GRIMSEL LAB

AN UNDERGROUND FACILITY FOR ANALOG SPACE MISSIONS

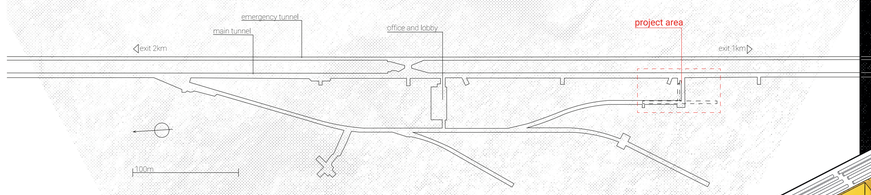
ARCHITECTURE FOR ISOLATION

ABSTRACT

Human space exploration is at its beginning, and since Yuri Gagarin's first flight in 1961, astronauts flight time increase more and more every decade. Since the early 2000's, a new era is starting through private actors going into space race. China developing a crewed space program, and the comeback of US as a leader in space exploration with Artemis program. Many projects are currently under development such as moon bases, lunar orbit space stations, mars base and interplanetary spacecrafts. All those projects imply to understand very well how environmental factors impacts astronauts and how crew psychology impact missions success. Furthermore, a new kind of housing and a new kind of architecture are emerging through those projects. Most of the previous habitats spacecraft weren't designed with an architectural vision, even if it should be considered as actual housing since people can live there for more than a year. Architecture can bring feelings to living spaces, and industrials interior of spacecraft can have very bad impact on mental health as shown in the past with the Skylab US space station for example.
Before sending people on long-range adventures, researches should be conducted on earth on those topics before. Long term isolation, absence of natural light, cramped environments are very stressful factors for crews and should be understand. To do so, analog missions are conducted since years, and requires specially designed spaces, able to emulates certain conditions similar to Space flight. The present project tries to answer this need and tackle an architecture thinking around Space habitat.

SITE

Located in Canton of Bern, the NASRA underground Grimsel Pass facility is a perfect environment for analog missions. Located at an altitude of 1730m ASL in the granitic Aar Massif. It is reached via the access 4km long tunnel of near by hydropower plant, the facility is 450m under the surface. Excavated and build between 1983 and 1995, the original research field was applied geology for the dam and tunnel construction. Nowadays, many analog Space mission projects are studied there, including analog Space mission with the EPFL Aeolipyos project. Indeed, going underground for such mission make sense since lot of the recent projects for moon bases are nested into lava tubes which are natural underground structures caused by past volcanic activities. Such environments can isolate humans from deadly cosmic rays, or meteorites impacts, but it is still an engineering challenge. The choice of the Grimsel facility is also motivated by 2 other elements. It is absolutely isolated from all external inputs such as day/night cycle, seasons, human activity, temperature variations, and some part of this facility are unused and can be resupposed.



LIGHTING SYSTEM

Lighting plays a crucial role in the Space habitat, the common space where all the crew members can meet, share a meal, watch a film, discuss, and share time together. The main feature is the panoramic virtual window, based on a large curved screen. Run by off-the-shelf computer graphic technologies, such as Unreal Engine 5, displays a constantly changing landscapes, recreating day and night, meteorological events or seasons. The landscape itself can be changed depending of needs and allow to test different types of technics. On one side a sofa and different sitting solutions are available along a modular table, and on the other side kitchen storage elements are featured.

PANORAMIC ROOM

In the middle of the upper level of the Panoramic room, the common space where all the crew members can meet, share a meal, watch a film, discuss, and share time together. The main feature is the panoramic virtual window, based on a large curved screen. Run by off-the-shelf computer graphic technologies, such as Unreal Engine 5, displays a constantly changing landscapes, recreating day and night, meteorological events or seasons. The landscape itself can be changed depending of needs and allow to test different types of technics. On one side a sofa and different sitting solutions are available along a modular table, and on the other side kitchen storage elements are featured.

1. Folding table for 6 persons
2. Storage compartements
3. Kitchen corner
4. Virtual Window
5. Sofa

SPORT AREA

Physical activity is one of the biggest parts during a typical analog astronaut day-to-day life. Indeed, the lack of gravity affects the physiology of the crew members. To keep in the best shape possible, sports are very efficient to maintain a good mental health. Exercises are simple, based on low needs for space: training bike, stretching, gym, or plate. Of course, in this project, gravity is still here, and it simplifies the way the crew can do sports. In orbit for example, to run on treadmill, you should be strapped on it. Activities proposed here are inspired by already existing equipment in various Space stations such as the training bike or the treadmill.

