Mission to Mars:
Habitat and Research Concepts

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This report presents a concept outlining a modular habitat and suggested research activities for a future Mars exploration mission. Focus lies on providing a safe and robust working environment for a crew of six astronauts during a 586 day stay on the surface of Mars. Three modules are proposed: a main habitat module, a special support and radiation sheltering module, and an equipment module. The design relies on the Water Walls system for providing life support as well as Radiation protection. For protection during SPE:s, thick masses of water are kept in the support module giving it a secondary role as a radiation bunker. All water is produced on site using hydrogen brought from earth. The planned research activities are selected to explore the possibilities of a future colonization of Mars, focusing on investigating different ISRU approaches and the planets potential for supporting basic agriculture. Notable technology needed to carry out the mission include improved SPE forecasting and further development of the Water Walls system into a fully operational version.

1 The Mars Environment

After successfully traveling from the Earths surface and safely landing on Mars, there is still the question of how to survive on the surface and preferably manage to do science in the meanwhile. The environment on Mars poses many dangers to human life, and life as we know it in general. Extreme temperatures, low atmospheric pressure, harmful radiation and low gravity is just a couple of obstacles that must be overcome. The everyday needs of the crew must also be taken into consideration: food and water, personal hygiene, recreation etc. Further, the potential for psychological issues are likely to increase because of the extreme living situation, for example the limited personal space; the very fact that they are on another planet far from home and the rest of humankind could also give rise to psychological discomfort - this is of course not well understood yet but precautions must probably be taken. One can also imagine the event of an emergency, because of the fact that the exploration crew is practically left for themselves and help is very limited, not even a single critical system can be allowed to fail. This creates the need for redundancy and buffers when it comes to systems and consumables. The need for backups is further justified by the fact that the uncertainties for a manned mission to Mars is huge; humans have never lived on another planet and unforeseen events should be considered as certain - but this is also why a mission like this is so important, it is a perfect opportunity to learn more about the difficulties concerning human colonization of other planets, and probably the only good way to do that.

To be able to successfully execute a manned mission to Mars, these challenges need to be addressed; potential risks need to be eliminated, or more realistically, reduced to an acceptable degree. One solution to protect the crew from some of the hazards present on the Mars surface is to create a habitat which emulates the conditions on Earth and where the astronauts can shelter themselves from most of the dangers. There are a lot of challenges connected with creating such a habitat and suggested solutions to some of them are presented here.

2 Habitat

2.1 Habitat Requirements

The construction of the habitat poses several challenges. It needs to provide the astronauts with protection from the hostile environment of mars, as well as accommodating life support systems to keep them alive and in good health. The mass and volume of the structure is limited by launcher capacity. Sending things to mars is prohibitively expensive, but there are also practical advantages to making the habitat as effective and compact as possible. A complex structure consisting of several modules will introduce unnecessary uncertainties to the mission, mainly due to the challenge of assembling them on the surface of mars. This drives the design towards a habitat that requires a minimal amount of procedures in order to make it ready for use.

For 586 days, the habitat will be the home and place of work for six people. This means that basic psychological needs such as privacy need to be taken into account when designing the layout of the living quarters. Most spaces in the habitat will be shared by the entire crew, such as galley and laboratory. In order to ensure that all crew members have access to privacy, the beds will be placed in separate compartments. This provides each astronaut with a small private cabin that can be accessed as needed during free time.

Keeping human beings alive on mars is a demanding task. The life support system needs to be robust enough to function reliably for the entire duration of the mission. The luxury of relatively swift and reliable deliveries of consumables available to for example the ISS will for obvious reasons not be possible on mars, and the amount of non-recyclables needs to be kept to an absolute minimum in order to reduce the habitat mass. A system also needs to be provided for protection from radiation.

Figure 1: A picture taken by Curiosity shows a possible window view during twilight on mars (Image source: NASA)

The habitat solution needs to be as redundant as possible. Malfunctions or accidents such as fires are not entirely unlikely, and the crew and habitat needs to be prepared for handling them. This means that all life-sustaining functions should be covered with back-up solutions. Robust contingency plans will be key to successfully planning the mission.

