STARPORT
MARS

In the future, interplanetary travel will become accessible. Humans will colonise Mars and build new cities and villages after the planet is terraformed.

'Starport' will support frequent travel with a landing port for crafts on the top; space elevators will bring passengers down to the ground base research facility and further to the subterranean habitats with living units. The tower structure with a self-sustaining ecosystem can be multiplied as needed and interconnected as a network. 3D printing robots, nuclear fusion, and space farming are key technologies that will make colonisation possible.

À l'avenir, les voyages interplanétaires deviendront accessibles. Les humains coloniseront Mars et construiront des communes après la terratransformation de la planète.

« Starport » prendra en charge les voyages fréquents un port de multiples pistes d'atterrissage disposées en étoile au sommet de la tour; les ascenseurs spatiaux amèneront les passagers au centre de recherche au sol et plus bas aux habitats souterrains. La structure de la tour avec un écosystème autonome peut être multipliée selon les besoins et interconnectée en réseau. Les robots-imprimantes 3D, la fusion nucléaire et l'agriculture spatiale seront des technologies clés qui rendront la colonisation possible.

2021 JACQUES ROUGERIE FOUNDATION AWARDS

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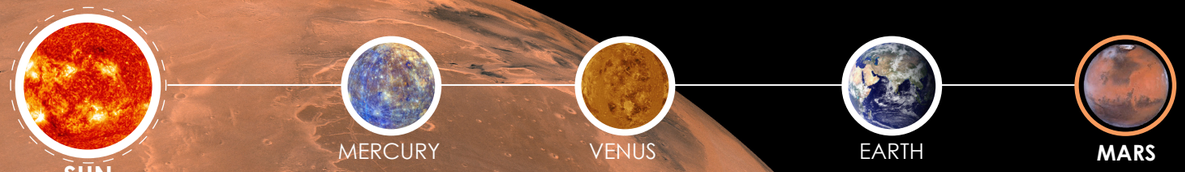
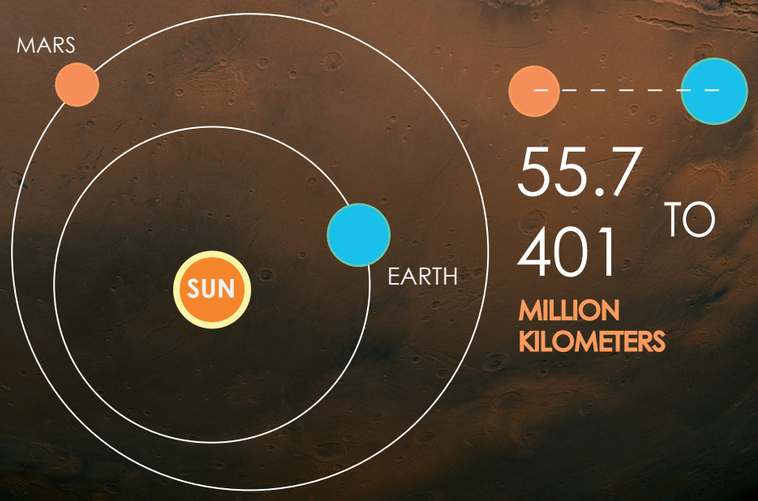
DISTANCE FROM THE SUN 142,000,000 mi



Why Mars?

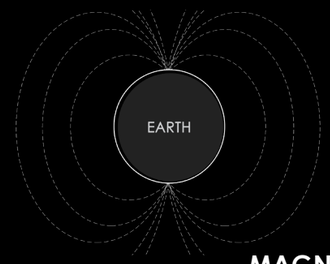
Mars is the fourth planet of the solar system after Mercury, Venus and Earth. It is also the second-smallest planet of all, being larger than only Mercury. Despite being further away from the Sun, Mars' geological evolution and climate cycles are comparable to those of the Earth. At one point in time, Mars had conditions suitable for life. Valuable resources for sustaining human pioneers, such as water and ice can be found just below the surface. Its similarity to Earth and valuable resources to maintain life and perhaps - build a civilization. The red planet has become a conquest for humans to step further into the galaxy as a spacefaring species.

MARS



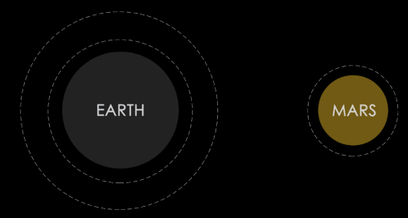
55.7 TO 401 MILLION KILOMETERS

Using the fastest spacecraft today, it would take an average of 162 days to reach Mars, depending on the distance between the two planets



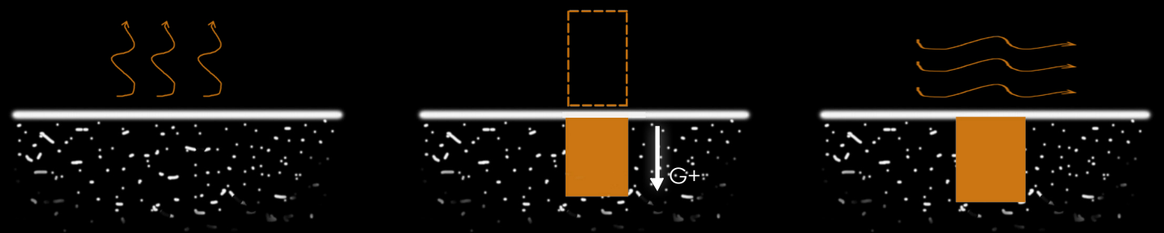
MAGNETIC FIELD

Mars' magnetic field is much smaller than that of Earths. This smaller and hence weaker magnetic field on Mars allows for more of the solar radiation to penetrate into the planet's surface.



ATMOSPHERE

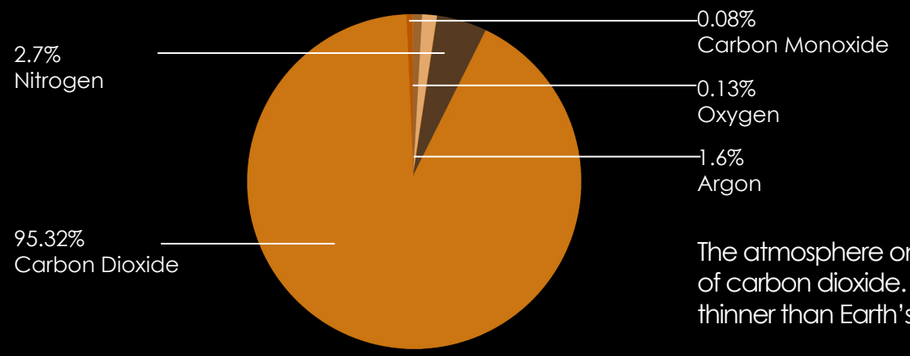
The atmosphere on Mars is much thinner compared to Earth's - 100 times thinner to be exact. The less dense atmosphere also contributes to the larger amounts of solar radiation reaching the Martian surface.



