MARDOVI
STATION

"Genetics is not about fate-it is about opportunity."—J. Craig Venter

Coordinating teachers:

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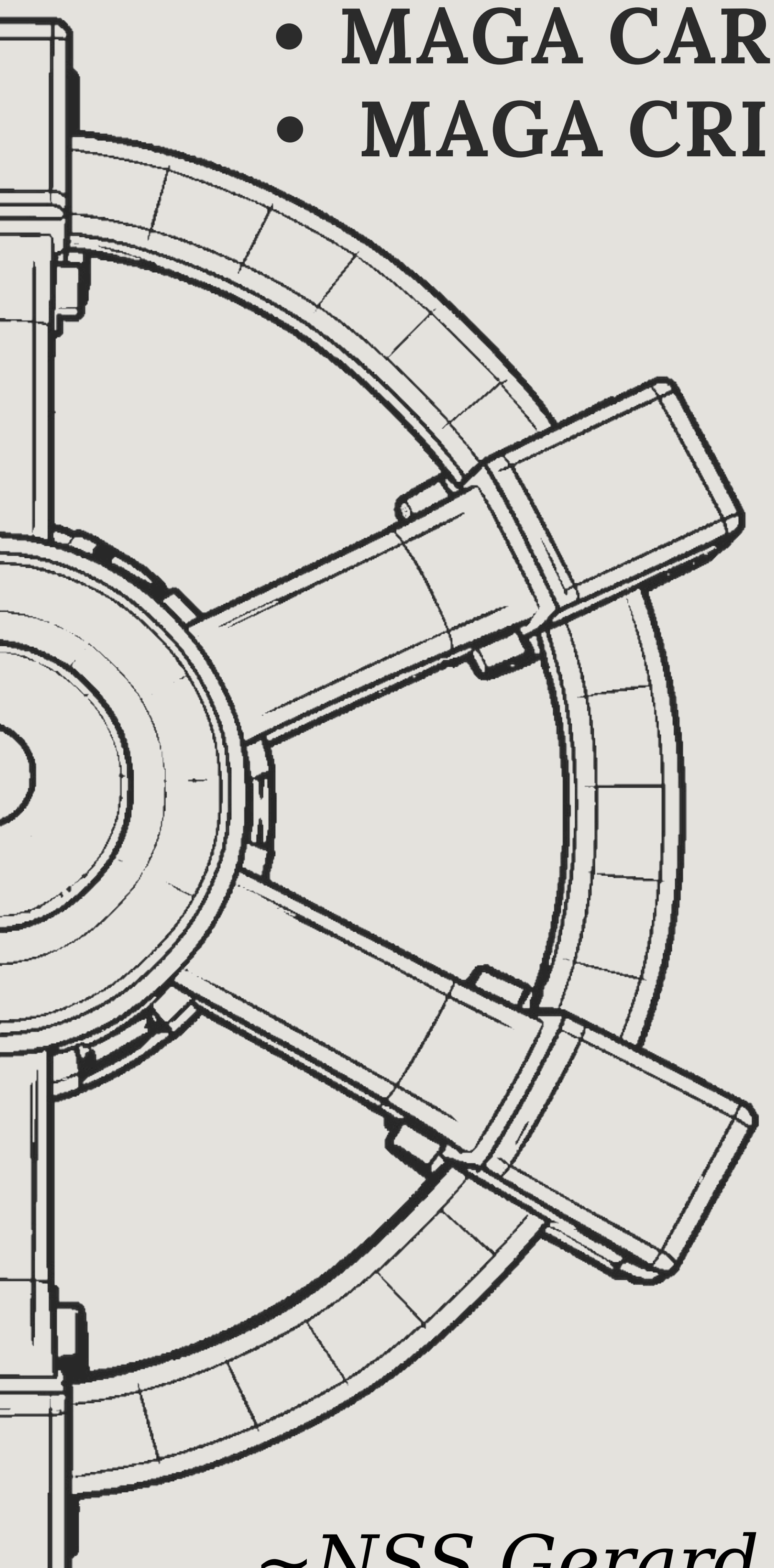


