Home away from home: Our journey to Mars - DSH Micro Internship

Eco-Nova

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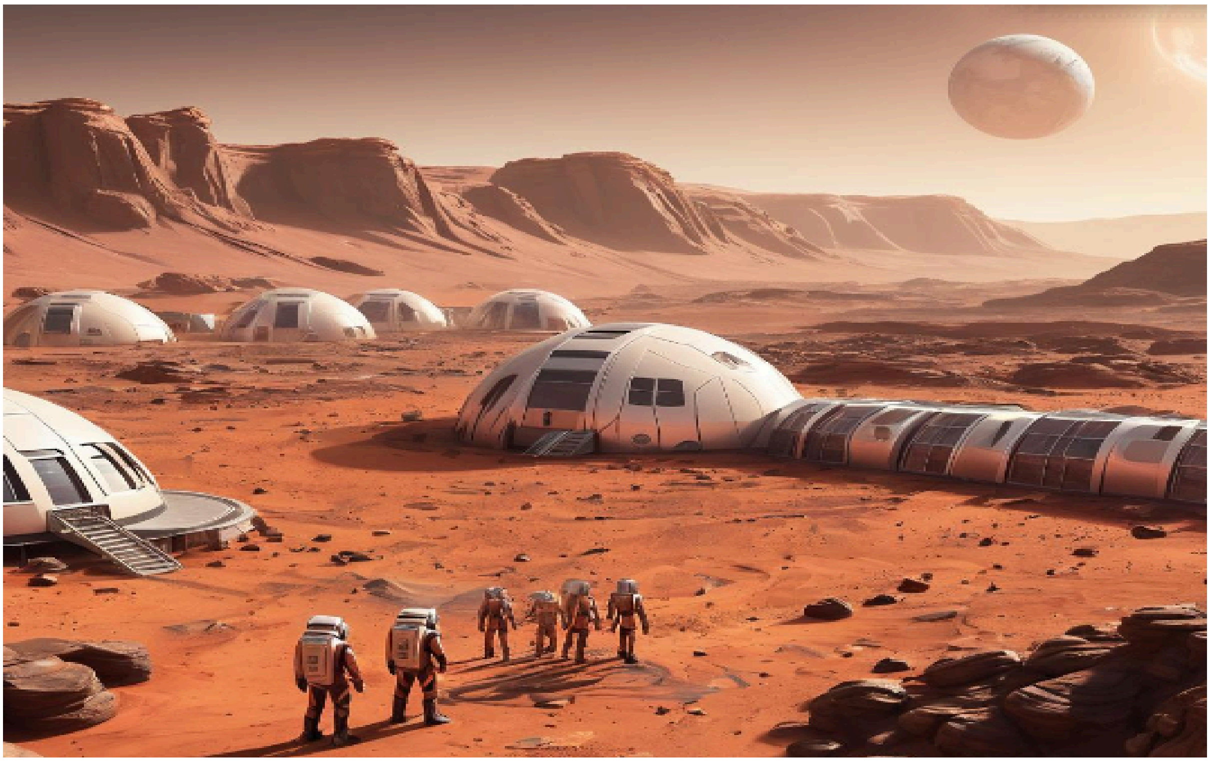


Sustainability is a broad term, and can have many definitions; each individual perceives it differently. It can mean efficiently using the resources available, recycling and reusing supplies, producing the least amount of waste, or producing no waste at all. But when considering a sustainable life on Mars, sustainability ultimately means preserving the red planet's environmental balance and treating it with respect; which is something we are failing to do with our own planet. If we are going to go to Mars, it must be our first priority not to ruin it or let it suffer a similar fate to what Earth is currently suffering because of us; the pollution, the climate change, and the depletion of natural resources. This signifies the necessity of developing habitats that are 'sustainable' by every definition while protecting us from the harsh Martian environment, and providing the inhabitants with a place they can gladly call their 'home away from home'.

