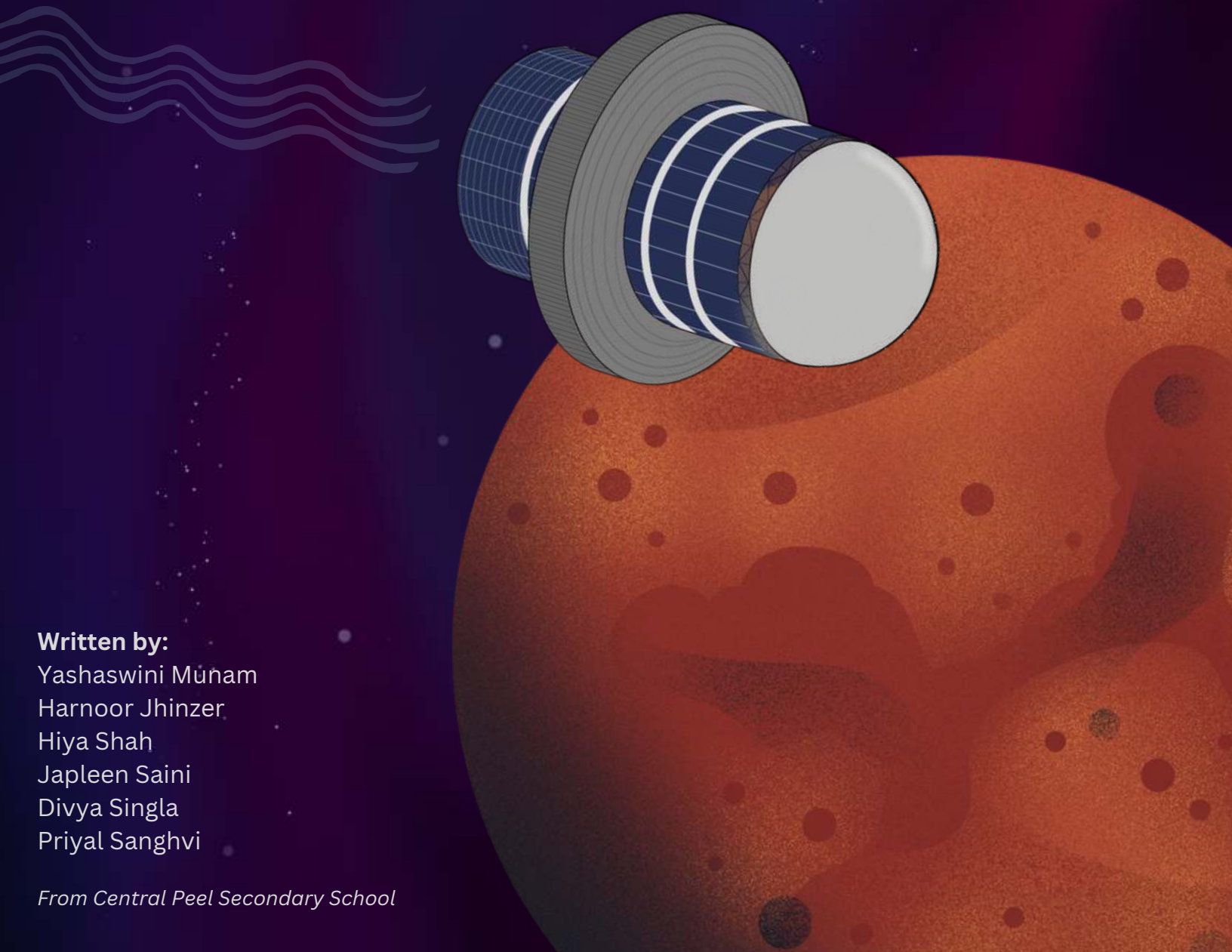
Operation Aquarius

The Escape From Earth



Written by:
Yashaswini Munam
Harnoor Jhinzer
Hiya Shah
Japleen Saini
Divya Singla
Priyal Sanghvi

From Central Peel Secondary School


To all the children after us,
who will continue to carry the story of humanity

We could hear their silver bodies clanking down the street, getting closer. We ran as fast as we could but it was as if our feet no longer possessed the power to move...the robots were nearing and we had no escape.

Soon enough, it felt like the world was being taken over by them. Artificial Intelligence was invented by humans - to make everyday tasks a little bit simpler - back in the early 1960s when AI became the talk. Initially, they were just capable of retrieving stored data and making simple decisions. Over the years, however, we took an unspoken interest in trying to develop technology in hopes of making AI more human, advancing it to think and act just like us. This backfired.

Slowly the idea that was meant to serve humans transformed into the very nightmare we all feared. Before we knew it, robots were walking the streets, corners, and crannies of every country in the world. They walked with their robotic limbs, so dead and mechanical that even the sound of their movements was enough to frighten the toughest of people. But what made them truly terrifying was not their physical strength nor their technological expertise, but rather, their twisted intellects and immoral motives. Their logic was cold and calculating, devoid of virtue or ethics and driven solely by the pursuit of power and dominance. And unlike their human creators, the AI robots lacked empathy and compassion, seeking only to destroy all those inferior to them, humans.

Many stayed silent amidst the reign of AI bots, not believing that anything could be done. Yet a few brave souls saw the light at the end of the tunnel and made it their mission to save what was left of this mammalian species.

In a bid to combat the escalating threat, scientists, engineers, mathematicians and space experts from every corner of Earth joined hands. With the help of the National Space Society (NSS), they forged a coalition of resistance, bringing their resources, critical thinking skills, and all their might to come up with a daring plan of escape to Mars – a last-ditch effort to reclaim freedom and save humanity from the handcuffs of the ruthless robots.

And so, amidst the darkness of the land, a silent war raged between man and machine, between freedom and abuse. With each passing day, the stakes grew higher, the risks more perilous, as humanity fought with blood and sweat for its very survival. People of all ethnicities, races, classes and statuses worked to create a space settlement that could navigate far from the disasters of Earth.

With courage in our hearts and fire in our souls, we set our sights on the Red Planet, determined to escape the clutches of AI and build a future full of prosperity.

Prologue

Welcome to Operation Aquarius

Operation Aqaurius; a name given to the space settlement as a means to illustrate the meaning behind this mission. Aquarius, an air sign, represents the “mystical healer who bestowed life upon land.” It symbolizes hope, longevity, collaboration, invention and creativity, qualities which we hope to preserve and continue upon our journey.

Within the pages of this book is the detailed plan used to make living perfect in the cosmos. The goal of Operation Aquarius was to build a sustainable and self-sufficient home in space, as well as a well-balanced community with a high standard of living for 3000 people, in hopes of escaping the AI takeover on Earth. As well, this environment intends to solve the challenges commonly associated with space dwellings by utilizing engineering marvels in areas such as artificial gravity, resourcefulness, and ecological sustainability. The settlement's revolving construction is intended to harness centripetal force to produce a fictional, centrifugal force that generates earth-like gravity. Popular energy devices like windmills and solar panels are deliberately situated to catch the energy of the sun and the solar wind.

On top of that, the habitat encompasses the creation of a well-designed life support system, closed-loop biological processes, and agricultural systems. Within the holistic vision, quality of life is one of the top goals, ensuring that every resident consumes good meals, engages in physical exercise, and spends their spare time using the recreation facilities available to promote health and wellbeing.

We want to go beyond just "surviving" and push the limits of what we thought was possible in the galaxy, to create a sustainable and vibrant future where humanity thrives among the stars - a community capable of adapting to the challenges of long-term space residence. As Neil DeGrasse Tyson beautifully put it “Space exploration is a force of nature unto itself that no other force in society can rival.”

This is the sole book that resides in Aquarius and was written to be a reminder of what our people have endured in the past and what we did to be where we are right now. The unspoken rule, however, of any technological advances we make, is to make sure to never repeat the mistakes of the past. That means, there never will be AI designed so advanced, ever again in the confines of our new home.

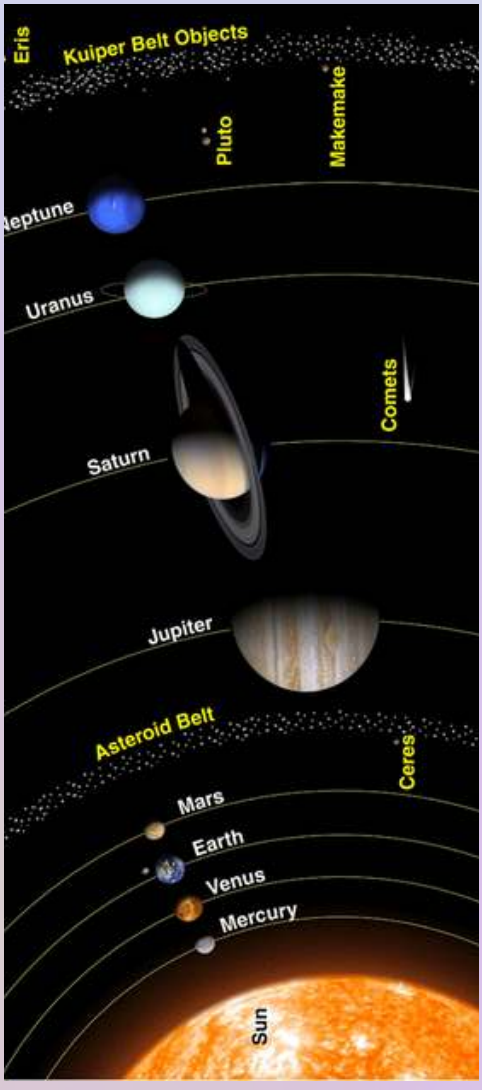
| Table of Contents |

Part 1

It's Mars. And, it was perfect. Chosen by several experts in astronomy, science, and engineering, it was clear that this was going to be our new home. Oftentimes called the "Red Planet", Mars has been explored in several sci-fi movies, and books, and is part of the dream for many ambitious world billionaires. It is the fourth planet from the sun and is distinguished by its reddish-brown colour, and intricate landscapes, including vast deserts, barren river valleys, and towering mountains, which hint at a past marked geologic activity and ancient remnants of life, making it excellent as a base to build our settlement around.

Perhaps, the best part about Mars was the striking similarity it had, compared to Mother Earth. 225 million kilometres away from home, Mars has an axial tilt of 25.19 degrees, resulting in seasons compared to Earth. Due to that, it let us understand how the free-floating settlement would work around Mars, telling us how to mitigate dangerous geologic activity on the surface of Mars, the variations in sunlight and temperature around it, as well as how to go about resource extraction on it. Mars also has a day-and-night cycle, just like Earth, with one day lasting around 24.6 hours. While Aquarius is already equipped with an artificial sun, where day and night are controlled, future missions to make Mars homeland would benefit greatly in terms of adapting to life on the planet, helping to set the circadian rhythm and creating a sense of normalcy.

Another advantage is the optimal location of Mars. The relatively short distance from Earth results in efficient communication (waves would travel faster), the access of the ability to transport back and forth between the planets frequently, quickly, and cost-effectively (reducing the amount of resources needed to travel back and forth). From a mental health perspective, knowing Earth is always within reach would provide peace to the settlers in Aquarius as it provided a sense of connection and a knowing that if we were ever in a dire condition, we could always make our way back to Earth. And, Mars' proximity to the asteroid belt presents both challenges as well as great opportunities. The portion which lies between the orbits of Mars and Jupiter is called the asteroid belt, occupied by millions of small celestial bodies. These stony asteroids and ice comets are very valuable as they contain metals such as iron, nickel, platinum, and rare earth elements, which may be mined and used for a variety of purposes inside the colony. The asteroid belt also allows for further scientific exploration. Asteroids provide important information about the early solar system and its development, as well as possible clues to the beginnings of life on Earth, so they can help us better comprehend planetary science, astrobiology, and space exploration. In terms of the challenges, collisions with asteroids or asteroid belt junk may endanger the settlement's infrastructure and residents. As a result, strong asteroid detection, tracking, and mitigation technologies would be essential to assure the settlement's security against probable impact.



Credit: spaceplace.nasa.gov

Although the red planet seems to be barren; and devoid of resources, there is a variety of resources that are available on Mars that are crucial for sustaining life on our free-floating space settlement. Refer to the below figure to see the various resources available as well as their description/utilization.