Finally, the habitat of course needs to serve its purpose as the first manned outpost on mars. The astronauts will be conducting a wide array of research projects in order to collect as much information as possible. This will require a well equipped laboratory with work benches, instruments and computers. An effective layout is key to creating a habitat providing as much work space as possible while still accommodating necessities such as galley and sleeping quarters.

2.2 Modular Concept

Limitations regarding launcher capacity mean that launching a six person habitat as a single module is not feasible, making division of the structure into two separate modules the only solution. With the goal of making habitat set up on mars as streamlined as possible, a simple solution for connecting the two modules is desirable. One way of achieving this is to dedicate one module entirely too living quarters, making the power supply, support systems, and supplies external. The pre-deployed positioning system will ensure that the habitat modules land at the same site, making it easy to connect the external systems in order to make the living quarters habitable. A third module will be loaded with science equipment, a rover for exploration, and other supplies such as back-up generators.

2.3 Main Habitat Module

The main habitat module will be the astronauts home during their stay on mars. It contains living quarters as well as a laboratory for analyzing collected samples. In order to maximize the capacity of the habitat, all support and supply systems have been stripped from the habitat and placed in the support module. This allows for fitting the entire habitat in a single payload, reducing the complexity of its assembly. It also means that the habitat will be rendered completely unusable without the support module; however the risk of failure in delivering the support module to mars is regarded as low.

The life support system of the habitat will be based around an emerging technology called Water Walls [1]. Experience has shown that mechanical life support systems have high failure rates, making them unsuited for this mission due to its long duration and limited possibilities for making reparations. Water Walls is based on a passive method called forward osmosis, and has very few moving parts. It has previously been suggested that water supplies could be stored in the walls of spacecraft and habitats in order to provide radiation shielding. Water Walls takes this one step further by also incorporating purification of urine and greywater. The wastewater is routed into a network of small containers mounted along the walls. Through forward osmosis, the clean water is produced within the bags. The system is highly redundant, and malfunctioning bags can easily be replaced manually when needed. Because of the good radiation protection properties of water, no additional layers will be needed in order to shield the habitat from radiation.

The flexibility of the Water Walls system allows for use of inflatable structures while maintaining sufficient radiation protection. Inflatable walls will drastically increase the available living space on mars, a precious commodity. The habitat will remain deflated until the support module is connected by the astronauts. A compressor will then pressurize the structure in order to inflate it and quickly ready it for use. The habitat layout will be designed to maximize living area volume. A good balance needs to be struck between recreational space and workspace. A convenient place to socialize and have meals together will be important to keep the crew in good mental condition, as they will likely be working hard and likely experience stress due to the isolation and nature of the mission. A well-equipped laboratory will also be mandatory for the habitat. Many samples collected will not be brought back to earth, and the ones that are will need to be selected carefully. This will require a large array of scientific instruments for sample analysis.

An airlock will be needed for conducting EVA's. It will be connected to a preparation area for pre-breathing and donning suits. Experience from the ISS will be valuable in creating an airlock that is sufficiently reliable and effective with regards to capacity.

2.4 Support and Radiation Sheltering Module

The external support module has several roles. As the name implies, it is built to provide the main habitat module with power and water. For this purpose, it is fitted with a nuclear Stirling generator as well as a system for creating water from hydrogen stored within the module. When the habitat module lands on mars, the Water Walls system meant to provide life support and radiation protection will be dry in order to reduce its mass during the transfer to mars. When the astronauts arrive on mars, they need a quick method for filling the system with water. This is where the support module comes in. As soon as it has landed on mars and jettisoned its shell, the generator will come online to supply power. After that, the water production system is started. As more and more water is produced, it will start to fill up an inflatable structure which will act as a water cistern. When the astronauts arrive on mars, they can immediately connect the support module to the main habitat module in order to fill up the Water Walls system, pressurize the inflatable structure, and supply power.

