

# Creating a sustainable Mars

**SOH**

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## **Creating a sustainable habitat on Mars!**

The idea of sustainability has taken on different meanings that have changed over time. In 1987, the United Nations Brundtland Commission defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs.”, Some other views suggest that sustainability is about our society thriving without using up all the necessary natural resources for our future survival. At the core of these definitions is the idea of using available resources efficiently without putting their long-term availability at risk.

As sustainability becomes increasingly important on Earth, especially in our efforts to protect the environment and resources for future generations, exploring Mars adds a whole new twist to this concept. Mars, often seen as a potential spot for humans to settle, brings both challenges and opportunities when it comes to sustainability.

So, why is heading to Mars a big deal?

Moving to Mars is crucial for several reasons, like safeguarding human survival from threats like pandemics and climate change, expanding our civilization beyond Earth's boundaries, tapping into new resources, and deepening our knowledge of the universe.

So, how can we ensure that life on Mars is sustainable?

The answers to that question lie ahead, so read on!

Interesting fact: Did you know Mars has two moons, Phobos and Deimos?

Sustainability is equally important in space on Mars as it is here and if we are to build habitats on Mars we will need to find sustainable ways to live and manage waste. We would have to make sure that we are reusing materials as much as possible. We would need to take care of Mars and look after it. If we are going to live on Mars, humans need to learn from what we have done to our home planet Earth and apply that knowledge in space. This could also work the other way round, if we are creating a sustainable habitat on Mars then what we are doing up there we could learn from and apply down here on our home planet (Earth). This article will feature many wonderful aspects, including, a sustainable habitat design, sustainable technologies, resource utilisation, and community well-being. As humanity sets its sights on Mars, the mission ahead demands more than just creating a sustainable habitat. It requires fostering a genuine sense of community among the pioneers who will call the red planet home. In this article, we will explore the essential elements, such as the music room and community space, designed to nurture connection and togetherness in this vast expanse of space.

## **Habitat design**

The primary objective of designing a habitat for Mars is to ensure the safety and well-being of its inhabitants inside the hostile Martian environment. It is necessary to create a space that not only shields residents from external dangers but also promotes a pleasant and sustainable lifestyle. Essential to this effort is the provision of all necessary functions required for long-term habitation. While integrating living and working areas can optimize space utilization, it's equally important to allocate private spaces to promote residents' psychological and emotional well-being.

In addition to living quarters, the habitat must include dedicated infrastructure areas to facilitate the supply of vital resources such as oxygen, temperature regulation, and waste recycling. A critical aspect of sustaining life on Mars is food production, which necessitates the incorporation of a greenhouse to cultivate a variety of vegetables and algae. This ensures a steady food supply while also contributing to the habitat's self-sufficiency and sustainability.

Addressing the threat of radiation exposure is critical for the safety of inhabitants. Utilizing advanced 3D printing technology, combined with locally sourced materials from Mars and additional reinforcements from Earth, offers a promising solution for constructing

radiation-resistant structures. Furthermore, employing inflatable structures can provide effective isolation from external hazards while maximizing interior space utilization.

Innovative ideas such as employing regenerative life support systems, harnessing solar energy, and utilizing advanced robotics for maintenance and resource management can further enhance the habitat's functionality and resilience. By prioritizing safety, functionality, and sustainability, the design of the Martian habitat aims to create a conducive environment for long-stay human habitation and exploration on the Red Planet.

## Sustainable Technologies

Actuating sustainable habitat designs and then managing, maintaining, and operating these habitats will require us to leverage the use of sustainable technologies.

### Sustainable energy

Many energy resources can be used on Mars to power the habitat and the machinery/robotics that are going to be used on Mars. Examples of such energy sources are **solar energy**, **nuclear energy**, or even **wind turbines** if current designs are altered to withstand the Martian environment. The most promising option here is nuclear fusion energy, because, unlike fission reactors, fusion reactors can generate large quantities of energy **and** usable elements. The fuel used for the fusion reactors is the isotopes of hydrogen, **deuterium**, and **tritium**, from these two, elements such as helium can be created (the reason why we use these is that they require the least energy to fuse together). There have been new breakthroughs in the field of nuclear fusion reactors, we managed to generate almost **70 megajoules** of energy in **5 seconds**. (*Whiting, K. and Torkington, S. 2024*). Considering this, nuclear fusion reactors can serve as a sustainable energy source to generate usable elements.

