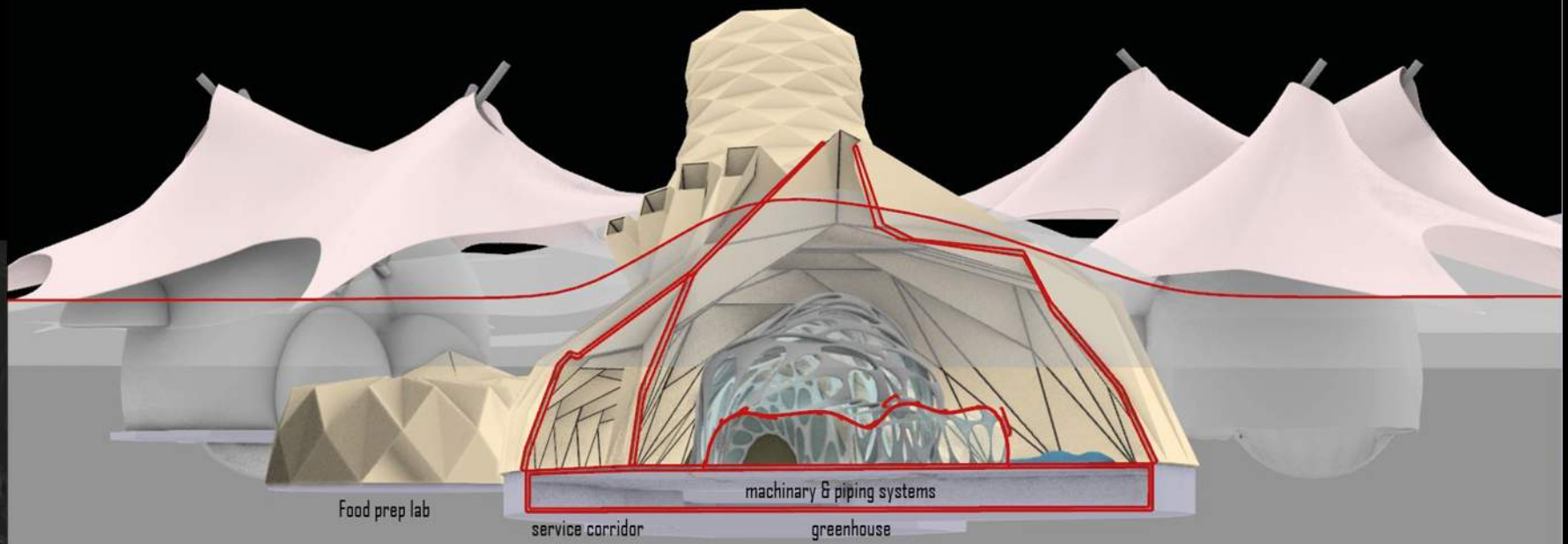
This is a case study that propose oxygen and water production through some chemical reactions on Moon.