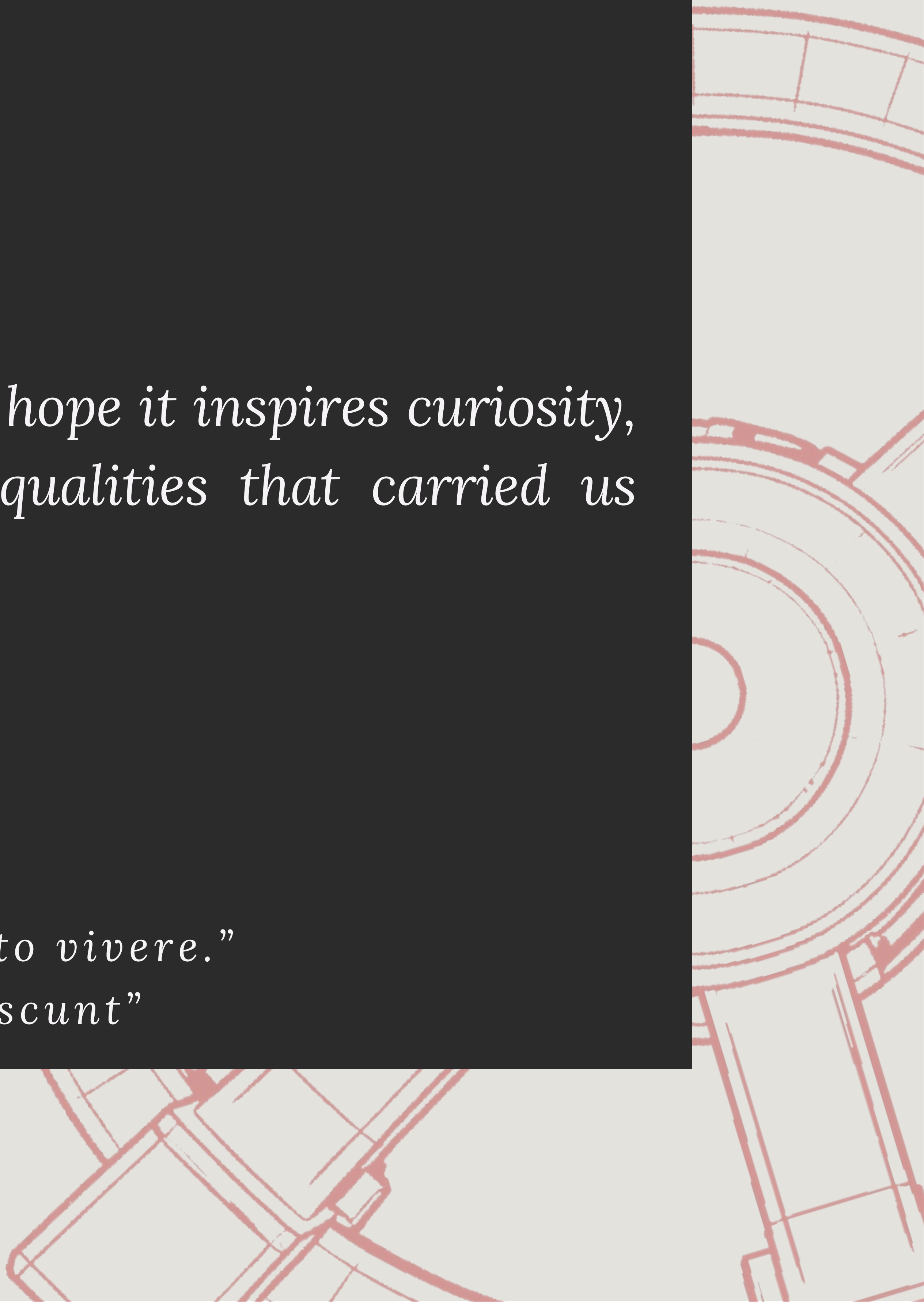
~NSS Gerard K. O'Neill Space Settlement Contest~