The surface of the Martain planet receives high levels of solar radiation, however beneath the Martian soil raditation levels drop.

The village is placed deep underground, providing the best defense against recieving high levels of solar raditation. Moreover, the deeper below the surface the larger gravity of Mars, and the closer to the one of Earth.

This subterranean typology will also protect the habitat against powerful storms on the surface of Mars.



The atmosphere on Mars is mostly made of carbon dioxide. It is also 100 times thinner than Earth's atmosphere

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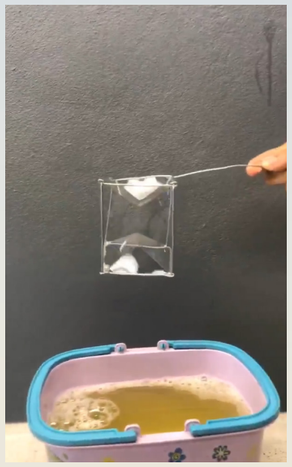
Minimal Surface

In mathematics, a minimal surface is a surface that locally minimizes its area. Any point on that surface has a zero mean curvature. It can be found in nature such as soap bubble and some plant forms. A minimal surface has been applied to architecture and design because of its attractive curvy form, which also gives good lighting effect. Some tensile structures approximate a minimal surface and use a minimal surface area to cover a space.

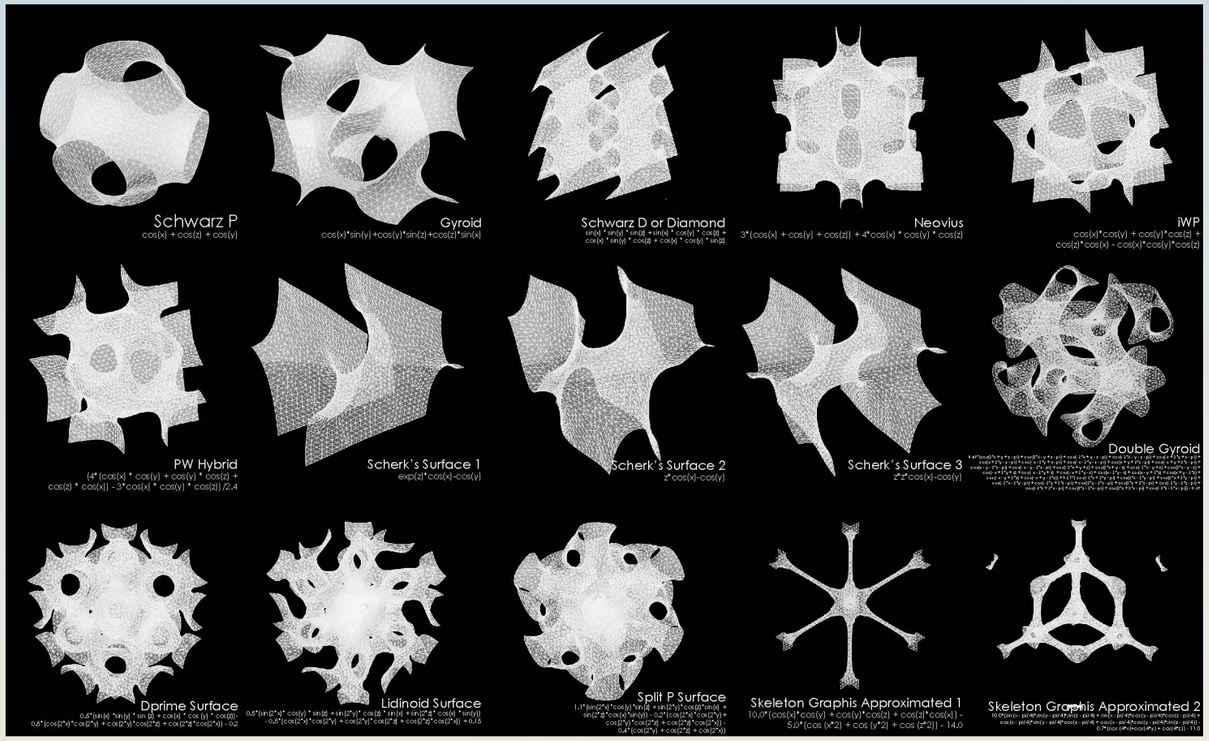
Minimal surface can be applied to space architecture because it is a self support structure by its own surface and can be constructed using 3D printing technique.



Mean curvature definition:
A surface M ⊂ R3 is minimal if and only if its mean curvature is equal to zero at all points.

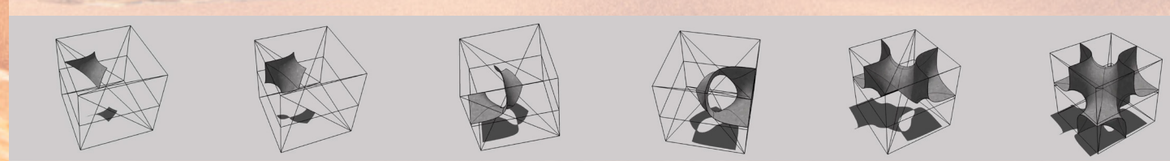
Minimal surface can be found in nature such as plant form and soap film. An experiment on minimal surface can be performed by dipping a wire into soap solution. Consequently, a soap film will be formed attaching to the wire and minimizing its surface area.

Study of the Triply Periodic Minimal Surfaces and their formula

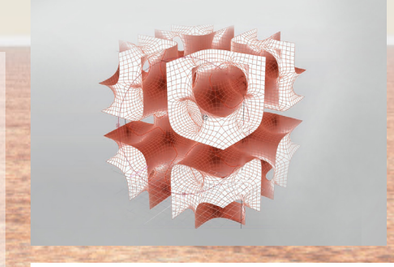


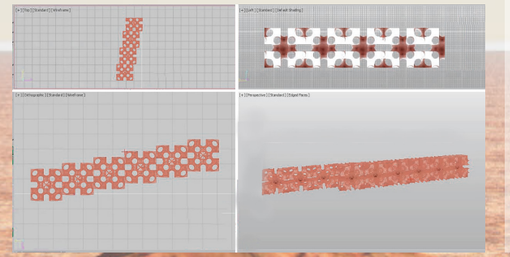
Triply Periodic Minimal Surface

A Triply periodic minimal surface is a type of minimal surface discovered by mathematicians. These surfaces have the symmetries of a crystallographic group, and have a grow ability property. TPMS are of relevance in natural science and have been observed as biological membrames, as block copolymers,equipotential surfaces incrystals etc. They have also of interest in architecture, art and design.