The life support system is designed to recycle as much water as possible, but since it cannot process blackwater, the system will need to be topped up in order to maintain its functionality. With a mission duration of over 500 days, a system malfunction cannot be ruled out. Disturbances in the water purification could pose a very serious threat to the crew safety. To provide a safety margin, the support module will continuously produce water in order to keep the cistern filled. In case of a life support system malfunction, the astronauts will have time to repair it while living on water provided by the cistern. The support module also serves a second purpose. During the stay on mars, solar particle events can be expected to occur, temporarily raising the radiation levels to points where the main habitats Water Walls can no longer provide sufficient protection for the astronauts. To provide protection in these extreme cases, the water cistern has a hollow compartment with room for the entire crew. In case of a strong increase in radiation, the astronauts will evacuate to the compartment in the cistern which will act as a radiation bunker thanks to the large amounts of water surrounding it.

2.5 Equipment Module

The equipment module will serve as a payload vessel for delivering the necessary equipment needed for research and exploration on Mars, as well as vehicles to be used during the mission. It can also be used to store equipment during the surface mission, acting as a toolshed and garage. To maximize its capacity, the equipment module will not carry a life support system and will not be pressurized, and can thus not be used as a secondary habitat.

2.5.1 Vehicles

For exploration purposes, a rover will be included in the mission. In order to give it good reach and capacity, the rover will be pressurized and equipped with its own generator. Samples can be collected and then brought back to the laboratory for analysis.

Exploration of the mars surface using autonomous rovers alone is potentially time consuming as there may be obstacles in the path of the rover, making the exploration slow and inefficient. Therefore the exploration can become faster and more efficient by aerially mapping the area to be explored and carry out the exploration with an optimized path. The Mars Flying Vehicle (MFV) concept can be used as a possible tool to aerially map the interested area of exploration. MFV can also be used as an instrument to study the Martian atmosphere. The selected MFV for the mission is a quadcopter design, providing robustness and relative simplicity.

Because of the thin atmosphere on Mars, a traditional quadcopter using four propellers is not a good option. Instead, the lift can be supplied by small rocket engines with variable thrust. The design is similar to the Curiosity descent vehicle, which means that the efficiency of the concept has already been proven. The result is an effective MFV which can easily be maneuvered by remote control and re-fueled on site. Using data supplied by the MFV, long-range routes can be planned in order to explore sites of interest in an effective way.

3 Power and Supplies

For reliable power generation, radioisotope Stirling generators will be used on the surface mission similar to those used by NASA:s reference design [15]. A common power source on space missions is solar power, but several factors prevent its use on a Mars mission. One problem is capacity; a very large array would be required to supply the habitat and all machineries with power. This would mean that the array would need to be elaborately folded for transfer and then successfully deployed when the destination has been reached, which would introduce a major uncertainty in the planning. There is also the problem of dust covering the surfaces, reducing the capacity. Some risks are of course related to nuclear power generation as well, and careful tests will be needed to ensure that the generators are reliable and that they are properly shielded.

The consumables needed to keep the crew in good health consist mainly of water, oxygen and food. The approximate mass one person consumes per day, as well as the total mass for 6 persons staying 586 days on the surface, can be seen in Table 1.

Table 1: Consumables per day and person, and mission total[12]

Consumable	Mass [kg]	Total [kg]
Drinking Water	3	10500
Dried Food	2	6200
Water for Food	1	3500
Water for Hygiene	3	11700
Oxygen	0.84	3000

There is also a need for water, oxygen and methane for the structures, buffers and for the fuel mix needed to propel the Mars ascend vehicle. With a water recycling factor of 0.8 [14], the total amount of water needed for shielding and consuming is approximately 50 tons. Almost two thirds of the water is for the radiation shielding in the quarter and bunker/supply structures. The numbers can be seen in Table 2. Notice that the amount of oxygen needed for the fuel mix is higher, but much of it is created as a byproduct when producing methane and water.

Table 2: Structures and Fuel [kg]

	H_2O	O_2	CH_4
Supply Structure	17300		
Habitat Structure	4000		
Ascend Vehicle Fuel		23300	6800
Consumables/Buffers	29700	3500	
Total	51000	26800	6800

Included in the water and oxygen consumables are buffers that should last 90 days in case of system failure. To minimize the amount of mass that needs to be transported from the Earth to Mars, resources readily available on Mars can be utilized. By using different chemical reactions both the water and the methane can be produced by exploiting the available carbon-dioxide in the Mars atmosphere combined with hydrogen supplied from Earth. The oxygen can be extracted directly from the carbon-dioxide through zirconia electrolysis [13]. By considering using In-situation resource utilization, the total mass to be transported can be drastically reduced, and one can also remark that the current state of engineering and science demands it. The resulting mass numbers for this mission can be seen in Table 3