Habitat Design

The criteria of a Mars habitat is a demanding one. The habitat must be able to withstand harsh conditions, like dust storms, extreme weather, and low atmospheric pressure. It should protect against radiation, which is abundant on Mars, it has to be technologically feasible, and most importantly, it should incorporate the all life-support systems we need to survive in the habitat. But then there's the question of the structure itself. What will *it* look like, and how can we ensure it can meet Mars's difficult requirements? One suggestion is a geodesic dome. To begin with, because they are made up of interconnected triangles, geodesic domes are very strong and stable; something we critically need in the hurricane-like environment of Mars. The construction material for the triangles must be such that is both sturdy and shields from radiation. While some types of metal could work, it would be extremely difficult to transport that much metal to Mars, especially when we'll have to bring robots along with us to assist in the construction process of the habitat. Apart from that, it will be very expensive to have to bring materials with us from earth. One material we could utilise that is plentiful on Mars is regolith, which is soil found on the surface of the red plane. Martian concrete (Brownlee, J, 2016), a concrete that is made up of this regolith, would be an ideal construction material for the geodesic dome since it is tough enough to withstand meteorites and thick enough to block radiation effectively.

Life support systems in a space habitat are crucial for keeping human life in the rough environment of outer space, in the same way that Earth does, from providing resources to live like water and food, to providing a comfortable environment to live in, good climate, air to breathe and interactions with organisms. These systems give astronauts the necessary resources to breathe, drink, eat, and maintain a comfortable living environment. These are some key components found in a space habitat's life support systems:

Oxygen Generation and Carbon Dioxide Removal

One of the main functions of life support systems is to provide a constant supply of breathable oxygen while removing carbon dioxide exhaled by astronauts. This is mostly achieved through processes like electrolysis, which splits water molecules into oxygen and hydrogen, or by using chemical scrubbers to remove carbon dioxide from the air.

Water Recycling

Water is a precious resource in space, so efficient water recycling systems are essential. These systems collect, purify, and recycle dirty water generated by astronauts for drinking, hygiene, and other uses. Technologies such as filtration, distillation, and ion exchange are employed to maintain a sustainable water supply.

Temperature and Humidity Control

Maintaining a comfortable temperature and humidity level within the habitat is important for the well-being of astronauts. Life support systems include climate control mechanisms such as heating and cooling systems, as well as humidity regulation devices to ensure a suitable living environment.

Food Production and Waste Management

Space habitats may incorporate systems for growing food crops through methods like hydroponics or aeroponics. These systems provide fresh produce for astronauts while helping to recycle organic waste materials. Efficient waste management processes are important for minimising waste buildup and maintaining hygiene within the habitat.

Radiation Shielding

Radiation has proven to increase the chances of getting cancer. Space habitats must protect the residents from harmful cosmic radiation. Shielding materials are integrated into the habitat's structure to minimise radiation exposure, while additional measures such as radiation monitoring systems help ensure astronaut safety, this is because radiation is dangerous for humans, it can cause burns, cancer and long term effects. .

Environmental Monitoring and Control

Life support systems include sensors and monitoring equipment to continuously assess environmental conditions within the habitat. This data is used to regulate various parameters such as air quality, water purity, and radiation levels, ensuring optimal living conditions for the crew.

Emergency Backup Systems

Systems that are not needed, and backup measures are important for maintaining life support functions in the event of equipment failures or emergencies. Space habitats can be equipped with backup power sources, reserve supplies of essential resources, and possible plans to ensure the safety and well-being of the crew.

Sustainable Technologies

Even with the perfect habitat if we do not have a waste management system, food production and energy regulation will need monitoring and controlling to function efficiently

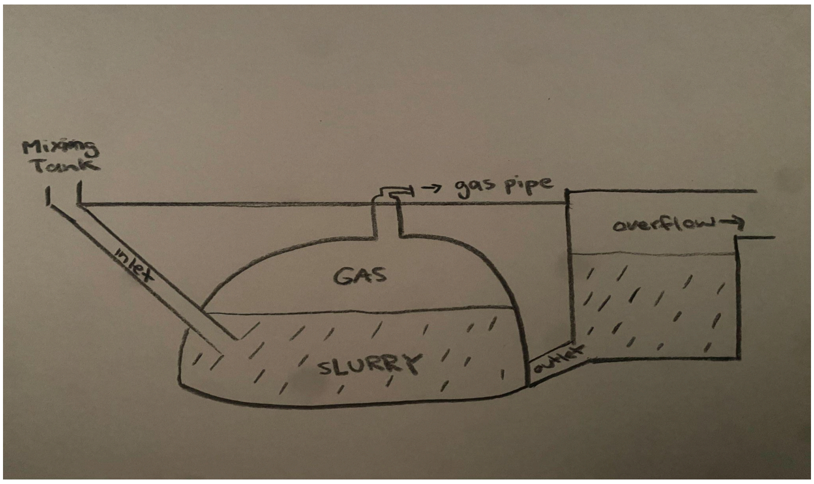
it will not function. Using sustainable technology we can create closed-loop and multi-purpose systems that are essential for sustainability and human flourishing. Let's explore how sustainable technology can be used on Mars to benefit us and the planet we live in a relationship with.