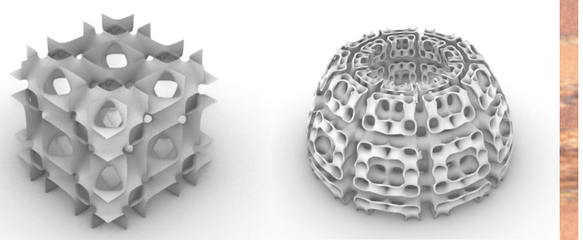


Modeling process of the PW Hybrid Surface
3D modeling by Kuang Sithu





Growing ability of the Triply periodic minimal surface. This growing property is benefitial for creating structures that needs to be expanded for immediate or future use.



iWP surface is developped into the Ground base research facility

Gyroid is developped into the subterranean expandable dweling units

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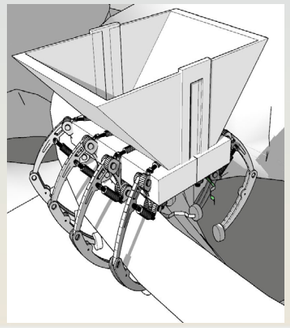
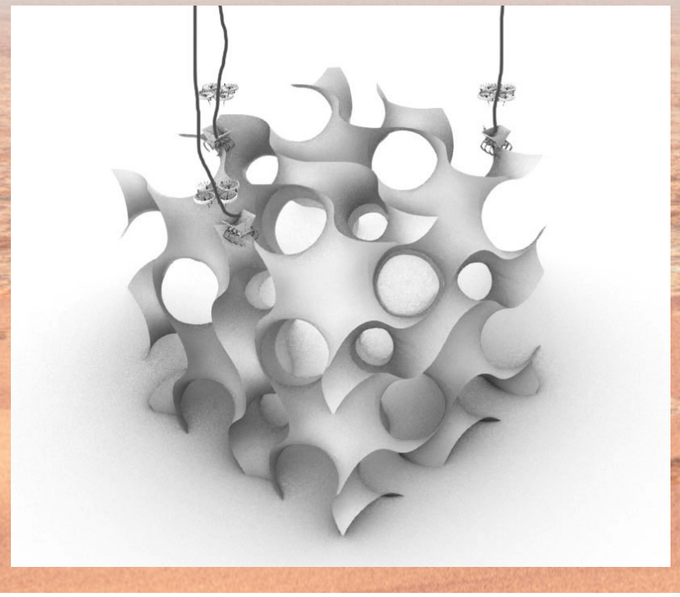
SPACE AND SEA GENERATION

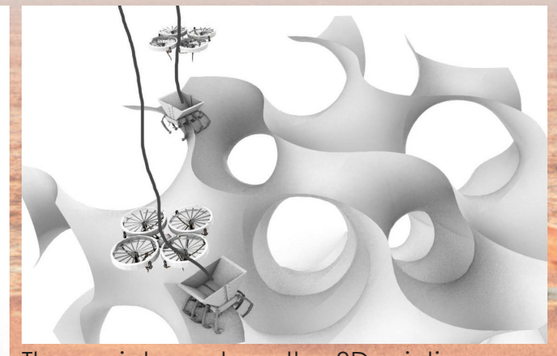
3D Printing on Mars

The high cost of transporting building materials mean that most will have to be found locally. Rocks, gravel and aggregates can be used and eventually industry will be able to mine minerals such as iron, titanium, aluminum and calcium. 3D printing will allow for structures to be formed by depositing a layer at a time and building on it. Special 3D printing robots 'walk' on the structure as they build it will be used to create the shapes that form the main body of the structure. As these are continuous surfaces they are ideal for printing as a smooth extrusion,.

While the robots walk along the surfaces, drones fly overhead loading them with new material. Thousands of robots work together, in the same way that ants or termites work together to build a nest.