Table 3: Mission resources to bring

Resources	Mass [kg]
Hydrogen (Methane Production)	1700
Hydrogen (Water Production)	3400
Dried Food	6200
Total	11300

4 Contingency Plans

In case of a malfunction in the life support systems or habitat integrity, help will be far away for the crew. Repairs may be possible but due to limited supplies they may require time. In order to maximize the chance of managing such a scenario, it is important that there are viable options in terms of life-sustaining compartments. In case of a malfunction in the main habitat, there are two options. The first is the radiation shelter, where the crew will be able to regroup in safety. Since it is limited in size it is naturally not suited for long-term solutions, but can easily be used as a temporary habitat while preparing or making repairs to the main habitat. A back-up solution is also available with the pressurized rover, however the rover on its own will be an extremely short-term solution as the small space will quickly fatigue the crew.

Due to payload limitations, it will not be possible to bring spare parts for all equipment from earth. Instead, this will mainly be managed through 3D-printing. The ability to produce customized parts could prove vital if something breaks since and will save a lot of payload. The equipment for the printing process will be located in the main habitat to maximize accessibility and effectiveness.

Thanks to the radiation shelter, plenty of water is readily available if the recycling system fails. A reserve of water and oxygen will reduce the stress experienced by the crew as they are not completely dependent on the recycling systems. Using the water will naturally eat away on the radiative protective capacity of the shelter, but in turn makes the astronauts completely independent of their water-recycling system for a sustained period of time.

To reduce the risk for the crew, the processing of the chemicals needed for life support are divided into three individual machines – each capable of producing the required supplies by itself.

5 Research Activities

5.1 Introduction

One of the main objectives of the mission is research. During the stay on mars, the crew will be constantly engaged in activities to collect as much usable information as possible. The available work time of the crew is likely to be a limiting factor, which means that the scheduling needs to be planned carefully to maximize effectiveness. The main purpose of the research of this mission is to assess the possibilities of future human life on mars by investigating how the resources on mars can be utilized and also how the environment affects our bodies. The main research projects have been designed to attempt to answer these questions.

5.2 ISRU

5.2.1 ISRU: In-Situ Resource Utilization

The purpose of In-Situ Resource Utilization or ISRU is to harness and utilize space resources to create products and services which enable and significantly reduce the mass, cost, and risk of near-term and long-term space exploration. ISRU can be the key to implementing a sustained and affordable human and robotic program to explore the solar system and beyond. Potential space resources include water, solar wind implanted volatiles (hydrogen, helium, carbon, nitrogen, etc.)[2], vast quantities of metals and minerals, atmospheric constituents, abundant solar energy, regions of permanent light and darkness, the vacuum and zero-gravity of space itself, and even trash and waste from human crew activities. Suitable processing can transform these raw resources into useful materials and products [3]. Below, several different concepts are outlined that will form the basis of the ISRU-related efforts during the mission to Mars.

Four major areas of ISRU that show promise for future robotic and human exploration architectures [3] are:

- Mission consumable production (propellants, fuel cell reagents, life support consumables, and feedstock for manufacturing and construction)
- Space utilities and power from space resources.
- Manufacturing and repair with in-situ resources (spare parts, wires, trusses, integrated systems etc.)
- Surface construction (radiation shields, landing pads, walls, habitats, etc.)

Numerous studies have shown that making propellants in-situ can significantly reduce mission mass and cost, and also enable new mission capabilities, such as permanent manned presence and surfacehoppers. Experience with the Mir and International Space Station and the recent grounding of the SpaceShuttle fleet have also highlighted the need for backup caches or independent life support consumable production capabilities, and a different paradigm for repair of failed hardware from the traditional orbital replacement unit (ORU) spares and replacement approach for future long duration missions. Lastly, for future astronauts to safely stay on Mars for extended period of time, surface construction and utility/infrastructure growth capabilities for items such as radiation protection, power generation, habitable volume, and surface mobility will be required or the cost and risk of these missions may be prohibitive [3].