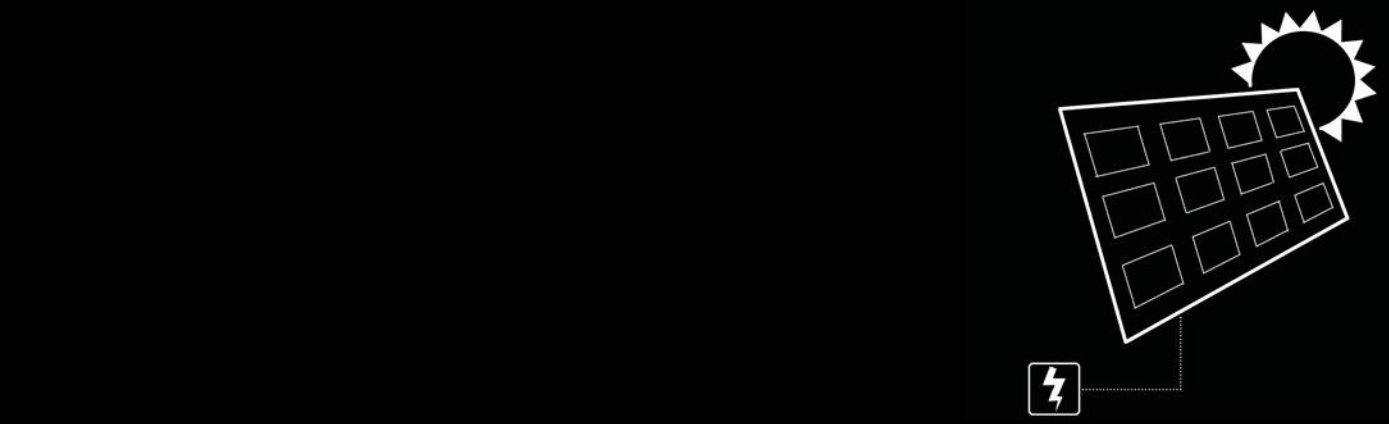




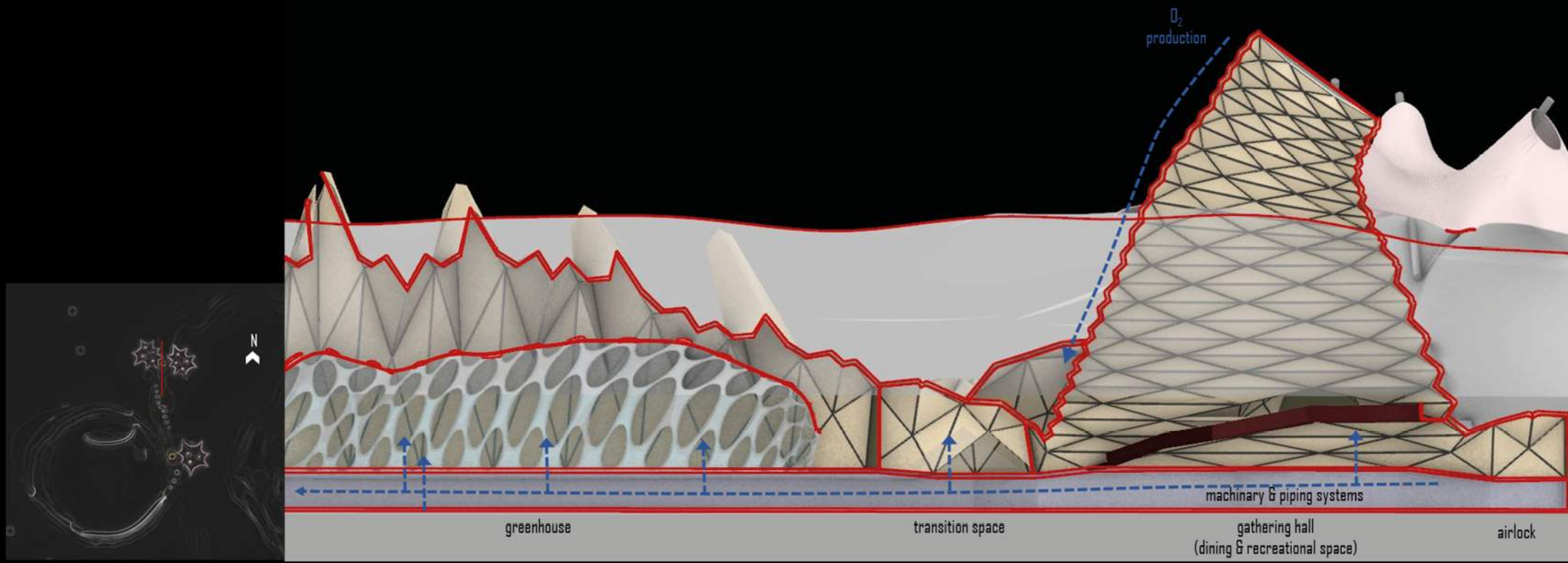
Food production starts with aquaponic farm. This system also provides increasment of oxygen rate.



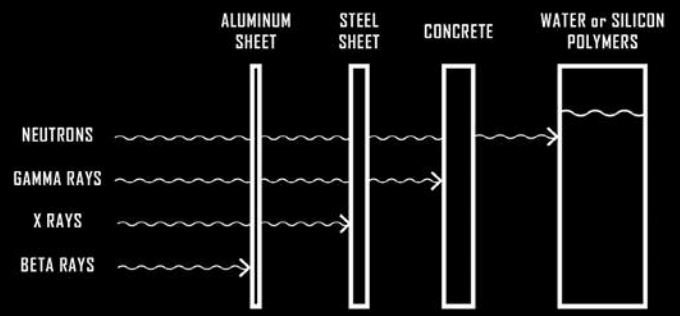




PVs applied in pop-out facade allows to produce electricity.



The greenhouse is enclosed with secondary structure to avoid uncontrolled water loss through evaporation. The organic form of geenhouse represents the man-made nature out of Earth. The gold color of main structure (aluminum foil against heat lost) represents the old active lava flow through the lavatube for users. The greenhouse unit can be used as a relaxation space by visitors and scientists. It has minimum contact with outside and rotation of light tubes allows to enlighten the space efficiently in different time of Moon days.