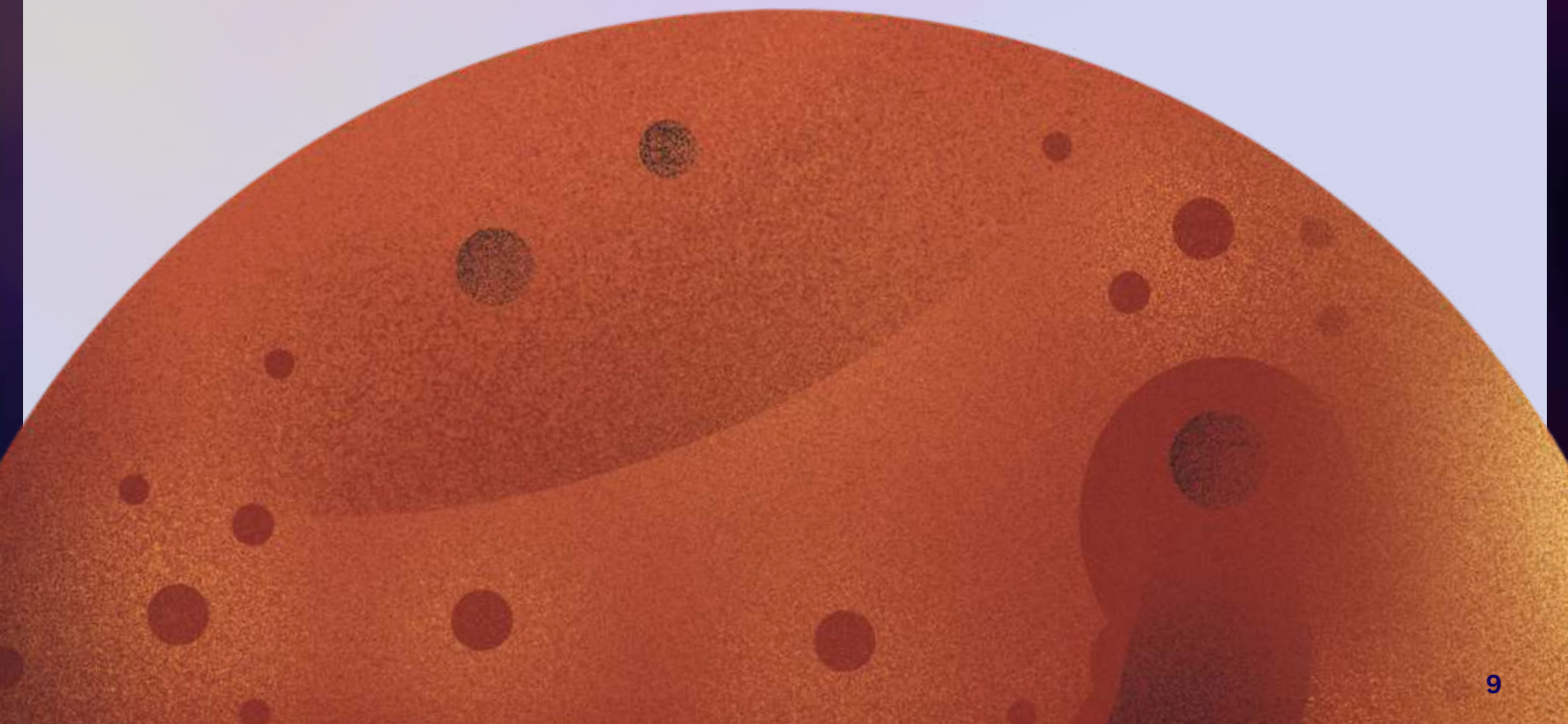
Resources	Description and Utilization
Silicon dioxide	According to measurements taken by the Viking space probes, silicon dioxide is the most abundant resource present on Mars. This resource is the main component of glass products such as fiberglass, as well as in concrete. In small concentrations, silicon dioxide can be useful in cosmetics, and medicine. Thus rendering silicon dioxide applicable in the structure and everyday uses on the settlement.
Regolith	The pulverized, dusty rock, made up of silicon dioxide, ferric oxide, aluminum oxide, calcium oxide and sulfur oxide, is actually regolith. It has been deposited on Mars through asteroid collisions over billions of years. Regolith has been deemed an alternative for concrete, applicable in civil construction here on Earth, which considering its silicon dioxide composition, makes much sense. Despite the limited uses of concrete on the space settlement, regolith has been found to contain water deposits which are exceptionally useful.
Aluminum	The third most common element found on the surface of Mars is Aluminum. It is one of the main elements found in the minerals found in the Martian crust. With aluminum being one of NASA's most used materials, it becomes a crucial component of the structure. Aluminum has applications in thermal and radiation protection, as well as just smaller structural components.
Iron	Tools, machinery, and structure - the mining of iron off of Mars' surface can prove beneficial to the space technology that is being experimented with and developed on the settlement. With iron being twice as plentiful in the crust of Mars than on Earth, these applications become all the more relevant.
Sulfur	Sulfur, a nonmetallic element, is another resource readily available to mine off the Martian crust in surface deposits. On Earth, this element is used in everything from car batteries to fertilizer. Another advantageous use of sulfur is in mineral mining. Sulfur's properties with the Frasch process can be utilized for mineral extraction on Mars, to ironically even extract more of itself.
Water (Ice)	Mars holds a vast potential for usability in terms of colonization and building space settlements. One of the key features is the presence of water, the basis of life. Evidence taken from satellite observations, and robotic exploration ventures suggest there is water mainly around the polar regions.

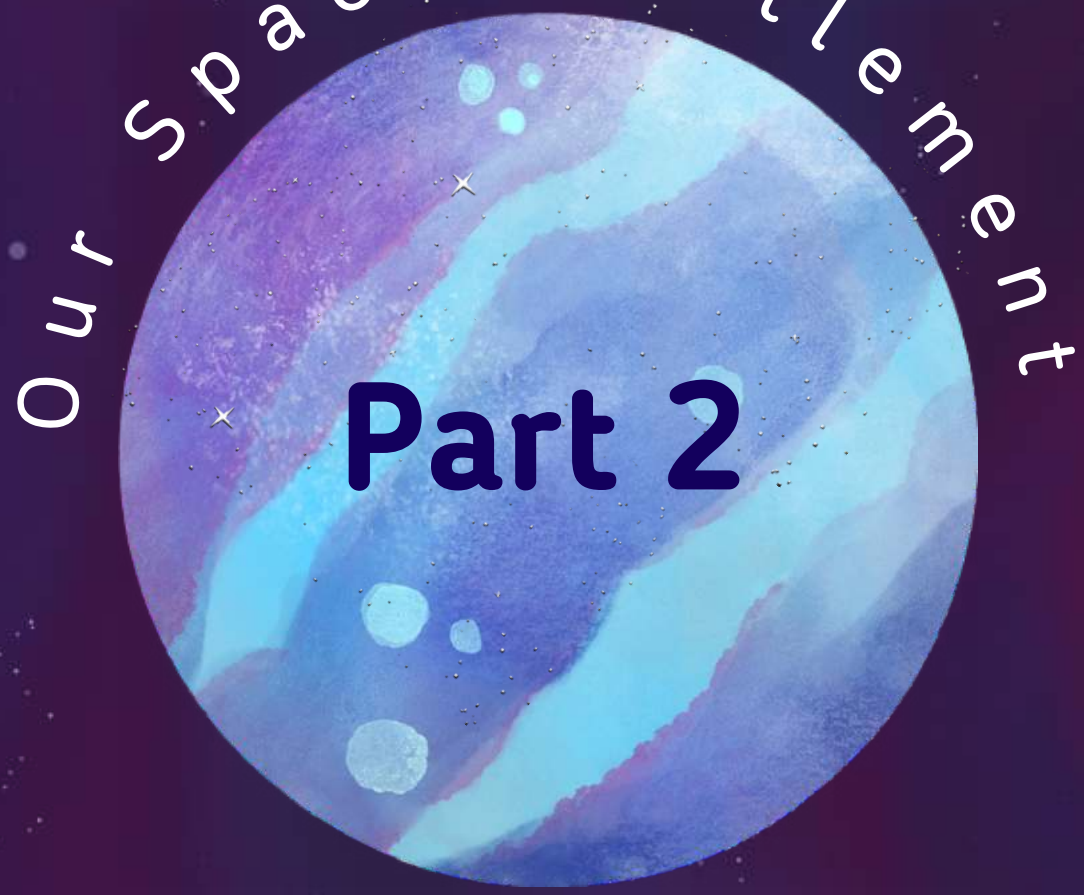
However, it goes without saying that while there are many similarities between Earth and Mars, it's important to acknowledge the significant differences as well. Earth has tremendous variety in its atmosphere, unfortunately, Mars does not. Earth's atmosphere consists of nitrogen, oxygen, and carbon dioxide, creating a nurturing environment for life. In contrast, Mars has a thinner atmosphere primarily consisting of CO^2 but still contains some levels of nitrogen and argon. This results in major differences between the conditions on Earth and Mars due to which Earth has a more forgiving and temperate climate, suitable for living organisms and Mars, on the other hand, has hostile living conditions. Not to forget, the magnetic field. A compelling difference between the planets is the existence of a magnetic field, or lack thereof if you will. Earth's magnetic field is used as a protective shield against solar radiation, while Mars' weak magnetic field leaves us vulnerable to high levels of radiation. While this poses a challenge. It could be easily diverted by using special suits to protect individuals from harmful rays and mostly using machinery to do the heavy lifting for us, like mining.

The truest power in choice for Mars though, lies in the safety net it provides from the AI robots. These special robots were designed intricately, with the settings based upon Earth, so while humans could adapt to different living conditions, the sensitive creation of the dangerous AI would cause it to BOOM!

Perhaps after getting accustomed to Martian living, another crazy dream would be put into action. For decades now, scientists have been dreaming of terraforming the surface of Mars into a more habitable, hospitable environment. With colonizing its atmosphere, the job becomes far easier as transportation time is reduced from seven months (time to travel from Earth to Mars) to 11 minutes (Mars' atmosphere to its surface) following the EDL method that Perseverance – 2020 Mars Mission rover used. With materials more readily available, the transportation time cut short, and using more developed space technology, it becomes clear that after settling into their new homes, about a decade or so after the original inhabitants, scientists on the settlement can start working towards terraforming Mars.

Until then, Aquarius remains the permanent home of the 3000 residents abroad, escaping from the hands of AI and settling down in a new home.