1. Training bike
2. Treadmill
3. Gym space
4. Moboulation

HYGIENE BLOCK

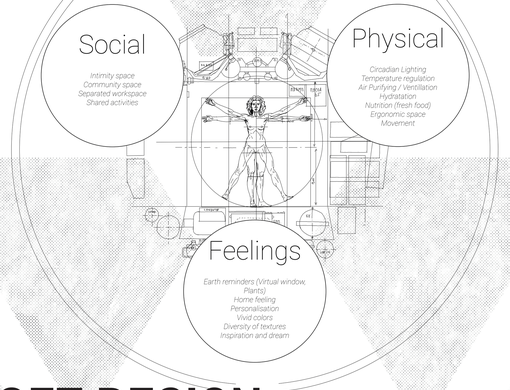
The main hygiene block is just between the Panoramic room and the sports space. Composed by two small capsules, one for feces and urines with 2 separates systems, and one for corporal hygiene where crew members can use dry shampoos, and dry shower technics to stay fresh and clean, such as sponge bath. Dry shower technics are very efficient in Space because they are consistent with space technology since it is impossible to use actual showers or toilets in Space due to the lack of gravity, and to the very parsimonious use of water (It's very heavy, and only a very small amount can be send into Space). To overcome those difficulties, Space engineers have developed dry shampoo and dry shower technics along feces and urine collecting units that consist of small vacuum systems that doesn't requires gravity nor water to works. Of course, such lab is a good place to test such technologies, and to familiarize crew with them before a mission. Another hygiene block is featured in the lower ramp: inner garden, keeping the biological waste near the garden avoid long pipe systems and possible problems. 2 garden spaces = 2 hygiene blocks. However, the lower one is smaller and dedicated to feces and urine, and the upper one is larger, more functional and adapt for sponge bath.

1. Sink
2. Storage compartement
3. Feces system (ISS type)
4. Urine system (ISS type)
5. Water and Waste system (partial)

INTIMACY SPACES

All intimacy spaces are the same for equality between crew members. It is a very compressed bedroom with all essentials. As the rest of the lab, personalization is very important since it add a personal touch to the architecture, and help to overcome psychological issues induced by isolation, and certain flip surfaces are designed to pinning personal pictures or posters, sheets for personal items.

PHYSICONFORM



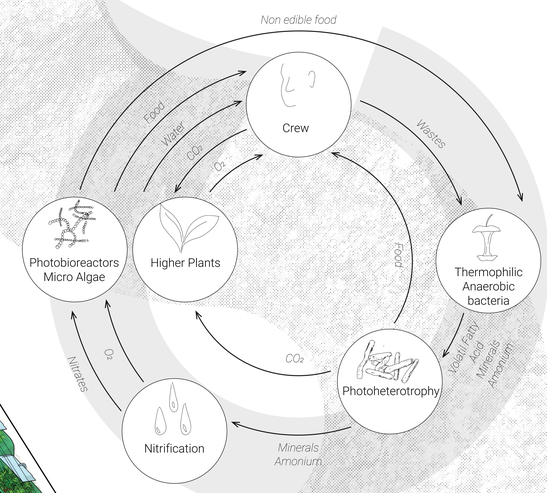
SOFT DESIGN

LAB SPACE

Exploring Space and Planets means doing research directly on site, since it is faster and might be cheaper. To do so, every humanized project mobile a laboratory where a wide range of experiences can be conducted. In fact, it is one of the main goals of Space stations. Nowadays, research in Space is mainly about biology and many more subjects should be possible to study in such labs. This working space is fundamental to crew mental health too since it give sense to their mission. It should feature a wide range of devices, and it should also be possible to manufacture spare parts and support maintenance operations using digital fabrication such as 3d printers.

1. Digital Working space
2. Enclosed biological experiment space
3. Equipement wall
4. Break and informal space
5. Main storage

CLOSED ECOSYSTEM



INNER GARDEN

The 2 ramps offer larges spaces for lot of life supports elements, such as air recycling, water recycling or food production systems. In contrary to most of existing Space design that include such elements, some parts are also dedicated to the crew itself, with tables, or sofas. Since the relationship between crew members and other terrestrials species is so important for the mental health, it must be possible to read a book for example surrounded by plants or connect people to earth, and facilitate the feeling of being part of an ecosystem. But it is also important to remind that from a biological point of view, and from a structural point of view, the design of these spaces tries to reflect the unity between crew members and other living organisms: they are all part of the same crew, from human to algae.

1. Air recycling system
2. Water recycling
3. Bioreactor
4. Small plants
5. Multifunctional workbench
6. Dodoponic
7. Lower hygiene block
8. Higher plants
9. Algae production

AIRLOCK

In contrary to most Space stations, the airlock doesn't usages in one piece. It is the actual airlock, which is a very small enclosed space, where astronauts can simulate EVA procedures (Extravehicular Activities), getting ready for Space suits, simulating air pressurizing, safety checklist... In fact, the whole procedure is about 1 hour long, and very stressful! Second, the wiper tank is nearby behind the dark path in the middle. It is accessible by the craft to facilitate refill of oxygen pressure. Its peripheral position is coherent with Space refilling usage. Wiper is often used as shielding against cosmic rays. Finally, a large cargo door is present to ensure big pieces of equipment to be moved. Keeping modular design is important during processing, it can be used as an actual cargo door.

1. Cargo door and utility space
2. Water tank
3. Airlock

#36BAD3 JOY #4AA667 CALM #36BAD3 FOCUS