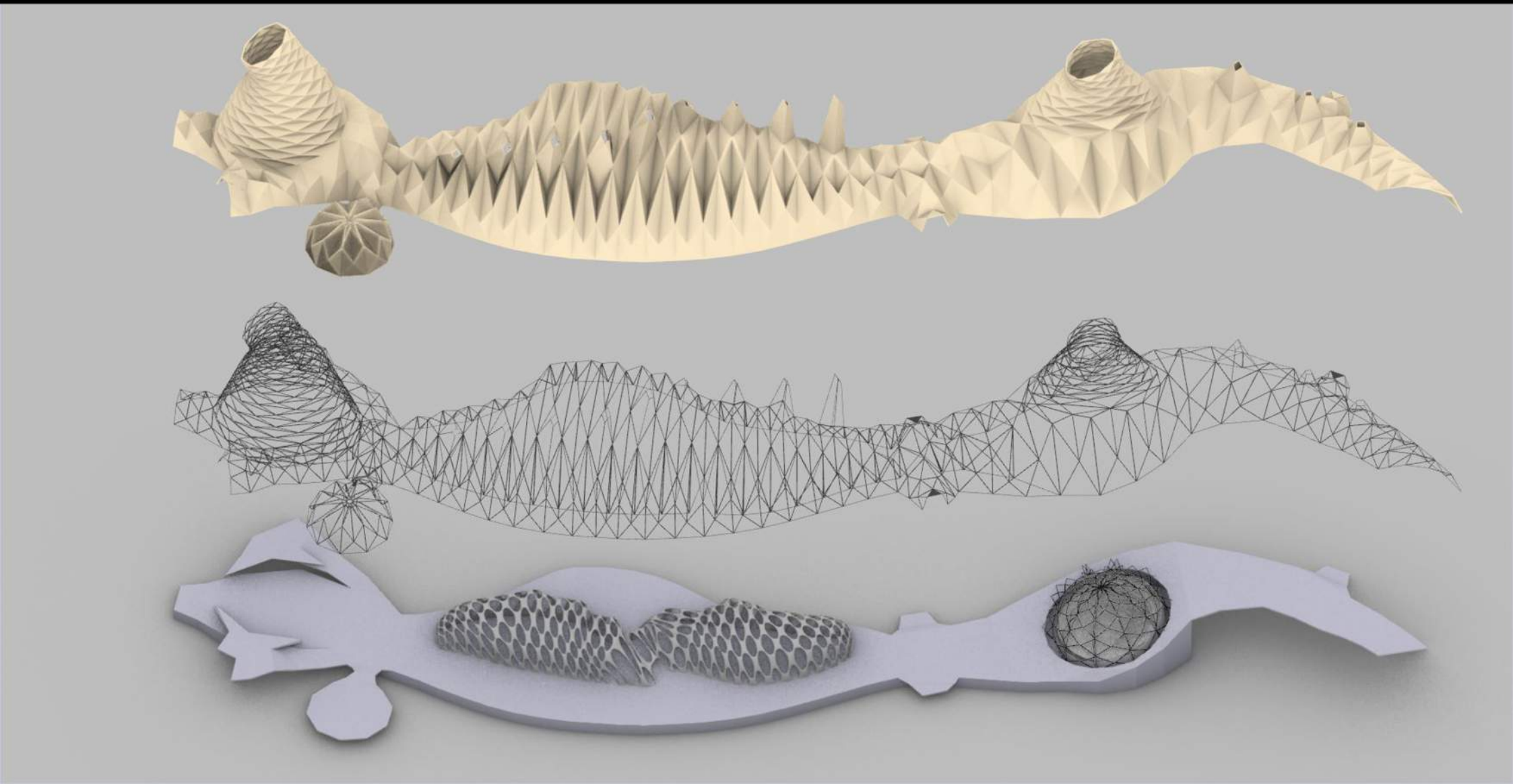


The flexibility and adjustability of foldable structure provides fast production through lavatube. According to changing size and dimensions through the lavatube the units are adjusted by 3D printing robotics.

materials:

Siliconpolymer (panels)
Iron (foldable structure)
Aluminum Foil (interior and exterior against heat lost)

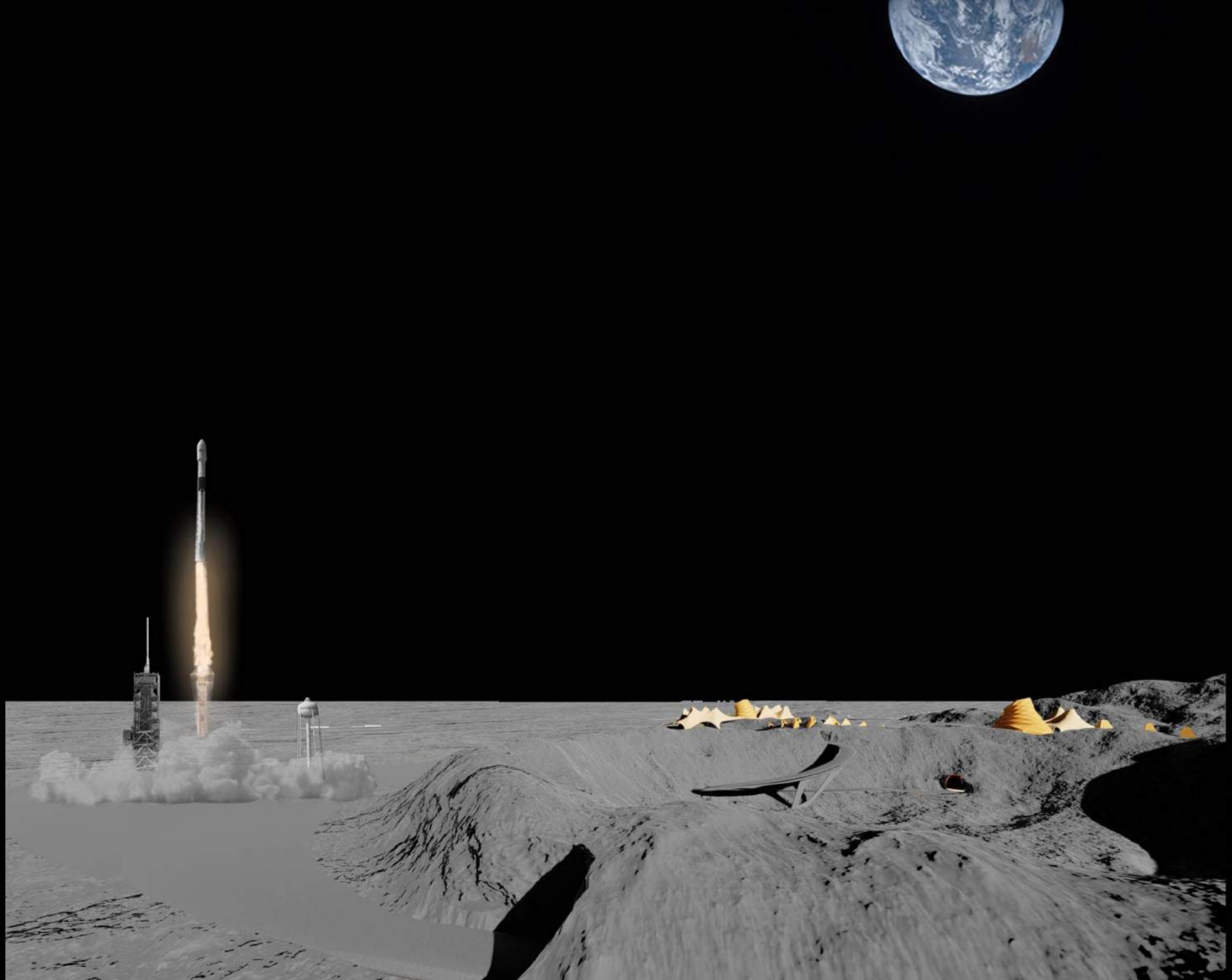
3D PRINTING MANUFACTURING



The second gathering hall will serve for recrational activities and dining hall. Also this space will be a transition area for habitation units for visitors. The ramps along the side walls will provide closer observation for users to Moon sky.