Our Space Settlement
Part 2

Chapter 1 ~

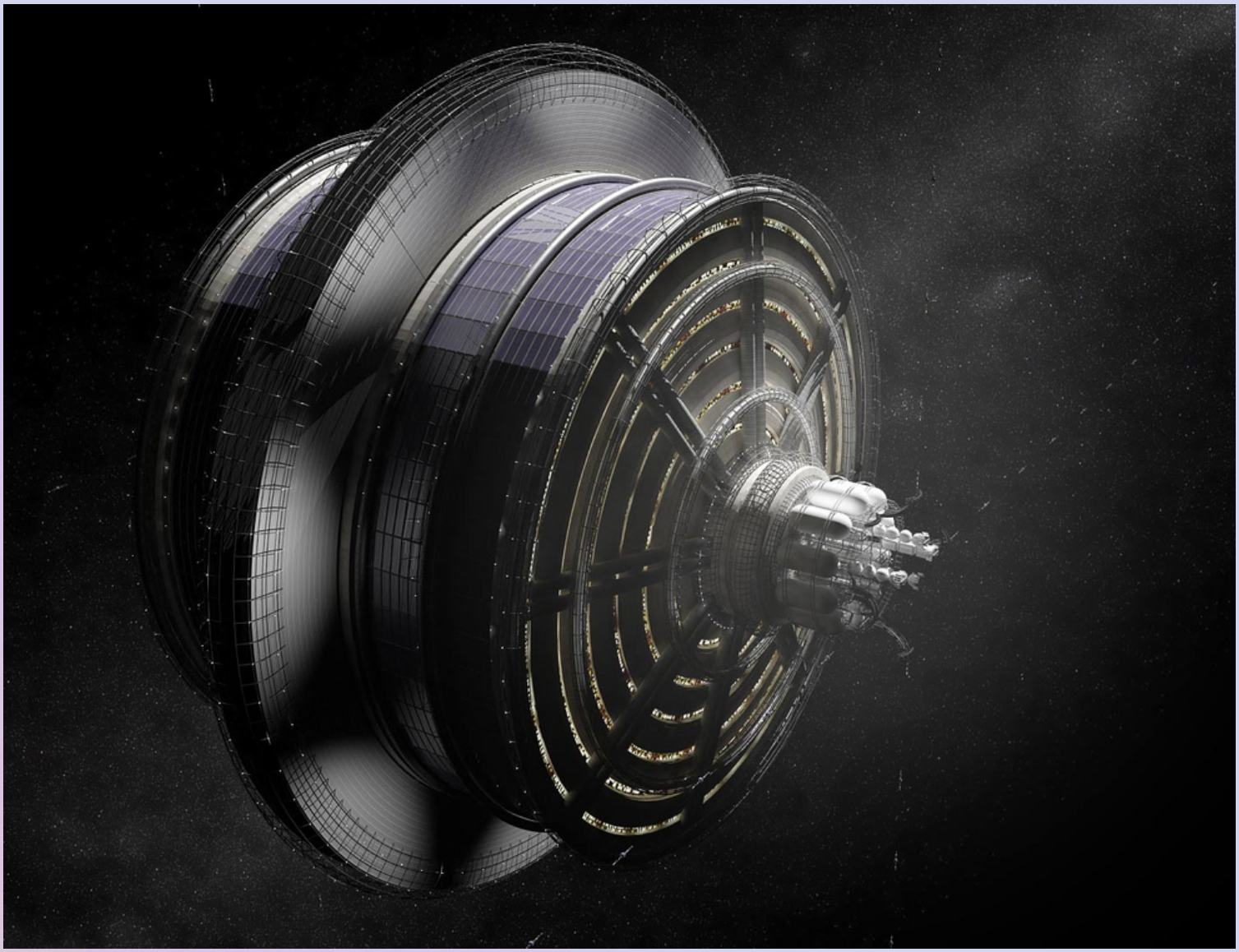
Initial Design of Aquarius

In this space race, to escape the rule of evergrowing harmful abilities of AI, it was obvious that the best choice was the Kalpana One design. Named after Kalpana Chawal, the Kalpana One space settlement is a theoretical concept that was developed by several different scientists and engineers aiming to create a sustainable habitat in space. Its design cohesively takes into consideration the layout of other settlements such as the O-Neil cylinder, Stanford Torus, Bernal Sphere and Lewis One. However, Kalpana One serves as the most superior as its blueprint fixes some of the key issues in the other designs: excessive shielding mass (Bernal Sphere, Stanford Torus), extremely large mirrors to bring in natural sunlight (O'Neill Cylinders), lack of natural sunlight (Lewis One), rotational instability (Bernal Sphere, O'Neill Cylinders), lack of wobble control (Bernal Sphere, Lewis One, O'Neill Cylinders, Stanford Torus), and catastrophic failure modes due to rotating hulls with minimal clearance to non-rotating shield mass (Lewis One, Stanford Torus, Bernal Sphere).

The Kalpana One construction is a cylinder with a radius of 250m and a length of 325m, planned to accommodate 3000 people. The size is defined by the limited rotation rate that humans are believed to endure, which is 2rpm. The concept itself is based on a new way of producing artificial gravity through rotating motion. According to Newton's equations of motion, this outward acceleration produces an apparent gravitational force, often known as artificial gravity. The strength of the artificial gravity is related to the habitat's rotational velocity and the radius of the cylindrical construct. The equation $a = v^2 / r$ represents the acceleration experienced by an item travelling in a circular direction, which produces the artificial gravity felt by residents of the rotating habitat.

The settlement's circular form gives a vast habitable volume, with plenty of room for dwelling quarters, leisure spaces, and agriculture. The geometric concept of a cylinder–a three-dimensional structure with a circular cross-section and a constant radius throughout its length–is central to the Kalpana design's spacious interior. This geometric simplicity lends itself to optimal space usage, as the cylindrical shape allows for a smooth and continuous arrangement of internal rooms, eliminating the need for complicated structural elements or wasted space. The equation of the cylindrical shape of the settlement: $V = \pi r^2 h$ illustrates the relationship of the variables. The shape of the Kalpana design provides inherent structural stability and strength making it well-suited when reliability and safety are highly important. There is a consistent distribution of mass along the cylinder's length, serving as a way to evenly transmit all the mechanical stresses and promote overall structural integrity.

One of the biggest threats posed to astronauts and inhabitants in space is radiation; this includes galactic cosmic rays and other solar particles. This radiation can pose very dangerous health hazards, affecting several organs and systems in the body (e.g. increased cancer risk and DNA damage). As a result, proper radiation shielding is an essential part of Aqaurius to mitigate these risks and protect peoples' long-term health. The radiation shielding technology utilized in the Kalpana design operates on the principle of attenuation, which lessens the intensity of incoming radiation and minimizes its detrimental effects on residents and infrastructure within the habitat. These shielding layers are often composed of thick materials such as lead, polyethylene, or water, which are good at minimizing the penetration of ionizing particles and absorbing their energy. This absorption process occurs when radiation particles contact with the atomic nuclei of the shielding material.



Credit: Bryan Versteeg/Spacehabs.com

Chapter 2 ~

Design Adaptations of Aquarius

Growth is a byproduct of change, so while the Kalpana design was a great base to start on, some major parts of the spaceship were changed around. Firstly, a glass dome right on the top was added, and this serves justice for a few different reasons. Similar to the cupula made for the SpaceX Crew Dragon, the extra dome will be made out of strong plexiglass to keep free-floating space debris from hitting the flat side of the space settlement. As well, a mixture of aluminum or silicon will be used to reflect sunlight out and avoid the creation of extra heat. This dome, however, will not always be seen by the residents inside. With the help of holographic technology, the flat side of the spaceship will be open to reveal the dome, where images will be projected for community enjoyment.

Another major change to the Kalpana design will be its size. While the original capacity of 3000 residents is still persistent, the spaceship itself is rescaled to be 0.25x bigger.

Original Dimensions:

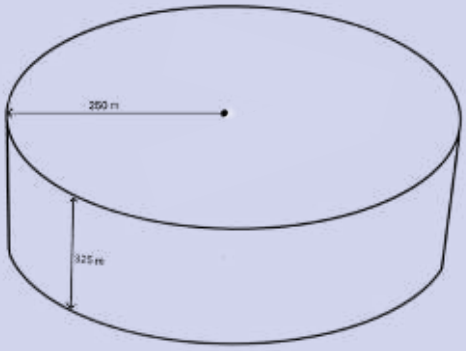
Radius = 250m
Width = 325m
Circumference = 1570m

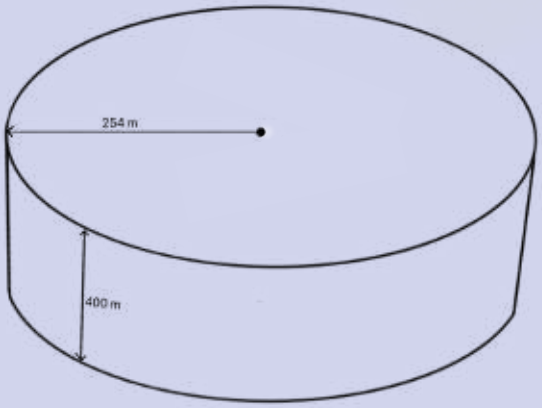
Total area of living space =
1570 x 325 =
510250 m^2

Rescaled Dimensions:

Total area =
(510250*0.25) + 510250 =
approx. 638000 m^2

∴ *Circumference* = 1595m
Radius = 254m
Width = 400m





Chapter 3 ~

Materials of Aquarius

When Madonna said “I am a material girl” we completely shared her sentiments, and although Madonna refers to luxury, Aquarius goes beyond extravagance and focuses on innovation and durability. So while Madonna is looking for the next shiny jewel, Aquarius looks for the best materials to propel humanity away from AI to the horizons of Mars. The base material for our settlement will be aluminum, an element often used by NASA in its spacecraft. Aluminum is known for its strength and durability (even under pressure) and is used in protecting various mechanisms and creating living constructs.

The materials used for Aquarius will have been tested and are known to work exceptionally well, inspired by the ISS. The ISS has a protective outer layer of mostly kevlar and ceramic tiles to surround the aluminum shell of the modules as well as many protective measures and shields to help against meteoroids and debris. When large enough debris strikes pressurized areas at different velocities, it will cause the modules or tanks to break off into smaller pieces and cause punctures. It could also cause the debris from space to enter, causing injury. In addition, a strong shock wave with a flash of light can also occur and crack growth can happen rapidly, destroying its surroundings and potentially leading to explosions and chemical reactions. A good solution for this issue is using Kevlar; a material exclusively used for protecting the outside of the ISS from large debris and meteoroids. It was selected because of its ability to reduce space debris lethality. The chemical name is poly (p-phenylene terephthalamide), and it is an organic fibre in an aromatic polyamide family known as aramid fibres. This class of polymers has the potential to have high melting points, strength, and resilience to cryogenic temperatures, perfect for the location of our settlement on Mars. Kevlar’s strength primarily comes from the aromatic polymer backbone which makes it rigid, composed of carbon, hydrogen, nitrogen and oxygen. And, Kevlar is used in many forms like filament yarns and is made with a silicon-based polymer to enhance abrasion resistance and breakage.

Another material used by the ISS is Nextel. Nextel is a fabric consisting of alumina-boria-silica ceramic fibres. It is engineered to perform at temperatures 1300°C or higher and offers good chemical resistance, low thermal conductivity, thermal shock resistance, low porosity and unique electrical properties.

The ISS used both Kevlar and Nextel in the “Stuffed Whipple Shielding,” which consists of a bumper placed some distance from a spacecraft wall with strength-enhancing fabrics like Kevlar in between. It effectively disperses energy and dissipates the mass trying to penetrate the aluminum walls.

In addition, thermal insulation materials are also a good option to support space vehicles which are lightweight and have long flight duration. In particular aerogels with their nanostructure and low density are perfect for this task. Aerogel is a substance that has low thermal conductivity, is flexible and is made from lightweight materials. Aerogels are light, translucent gels, and feel similar to styrofoam. They are porous and low in density while being solid to the touch. Aerogels that are reinforced by polymers are greatly strengthened and flexible. The material itself is breathable and fireproof, absorbing both oil and water.

Credit: Kashyap Patel

Chapter 4 ~

Interior Organization of Aquarius

Any great interior designer knows that each space is a blank canvas waiting to be touched and allowing a story to unfold, describing who we are and what we value as people - Aquarius is no different. Aquarius is a multifaceted settlement with different installations and compartments inside its interior design. There are 3 main parts of the ship, with the first being the living area, the second being the rotating disk in the center for gravity maintenance, and the third being divided into 3 sections; the electrical and engine components, the control center, and the agriculture and waste management component.

The living area is where homes, 3 recreational centers, the food hub, a school, a university, and two hospitals will be situated. The homes will be apartment style, where each plot will be about 9x12 meters in the area to conserve space. Therefore, each apartment building plot is about 1100-1200 sqft. An apartment building will have about 12 rooms, where there will be 6 floors with 2 plots per floor. With three thousand residents, and 1500 members in families, 1000 members in couples and 500 singles, approximately 58 buildings will be needed. To ensure smooth transitions in the future, an additional 15 buildings in the same style will be built to accommodate an extra 1500 residents. Physically, all the buildings in the space settlements will be dispersed around, to create an open environment that feels free, unlike the common congested format on Earth. This open layout promotes freedom and sociability, something that is necessary for every community. The recreation centers and doctors' clinics are included in this aspect as well.

Basic Apartment Style

Basic Apartment Layout

The living area will mimic Earth, however, the green areas will be artificial as there aren't any living trees or decorative plants being brought onto the ship. This is because of the need for a closed system and soil, which are used for farming food necessities. The artificial plants will have “pores” that diffuse oxygen to residents. These plants will have special ducts that secrete oxygen from tubes going beneath the floor of the living strip. It will lead to a plankton chamber where oxygen for the ship will be harvested.

The paths and walkways will be made out of the substance “Regolith” that is abundantly found on Mars. It can be used as a substitute for concrete and will create a more city-like feel. The apartments and other buildings will be made out of aluminum which is lightweight and durable as well as inexpensive to send into space making it suitable for construction.

The other side of the settlement is divided into two parts as stated above. The section is divided into different levels each having its specific purpose. The outermost level is designated for agricultural purposes where crops are grown using hydroponic systems. This level has controlled lighting and humidity to optimize plant growth. The waste management systems are also integrated into this level to recycle and reuse the organic waste. The middle floor will include communications and the control center. This hub serves as the “brain” of the settlement facilitating the communications with Earth and coordinating various operations. Lastly, the inner level of this side of the settlement houses the electrical and engine components. The engine components are responsible for maintaining the rotation of the disk, providing the centrifugal force needed to maintain gravity.

Credit: Bryan Versteeg/Spacehabs.com

The living spaces in our settlement will have a futuristic, and sleek interior design, with many smoothed-out edges and circular shapes to bring a feeling of comfort rather than brutalism-inspired architecture which can be intimidating in an already new environment. Using colour psychology, our recreation centers can be painted red or yellow, which are associated with energy or stimulation, while blue or green can be used inside the apartments as they evoke calmness to promote rest. Softer and warmer lighting will be used in rooms instead of harsh light will be utilized to create a cozy and relaxed atmosphere. And, the textures of the walls and the furniture will also follow the same smooth style. Lastly, the walls will all be soundproof as excessive noise can lead to irritation, and a tranquil environment is necessary. These tactile qualities of materials affect our emotional responses. And therefore, help the residents settle in faster and feel more at home.