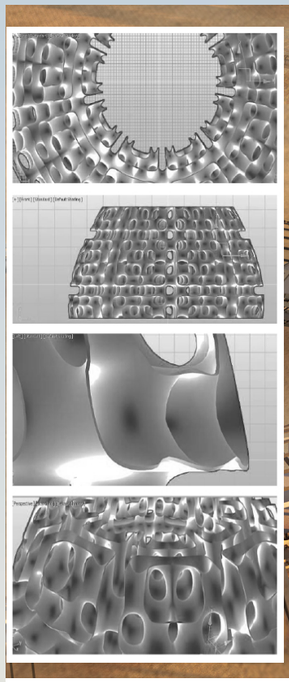


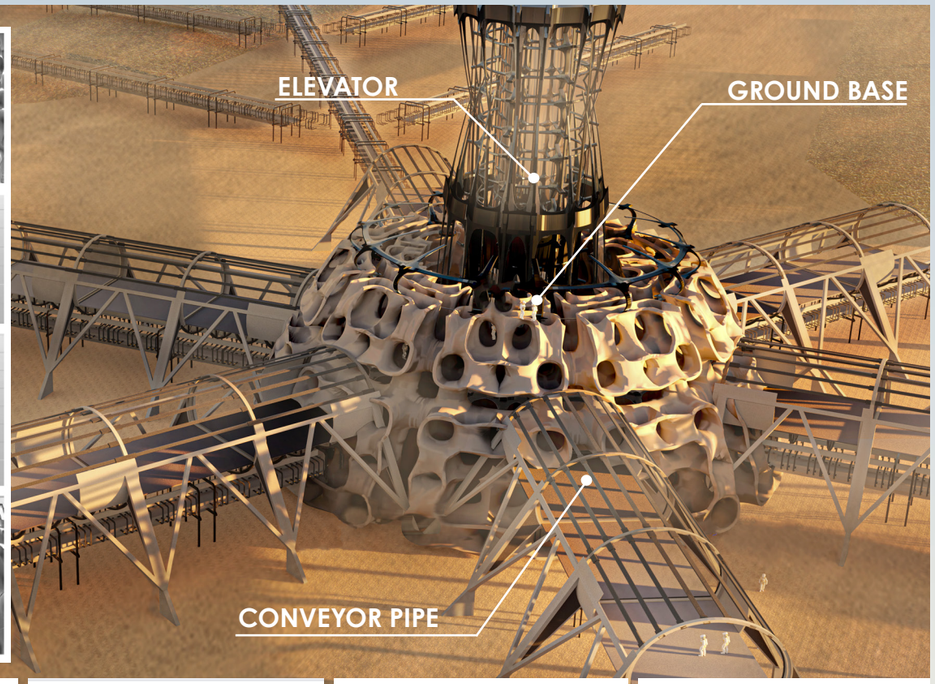


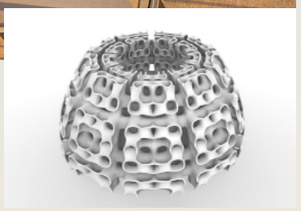


These pictures show the 3D printing process of the underground dwelling units in the form of the gyroid surface. Multiple set of 3D printing robots coupling with drones can be used concurrently in order to increase the speed of the construction.

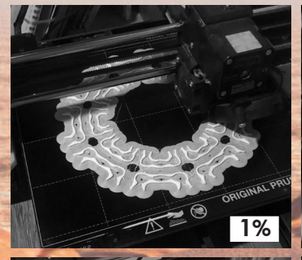
3D Printing Minimal Surfaces

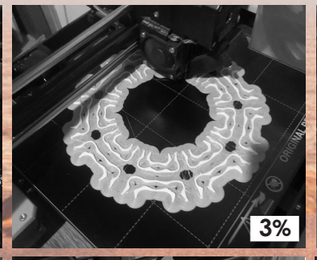


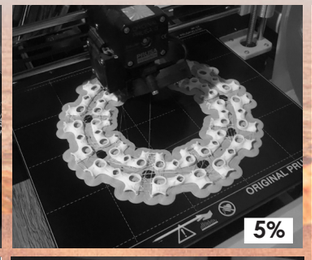


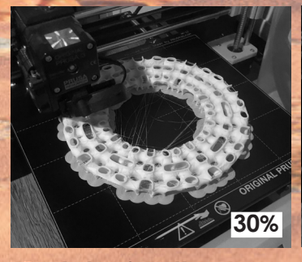


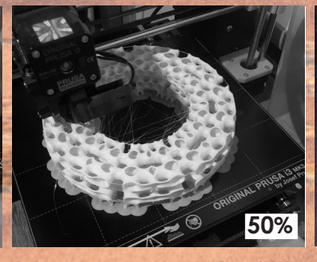
The ground base research facilities is a circular structure developed from the iWP surface.











Prototoping the ground base research facilities: our 3D printing experiment shows that the minimal surfaces can be printed continuously without support.

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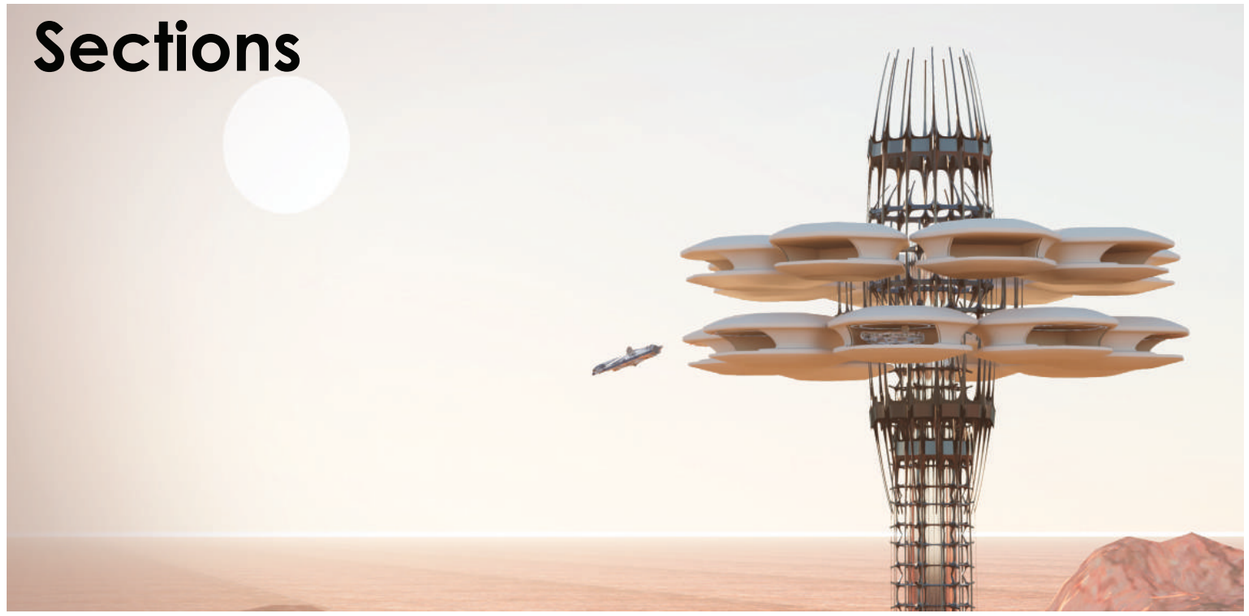
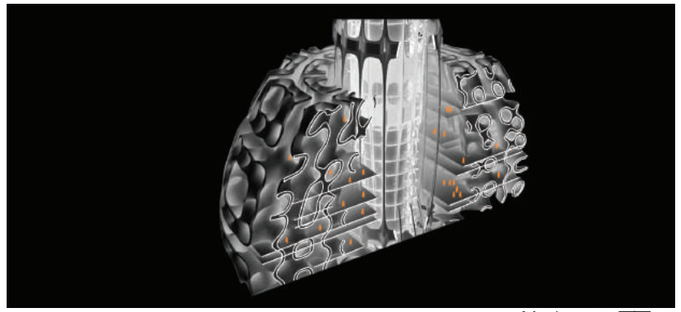
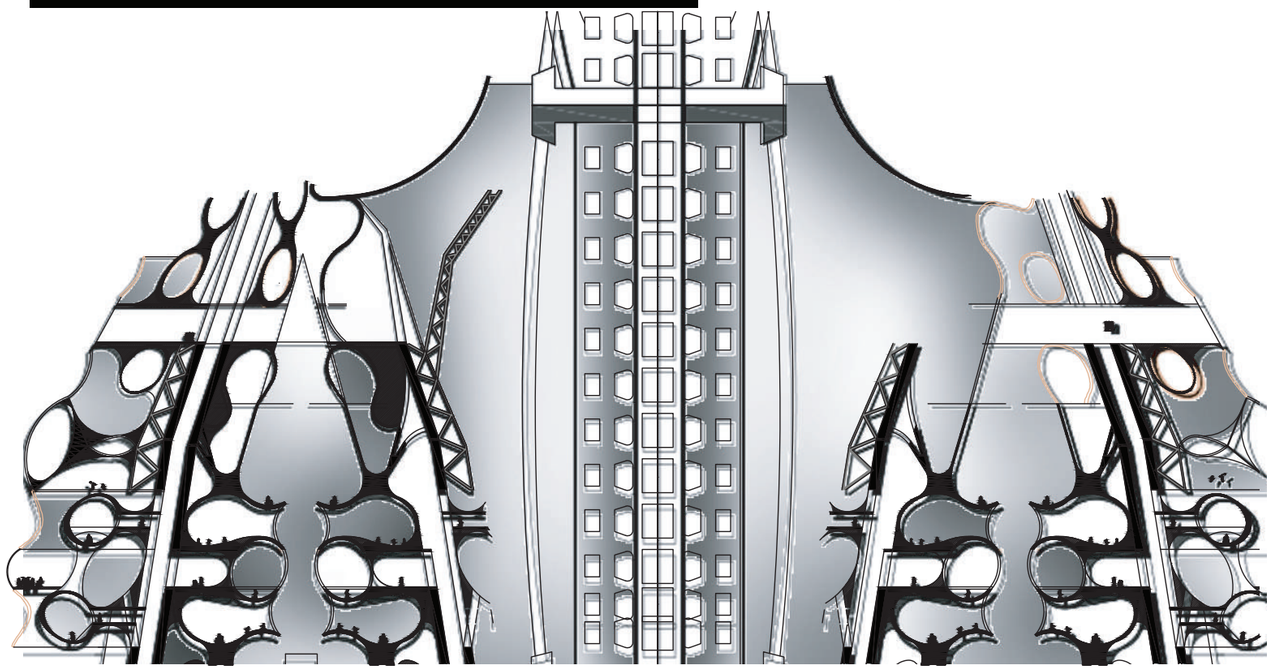
Sections