PHASE 03
EXPORTATION

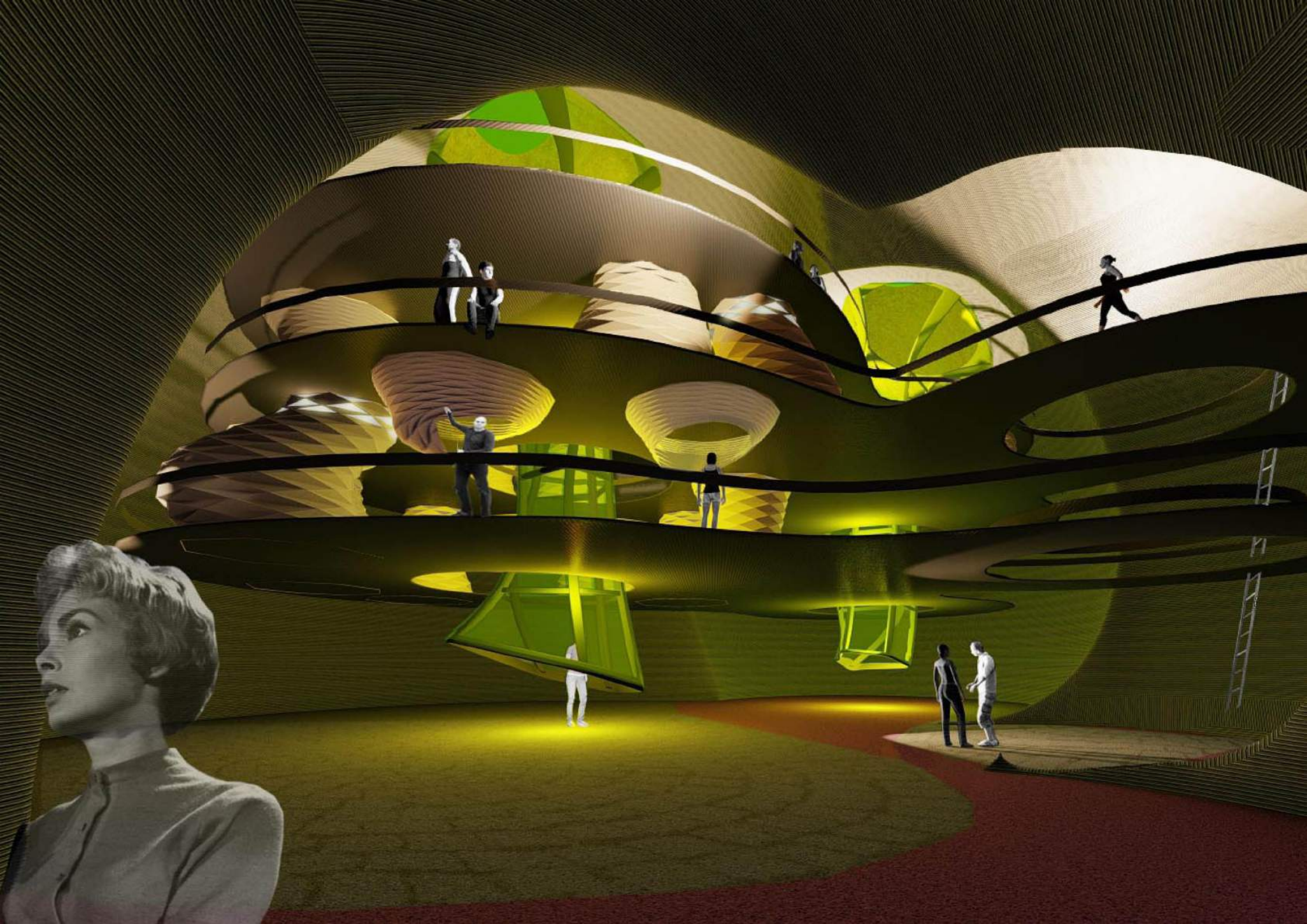
The exportation stage will increase the fund for this project and it will provide a sustainable growth on Moon mission. The resources will also help us to develope sustainable energy production on Earth.

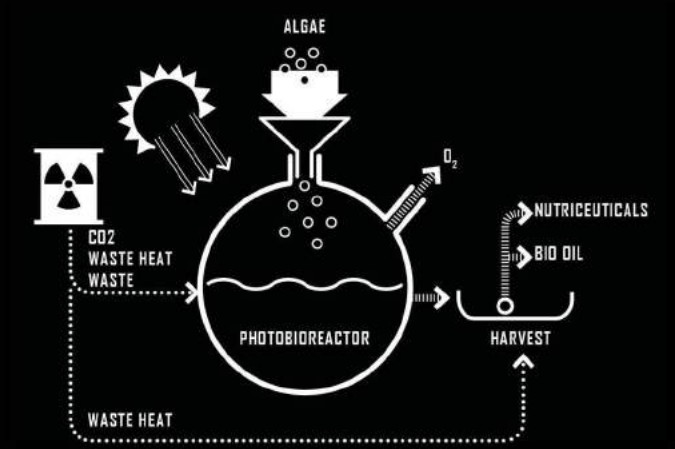


PHASE 04

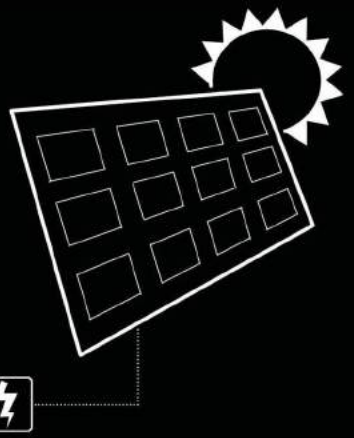
SPACE TOURISM

The habitation units are carved out spaces on the side walls of lavatube. The light-weight slabs, photobioreactor cores, and rapid deployable sleeping units will provide unique experience for visitors under low gravitational force. The photobioreactors will be air qualifiers, additional food resource, light resource for space, and energy resource for heat and electricity production.