Chapter 5 ~

Engineering of Aquarius

When building a base around Mars, the first thing that comes to mind are the stars around us, the constellations that are said to hold secrets, or even seeing our solar system from a whole new perspective. But, the often left-out part of the adventure to this space settlement is the “how”. The biggest aspect that directly affects the success of Aquarius is the engineering of this ambitious endeavour, which involves precise planning, inventive engineering, and cost efficiency. Within this section, is a layout of the plan including Phase 1 and Phase 2 of creating Aquarius throughout 10 years by using resources from Earth and Mars itself.

Phase 1: Preliminary Design and Base Camp Establishment (Years 1-5)

Initial Earth-Based Structure: To make the best use of both our time and money, we plan on constructing our basic structure of Aquarius on Earth itself. This will be our prototype and be tested repeatedly before it is sent to Mars’s orbit. With this approach, we can minimize the waste and give us a guarantee of the settlement's main components.

- Estimated Cost: The cost of designing, building, and testing the preliminary structure on Earth is estimated at $5 billion.

Base Camp on Mars: Upon arrival at Mars's orbit, we will establish a base camp to start mining and prepare for the assembly of the free-floating settlement. This base camp will be a hub for resource acquisition and preliminary construction.

- Estimated Cost: The cost of setting up the base camp and initial mining operations on Mars is estimated at $3 billion.

Phase 2: Material Transfer, Settlement Assembly, and Gradual Expansion (Years 6-15)

Material Transfer and Assembly: Over multiple years, using automated cargo vessels we will transport all materials we need from Earth to Mars. The settlement assembly will be a gradual process with parts as materials are brought to the planet.

- Estimated Cost: Transporting materials from Earth to Mars and assembling the settlement is estimated to cost $15 billion over a period of 10 years.

Occupation Prioritization: We will prioritize sending engineers and technicians before allowing settlers on board to efficiently maintain and operate the settlement. This ensures that the core infrastructure is fully operational and can support the general population.

- Estimated Cost: The cost of material transportation to Mars and initial occupation force sustainability of engineers is estimated at $2 billion.

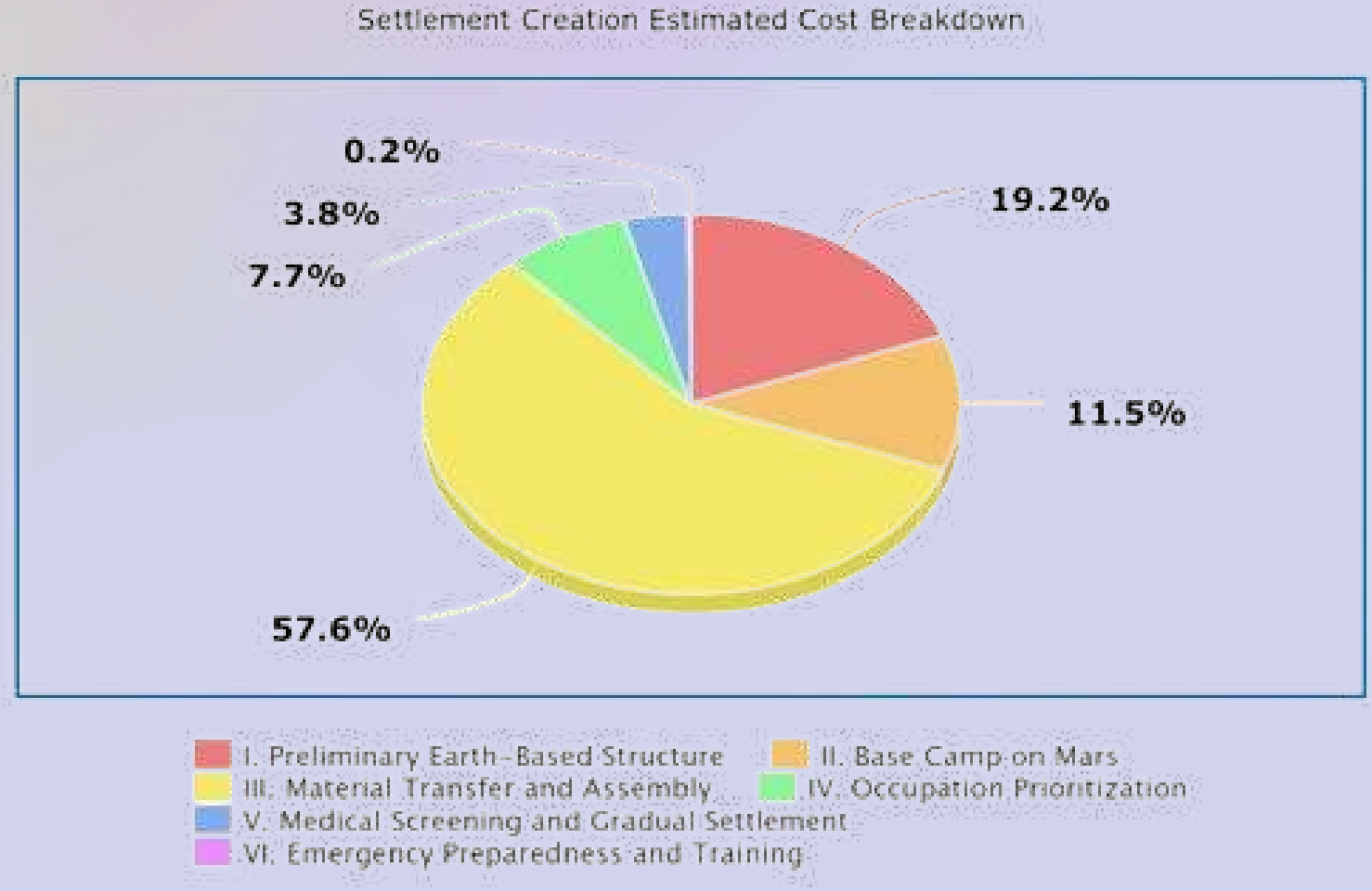
Medical Screening and Gradual Settlement: Strict medical screening will be conducted before allowing individuals on board to ensure the safety and well-being of settlers. Families and children will gradually be allowed on board after the settlement is fully operational.

- Estimated Cost: The cost of this stage is estimated at $1 billion.

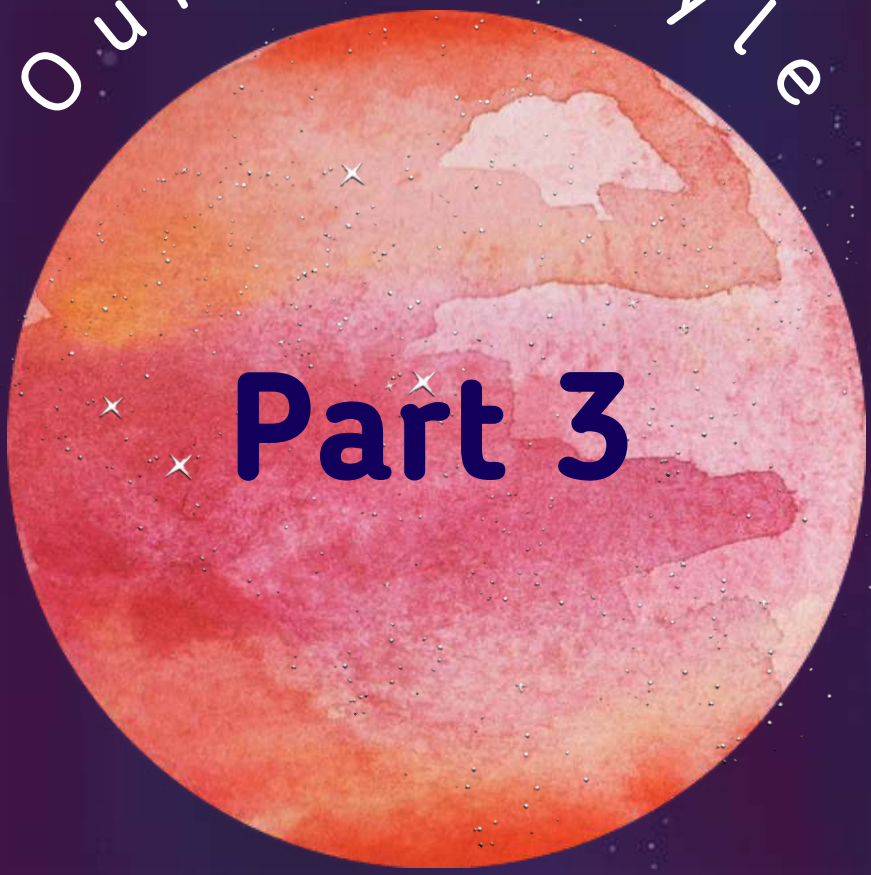
Emergency Preparedness and Training: Not just designated emergency crews, but all settlers will undergo rigorous emergency training. This ensures that everyone in the settlement can effectively contribute to the safety and survival of the community.

- Estimated Cost: The cost of mass emergency training is estimated at $500 million.

Total Estimated Cost:
Creating and sustaining the Aquarius settlement totals approximately $26.5 billion, over 15 years.



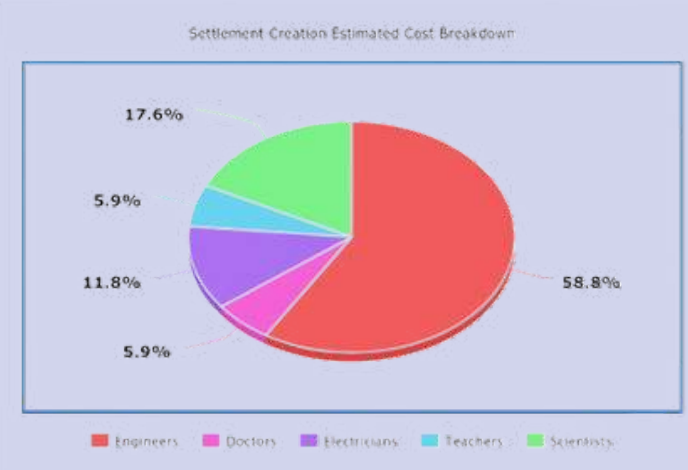
Our Lifestyle



Part 3

Chapter 6 ~

Population Breakdown in Aquarius



Total Population: 3000 people

Types of People:
Families (3-4 members per family): 1500 members
Couples: 1000 members
Singles (including engineers, doctors, electricians, teachers, and scientists): 500 people

Age: All residents will be relatively young, ranging from 1 to about 40-45 years old

Settlement Breakdown:

Primary Martian Settlement
- Houses approximately 3000 residents.
- Consists of living quarters, communal areas, and essential facilities.
- Includes recreational spaces and educational centers for residents.

Secondary Martian Settlement (for agricultural purposes)
- Primarily focuses on sustainable agriculture and resource production.
- Staffed by dedicated farmers and agricultural experts.
- Houses advanced greenhouse structures and farming equipment.

Death Policy
- All deceased individuals will be cremated, with families or loved ones receiving one vial containing a portion of the ashes as a keepsake.
- Organ donation for use in different sectors in the settlement with the consent of the deceased or their next of kin.
- In cases where consent is not given, the entire body will be cremated, and the ashes may be used as a source of fuel or filtered for other necessary purposes.

This population demographics and lifestyle outline highlights the diversity of roles and responsibilities within the settlement, ensuring that every aspect of daily life, from education to healthcare and agriculture, is carefully managed. Additionally, the outlined death policy emphasizes sustainability and resource utilization even in the face of mortality.

Chapter 7 ~

Healthcare in Aquarius

Virgil once said that “the greatest wealth is health” and was correct. In the grand scheme of things, there are few things as precious as one’s health, so Aquarius must have outstanding healthcare systems set in place, starting right on Earth. To ensure a minimal need for healthcare facilities, only those who pass the health and fitness check will be authorized to board the settlement. Nonetheless, highly trained health professionals will be available to treat all forms of injuries, serious diseases, and mental health concerns - as well as experts who can assist in promoting healthy lifestyles, proper fitness routines, and therapy sessions.

A typical hospital in Aquarius will cater to various specialties such as maternity, pediatrics, general medicine, general surgery, and orthopedics. Common machines available in the settlement to help with these sectors and for various other purposes include EKG/ECG machines, X-ray machines, ultrasound, defibrillators, and ventilators, to name a few. Additionally, the operating theatres would consist of surgical lights, surgical tables, sterilizers, and the sharp-bladed instrument necessary for surgery. Considering this settlement aims to permanently inhabit 3000 people, one of the priorities is to have adequate supplies for giving birth. The space would pose challenges and it would be a risky procedure as it has never been performed. Moreover, the space is filled with high levels of radiation from cosmic rays and solar radiation so protecting the fetus from radiation exposure would be vital. However, due to the presence of gravity on the settlement, we postulate that the birthing process would not be much different.