Organic Waste Management

The anaerobic digestion technology uses human waste and organic waste such as food scraps and animal dung to create biogas. Biogas is a sustainable energy which can be used for various needs and purposes. Biogas technology can be used for waste management within the habitat, reducing the need for storage and disposal of organic waste. Harnessing and using this technology helps power lighting, heat homes, fuel vehicles and can be used as cooking gas. It reduces the dependency on other energy sources, thus contributing to a more sustainable lifestyle.

Using this sustainable technology human waste can power human consumption.

The materials used to build an anaerobic digestion system include brick, pipes and gas sealer. With the help of robots, the bricks could be manufactured on Mars. The disadvantages of this system are special sealant is required from earth, beeswax wax or acrylic emulsion. It also requires technical skills to build. To counterbalance this, the advantages are a long lifespan and the overflow of slurry can be used as a nutrient-rich fertiliser. It reduces the need to apply chemical fertilisers and pesticides, improves plant growth, reduces soil erosion and nutrient runoff and helps increase the soil's water retention ability, which is important on a dry planet. We cannot take out our bins on Sunday and forget about our waste on Mars as we do here on Earth so let's make one man's waste another man's treasure.



Basic diagram of an underground anaerobic digestion system

Non-biodegradable waste management

Fungi is nature's fight for a flourishing planet. Recent studies have proven that certain strains of fungi can break down non-biodegradable plastics such as Polypropylene and 'forever chemicals' like PFAS, (University of Sydney, 2023). With this habitat design, there will not be an overproduction of plastic or PFAS in the water but plastic and chemicals are essential in some technologies. *Aspergillus terreus* and *Engyodontium album* are two strains of fungi that have an enzyme called Hydrolase which breaks down nutrients into smaller parts for digestion. The fungi use this to and a few other enzymes to successfully break down non-biodegradable waste. It is a slow process but with the help of UV lights and heat it can be sped up.

Food Production

Growing food outdoors takes acres of land and is susceptible to harsh weather conditions that can whip out entire crops. Mars is not a planet of green rolling hills made of fertile and wet soil, technology will need to be implanted to create an environment for food to grow. We can grow thriving gardens using vertical farming designs while using 98% less water and 99% less land (Green, E, 2023). It is the perfect solution for growing food in inhospitable areas. Vertical farming allows us to control the environment for each plant. Using the Eden Green design air can flow around the plant creating an optimal balance of humidity, oxygen and carbon dioxide. Water also runs down the veritable poles allowing each plant to thrive. To build a flourishing vertical farm shade from intense sunlight, ventilation systems and appropriate lighting to provide the energy is needed. The greenhouse can be monitored through data points so that the grower can optimise the growing capacity and control the environment.

Energy

Nuclear fusion is the process by which atomic nuclei combine to form heavier nuclei, releasing tremendous amounts of energy in the process. We would consider this over solar panels, simply because the 'energy production: resources used' ratio for nuclear fusion is a lot higher than solar energy. Unlike nuclear fission, which requires heavy radioactive elements like uranium or plutonium, fusion fuel sources such as deuterium and lithium are readily available in large numbers in seawater and certain types of rocks. This abundance ensures almost a limitless fuel supply for fusion reactors, making them highly sustainable for a long time. Fusion reactions release energy at a much higher rate compared to chemical reactions or even nuclear fission. This high energy density means that relatively small amounts of fuel can generate large amounts of energy. Nuclear fusion is a lot safer than something like nuclear fission because it does not produce radioactive waste, and the fusion is non-toxic.