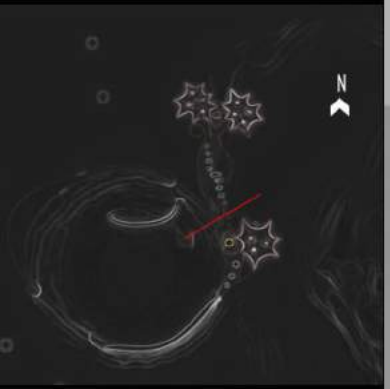


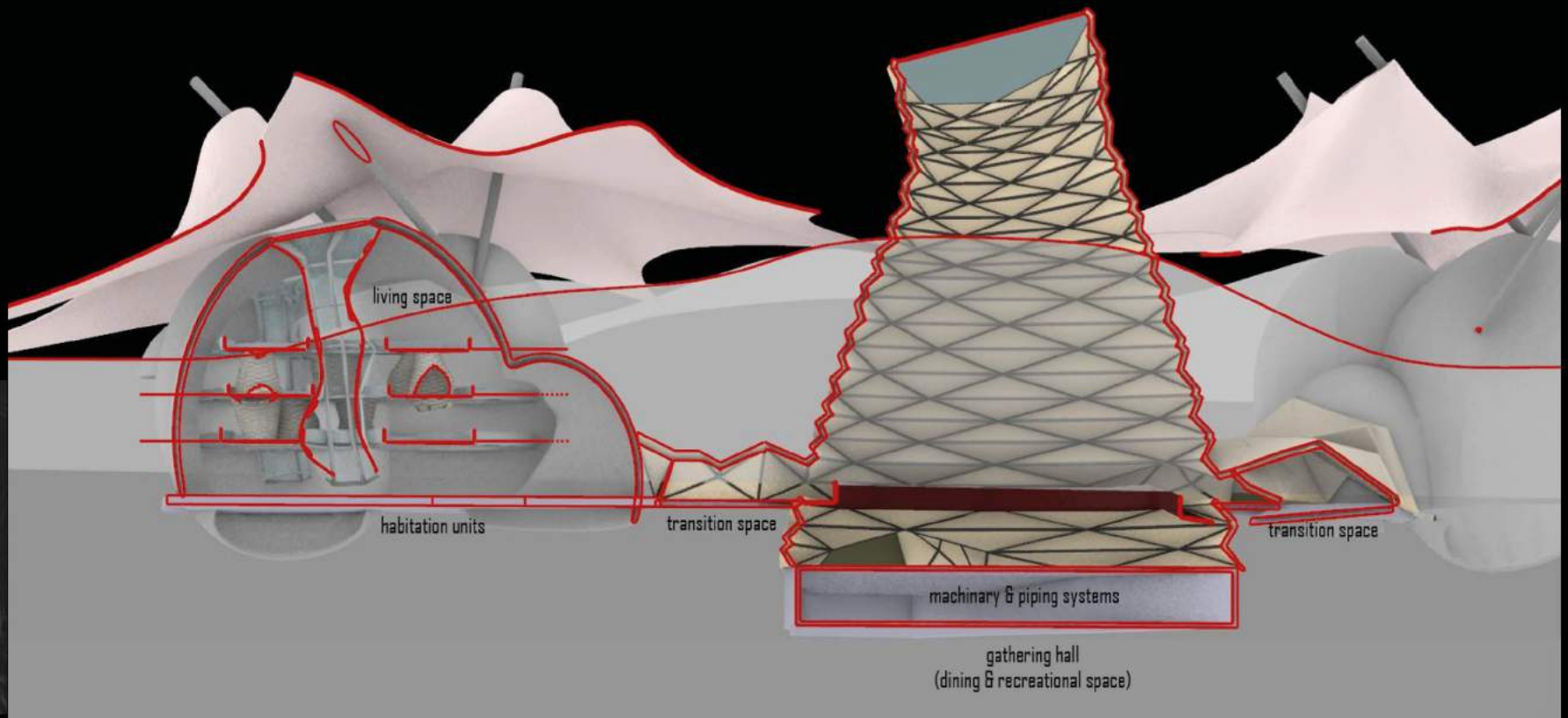


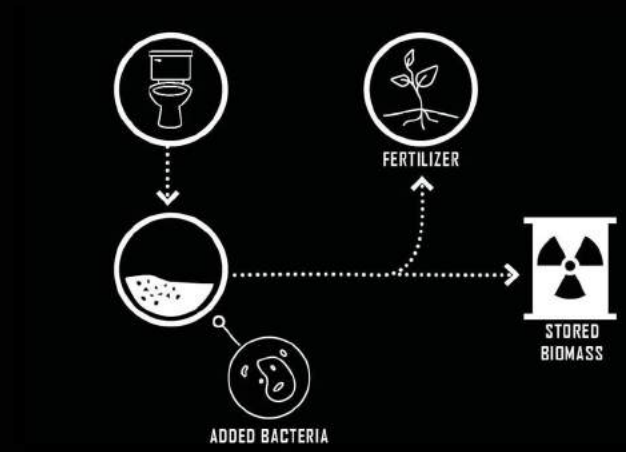
Photobioreactor is the core unit for habitation space. It serves mainly as air qualifier, food resource, and energy resource.



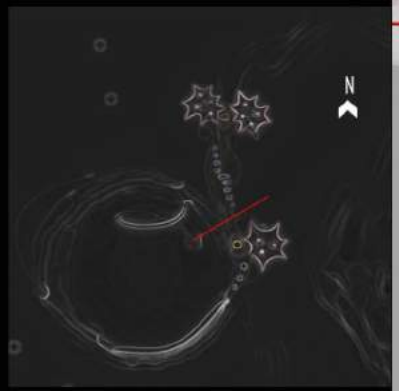
The tents are covered with PVs for electricty production.