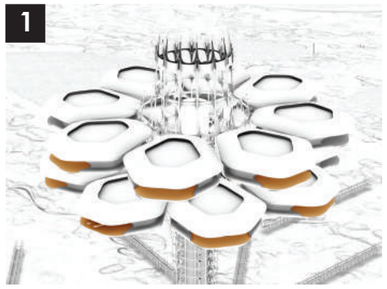


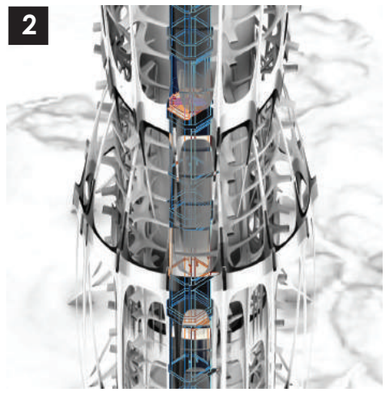


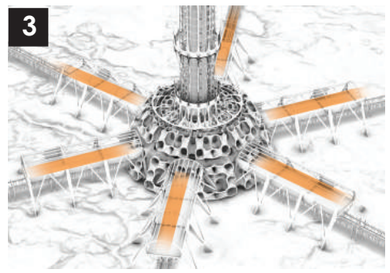
As the structure is made from compacted material excavated and 3d printed, the main design challenge was to find forms that were continuous so that they could be printed by a machine printing a curve that layered on itself.

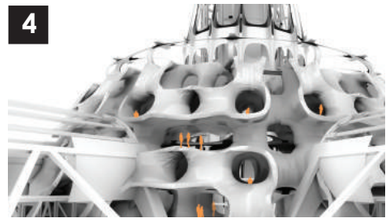
We used minimal surfaces to create such geometry. The spaces would first be filled with capsules and then eventually with an environment that is hospitable for life.