### Oxygen Production

The lack of oxygen proves to be one of the hardest challenges of the habitation of Mars. Although cumbersome, some methods can be used to produce **molecular oxygen** from the Martian environment; NASA created and launched a robot called **MOXIE (Mars Oxygen In-situ Resource Utilisation Experiment)**, MOXIE generates oxygen via a process called **solid oxide electrolysis**, where CO<sub>2</sub> (which makes up up to 95% of Mars's atmosphere) reacts with the

ceramic electrolyte in the extreme temperatures of 700°–800°C. MOXIE managed to generate 10 g/h of oxygen, which is enough for someone to breathe for up to 20 minutes (it is important to note that this process generates some carbon monoxide as a by-product). (Platt, J. 2020)

## Nutrition Sources

With two integral factors to the functioning of the habitat, having a consistent sustainable food source will play a major role in human habitation. The Martian regolith lacks the required **chemicals** for the growth of any plant, in addition to that, the regolith contains **toxic** levels of **salts** and other **dangerous compounds**. Because of this, methods such as **hydroponics** and **aeroponics** can be used to replace the need for soil as a growth medium. When comparing hydroponics and aeroponics, aeroponics can provide **larger quantities** of food, while hydroponics uses **fewer resources**. (Klingler, 2021). An example of the use of hydroponics is the growth of certain algae (*Arthrospira maxima* and *Haematococcus pluvialis microalgae*) that can be used to produce bread, biscuits, and cereal bars while being resource-efficient. (German Sarmiento, 2021)

## Resource utilisation

Being more sustainable on Mars would be far easier when using resources found and created on the planet with as few resources from Earth as necessary. It is important to know that Mars has resources such as ice/water and minerals like Iron oxide and an atmosphere of 95% carbon dioxide, Nitrogen at 2.85%, and argon at 2%; The problems that come with these are that:

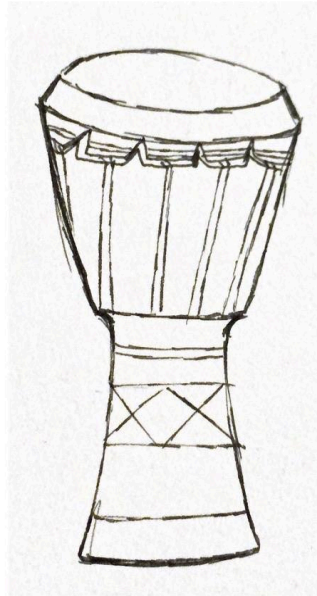
- The water is not drinkable due to high salt and perchlorate
- Martian soil is too nitrogen-full
- Temperature changes between 20\*c-153\*that can cause issues with crop growth and problems finding drinkable water
- Iron oxide, specifically hematite, is not typically used as a building material on its own

These problems are quite difficult to solve but can be worked over with:

- Moxie - makes oxygen from the carbon dioxide from Mars' atmosphere
- Point-of-use reverse osmosis device- this method can filter out potentially give drinkable water from the water on mars
- Human waste- can be used to hold water better and can be used as a fertilizer giving the soil necessary nutrients.
- Nitrogen-draining crops- Plants like squash, cabbage, broccoli, and corn can absorb excess Nitrogen from the soil

- Iron oxide can be used in the production of steel, which is a significant building material

## Community well-being



Community well-being in space will be one of the main factors to consider when building sustainable Martian habitats. Implementing strategies that ensure the habitat design promotes its residents' physical and mental well-being will be crucial for the Martian habitat to thrive. For example:

### Biophilic design

Maintaining our connection to Earth and recognising humans' strong and earliest bonds with nature can have positive effects on our well-being. Biophilic design is a design concept that is used to increase connectivity to natural environments often following a biophilic design means using natural elements including plants and natural materials, to forge a connection with nature.