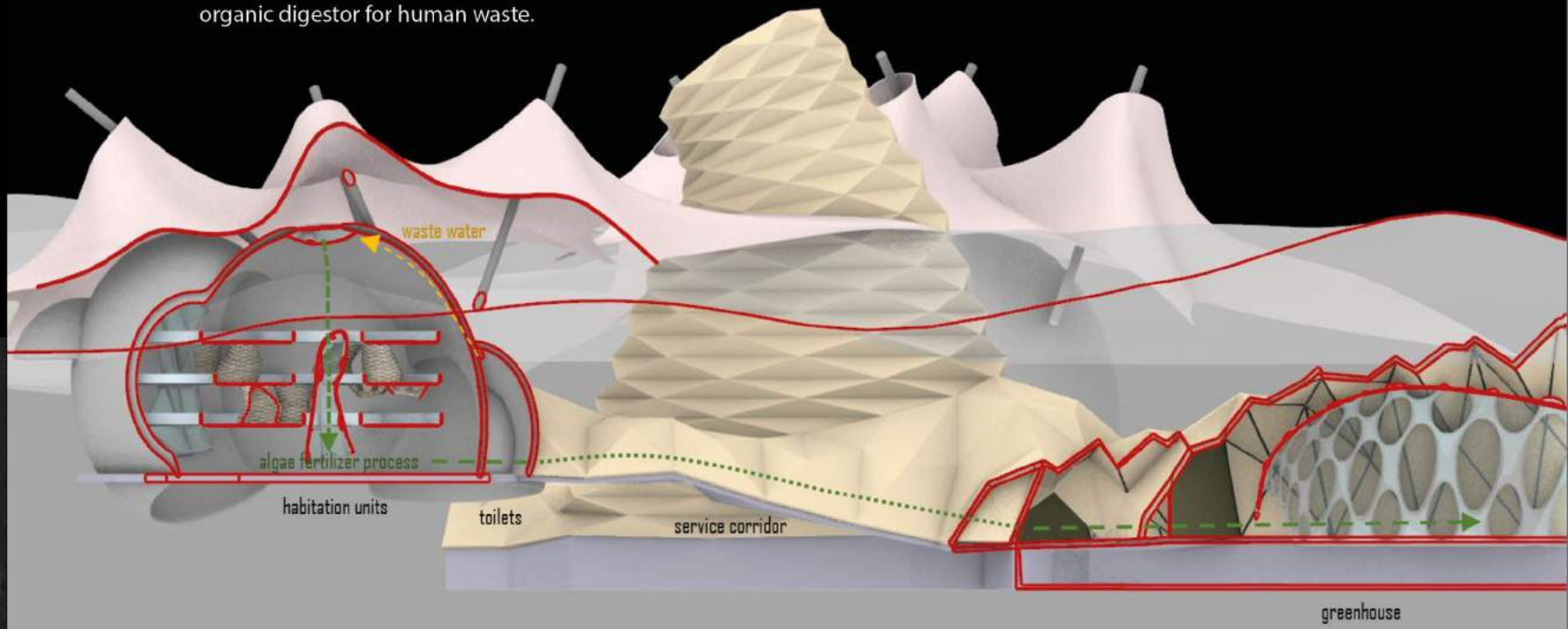


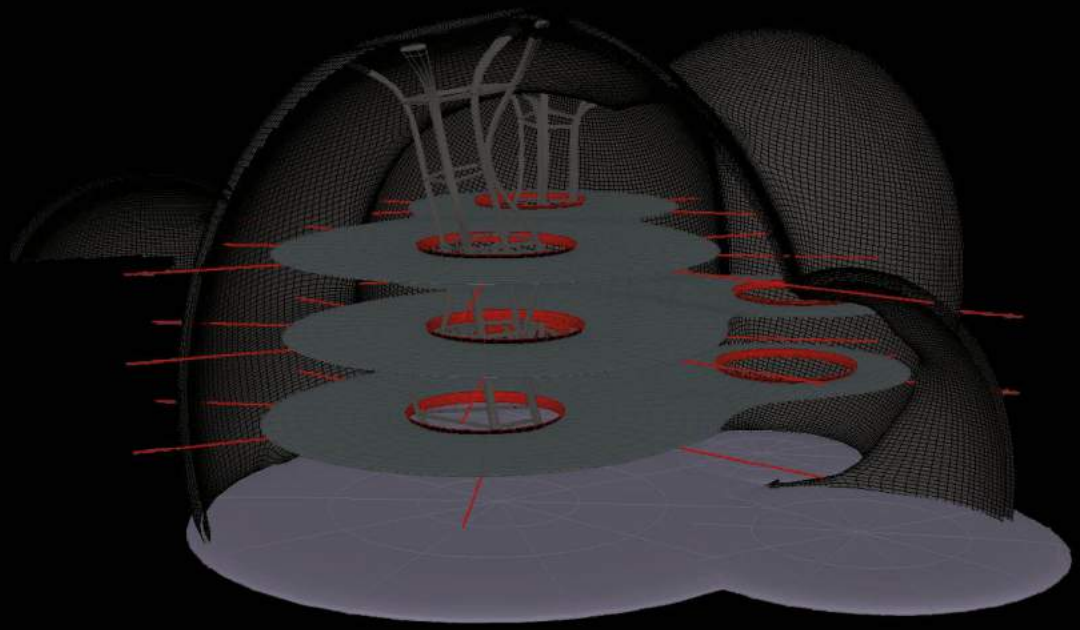




Waste treatment provides sustainable cycle and produce fertilizer for algae and greenhouse. The aquaponic farm is also used in waste treatment process since tilapia (fish specie) is an organic digestor for human waste.