Preface-Initial considerations

- *Our team has traveled a long and sometimes challenging journey while developing this project. Each of us has brought our own passions, aspirations, and unique perspectives, which made even choosing the main theme a lively and sometimes difficult discussion. Along the way, we didn't just learn about how space stations operate, we also learned to value each other's qualities, listen, adapt, and collaborate as a team.*

- *Every photo in this presentation will be numbered. Those that were not created by our team are all credited at the end in a dedicated section of the bibliography. Under each image, we have included a brief explanation of its purpose to help guide the viewer through our thought process and design choices.*

- *As we present the vision of* MARDOVI, *we hope it inspires curiosity, perseverance, and teamwork—the same qualities that carried us through the creation of this project.*



"memento mori, et sic memento vivere."
"concordia parvae res crescunt"

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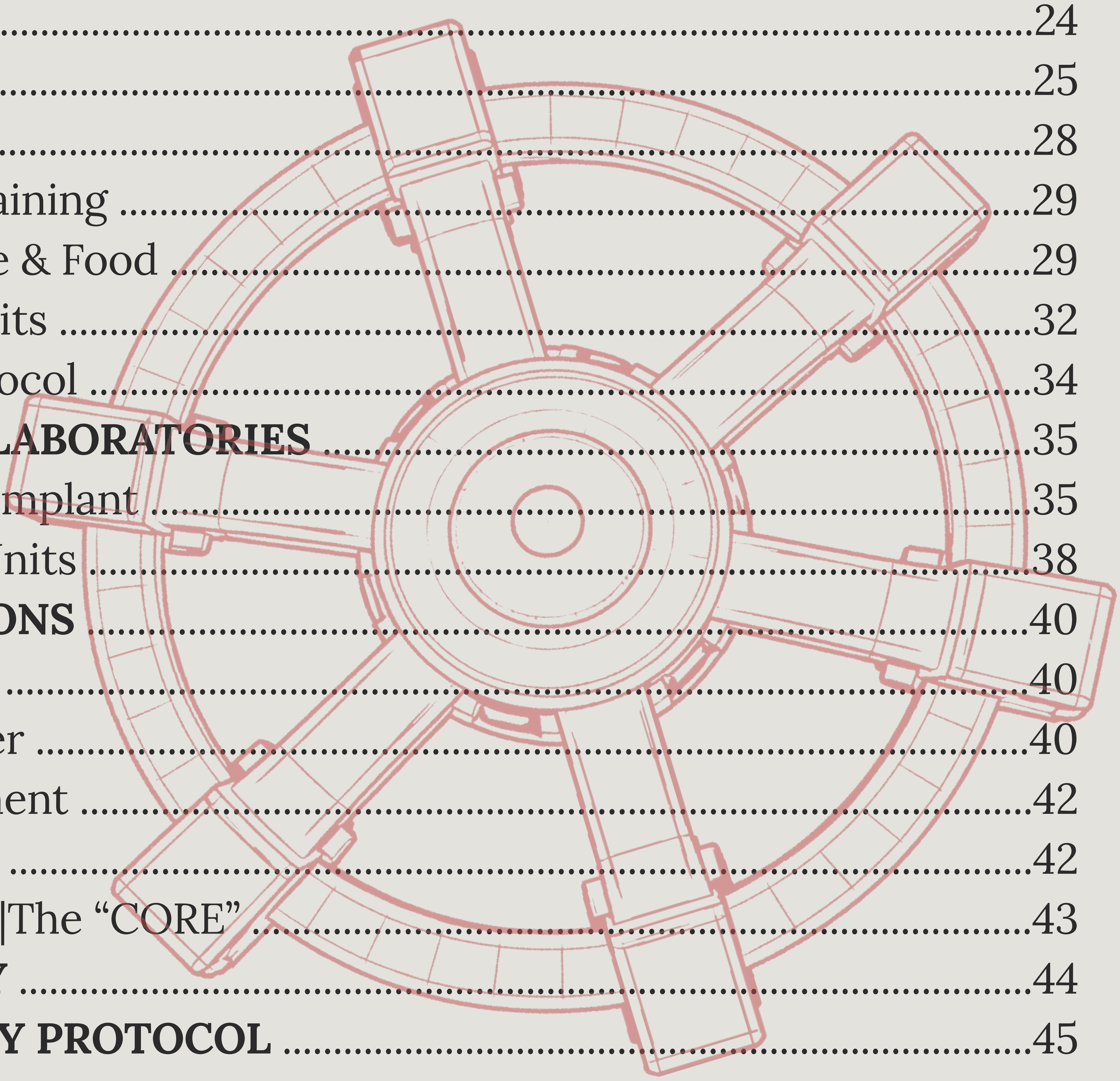