Resource Utilisation

Efficient resource use on Mars is highly important to have a sustainable life and for us humans to become a “Multi-Planetary Species”, so here are some resources that can be utilised on a sustainable Martian habitat.

Martian Regolith

The regolith on Mars is a great material when it comes to 3D printing, given its high availability on the Martian surface making it a good example as a sustainable material. One of the most prominent ways to use it is mixing regolith with a titanium alloy and printing it using laser-based additive manufacturing to create a “composite” of Martian regolith and “Ti6AlV” which is 90% titanium, 6% aluminium and 4% vanadium. Looking at the extraction process, regolith can be found rather easily through the use of mining robotics, reducing the need for human labour and the risk that comes with it. These robots such as the RASSOR Rover Model which can navigate the Martian surface, excavate the regolith with an amount of up to 14.5 Kg each and transport it to the designated processing facilities (NASA, 2013).

An on site facility can be built within the habitat and be used to process the regolith for 3D printing. Many techniques are available for use, but arguably the most efficient one goes through the steps of crushing, sieving and heating (Seiferlin et al. 2008). Crushing breaks down larger particles into smaller ones, sieving separates them and heating leads to a much more uniform material and making it finer. The processed regolith is then combined with titanium alloy, typically in a powdered form. The titanium alloy mixed with the regolith leads to enhanced strength and durability while still keeping titanium's lightweight properties. Lastly, the mixture is fed into the 3D printing robots to be used.

Polar Ice Caps

Another material that can be taken advantage of is water on Mars but as studies have shown most of the water on Mars is in the form of “polar ice caps”, we can’t simply boil it off due to the lack of atmosphere leading to it either instantly boiling or freezing, also some of it if not on polar caps is in a hypersaline form making it not usable for human consumption. An idea that came to mind is to create a “Drill-Pump System” to extract the ice, purify it Store it in a suitable place with the proper pressure.

Volcanic Stone

Lastly, a prime example of both a sustainable and cost-effective material is Volcanic stone which can be found on Mars in huge quantities. Even though Martian volcanic rock on the Martian surface isn’t useful, it does contain basaltic rock, which can be extracted to create basaltic fibre for habitat construction reinforcement. Volcanic stone is also relatively easy to extract and process, making it a cost-effective option for construction bases on Mars and sustainable! By using volcanic stones as a construction material, it is possible to create a sustainable and resilient habitat on Mars.

Community Well-being

Journeying from Earth to Mars is a huge step, and that can have a toll on your mental health. Incorporating biophilic designs that support the physical health and well-being of inhabitants is very important to foster a deeper connection to the natural world.

Green Spaces

Whether it is an indoor garden or farm, these recreational green spaces improve air quality by removing toxins and producing more oxygen. They also offer a range of psychological benefits, such as reducing stress and improving mood.

Water Features

Indoor ponds, lakes, and fountains can help stimulate the soothing effects of water for individuals, thus improving and enhancing physical health and well-being.
With the help of these unique designs, we can resemble and recreate some aspects of our current planet, which could help inhabitants combat feelings of stress, anxiety, and isolation from Earth.

Enjoyment

People connect and build community by listening to music, admiring art, or working on something together. Being in an engaging community gives people a sense of being part of something larger. This leads to belonging, support and connection which are all necessary for mental health and a good life. With a communal space full of activities such as dance, art workshops, sports, yoga and much more it would become a pulsing place of activity and shared experience.

Education

There is a lot to learn when living on Mars. The knowledge and skills of how to build habitats, grow food and create technology need to be passed down. An educational program available to people of all ages to come together to share skills, knowledge and history will act as a hub of inspiration and community.

Conclusion

Imagination has no boundaries, and by using that tool, we can pave the road to a sustainable life on Mars. Nothing, if we put our minds to it, is out of reach. Mars is full of great opportunities. If we are mindful of sustainability and implement sustainable practices and strategies in our habitats, we could build ourselves a future on Mars that reflects how far we've come as a human race. With the sophisticated and spectacular technologies we have created, and techniques we have found to maintain sustainability, and how we have learned from our mistakes here on Earth, we can use our knowledge to protect Mars while benefiting from it.

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