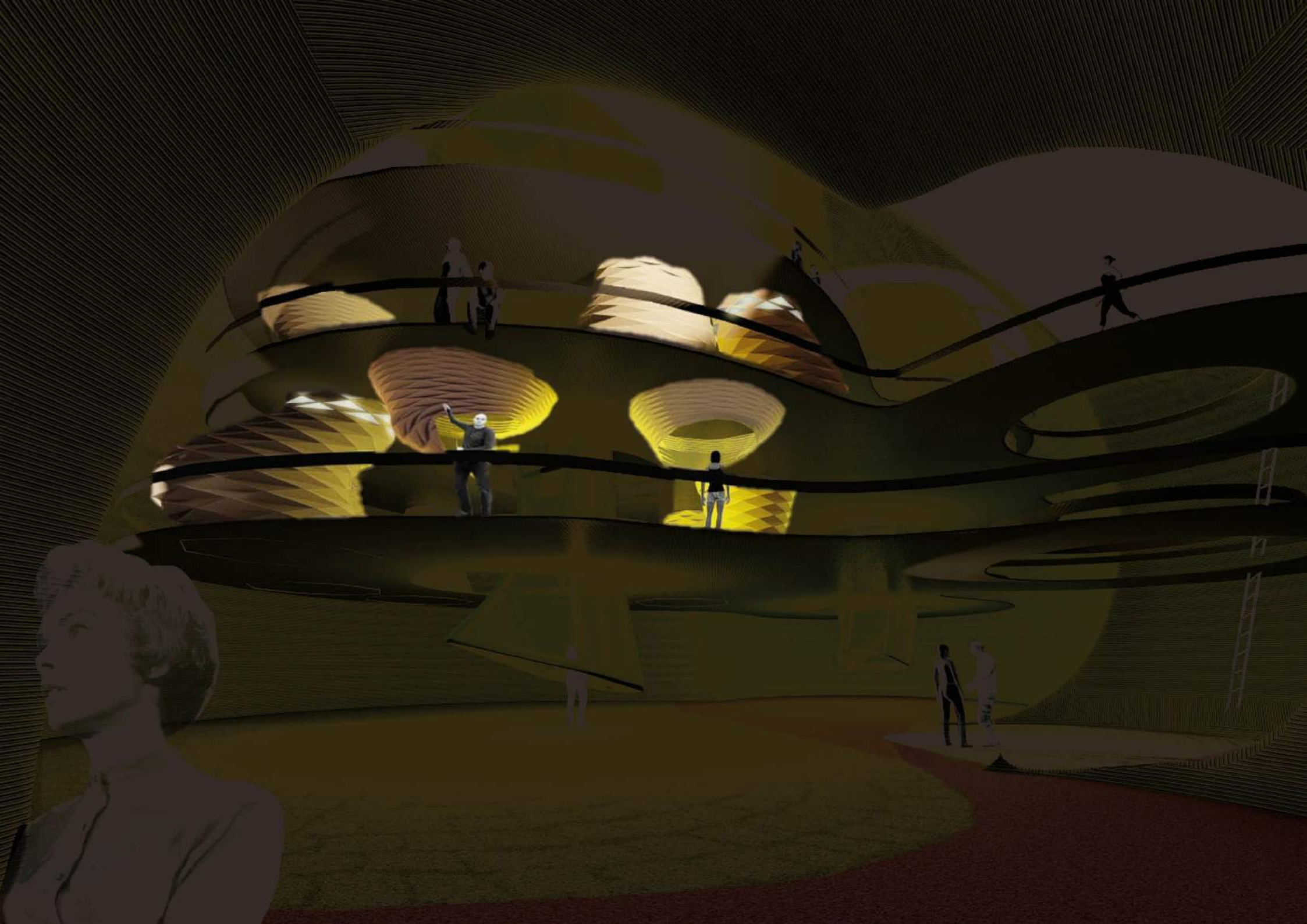


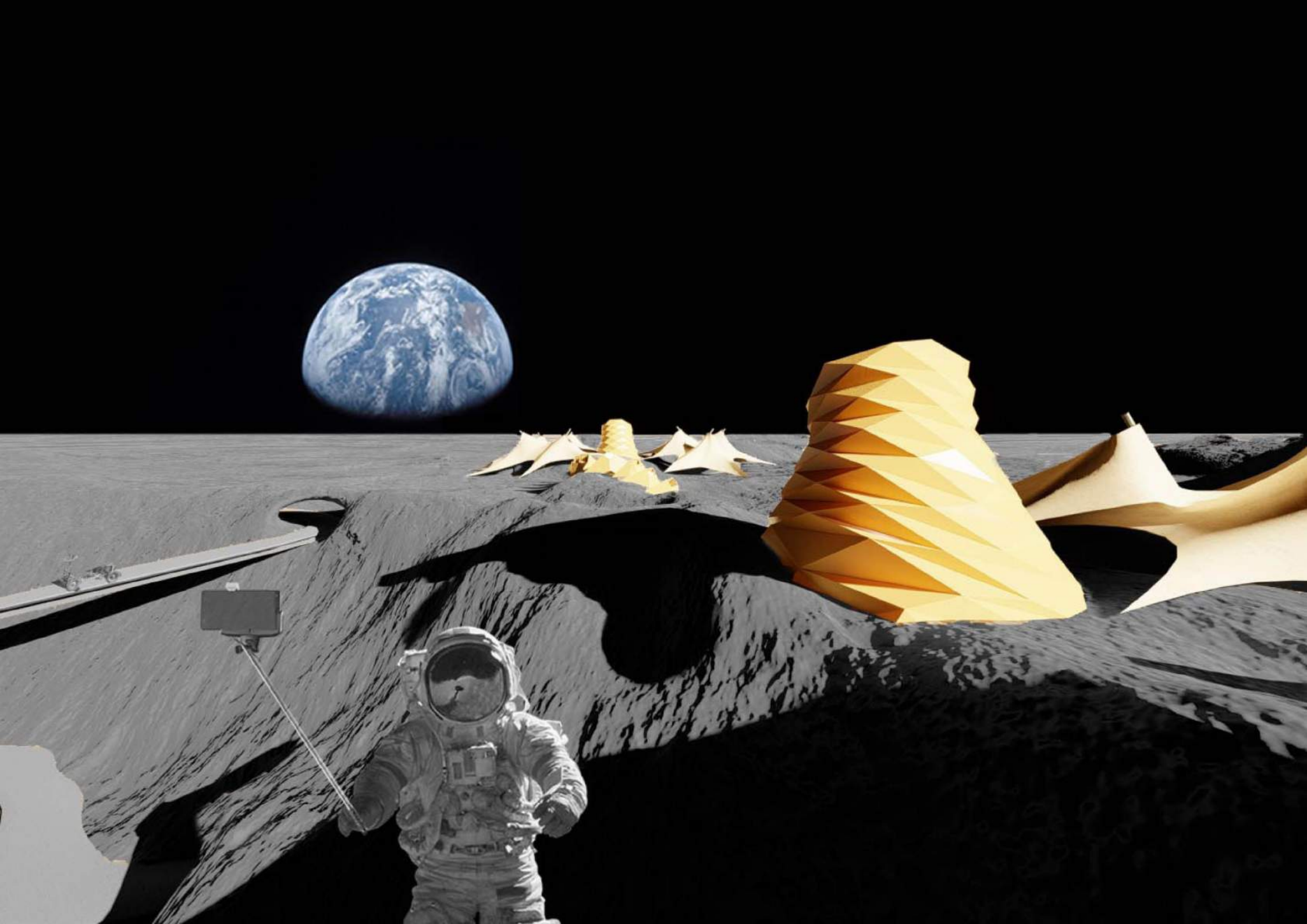




The carved out space is solidified with lunacrete. The slabs are PTFE fabrics and they are in tension between the tension rings and tension cables. The cables are anchored to the side walls of the space. The advantage of this structure is that it can be produced in the ground floor with robotics and mounted fast. The lightweight slabs will decrease cost and increase efficiency. Algae cores are iron beams that are anchored to the ceeling of the space. The skylight will allow light in and the water barrier will protect habitants from hazardous effects of radiation.

The rapid deployable sleeping units are polymer 3D pritnted fabrics with magnet grids on fabic, floor, and ceeling. This allows to enlighten whole space better. Also, it gives flexibility to each floor for different activities in a day time.





TO BE CONTINUED . . .

[09]

REFERENCES

https://quickmap.lroc.asu.edu/query?extent=-19.9599758,-20.0362322,35.2830086,4.4810477&proj=10&layers=NrBsFYBoAZIRnpEoAsjYIHYFcA2vlBvAXwF1SizSg
https://trek.nasa.gov/moon/#
https://news.cnrs.fr/articles/in-arizona-a-miniature-earth-under-a-dome
https://www.dailymail.co.uk/sciencetech/article-5270373/Nasa-finds-potential-path-water-moons-surface.html
https://www.nasa.gov/feature/ames/ice-confirmed-at-the-moon-s-poles
https://www.nasa.gov/specials/artemis/
https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/Bricks_from_Moon_dust
https://www.spacex.com/human-spaceflight/mars/
https://www.nasa.gov/content/goddard/lunar-pits-could-shelter-astronauts-reveal-details-of-how-man-in-the-moon-formed
https://www.designboom.com/technology/esa-plant-shows-how-astronauts-could-extract-oxygen-from-moondust-01-20-2020/
https://www.aispacefactory.com/
https://settlement.arc.nasa.gov/Contest/Results/96/winner/tres.html
https://www.melissafoundation.org/page/melissa-pilot-plant