Biophilic design will be beneficial in space as we will need to incorporate some type of connection to nature. It can benefit us in many ways like helping you be more creative and

15% more productive, relieving stress, improving mental well-being, and helping you feel happier and healthier (Planteria, 2020). It can also lower blood pressure and heart rate, improve mental engagement and attentiveness, and positively impact attitude and overall happiness. Incorporating design choices like organic materials, soft lines and natural colours, natural shapes and patterns, indoor gardens and water features like water fountains can create a calming and soothing atmosphere, promoting relaxation and reducing stress (Misra, 2023).

Biophilic design can help maintain regular sleep-wake cycles by implementing dynamic lighting systems that mimic natural daylight patterns in space ensuring better sleep quality and overall well-being (Mars Planet 2024). Much research has shown that biophilic environments trigger healing within the human body and invoke positive feelings of rejuvenation and relaxation.

## Comfortable Bedrooms or sleeping areas

Getting enough rest is key for our well-being. We need to rethink how we can improve sleep in this new place with its different surroundings and day/night cycles to make sure we get the best sleep possible.

So, how can we potentially enhance sleep in a challenging environment like Mars?

Enhancing sleep in such a challenging setting necessitates innovative strategies and meticulous planning.

Here are some methods to improve sleep quality for astronauts on Mars missions:

- **Maintain a Consistent Schedule:** Establishing a regular sleep routine synchronized with Martian day-night cycles can help regulate the body's internal clock and enhance sleep quality. It is believed that adhering to a consistent bedtime routine can reinforce the circadian rhythm, promoting good sleep quality. Even a single-night deviation from the sleep schedule can lead to difficulty falling asleep (Kang, H. 2009). A sample bedtime schedule could include sleep-inducing practices such as bedtime yoga, avoiding electronics, drinking bedtime tea or warm milk, taking a warm bath, meditation, reading a book, and journaling.
- **Lighting Management:** Implementing appropriate lighting protocols, such as adjusting intensity and colour temperature lights, can help synchronise circadian rhythms and

improve sleep-wake cycles. According to studies, different colours of light can affect the quality of our sleep. Red and green lights are considered to be the best options for bedtime as they promote sleep, while blue and bright white lights are effective in waking a person up. We can integrate programmed light sequences that alternate according to specific periods to improve disrupted circadian rhythms. This will be done using light projectors in the sleeping areas. Not only will this enhance the overall aesthetics of the sleeping areas, but it may also help improve sleep quality.

- **Temperature control and sound insulation:** including temperature control and sound insulation, can enhance sleep quality for astronauts. Cooling mattress technology utilises different materials to dissipate or absorb heat. These materials can range from gel-infused memory foam to wrapped wire coils that enhance airflow. One noteworthy company, Eight Sleep, has developed innovative cooling systems to create self-cooling beds. We would incorporate and integrate similar technology to manufacture self-cooling sleeping bags. Two types of noise-reduction headphones are available for astronauts to help them sleep better. The first type is noise-cancellation headphones, which completely block out external noise. The second type is noise-isolation headphones that play different sounds to help astronauts sleep. These sounds include green noise, ASMR sounds, and other relaxing sounds. Both types of headphones are specifically made for astronauts and help them sleep better while in space.

#### **Other ways to help improve sleep include:**

- **Physical Activity:** Encouraging regular physical activity and exercise can promote better sleep quality and overall well-being, helping astronauts adjust to the challenges of the Martian environment.
- **Psychological Support:** Providing psychological support, such as counselling and stress management techniques, can help astronauts cope with isolation, confinement, and other stressors that may impact sleep.
- **Health Monitoring:** Monitoring astronauts' health and sleep patterns through wearable devices i.e. actigraphy, sleep apps i.e. sleep Genius, and regular assessments can help identify issues early and tailor interventions to improve sleep quality.