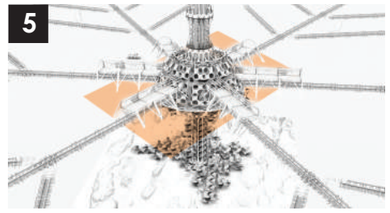


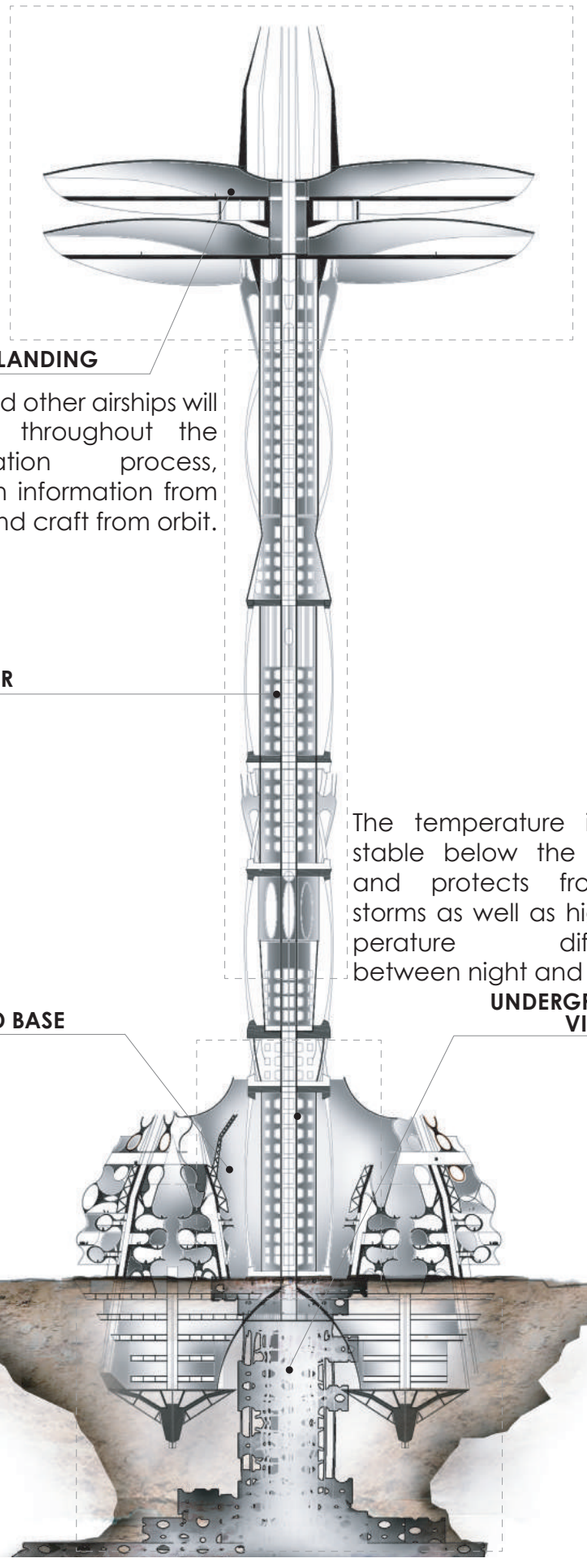












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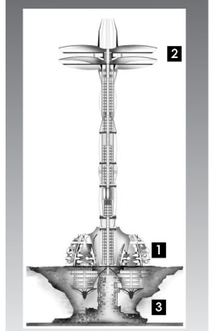
Interior

Interior of the Ground base research facility **1**

Interior of the landing port for spacecrafts on the top **2**

Interior of the subterranean living unit **3**

Underground village developped from Gyroid surface, spiraling down.
The living units can be multiplied as needed. **3**



1. Ground research facility
2. Landing port
3. Subterranean habitats

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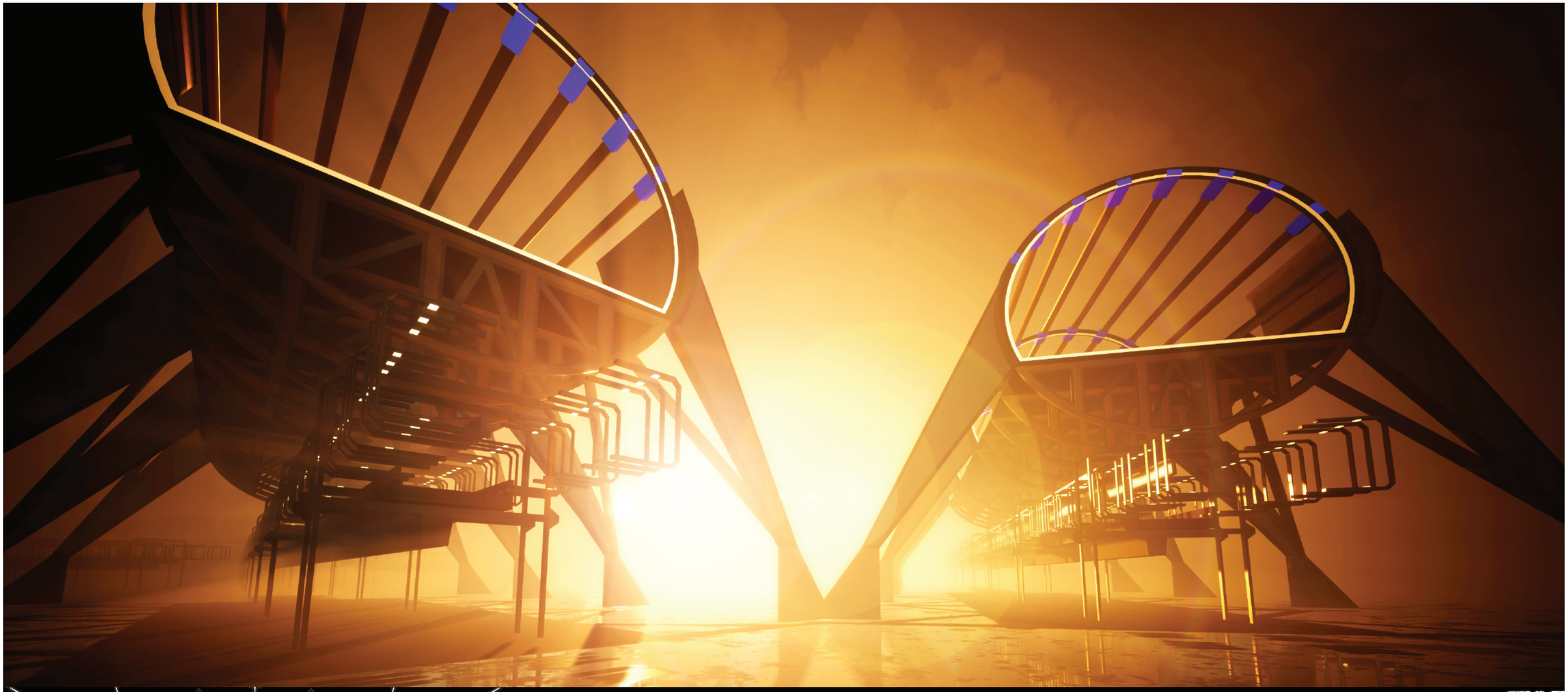
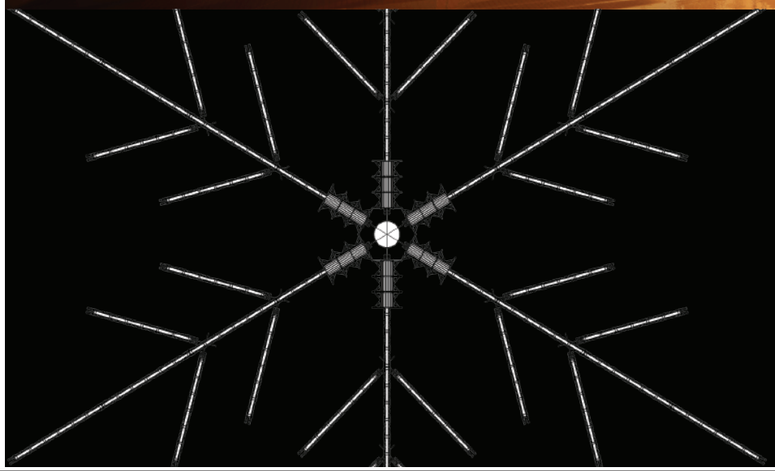
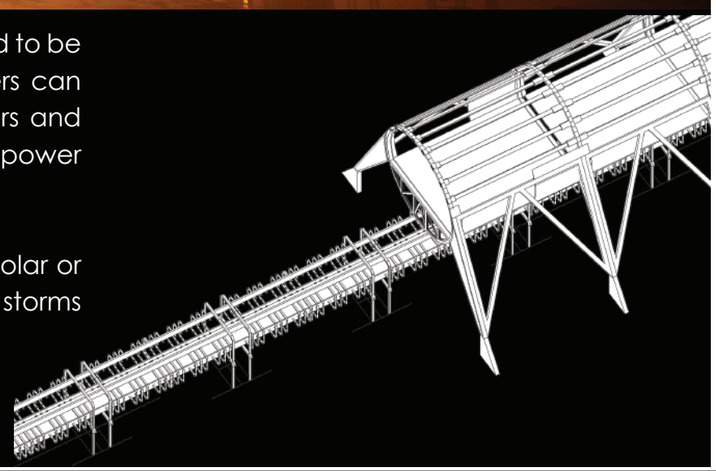
Network