http://www.paslanmazkalem.com/gelecek-artik-burada-anish-kapoor-meshuggah-ve-hiper-yapaylik
https://www.esa.int/Enabling_Support/Preparing_for_the_Future/Space_for_Earth/Energy/Helium-3_mining_on_the_lunar_surface
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20130011785.pdf
https://books.google.com.tr/books?id=ho65r66FVEsC&pg=PA667&dq=moon+in+situ+construction+methods&hl=tr&sa=X&ved=0ahUKEwjv-oiLreznAhUN0aYKHQ3fDDQQ6A-EILDAA#v=onepage&q=moon%20in%20situ%20construction%20methods&f=false
https://www.dezeen.com/2015/10/19/lowline-lab-underground-park-essex-street-lower-east-side-new-york-city/
https://www.nasa.gov/centers/ames/news/releases/2009/09-147AR.html
https://www.designboom.com/architecture/iaac-translated-geometries-08-19-2014/
https://www.wired.co.uk/article/moon-solar-energy-power
https://pubs.acs.org/doi/abs/10.1021/am300783d
https://books.google.com.tr/books?id=oxLBa_8tLHAC&pg=PA56&lpg=PA56&dq=moon+gravity+advantages&source=bl&ots=p6opn9DC5n&sig=ACfU3U3zEqHYjot00XvYZPv8anjyDS-8mCQ&hl=tr&sa=X&ved=2ahUKEwin_On11MzpAhWToVwKHaluADQQ6AEwAHoECAwQAQ#v=onepage&q=moon%20gravity%20advantages&f=false
https://www.space.com/space-station-algae-experiment-fresh-air.html
https://www.nasa.gov/pdf/284275main_Radiation_HS_Mod3.pdf
https://www.esa.int/gsp/ACT/doc/POW/ACT-RPR-NRG-2005-ESPC-Feasibility%20of%20Biomass%20based%20Fuel%20Cells.pdf
https://www.nasa.gov/pdf/143163main_Space.Food.and.Nutrition.pdf
https://www.researchgate.net/publication/27238321_Nile_Tilapia_Oreochromis_Niloticus_as_a_Food_Source_in_Advanced_Life_Support_Systems_Initial_Considerations
https://www.nasa.gov/feature/fundamentals-of-3d-deployable-mechanisms-in-space/
https://phys.org/news/2017-09-explore-origami-spacecraft.html
http://www2.eng.cam.ac.uk/~sdg/preprint/SDG%20dissertation.pdf
https://ieeexplore.ieee.org/document/4161698
https://en.wikipedia.org/wiki/Biosphere_2
https://en.wikipedia.org/wiki/Lunarcrete
https://bustler.net/competitions/4770/moontopia-an-out-of-this-world-challenge