Atmospheric Composition of Mars as measured by the Viking Mission is as shown in Table 4. The major component of Martian atmosphere is CO_2. Hence utilization of Martian CO_2 to build the basic life support system is pathway to self-sufficient life support system.

Table 4: Composition of martian atmosphere

Quantity	Gas
95.32 %	Carbon dioxide
2.7 %	Nitrogen
1.6 %	Argon
0.13 %	Oxygen
0.07 %	Carbon monoxide
0.03 %	Water vapor
Traces	Neon, Krypton, Xenon, Ozone, Methane

5.2.2 Processing of Martian Elements

The discoveries on Mars over last 10 years by the robotic missions have significantly changed our understanding of the Mars resources [5, 6, 7, 8, 9]. The indication of the presence of water in significant amounts at high latitudes, and possibly at lower latitudes, has a significant impact on ISRU technology and human exploration architectures.

Smith and coworkers [8] reported a water ice table at the Phoenix landing site at depths of 5 to 18 centimeters. Also, a water vapor pressure in the atmosphere of 2 pascals, corresponding to the saturation vapor pressure of water at 210 K, was measured by Phoenix instruments. The utilization of water ice on Mars will require excavation techniques and soil processing technology to extract water.

5.2.3 Supercritical Fluids

The recent findings by chemical engineer Dr. Ken Debelak of Vanderbilt University proposed ways to harvest rocket fuel and water in Mars's atmosphere using CO_2 [11]. Mars has a thin atmosphere, compared to Earth's, and it's about 95 percent carbon dioxide (CO_2) But that turns out to be an advantage. Inside Martian rocks and soil lies a bounty of useful elements: magnesium and hydrogen for rocket fuel, oxygen to breathe, water to drink. What's needed is a solvent to get them out, and that's where the carbon dioxide comes in handy.

5.2.4 Carbon Dioxide Freezer

The best current technology for CO_2 capture is cryofreezing [9]. There a very active research going on in Kennedy's Space Center (NASA) on cryofreezer for the ISRU technology. They have been designing a CO_2 freezer to provide feed to a Sabatier reactor as a part of the MARCO POLO (Mars Atmosphere and Regolith COllector/PrOcesses for Lander Operations) [8]. The purpose of MARCO POLO project is to demonstrate the conversion of Martian CO_2 and water from regolith into methane/oxygen bipropellant on the scale needed for Mars sample return mission. The requirement are to provide 88g of >99% pure CO_2/hr at 50 psi for a 14-hr day with an initial power limit of 500 W. Figure 2 shows the conceptual drawing of the current design of the module with the Sabatier reactor module in the background. Two cryocoolers are required one to collect dry ice and the other supplies to the Sabatier reactor.

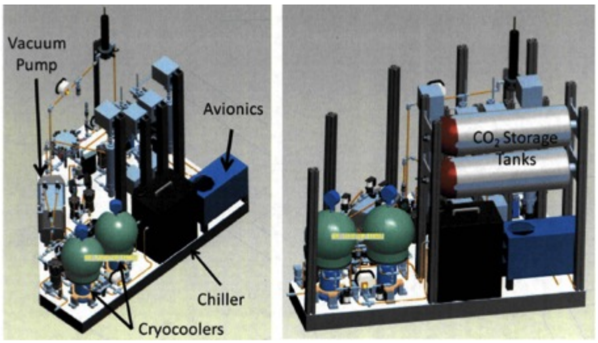


Figure 2: CO_2 freezer and storage module (Image source: [9])

5.2.5 Conclusions ISRU

An efficient ISRU technology is a very promising means to colonize the Matrian land as it enables to bulid a self sufficient Matrian architecture. ISRU technology is still in the resarch and development phase. The reliability level is still not in the acceptable range. But with the amount of research going on around the globe it will definitely turn out the be the most reliable technology in about ten years from now. It becomes very important mission objective to do an extensive research on Mars regarding ISRU technology. A brief technology assessment is described for the most promising Mars atmospheric gas processing techniques: Reverse Water Gas Shift (RWGS) and Methanation (aka Sabatier), as well as an overview of soil processing technology to extract water from Martian soil. The authors conclude that the technologies needed to (1) concentrate carbon dioxide, nitrogen, and argon on Mars, (2) separate them, (3) process them into oxygen, methane, and buffer gases, and (4) store them for use are already available at a sufficiently high level of development at the component level that further efforts should be focused on engineering development and field demonstrations of integrated systems of these processes. The availability of local Martian water resources will limit landing sites somewhat to known locations, but this is a minor disadvantage because Mars is a large planet with the same surface area as the continents of Earth. In addition, sites with water would enhance the possibilities of finding signs of past or current Martian life forms, a significant scientific goal for Mars exploration.