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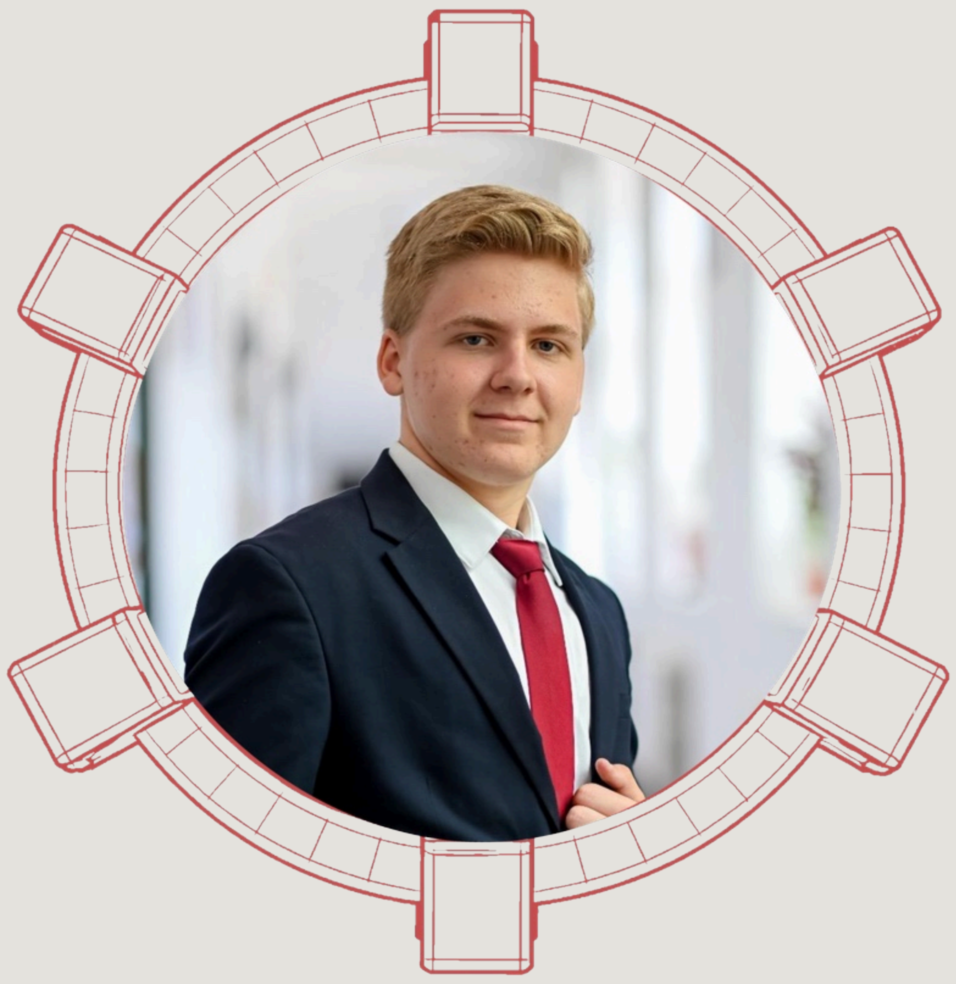

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I. INTRODUCTION TO MARDOVI

1.1 Why MARDOVI?

MARDOVI is designed to serve as a space station dedicated to scientific research, focused especially on genetics, in an environment that cannot be replicated on Earth. The main advantage of MARDOVI is the sterile and highly controlled conditions of our space station, which significantly reduces the risk of contamination from environmental pathogens, airborne particles, or uncontrolled biological variables.