## **Music room**

In 2009, archaeologists excavating a cave in southern Germany discovered and uncovered a flute carved from a vulture's wing bone. The beautiful instrument is the oldest known musical

instrument on earth. This discovery has shown that humans have been making music for 40,000 years, isn't that amazing? Sadly, however, We can not be precisely sure when humans began listening and playing music. But what scientists do know is something about why we listen and play music. Listening and playing music benefits us individually and collectively, it brings people together as a community and is brilliant for our physical and mental well-being. Positively, playing and listening to music has shown that it can reduce anxiety, blood pressure and pain and improve your sleep quality, mental alertness, memory, and mood and serve as a great brain workout.

Evolutionary scientists say humans may have developed a great dependence on music as a communication tool.

### **Music's effects on the mind**

Music can lead to better learning. Researchers now know that just listening and playing music can make you want to learn more. In one 2019 study, people were more motivated to learn when they expected to listen to a song as their reward.

### **What is music therapy?**

Sound healing uses aspects of music to greatly improve physical and emotional health and well-being. The person being treated takes part in the experience with a trained practitioner. Healing with sound is believed to date back to ancient Greece when music was used in an attempt to cure medical disorders. Research has linked music to a number of health benefits such as helping to boost the immune system and lowering stress levels to improve the health of premature babies. **Guided meditation**

Guided meditation is a form of sound healing in which you meditate to voiced instructions, either in a session or class or using a video or apps such as, Insight timer, (Stanborough. R 2020)

### **Communal areas/activities**

Including communal areas can reduce isolation and promote social interaction. Social connection with others can help Improve your ability to recover from stress, anxiety, and depression, promote healthy eating, and physical activity, and help maintain a healthy weight, improving sleep, well-being, and quality of life. Communal areas like game rooms, movie rooms, gardens, or even just a dining area could help invoke feelings of belonging, and joy, and bring people together. Activities like gardening, journaling, meditation, cooking, and reading can help with the emotional well-being of residents so including indoor gardens and reading corners may be useful to promote relaxation. (Loving Life, 2023)



## Socialisation events

Communication and interaction are essential aspects of human life. However, moving to Mars may lead to isolation, which can result in mental health issues like loneliness, depression, and anxiety, as well as physical health problems such as a sedentary lifestyle. It is also linked to cognitive decline, has emotional impacts like sadness, low self-esteem, and strained relationships (Cherry, K., & Gans, S. 2023). Maintaining social connections and seeking support are crucial to prevent these negative effects. Organising social events is a way to achieve this.

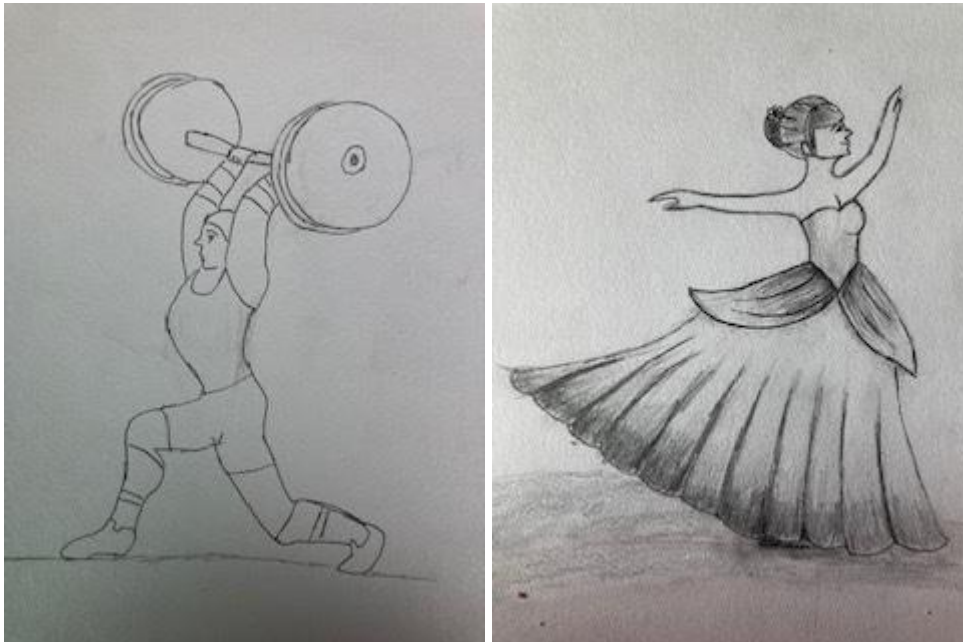
Here are some possible socialisation event ideas for Mars:

- **Interstellar book club:** Discuss and exchange thoughts on science fiction novels set in space while in a Martian habitat library.
- **Space art workshops:** Unleash your creativity in a space-themed art workshop, where you can paint, sculpt, or create art inspired by the cosmos.
- **Astronaut talent show:** Showcase talents like microgravity acrobatics, musical performances, or science experiments in a friendly competition among martian travellers.
- **Martian Movie Marathon:** Enjoy movie nights featuring films set on Mars or space exploration documentaries, eating Martian snacks, while surrounded by a Mars-like landscape.
- **Red Planet Relay Race:** Hold a relay race around the Martian habitat to promote teamwork and physical activity in the simulated gravity environment.
- **Mars Yoga Retreat:** Practice yoga in the Martian landscape, focusing on mindfulness and relaxation while connecting with the environment.
- **Interplanetary Cultural Exchange:** Host cultural exchange events with Earth, sharing traditions, music, dance, and cuisine to celebrate diversity in space.
- **Martian fashion show:** A Martian fashion show could feature space-inspired designs, sustainable materials, adaptive clothing, tech-integrated fashion, versatile designs, and celestial themes. Designers would showcase futuristic and practical fashion concepts tailored for life on Mars.

These events can enhance social bonds, promote well-being, and create a sense of community among future Mars colonists, making life on the Red Planet more enjoyable and fulfilling.

## Exercise areas/gyms

Exercise is important for both physical and mental well-being including exercise areas or gyms will be useful. Physical activity raises self-esteem, positively affects our mood and encourages us by setting goals. (Elion Grajcevci 2023) Exercises like walking, jogging, dancing, and yoga can be relaxing and relieve stress so places like yoga rooms and dance studios will also be beneficial to be implemented in a Martian habitat giving people a place where they can progress and a place to push themselves and hone their ability to focus, to grow, and to achieve self-improvement. (Justin C. Scott 2017) Bone and muscle loss are challenges astronauts face while they are in a weightless environment such as space. According to NASA, astronauts must exercise approximately 2.5 hours per day when they are in space, to mitigate the effects of zero gravity on their bones and muscles so exercise areas will be crucial. (Space Center Houston 2021)



## Hospitals or medical rooms

A hospital or medical room will be needed on a Martian habitat to help keep astronauts fit and treat any possible health conditions that may occur. It should be able to meet the basic needs of diagnosis and treatment. These facilities would need to be equipped to handle a variety of medical issues that could arise in a harsh and potentially hazardous environment

like Mars, including issues related to low gravity, radiation exposure, and isolation so a place where astronauts can get medical attention will be crucial. There will need to be doctors, but emergency health care could also be self-administered and could possibly be autonomous.

## **Conclusion**

In conclusion, sustainability in Martian habitats will involve careful consideration and will include many factors from sustainable technologies, community well-being to habitat design and resource utilization.

The design of a Martian habitat must ensure the safety of its inhabitants and have the needs humans will need to live on Mars, incorporating features such as radiation-resistant structures, life support systems, and sustainable energy sources like solar energy or nuclear energy. The production of oxygen using technologies like solid oxide electrolysis and the creation of sustainable food sources using hydroponics and aeroponics are pivotal for sustaining human life on Mars.

In order for the Martian habitats to thrive, the residents' mental and physical well-being needs to be considered. This will involve implementing biophilic design elements, promoting social connections through communal areas and events, and access to exercise areas and medical care. These features are an important part of making sure people feel connected, have a sense of belonging, and are healthy on Mars.

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