5.3 Psychological and Physiological Research

The psychological situation of the crew will be unique in many ways. The isolation is an important factor. The astronauts will be separated from earth both in terms of distance and partially also communication due to the long signal delay. They will have to rely on each other to complete the mission and get safely back to earth. The mental condition of the crew will be carefully monitored and assessed both in order to ensure the success of the mission but also for studying how this unique situation affects them.

Another interesting factor is the martian gravity. The gravity on mars is about a third of that on earth, and it is difficult to foresee exactly how it will affect the astronauts' physiology. Though the microgravity on the ISS has been extensively studied, this will in large parts be new territory for physiologists. The ability of human beings to function properly during a long period stay on mars and then return to earths gravity without overly severe effects will greatly affect the possibility of future missions to mars.

While the radiation shielding has been carefully designed to mitigate radiation damage on the crew, there is no real way of guaranteeing its effectiveness without actually using it in its target environment, namely on the surface of Mars. The astronaut's health will be carefully monitored in order to see how well the shielding is functioning. Knowing the radiation affects of a long term stay on Mars will be important when designing future missions. This data could also be used when looking at new shielding technologies.

5.4 Biological Research

5.4.1 Life on Mars

Living organisms, as we know, are not capable to survive in every kind of environment. For any kind of life to be able to thrive a series of criteria must be met, such as temperature range, radiation levels, availability of resources,

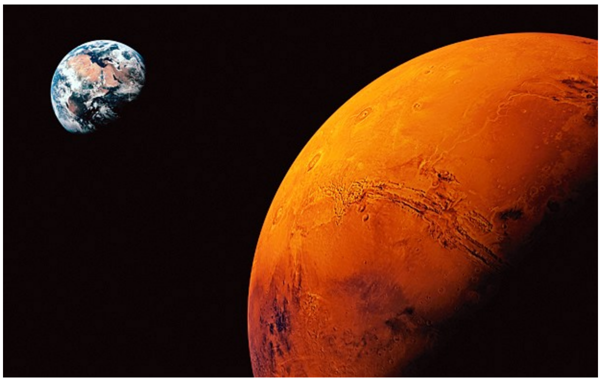


Figure 3: Render of earth in view from the red planet (Image source: getty images)

and others. Planet Earth's conditions made it possible for a variety of organisms not only to survive, but to develop, reproduce and evolve. This is mainly due to a privileged location in the solar system, which limits the temperature range on the surface to an amount that is life-friendly. With Mars being the next planet in the Solar System it is possible, depending on other parameters, that life can actually exist outside of our planet. In this section, promising research in the field is outlined that will be used to define the research acitivities regarding plant growth on Mars.

5.4.2 Life in extreme conditions

Although the environment in Mars may seem inhospitable at first, there are some bacteria, named Extremophiles, which can withstand some of the most extreme conditions. These are found on remote regions of the Earth, such as volcanoes, mountaintops and Polar Regions. Examples include

- Hyperthermophile: An organism able to thrive at temperatures between 353K and 395 K.
- Lithoautotroph: Life form whose sole source of carbon in CO_2 and exergonic inorganic oxidation.
- Cryophiles: Organism capable of growth and reproduction in low temperatures, ranging from 258K to 283K.
- Radioresistant: Being resistant to high levels of ionizing radiation, being ultraviolet the most common one.
- Xerophile: Capable of growing in extremely dry conditions, such as the Atacama Desert.
- Polyextremophile: An organism that qualifies as an Extremophile under more than one category

The Extremophiles are a strong indication that life is possible under the conditions present on Mars.