For the first stage of making Mars habitable, material resources will need to be distributed to the different sites, so that the different industrial centers can make use of them. Lines of transport connect up the different towers and underground centers and as the network grows, materials and power resources are balanced throughout the colony.

As no fuel is present, in the first stage, all energy is created by either solar or fusion power. The network also provides some cover against the dust storms that are present on Mars.



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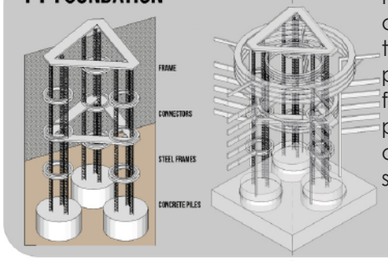
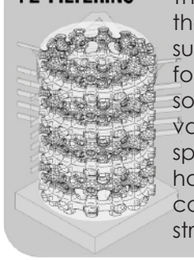
Modules

F1-FOUNDATION

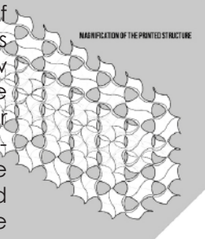


Framing elements anchor the tower to the site and provide cavities for vertical transport where most of the occupants stay.

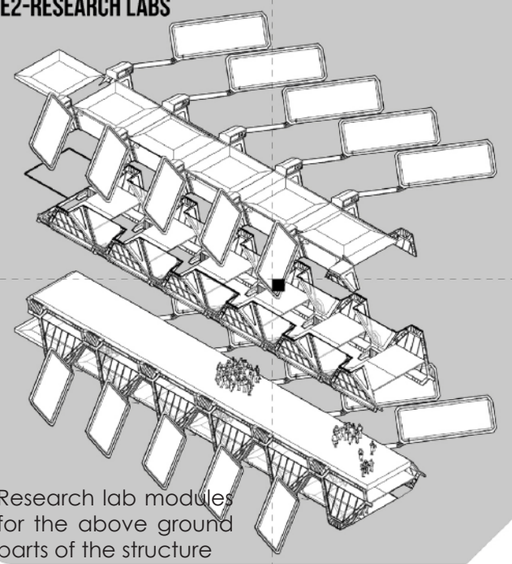
F2-FILTERING



The 3d printing of the structures surface will allow for minerals in the soil and any water vapur in the atmosphere to be harvested and collector near the structure.

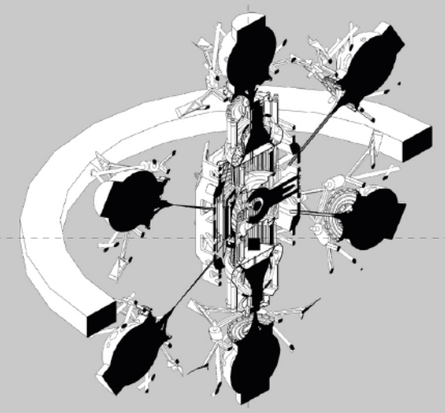


E2-RESEARCH LABS



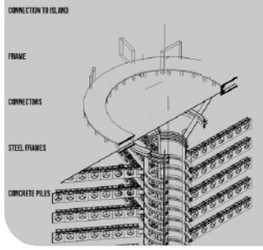
Research lab modules for the above ground parts of the structure

G1-FUSION REACTOR



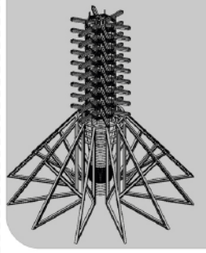
Along with solar, most of the power will be provided by fusion power. The hydrogen needed for fusion has been found in composition of the subsurface of Mars.

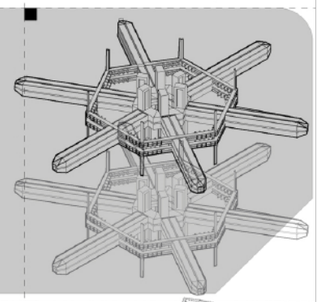
K1-ENERGY MATRIX



The enery system is distributed throughout the network and high density storage is used to provide power when other systems are offline.

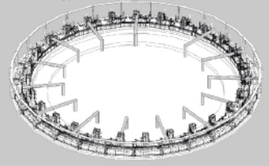
I1-STRUCTURE

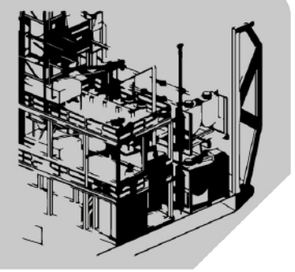




H1-PROCESSING PLANT

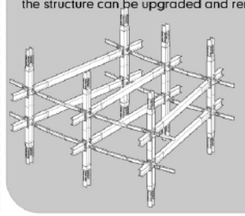
From the ocean, water is desalinated to support the life systems. At the same time, minerals are mined for manufacturing the various byproducts used for research.

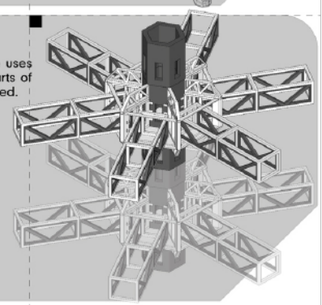




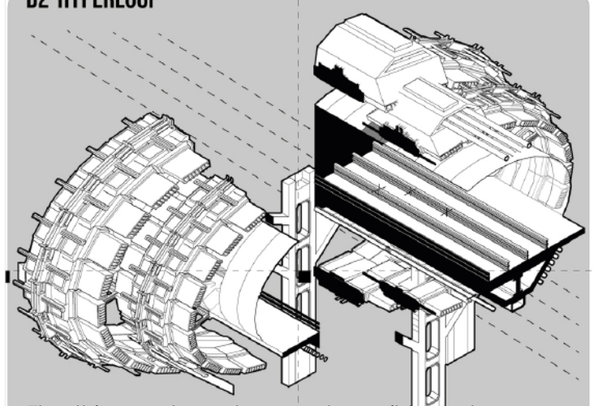
J1-CONSTRUCTION

Inspired by the metabolists, the structure uses modules to create the 'whole' so that parts of the structure can be upgraded and removed.