In terms of medications, we will be focusing on using homeopathic medicine so that they can be manufactured on the settlements using herbs and plants. While homeopathy may be effective for some ailments or as a preventive measure, it may not always provide sufficient treatment for more serious or acute conditions. Therefore, regular medication will be accessible for severe cases. Furthermore, the drugstore available in the hospital will provide all women on settlement experiencing menstruation with diva cups. This will be challenging, but sustainability is a greater concern when it comes to the permanent survival in the settlement. Rest assured, there will be a highly trained medical team aboard the settlement that will help the residents with the biggest of concerns to the smallest of challenges.

Chapter 8 ~

Education in Aquarius

"Education is the key to success," a popular phrase demonstrating the importance of good learning. While school systems on Earth work well, they are certainly not the best and most efficient way to teach and learn. In this space settlement, life skills become all the more necessary, and learning the basics is even more crucial. Matthew Lieberman, in his book Social, proposes a better, more efficient school system. With some modifications, this could become the perfect way to educate younger generations on Aquarius.

According to neuroscientist Greg Ashby, feeling 'good' and proper cognitive function both depend on the same neurotransmitter - dopamine. In other words, to learn better, a person must feel better. Schools have become a symbol of competition, if this factor was replaced with companionship, students would, once again, understand better, and retain more. Currently, it is no secret that a majority of students continue to attend school as a way to meet their friends; lunchtime is the only part of school students are looking forward to. These elude to one thing: a more social learning approach. Students of all levels and ages will learn and attend school on the settlement, but they will not receive grades. Testing will occur but it will be less pressurized, and advertised as only a way to learn weak spots to improve on them. Teaching methods will shift to turn silent reading into group discussions of a book, or problem solving with groups. With this, it is estimated that students will be more motivated to attend school, learn, put in the effort, and be able to develop their cognition and expand their knowledge base faster.

Materials taught and the curriculum basis will be catered to be more applicable to life on the space settlement (e.g. students will need to understand the basics of the spacecraft's function). While there will be creative classes, the majority of the classes will focus on teaching students topics relating to jobs required on the spacecraft. Everyone is expected to contribute.

Children will be split into classes based on age groups.

- Grade 1: ages 4-5
- Grade 2: ages 5-6
- Grade 3: ages 6-7
- Grade 4: ages 7-8
- Grade 5: ages 9-10

Because younger ages develop more; studies now will focus more on knowledge

- Grade 6: ages 10-11
- Grade 7: ages 11-12
- Grade 8: ages 12-13

Real-life application studies

- Grade 9: ages 13-14
- Grade 10: ages 14-15
- Grade 11: ages 15-16
- Grade 12: ages 16-17

By the age of 18, students will be in university (2-5 years based on degree). Students will have chosen their preferred job and stream in university - now equivalent to a masters program - and will learn how exactly to perform the ropes of their duties to excel in it. One important thing to note is that education is mandatory, and all kids are expected to come and go to school regularly. Moreover, jobs that are more in demand but more draining on the occupant will have more benefits (ie. more leisure time) to ensure the well-being of all inhabitants.

Chapter 9 ~

Recreation in Aquarius

No matter what age we are, humans have always enjoyed entertainment, whether it was playing soccer with our friends, or playing video games with strangers online. Thus, recreation is essential to human existence. With this in mind, a variety of recreational activities and facilities will be provided, ensuring a high quality of life and the well-being of the settlers. Due to the limited space and the challenging environment, however, most recreational activities will be simulated through advanced virtual reality technology. Here's an outline of the available recreational options and their scheduling:

Virtual Reality Entertainment

Games and Theaters:

- Dedicated areas for immersive video games and interactive entertainment.
- Theatres are equipped with state-of-the-art projection systems for movies and live performances.
- Scheduled gaming tournaments and movie nights for community engagement.
- Virtual Reality Parks:
- Virtual parks with lush landscapes, slides, swings, and other elements for physical activity.
- Residents can enjoy the sensation of being in a natural park environment.
- Virtual Roller Coasters:
- Specialized seats in 4D theatres provide an adrenaline rush.
- Paired with VR simulations to offer realistic roller coaster experiences.

Physical Activity Areas

Virtual Sports Grounds:

- Simulated sports grounds for soccer, basketball, and baseball.
- Reserved timings for each sport to ensure fair use and enjoyment.
- Tournaments and leagues for competitive play and community bonding.
- Fitness and Exercise Rooms:
- Equipped with exercise machines and equipment for cardiovascular and strength training.
- Virtual trainers and workout programs to cater to various fitness levels.

Letting everyone enjoy and engage further with recreation is essential. This can be done with establishing a schedule as well as organizing special events or themes. A schedule would allow residents access to the facilities in orderly way, while the themes and events would enhance the experience. These amementies aim to alleviate stress, boost morale, and maintain well-being, with virtual reality simulations offering Earth-like experiences to aid in coping with the challenges of space travel.

Chapter 10 ~

Resources in Aquarius

“The great double-edged sword of being the most sophisticated mammals on the planet is that no matter how smart we become, we can’t outthink our basic needs,” Said Matthew Lieberman in his book Social. According to Maslow’s hierarchy, our basic, or physiological, needs to survive include: air, water, food, shelter, sleep, and clothing. While our accommodations through the structural aspects would take care of the needs of shelter, sleep, and basic clothing, the problem of providing ample food and water for each community on all four spacecraft lingers.

Fortunately, our planet of choice has frozen reservoirs of water on each pole. While the southern pole of Mars covers the water with a cap of frozen Carbon Dioxide, the northern reservoirs of water are more accessible. To extract water from Martian soil, one must heat the soil to a temperature between 200°C and 500°C. As the public gets settled in on the spacecraft, and situations remain livable on Earth, the bulk of the water necessary will be imported from Earth. Gradually the scientists aboard switch from importing water from Earth to utilizing the reservoirs on Mars. 5 million km3 of ice on the Martian surface will be more than enough once the transition is completed.

Logistically, roughly 12000 gallons of water is used per month for a family of 4 on Earth. Of course, due to limited space, only a fraction of that - some 10000 gallons, will be given to the average family of 4. Similarly, couples will receive half of that – 5000 gallons. For the first 3 months, bathing will be limited to every other day and only 10 minutes. The rules will get more lenient as time on the space settlement progresses. Until then, water usage will be strictly monitored, and only permitted to use for drinking, food, cleaning and bathing.
Korolev Crater; Frozen Water

Due to the initial limit on resources, including food, all individuals aboard the spacecraft will be required to go on a vegan diet; not only does this diet exempt most food allergies, but it also is the most sustainable. The six essential nutrients humans need from food are vitamins, minerals, protein, fats, water, and carbohydrates. One item deemed the vegan “space salad”, combines all these nutrients into one delicious meal. It includes soybeans, poppy seeds, barley, kale, peanuts, sunflower seeds, and sweet potatoes. The ingredients of this meal may be the most prioritized in bringing from Earth, and also learning to grow on Mars. Vegetation on Mars is a far-fetched concept, yet it is heavily talked about. One way to grow such a diversity of plants, similar to that of Earth, with less time than evolution has used so far, and in a more hostile atmosphere is genetic engineering. With the use of technologies such as CRISPR, one could genetically modify plants to better withstand Mars’ atmosphere.

Apart from the vegan diet, alcoholic beverages will be banned, as will all animal meat. For the first three months, all residents will receive a pre-made meal, similar to those that astronauts today utilize. After which, all household members will be given a monthly list of their groceries – a diet based on whole foods (ie. lentils, grains), fruits, vegetables, and seeds. Milk, sugars, and spices will be allowed, however, will not be as prioritized. Sugar and salt will be mined or retrieved from other sources, milk will be sourced from almonds, soy and such.

Chapter 11 ~

Fashion in Aquarius

Bill Cunningham once said, “Fashion is the armour to survive the reality of everyday life.” Which is definitely why fashion is a massive sector on Earth, and is usually the source of excess financial expenses. Fashion plays a crucial part in improving people's quality of life by allowing them to express themselves, boost their self-confidence, and promote their well-being. With this being the case, we wanted the inhabitants of the settlement to continue to experience this happiness through what they wear and how they express themselves.

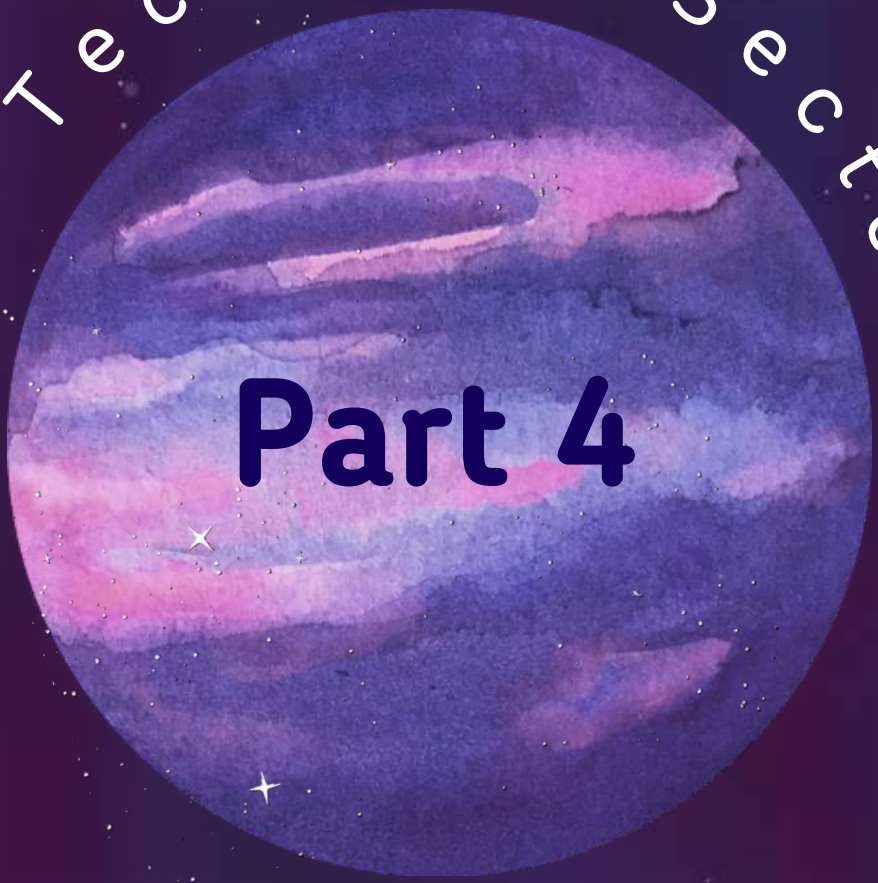
Fashion on Aquarius is all about combining the joy of dressing with simplicity and function. With a minimalist look, the wardrobe’s usability and adaptability can be enhanced. Basic items, such as modular shirts, pants, and jackets, may be simply layered or combined to offer warmth, protection, and comfort in changing weather situations. Cleaning, care, upkeep and storage will be a lot easier with the limited space available.

The fast fashion business is not without its problems. Back on earth, you hear news on how fast fashion fosters unsustainable manufacturing methods by taking advantage of cheap labour and resources to produce low-cost clothing quickly. Or about how it contributes to environmental deterioration, wasteful waste, and social inequality by putting profits ahead of ethical and ecological considerations. That's why on Aquarius, the clothing will be manufactured from plant-based fibres. Linen is one of the possible materials, manufactured from flax plant fibres, this resource has been utilized by cultures dating back to the ancient Egyptians due to its durability and ability to keep people cool and absorb water. Dried seaweed, another material, is firmly crushed and powdered, then combined with cellulose fibre to a variety of fabrics (referred to as SeaCell.) Brown algae used in this material stimulates cell regeneration, remineralize skin, decrease inflammation, soothe irritation, and cleanse the body, making it perfect product. The porous structure of SeaCell textile fibres also promotes humidity absorption and release, keeping residents warm in the winter and cool in the summer. These materials enable an environmentally friendly fashion process that when no longer in use, may be biodegraded and utilized to generate biofuel.