5.4.3 Mars Survivability

The Extremophiles found on Earth are apt to live under some of the conditions found on Mars, but in order to test if they are able to live on the alien environment it makes necessary to simulate some conditions, such as radiation levels and low pressure.

Planetary researchers at the German Aerospace Center (DeutschesZentrumfürLuft- und Raumfahrt; DLR) simulated the conditions on Mars for 34 days and exposed various microorganisms to this environment. Lichens from inhospitable parts of Earth have demonstrated their ability to survive even under the conditions on Mars – organisms that live at altitudes of up to 3500 meters, collected in Switzerland, and cyanobacteria and lichens from the Antarctic. The microorganisms adapted to this environment, primarily in niches in rocks and in fissures and gaps in the simulated Martian soil. This might be an indication that such adaptation strategies would make life possible in niches on the actual surface of Mars as well.

5.4.4 Plants on Mars

With unicellular life on Mars being a reality, the possibility of larger beings surviving there should be a main research objective. Of all pluricelular beings, plants would be the most interesting ones to study, since they are a source of O_2, food, medicine, building materials, and more self sufficient than animals. But plants on Earth are adapted to live under terrestrial conditions, and thus would quickly succumb if exposed to the Martian environment. That being the case, some modifications would be necessary for them to thrive.

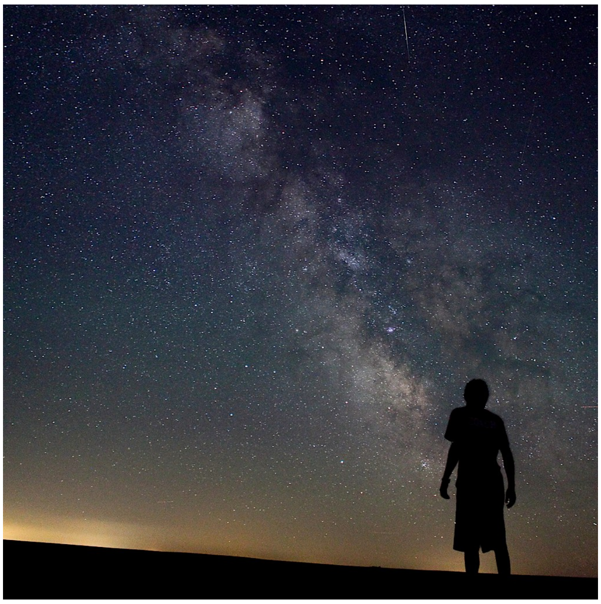
The extremophiles, previously mentioned, have in their genetic material the key to survive on Mars. A plant combined with the right set of proteins would be able to live even in such an inhospitable terrain. These plants would be performed and thoroughly tested before the manned launch to Mars, so the mission of the crew will be reduced to maintenance, analysis and support, if necessary. Since the primary focus of these plants is research of possibility of life, the mission won't depend on it for O_2 and food production, due to the uncertainty of the successfulness and quality.

The studies and knowledge presented in this report indicates that life on Mars is a possibility and therefore one of the research goals for this Mars mission is to study the environment with respect to it's potential to sustain life in various forms. Specific research will include the production of a detailed description of the Martian environment made by observations but also from experiments conducted on the surface. These experiments will include plants and organisms brought from Earth and will thus demand a very high level of assurance that there is an absolute minimal risk of contamination.

6 Future Frontiers

Throughout the history of mankind, it has been evident that as soon as we have have the means of exploring a new frontier, it is only a matter of time before someone does. It was true for crossing the Atlantic ocean to the new world, it was true for the Apollo 11 flight, and it will be true for putting the first human being on a different planet. After a century of staggering technological evolution, we are finally so close to achieving those means. And so the mission to Mars is no longer a question of if - it is a question of when.

The search for existing life, but also signs of the possibility that life once existed, will be a high priority task. The idea of life existing outside our planet is one of the most exciting prospects and one of the key drivers for space exploration; a find or even a hint of life would give the mission enormous media exposure and help with the funding and support of new missions. This is of great importance since the long term goal of the mission is to find and emphasize the reasons to keep on exploring our solar system - to show that Mars is not the end but the beginning; as Carl Sagan nicely put it *"If we do not destroy ourselves we will one day venture to the stars."*



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