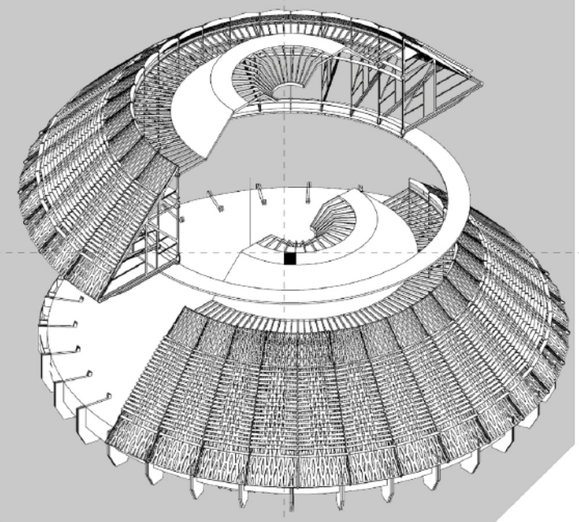


D2-HYPERLOOP



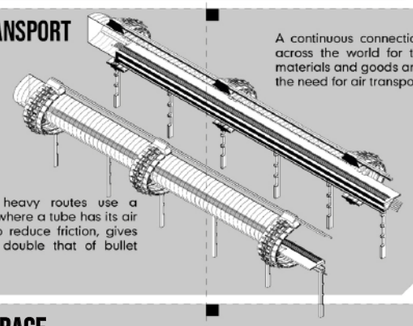
The thinner atmosphere makes rail based movement easier though without oxygen, electrical and magnetic power is needed. This module operates like a railgun accelerating pods using electromagnetism.

H2-GREENHOUSES



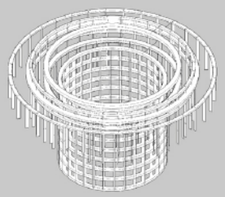
N1-TRANSPORT

A continuous connection is made across the world for transporting materials and goods and reducing the need for air transport.



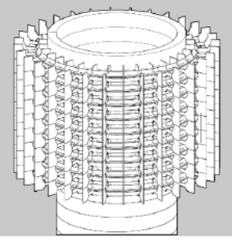
Passenger heavy routes use a hyperloop where a tube has its air removed to reduce friction, gives speeds of double that of bullet trains.

L1-SANCTUARY



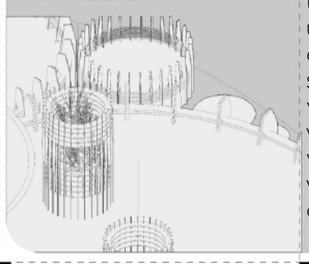
Throughout the network, excavation such as these create volumes that will slowly start changing the atmospheric balance to 20% oxygen 80% nitrogen, extracting gases from the Martian atmosphere.

H3-STORAGE



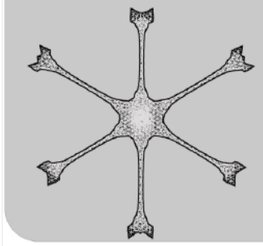
Storage unit for elements that are brought in on the journey or manufactured on Mars in preparation for the coming population.

M1-CONSERVATION



Until a critical mass is built up that the atmosphere can be terraformed, small pockets of conservation will slowly be filled with greenery and biodiversity. Over time, these will connect up to create ecosystems.

E3-FRAMING



The framing elements are also made as minimal surfaces as they are printed using composites from the minerals harvested. These make up the outer structure of the tower.

The eventual aim is to create a self-sustaining colony, so farming will be one of the most critical elements to attain. These modules which sit half above ground attempt to maximise the light that they can receive naturally while also being able to light through artifical means. As they are hermetically sealed elements, all water and oxygen is retained within the system - the atmostphere which is 95% CO2 can slowly be converted to conditions closer to earth.

2021 JACQUES ROUGERIE FOUNDATION AWARDS

Award's category : Architecture and Innovation for the Space award

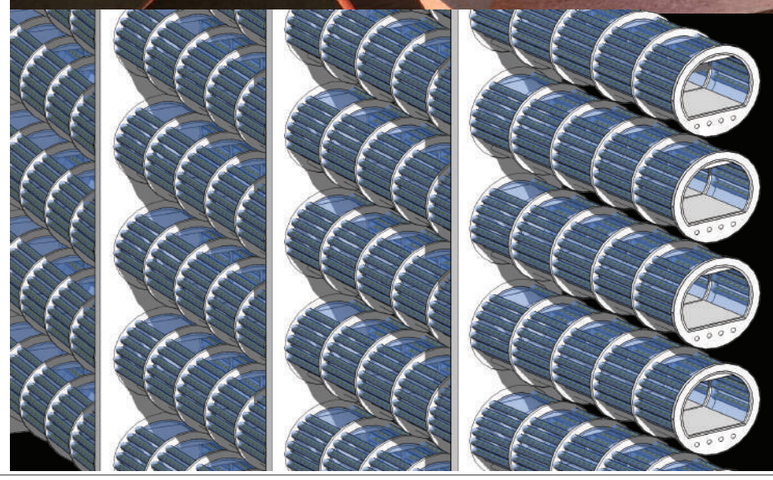
Focus Prize: The lunar or martian village

Project's Name: Starport Mars

Description: A Martian village in a vertical form consisting of a landing base on top, a ground base research facility, and subterranean habitats.

JACQUES ROUGERIE FOUNDATION
SPACE AND SEA GENERATION
INSTITUT DE FRANCE

Farming



The goal of having a self-sustaining colony means having a steady food supply. A controlled system of farming would have to scale in such a way that more modules could be added on and conserve water and energy in the production of food. The system should be maintainable with a minimal work-force heavily making use of robotics.

In this design, lines of tubes revolve around the core and are open to the natural light of the atmosphere but can also be supported with artificial light. The breakdown of CO_2 into oxygen and carbon supports the growing internal atmosphere and this node feeds oxygen back into the network.