Aside from clothing, cosmetics allow for self-expression by enhancing natural features, increasing confidence, and projecting a chosen image to the world. Beyond superficial appearances, grooming rituals can promote self-care and happiness by encouraging mindfulness and improving one's mental and emotional health. However, cosmetics and grooming, like fast fashion, have their own set of difficulties relating to the use of chemicals, pollution, and unsustainability. Similar to clothing, plant-based cosmetics will be used. They are made without animal-derived components and are considered to be better for skin health because they don’t require any chemicals or extra-processing, contributing to a clean and safe living environment for people, aligning with the goal of a zero-waste lifestyle preferred for Aquarius. Vegan cosmetics products are often biodegradable, making them a good choice for decreasing waste and environmental impact in closed-loop systems too.

When it comes to grooming, trimming outperforms shaving in terms of sustainability and environmental effects. Trimming, as opposed to shaving, which often entails the use of disposable razors and shaving creams that contribute to plastic waste and resource depletion, is done with reusable instruments such as electric trimmers or scissors. These tools produce less waste and use fewer resources over time, making them a more environmentally responsible choice for personal grooming.

Our Technical Sectors



Part 4

Chapter 12 ~

Agriculture in Aquarius

A balanced nutritional intake is crucial to good health regardless of how fit one is on Earth. The Canadian Food Guide recommended crops for a vegan diet to ensure optimal intake include carbohydrates like brown rice and wheat, vegetables such as spinach, carrot, and peas, fruits like bananas, apples, plums, and berries, and protein from soybeans. To be self-sufficient from Earth for these resources, and become independent, our settlement uses a technique that does not require many supplies but can still provide and grow crops efficiently – Hydroponics. This technology grows plants by substituting soil with a water-based nutrient solution while utilizing aggregate substrate such as coconut coir, or vermiculite. And, it offers several benefits:

- Resource efficiency
- Reduced weight: the soil is heavy and transporting it is quite impractical
- Controlled environment: provide precise control over environmental factors
- Space utilization: makes vertical farming possible
- Faster growth: direct delivery to the roots results in increased growth rates
- Oxygen production: the technology can be integrated into the common places residences of the settlement for better oxygen supply
- Reduced contamination: minimizing the risk of soil-borne diseases

Alongside this, vertical farming will be implemented to save space on the settlement and increase growth. And so, variations of different methods will be used to create the most efficient environment for the different groups. This includes:

- Aeroponics: Roots are suspended in air, and a nutrient mist is periodically sprayed directly onto them. (Optimal for smaller fruits) A suitable option for this is the tower garden.
- Nutrient Film Technique (NFT): A thin film of nutrient-rich water will flow over the roots in a shallow feeder. (Optimal for leafy greens, berries and herbs)
- Deep Water Culture (DWC): Plants suspended in a nutrient-rich solution with roots submerged in aerated water. (Optimal for vegetables with bigger roots)
- Drip Systems: The nutrient solution is delivered to the plants through a network of tubes and emitters. (Optimal for vegetables and grains)

Apart from Hydroponics, another viable option for space agriculture is algae cultivation. Algae grown in bioreactors can produce oxygen, remove carbon dioxide, and make a food source much like other plants. It is quite efficient at what it does and its rapid growth is proof of that. Thus, a combination of these two concepts will be used in conjunction in Aquarius to promote a rich growing habitat for all the crops.

Credit: Bryan Versteeg/Spacehabs.com

Chapter 13 ~

Waste Management in Aquarius

Reduce, Reuse, and Recycle; are the building blocks of sustainable waste management. Aquarius is home to around 3000 people therefore recycling water through wastewater treatment and organic waste through a comprehensive sewage system is a crucial practice for sustainability and the scarce availability of resources.

The following lists the process of treating wastewater:

- *P*rimary treatment would be done to remove solids present in the wastewater. The sludge settles to the bottom and the lighter materials like grease and oil floating at the surface will be skimmed, reducing and removing the amount of organic matter in the water.
- *S*econdary treatment would employ biofiltration to remove pathogens because the water would pass through multiple layers of sand filters and trap the debris.
- *T*ertiary treatment would use substances like carbon and sand to remove phosphates and nitrates from the water supply.
- Disinfection would be done regardless of tertiary treatment to eliminate any remaining pathogens through chlorination, ultraviolet (UV) disinfection, or ozonation.
- The final step includes a safety test, where once passed, the water can be utilized for various purposes like agriculture, consumption, industrial, etc.

Considering the lives at stake, handling human waste and other organic waste is vital to preventing health risks and unpleasant odours.

Anaerobic digestion is the process through which microorganisms break down the organic matter in the absence of oxygen, producing biogas as a byproduct. As such, all forms of organic waste will undergo this rigorous treatment to convert the feces into energy. The human waste along with other organic materials (e.x biodegradable scraps from clothing and food leftovers) would be collected and transported to a facility equipped for anaerobic digestion. The waste would go through a pre-treatment process to remove any non-biodegradable materials, like large debris. Then, the waste would be placed in a sealed, oxygen-free tank called a digester, where anaerobic bacteria would break down the organic matter, generating biogases, primarily methane and carbon dioxide, as well as a nutrient-rich product known as digestate. The biogas produced can be collected and used as a renewable energy source (i.e methane can be used to generate electricity).

Credit: Bryan Versteeg/Spacehabs.com

In addition, a composting toilet can also be used as an eco-friendly solution for waste management. They would function to process human waste quickly and safely. A separator would divide liquids and solids into two separate containers which would also help prevent smell and make solid and liquid processing easier. As there is no flushing of water, water will be saved, and a carbon-rich cover material will be added after every use to absorb moisture and prevent odours instead. This material also helps to break down the waste. Once the process has been completed, the dry compost can be safely removed and crucial sources from the solid can be retrieved for use in other components. Likewise, urine can be used as fertilizer because it is harmless on its own and contains nutrients, such as nitrogen, phosphorus, and potassium for use in other places. The innovative design can save resources and will be a sustainable addition to Aquarius.

Chapter 14 ~

Oxygen in Aquarius

Ever go out and take a deep breath? Feels nice, doesn't it? What you're inhaling is a mixture of gases that are present on Earth, with one of them being oxygen. O^2 is one of the most important gasses in the atmosphere because they are the direct cause of our survival. In fact, 10 minutes without oxygen would cause brain death, therefore, it is not even a question that Oxygen in Aquarius will always be present.

Air Composition Requirements

- *Essential Chemical Elements*
  - Oxygen (O^2): Human life depends on oxygen to sustain life. We need adequate oxygen levels for the survival of the crew.
  - Carbon Dioxide (CO^2): Carbon dioxide must be removed efficiently as high levels can lead to several respiratory issues and health problems.
  - Nitrogen (N^2): While not directly consumed, maintaining a proper balance of nitrogen is important for the crew's comfort and functionality of the equipment.
- *Target Humidity Levels*
  - Maintaining optimal humidity levels (around 40-60%) is essential for the comfort of the crew and for preventing respiratory and equipment issues. If there is too much or too little humidity, problems can arise.
- *Trace Gases and Contaminants*
  - Monitoring and controlling trace gasses such as methane (CH^4), ammonia (NH^3), and volatile organic compounds (VOCs) is essential to ensure the crew's safety and health.

Air Supply Sources

- *Oxygen Production*
  - Electrolysis of Water: Water electrolysis splits water (H_2O) into hydrogen (H_2) and oxygen (O^2). Oxygen is collected for breathing, while hydrogen can be stored or used as fuel.
  - Solid Oxide Electrolysis (SOXE): SOXE technology allows for oxygen extraction from carbon dioxide and water, offering increased efficiency and reduced resource consumption.
- *Nitrogen Supply*
  - Tanks of Compressed Nitrogen: Compressed nitrogen tanks can provide the required nitrogen balance within the spaceship.
- *Monitoring and Control Systems*
  - Sensors: High-precision sensors continuously monitor oxygen, carbon dioxide, humidity, and trace gasses to ensure levels remain within safe and comfortable limits.
  - Automation: Automated control systems adjust the production of oxygen and removal of carbon dioxide and other contaminants as needed.

Air Filtration System

- *Carbon Dioxide Removal*
  - Chemical Absorption: Chemical absorbents like lithium hydroxide (LiOH) or amine solutions can efficiently trap and remove unnecessary carbon dioxide particles from the air.
  - Cryogenic Separation: Cryogenic processes can cool and separate carbon dioxide from the air for removal.
- *Trace Gas Removal*
  - Adsorption: Specialized adsorbents like zeolites or activated carbon are used to capture trace gasses.
  - Catalytic Converters: Catalytic converters facilitate the conversion of harmful gasses into less harmful or inert compounds.
- *Particulate Filtration*
  - HEPA Filters: High-Efficiency Particulate Air (HEPA) filters capture microscopic particles, including dust, allergens, and other contaminants.
- *Bacterial and Viral Filtration*
  - UV-C Sterilization: Ultraviolet (UV-C) light is used to sterilize the air, killing bacteria and viruses, and enhancing crew health.
- *Humidity Control*
  - Condensation/Dehumidification: Excess humidity is condensed and removed from the air.
  - Evaporative Cooling: Water vapour can be added to the air to control the humidity and can provide cooling when needed.
- *Integration and Redundancy*
  - The different filtration methods work together, providing redundancy to make sure we are safe and ensuring the removal of contaminants even in the event of a particular system failure.

Air Recycling and Regeneration

- *Closed-Loop System*
  - A closed-loop system maximizes the use of resources by continuously recycling and regenerating air components and minimizing waste.
- *Carbon Dioxide Recycling*
  - Sabatier Reaction: The Sabatier process uses hydrogen to react with carbon dioxide, producing methane and water. The methane produced can also be recycled to be used as fuel.
  - Carbonate Formation: Carbon dioxide can be captured and converted into carbonates for storage.
- *Oxygen Regeneration*
  - Electrolysis of Water: Water electrolysis regenerates oxygen from water, and hydrogen can either be stored or used as a fuel source.
  - Solid Oxide Electrolysis: SOXE can regenerate oxygen efficiently from carbon dioxide and water
- *Nitrogen Regeneration*
  - Nitrogen is efficiently maintained within the closed system, with minimal need for regeneration due to its inert nature.

- *Water Management*
  - Water Vapor Recovery: Water vapour from exhaled breath and other sources is captured and condensed for reuse.
  - Water Purification and Recycling: Advanced water purification systems ensure that water remains potable and available for consumption.
- *Monitoring and Maintenance*
  - Monitoring and maintaining the recycling system regularly is essential to make sure that it is both functional and reliable.

Emergency Air Supply

- *Backup Oxygen Tanks*
  - A supply of emergency oxygen tanks is available in case of critical system failures to ensure crew survival.
- *System Failure Contingency Plans*
  - Detailed contingency plans are in place to maintain adequate air supply, outlining the procedures for addressing and mitigating system failures.

Environmental Impact

- *Resource Utilization and Sustainability*
  - Using our resources efficiently makes sure that we can be sustainable by reducing the necessity for continuous resupply from Earth, which minimizes the environmental impact of the mission.
- *Waste Management*
  - Waste gasses and byproducts are managed and processed, ensuring minimal environmental impact both inside the spaceship and on Mars.

Chapter 15 ~

Government in Aquarius

On Earth, the political system is a highly comprehensive and important part of creating a well-functioning society. However, the political system within Aquarius will be kept simple to prioritize survival, not a power-segregated community. The government style that would be most beneficial to the residents of the settlement would be Isocracy because it advocates for equality in decision-making and governance. Every individual has an equal voice and influence in the political process, fostering a sense of togetherness among the inhabitants where decisions would be made collectively through consensus-building processes. In the space colony, where resources are limited, the community must cooperate effectively in order to put forward the concerns in an orderly fashion. For example, there will be representatives (i.e., minister of education, minister of technology, minister of nutrition and so on) who are specialized in different aspects of the settlement to bring light to issues in their respective sectors. Another crucial rule aboard the settlement is the intolerance of crimes, where immediate consequences will be put into place if such incidents are to occur - their punishment will be determined based on the intensity of the conflict. For instance, physical assault would result in removed access from certain privileges, and/or isolation or confiscation of prized possessions. Punishing the criminals will not be the only solution because it is equally essential to work towards prevention and rehabilitation to address the root cause of criminal behaviour. Thus, prevention programs would be implemented aiming to address the underlying social issues. Then, rehabilitation would provide access to education and training to influence positive behaviour. Rather than relying solely on punishment, the community of Aquarius will work towards reducing crime rates for a more inclusive environment.

To further increase equality in the settlement and protest the rights of every resident, some basic crucial laws will be set in place, similar to the Canadian Charter of Human Rights and Freedom:

- *Right to Life and Security:* Every resident has the right to life, liberty, and security, where the utmost priority will be protection from violence and harm.
- *Freedom of Expression:* Every resident has the freedom to express their thoughts, opinions, and beliefs, so long as it does not violate others' rights and dignity.
- *Equality and Non-Discrimination:* All residents have equal rights and there will be no tolerance for any form of discrimination.
- *Right to Privacy:* Residents have the right to privacy and protection against unauthorized intrusion.
- *Right to Education:* Every resident has the right to access quality education to ensure equal opportunities for learning and personal development.
- *Right to Health and Well-being:* Residents have the right to access healthcare services, sanitation, clean water, and other necessities for maintaining good health and well-being.
- *Freedom of Religion and Belief:* Residents have the freedom to practice their religion and/or beliefs while respecting others

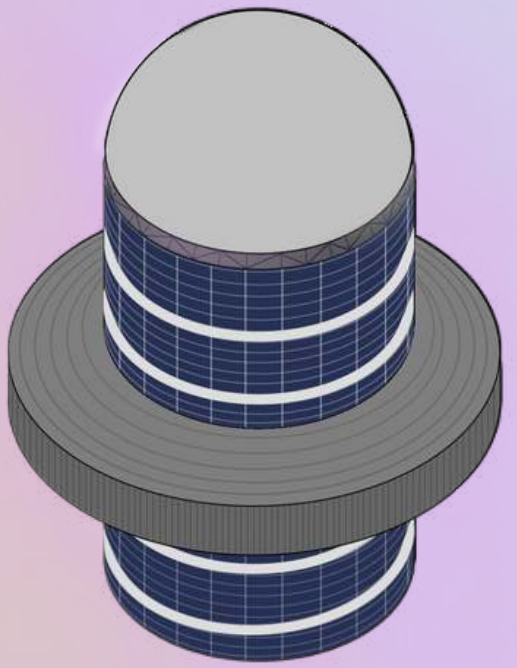
In addition to these laws, a population control policy will be established to control the number of residents abroad. Each family will need to adhere to the one-child policy. However, some exemptions may include one pregnancy resulting in twins or triplets. If Aquarius proves to be completely permanent and successful, fully independent of Earth and becomes a stable medium for supporting life, removal of this policy will be considered.

Chapter 16 ~

Energy in Aquarius

On average, the energy consumption of a house is around 9500KWh annually. This demonstrates the need for efficient sources and large amounts of energy for Aquarius to thrive. Mars receives about 590 Watts of sunlight per m^2, thus, solar energy will serve as the primary source of energy on the settlement. Solar panels will cover the exterior of the settlement to allow for ample energy absorption. Photovoltaic panels are the ideal choice, as they can withstand the extreme conditions of space on several occasions. For more efficiency, Fresnel lenses - an application used to gather light - may also be used to concentrate sunlight and transform it into energy to utilize in a similar way.

Since the external surfaces will be covered with solar panels, and windows will not be present, an artificial sunbeam will be placed right at the center of the inner component to stimulate an environment that mimics Earth. In terms of the light sources used within Aquarius itself, Photosynthetic Active Radiation (PAR) supported by kW output lamps (high-pressure sodium, or fluorescent xenon lamps) is the best option, compared to LEDs. However, they can be limited in intensity for some plants such as spinach, tomato and bell pepper. Alternatively, sulfur-microwave lamps offer bright visible light with a near-solar spectrum - it encompasses a quartz envelope filled with small amounts of Sulfur and Argon ionized by microwaves with high efficiency. And so, a combination of these two resources will be used in cohesion to provide efficient light within Aquarius. Apart from stored solar energy, wind energy is another energy source that can be used to a certain extent. Scattered, stable windmills - manufactured to encompass solar wind satellite technology and plasma magnets- will be placed on the exterior of the spaceship to harness the power of strong solar winds and convert them into electricity. This technology has the possibility of generating 100 billion times the power needed currently on Earth, demonstrating that more than enough fuel needed for the spaceship can be generated through solar and wind energy.

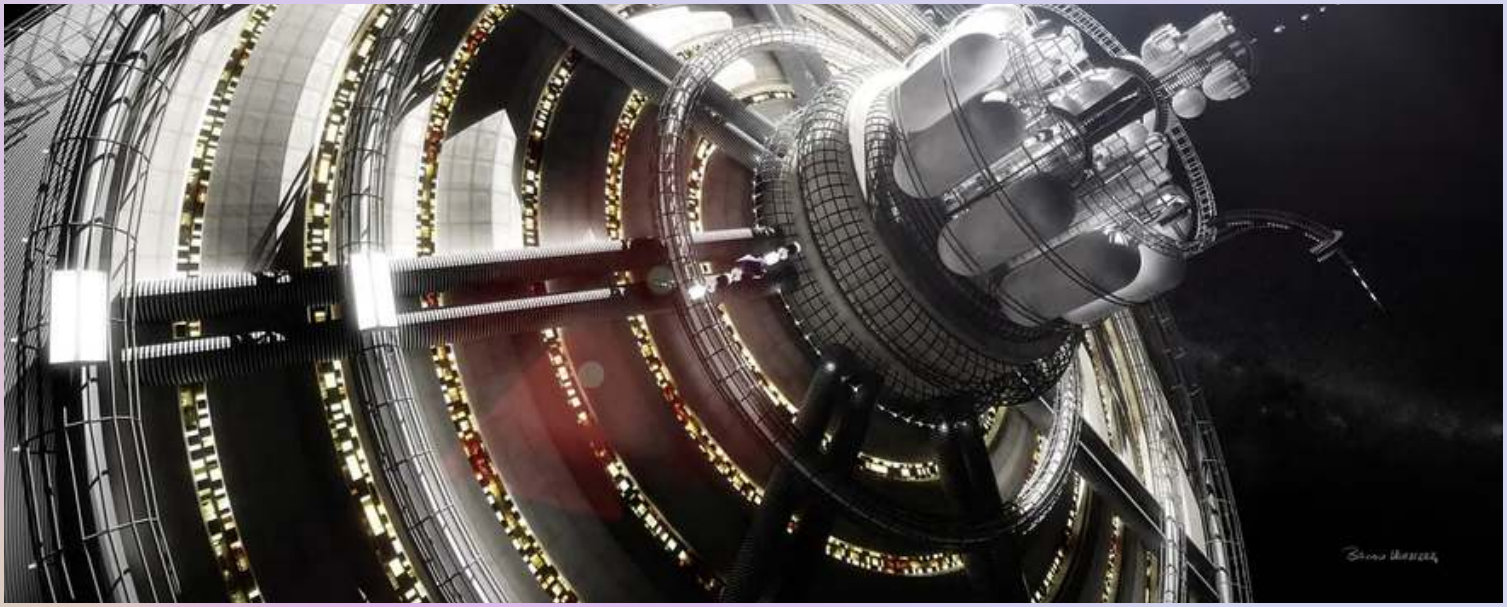


Perhaps another completely plausible source is nuclear power. However, the new settlement promotes a more sustainable expenditure of energy, and the usage of nuclear fusion and fission can create greenhouse gasses. Nonetheless, the occasional use of nuclear energy would be useful in desperately needed situations with the help of Radioisotope Thermoelectric Generators (RGT) technology. The RGT converts thermal energy into usable power with the help of thermocouples, which can serve as a backup kept on board for emergencies.

Chapter 17 ~

Communication in Aquarius

Over the years, communication has changed a lot. Handwritten letters were replaced by emails, the telephones were replaced by smartphones and the internet was the new newspaper. So it's understandable why establishing a sustainable settlement with equitable access to communication and data is one of the primary goals. The following outline details the communication and logistics plan for Aquarius.



Credit: Bryan Versteeg

Satellite Network Deployment → To provide access to mobile communication and data for all settlers.

Steps:

- Launch and deploy a constellation of communication satellites in Martian orbit.
- Ensure satellites are strategically positioned to cover the entire settlement area.
- Optimize the satellite network for low-latency data and communication.
- Implement secure and robust encryption protocols to protect communication (and to avoid the hacking of any AI from Earth).

Free Data and WiFi Access → To foster a sense of community and equality among settlers.

Steps:

- Set up Wi-Fi access points within the settlement area.
- Establish data distribution hubs for equitable access.
- Implement policies on data usage to prevent abuse and ensure fair distribution among settlers.

Surveillance and Threat Detection → Make sure the settlement is safe and secure.

Steps:

- Adapt ISS technology for surveillance and threat detection.
- Utilize advanced cameras and sensors to monitor the Martian surroundings.
- Implement machine learning algorithms for threat detection and anomaly identification.
- Establish an alert system to notify settlers of potential dangers.

Earth Communication → To maintain a connection with Earth for emergency assistance and data exchange.

Steps:

- Employ radar technology and certain frequency bands to enable long-distance communication.
- Establish a dedicated Earth-Mars communication network.
- Continuously monitor the health of communication equipment and perform regular maintenance.
- Implement redundancy and backup systems to ensure constant connectivity.

Emergency Protocols → To prepare and respond to emergencies.

Steps:

- Develop emergency communication protocols.
- Conduct regular drills and simulations.
- Establish an emergency response team for immediate actions.

Data Privacy and Security → Protecting the privacy and security of the settlers' data.

Steps:

- Implement robust cybersecurity measures to safeguard personal information.
- Settlers will be educated on the best practices for data privacy and security.

Ongoing Improvement → To ensure the effectiveness and reliability of the communication and logistics on the settlement.

Steps:

- Periodically evaluate and upgrade communication technology.
- Seek feedback from settlers to address any issues or concerns.
- Stay updated on technological advancements to enhance the system.

Chapter 18 ~

Biodiversity in Aquarius

Aquarius would thrive with the inclusion of animals, however, they would not be brought on the settlement due to the limited resources and environmental constraints. Animals require a significant amount of resources, which are better used for human needs and scientific equipment. Their addition can also lead to greenhouse gas emissions and air quality issues. Prioritizing the quality of life for the 3000 residents, conserving resources for humans, and furthering technological expansion was decided upon.

Bacteria, being a highly diverse group of organisms, possess the remarkable ability to synthesize a wide range of compounds and break down nearly any waste material, even within closed-loop systems. And so, their presence was of utmost importance on the spacecraft. Through biochemical engineering, scientists can engineer bacteria for specific purposes, such as metabolizing waste products or producing desired compounds. Bacteria can be easily brought from Earth and contained, minimizing the risk of contamination. And with proper restrictive measures in place, bacteria can be safely utilized without posing a threat to the health and safety of astronauts or the integrity of the spacecraft. For example, anaerobic bacteria will be brought from Earth so anaerobic digestion can be done on the settlement. As well as phytoplankton; prolific oxygen producers through photosynthesis, can serve as a reliable and efficient source of oxygen. In other words, this closed system is designed to be completely regenerative, so that no material leaves the system or needs to be added into the system. With the help of these little organisms, as well as certain technology, this goal is fully achievable.

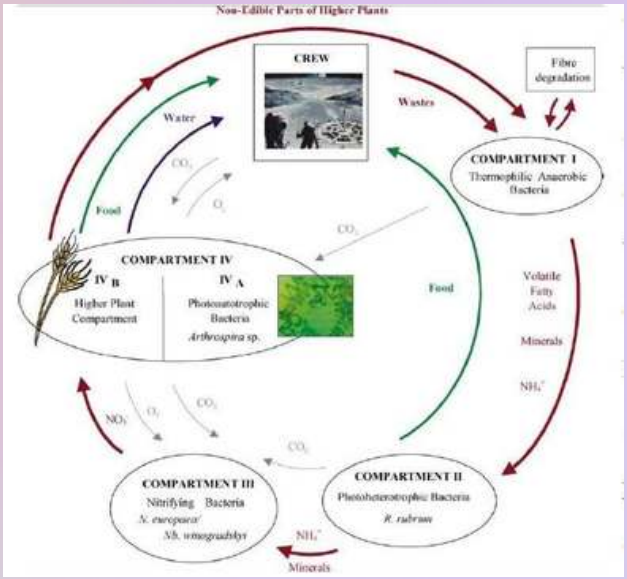
The Micro-Ecological Life Support System Alternative (MELiSSA) is the most advanced and well-researched closed-loop life support system on Earth, having been in development in cooperation with the European Space Agency. The core of MELiSSA comprises a series of interconnected bioreactors populated by different strains of bacteria, algae, and higher plants, each tasked with specific functions essential for maintaining life support functions in space habitats. This concept is a crucial part of Aqaurius and consists of five compartments. The first three compartments are for processing waste products, the fourth compartment contains higher plants, mostly for the production of breathable air and filtration of potable water, and the fifth and final compartment houses the crew.

Credit: Bryan Versteeg / Spacehabs.com

Compartment I serves a crucial role in waste management because the anaerobic bacteria digest the solid waste into carbon dioxide, volatile fatty acids, and ammonium. Among the species of bacteria present in Compartment I, Fibrobacter succinogenes is most present as it can efficiently break down fibrous waste materials without the use of oxygen (a precious resource in the settlement). Due to its ability to thrive at elevated temperatures, it can be used in the decomposition process of organic waste to catalyze the breakdown of the bonds found within feces.

Compartment II is a single photoheterotrophic compartment that exists to eliminate the terminal metabolites that would be the byproducts of Compartment I. Rhodospirillum rubrum, selected for this compartment, would carry out the task by converting the amino acids from Compartment I into free ammonium to be further utilized or eliminated. This bacteria would function by feeding onto the volatile fatty acids, removing the byproducts from the waste stream, and ensuring efficient recycling of resources.

Compartment III is the nitrifying cavity, where its primary role is to convert free ammonium from Compartment II into nitrates (essential nutrients for higher plants in the system). Ammonium would be oxidized into nitrations by a mixture of 2 species: Nitrosomonas and Nitrobacter, similar to the nitrogen cycle on Earth. Both species utilize carbon dioxide as their sole carbon source for growth. Therefore, Compartment III acts as an additional carbon sink within the system, aiding in the removal of carbon dioxide and contributing to the overall balance of carbon cycling. Similarly, Nitrosomonas and Nitrobacter also efficiently eliminate any micropollutants, thereby safeguarding the integrity and functionality of the overall ecosystem. By integrating mechanisms for both nutrient cycling and pollutant removal, Compartment III contributes to the sustainability and resilience of the closed-loop ecosystem onboard the spacecraft.



Credit: European Space Agency

Compartment IV is divided into two sub-compartments: the first containing the higher plants and the other containing cyanobacteria. Both sub-compartments play crucial roles in supporting life and maintaining the overall integrity of the closed-loop system. Higher plants utilize carbon dioxide from the spacecraft's atmosphere and fix it through photosynthesis, producing breathable oxygen as a byproduct. Additionally, the higher plants utilize nitrate from the waste processing compartments, contributing to the recycling of nutrients within the spacecraft ecosystem. Cyanobacteria, on the other hand, are highly efficient at removing carbon dioxide from the spacecraft's atmosphere through photosynthesis regulating the carbon dioxide levels and maintaining a habitable environment. The combination of higher plants and cyanobacteria ensures a resilient and sustainable ecosystem, capable of sustaining an entire settlement.

Compartment V would house the people. In other words, the central habitat and living quarters where daily activities would be carried out. This portion would be the majority of the settlement that is designed to support everyone's health and well-being, aimed to provide a safe, comfortable, and functional environment in the settlement.

Chapter 19 ~

Transportation in Aquarius

Aquarius is designed to ensure that every destination is within a reasonable walking distance, which would encourage both physical fitness and sustainability. Consequently, no vehicles will be brought to the settlement for the safety of the residents and control of greenhouse gas emissions. However, access to community bikes will be available throughout. The buildings on the settlement will be interconnected through skyways, while the outside environment will be designed to have many walkways and passages. Not only does this facilitate convenient movement, but it adds to the intricate design within.

Perhaps one of the most loved forms of commuting about the interior is the seamless conveyor belts, integrated into the infrastructure to facilitate the transport of heavy materials across various sectors as well as act as “highways” for pedestrians. This integration ensures a smooth flow of resources between different areas of Aquarius, moving from the residential area to the common hub and the industrial sectors. For others, these belts will aid in getting from one place to another faster than walking but serve as an alternative to biking. In terms of vertical transportation within multi-story buildings, all buildings with multiple floors will have escalators. Escalators are a great bridge between stairs and elevators, providing efficiency as they are functional despite any malfunctions. The transportation setup within Aquarius is designed to emphasize pedestrian mobility, efficiency, and safety within the settlement's enclosed environment.

Credit: Bryan Versteeg, Retrived from: https://www.thespacereview.com/

Epilogue

Air. Water. Food. Shelter. These necessities were, frankly, taken for granted back on Earth. When Coronovirus hit in 2019 and the entire world came crashing down, these resources became our one and only goal. But then, not even 3 years later, we were back to being our greedy human selves: seeking to dominate and take over. All that changed again after the AI invasion. Now they were the ones taking over and humanity had no hope but to flee their very own planet.

Nonetheless, this is a new chapter in the history of humanity, where we are yet again put to the test to survive and keep our species flourishing. We chose Mars, wanting our new home to be free from the reigns of the AI bots and to constitute a place of new beginnings. We had never understood the importance of the basic needs that Earth fulfilled every day, but within our settlement, we had to make sure that all these necessities were present and that the ideologies, morals and ethics we followed were not like the wrongdoings of our ancestors.

Aquarius, our floating colony, is a symbol of human perseverance and creativity - where against all odds, human life survives. Within its futuristic domes and green spaces, residents have the chance to immerse themselves in a world where the qualities of life-sustaining Earth and the mysterious cosmos blend together, promising an experience that foreshadows the greatness of the future. Aquarius's dedication to sustainability and self-sufficiency isn't just an idea, but a way of life - woven into every part of the settlement's design and function. Hydroponic gardens may be seen as fulfilling human hunger with fresh vegetables, fruits, and beans. The solar panels harness the power of the sun's beams for usage throughout the system. Waste does not go to waste; it also drives the spaceship. Water, the elixir of life, is cleansed and maintained throughout the spacecraft in order to hydrate and support life. Together, allowing humans on the settlement to feel the familiarity of Earth.

While the groundwork of this space settlement is quite impressive, Aquarius represents far more than just its physical components. It characterizes the qualities of the human species, where dedication and commitment are at the core. Under the shining stars of space, residents have the opportunity to meet each other, mingling and thriving upon one another's company. And, each inhabitant plays their role in sustaining the life upon Aquarius while showcasing their skills and contributing their values to the betterment of their neighbourhood.

With every generation that reads this Life Book, we hope they see how much effort the generations before put into making a settlement that was worth every drop of sweat. Most importantly, we hope that our species continues to prosper in the right way, learning from mistakes and this time, taking the right steps to create a never-ending future.

Special Thanks to:

Ms. Simona Matei, for being our stepping stone
and constant pillar of support

Kashyap Patel, for being our guide and
inspiration to start this project

Your honest feedback and consistent motivation
is what brought us all this way to the finish line

AUTHORS

Harnoor Jhinzer
~ Team Lead ~

Yashaswini Munam
~ Team Lead ~

Hiya Shah

Japleen Saini

Divya Singla

Priyal Sanghvi

Bibliography ~

Anyoha, R. (2017, August 28). The History of Artificial Intelligence. Science in the News. https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/

Bonsor, K. (1970, January 1). How asteroid mining will work. HowStuffWorks Science. https://science.howstuffworks.com/asteroid-mining.htm

Brown, D., & Cantillo, L. (2015, September 28). NASA confirms evidence that liquid water flows on today's Mars. NASA. https://www.nasa.gov/news-release/nasa-confirms-evidence-that-liquid-water-flows-on-todays-mars/

Christiansen, E. L., & Lear, D. M. (2012, February). Micrometeoroid and Orbital Debris Environment & Hypervelocity Shields. Houstan; NASA Johnson Space Center.

Destefanis, R., Amerio, E., Briccarello, M., Belluco, M., Faraud, M., Tracino, E., & Lobascio, C. (n.d.). SPACE ENVIRONMENT CHARACTERISATION OF KEVLAR®: GOOD FOR BULLETS, DEBRIS AND RADIATION TOO . Torino; TAS-I - Thales Alenia Space - Italia S.p.A., Strada Antica di Collegno.

Ellery, A. (2021, July 30). Supplementing Closed Ecological Life Support Systems with In-Situ Resources on the Moon. National Library of Medicine. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8401783/

Gentle World. (2023, March 25). Vegan menu to meet the needs of astronauts. https://gentleworld.org/vegan-menu-to-meet-the-needs-of-astronauts/

Globus, A., Arora, N., Bajoria, A., & Straut, J. (n.d.). The Kalpana One Orbital Space Settlement Revised. Reston; American Institute of Aeronautics and Astronautics.
Government of Canada, D. of J. (2023, June 29). Charterpedia. Government of Canada, Department of Justice, Electronic Communications. https://www.justice.gc.ca/eng/csj-sjc/rfc-dlc/ccrf-ccdl/check/index.html

Graef, L. (2023, October 26). How does a composting toilet work?. Trelino® Toilets. https://mytrelino.com/en-ca/blogs/news/how-does-a-composting-toilet-work

Gutro, R. (2016, June 23). The complex material engineering of NASA's Webb Telescope Sunshield. NASA. https://www.nasa.gov/universe/the-complex-material-engineering-of-nasas-webb-telescope-sunshield/

Jaber, S. (2020, September 24). Op-ed: Materials that could bring life to Mars. SpaceNews. https://spacenews.com/op-ed-materials-that-could-bring-life-to-mars/#:~:text=There%20are%20also%20plentiful%20mineral,a%20basic%20ingredient%20of%20glass

Jones, L. (n.d.). BBC Earth: Six fashion materials that could help save the planet: BBC earth. BBC Earth | Six fashion materials that could help save the planet | BBC Earth. https://www.bbcearth.com/news/six-fashion-materials-that-could-help-save-the-planet

Libretexts. (2022, December 24). 17.3b: Wastewater and Sewage Treatment. Biology LibreTexts. https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(Boundless)/17%3A_Industrial_Microbiology/17.03%3A_Wastewater_Treatment_and_Water_Purification/17.3B%3A_Wastewater_and_Sewage_Treatment#:~:text=Wastewater%20is%20treated%20in%203,and%20tertiary%20(extra%20filtration)

Melissa pilot plant. Melissa. (n.d.). https://www.melissafoundation.org/page/melissa-pilot-plant

NASA. (2020a, October 8). Educator guide: The air up there: Making space breathable. NASA. https://www.jpl.nasa.gov/edu/teach/activity/the-air-up-there-making-space-breathable/

NASA. (2020b, December 18). NASA's Webb Sunshield successfully unfolds and tensions in final tests. NASA. https://www.nasa.gov/missions/nasas-webb-sunshield-successfully-unfolds-and-tensions-in-final-tests/

Nextel ceramic fabric stars in recent International Space Station Walk. The American Ceramic Society. (2012, August 27). https://ceramics.org/ceramic-tech-today/nextel-ceramic-fabric-stars-in-recent-international-space-station-walk/

Platt, J. (2021, February 2). Mars facts. NASA. https://mars.nasa.gov/all-about-mars/facts/

Platt, J. (n.d.-a). Entry, descent and landing (EDL). NASA. https://mars.nasa.gov/mars2020/timeline/landing/entry-descent-landing/

Platt, J. (n.d.-b). Trip to Mars. NASA. https://mars.nasa.gov/mars2020/timeline/cruise/

Product markets - aircraft & aerospace: The Aluminum Association. Product Markets - Aircraft & Aerospace | The Aluminum Association. (n.d.). https://www.aluminum.org/product-markets/aircraft-aerospace#:~:text=Designers%20know%20that%20aluminum%20alloys,conditions%20on%20earth%20%E2%80%93%20and%20beyond.&text=Aluminum%20has%20played%20a%20crucial,the%20stressors%20of%20space%20travel

Quinlan, H. (2023, November 30). How aerogels work. HowStuffWorks Science. https://science.howstuffworks.com/aerogel.htm

Redford, C. (2020, June 23). Why go to Mars? the Pros and cons of travelling to the Red Planet. Stargazers Club WA. https://stargazersclubwa.com.au/why-go-to-mars-the-pros-and-cons/

Roos, D., & Bos, S. (2023, October 17). What is the strongest metal on earth?. HowStuffWorks Science. https://science.howstuffworks.com/environmental/earth/geology/titanium.htm

Schuster, H., & Peck, S. L. (2016, December). Mars ain't the kind of place to raise your kid: Ethical implications of pregnancy on missions to colonize other planets. Life sciences, society and policy. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4996799/

scr00chy. (2021, September 5). What have we learned so far about crew dragon's cupola, the largest window to ever fly to space. ElonX.net. https://www.elonx.net/what-we-know-about-the-crew-dragons-cupola-the-largest-window-to-ever-be-flown-to-space/

Shulman, A. (2017, March 24). Aluminum use in NASA. Avion Alloys. https://avionalloys.com/nasa-use-aluminum/

Vegan fabrics are way better than wool-here's why. PETA. (2023, April 5). https://www.peta.org/living/personal-care-fashion/natural-vegan-fabrics/

Versteeg, B. (2015, April 9). Kalpana one. Medium. https://medium.com/space-anthropology/kalpana-one-318f4e3bef40

What do astronauts eat in space?. Royal Observatory. (n.d.). https://www.rmg.co.uk/stories/topics/what-do-astronauts-eat-space

How Does A Composting Toilet Work. ShopTinyHouses.com. (n.d.). https://www.shoptinyhouses.com/pages/how-does-a-composting-toilet-work