We decided to focus our research on fibrodysplasia ossificans progressiva (FOP), an extremely rare genetic condition that affects the locomotor system. This condition requires delicate care, plenty of patience and demands tedious research because FOP affected individuals are very sensitive.

MARDOVI provides an optimal platform where experiments can be conducted with the use of artificial, but earth-equivalent gravity while still benefiting from the isolation, sterility, and control offered by a space-based laboratory.

We chose an illness that affects the locomotor system because we believe that being able to move freely is an ability that everyone should have. This is exactly how we chose the name of our space station. It is inspired from many mythology figures, each letter being a symbol of freedom for movement.
M- MARS, god of War, a symbol for fighting for what you believe in.
A- Apollo, god of music and healing
R- Rhea, mother of the Olympian gods
D- Dionysus, also known as ‘the wandering god’
O-Olympus, home of the gods. Chosen by us to show that MARDOVI isn’t just for research, it is also meant to be a home.
V-Victoria, goddess of Victory
I- Icarus , who we see as a symbol of ambition and freedom

1.2 Our Goal

Our space station’s long-term scientific mission is to advance research toward potential treatments for Fibrodysplasia Ossificans Progressiva (FOP). While a complete cure is not currently supported by sufficient scientific evidence, we aim to contribute meaningful data and technological innovations that may, over time, improve understanding of the disease and inform future therapeutic approaches. Rather than guaranteeing a cure, our objective is to achieve measurable progress, such as reducing flare-up frequency, improving mobility outcomes, and extending quality-adjusted life expectancy for individuals affected by FOP.

In the short to medium term, our primary goal is to improve daily life for people living with FOP. We plan to design and test adaptive prosthetic and assistive devices that enhance mobility while minimizing the risk of triggering flare-ups. Success will be measured through clinical indicators such as range-of-motion improvements, user-reported comfort levels, and reduced incidence of inflammation associated with movement.

To help provide a better understanding of our plan, we created the following chart:

Phase	Timeframe	Primary Objective	Key Activities	Measurable Outcomes	Risks & Limitations
Phase 1	0–5 years	Advanced monitoring and assistive technologies	Continuous monitoring of FOP progression Design and testing of non-invasive implants and prosthetic devices Collection of biomechanical and inflammatory data	Improved functional mobility (%) Reduced patient-reported discomfort Lower incidence of movement-induced flare-ups	Limited patient sample size, risk of flare-ups despite non-invasive design , technical constraints of long-term monitoring systems
Phase 2	5–15 years	Experimental and early-stage therapeutic trials	Evaluation of emerging pre-clinical and early clinical therapies, analysis of biological response and safety profiles, correlation of genetic, environmental, and physiological data	Safety and tolerability metrics, changes in validated FOP biomarkers, slowed rate of heterotopic ossification	Uncertain therapeutic efficacy, potential adverse effects, regulatory and ethical constraints on trials
Phase 3	15+ years	Advanced research toward potential curative strategies	Fundamental research into molecular and genetic mechanisms of FOP , exploration of gene-modifying or regenerative approaches	Identification of viable curative research pathways (without clinical guarantees)	High scientific uncertainty, long development timelines, ethical and safety challenges of advanced genetic interventions

All research conducted as part of this project will adhere to strict ethical standards. Participation will require informed consent, ensuring that patients fully understand the purpose, risks, and limitations of the research. An independent ethics committee will review and approve all study protocols. Patient data will be securely stored and anonymized in accordance with data protection regulations to safeguard privacy and confidentiality at every stage of the project.

1.3 Key Parameters

To simplify the data, we've added several charts highlighting the most important values and measurements.

Workforce distribution:

Unit/Functional Area	Positions
Command & Operations Unit	150
Engineering & Maintenance Unit	420
Healthcare Unit	260
Scientific Research Unit	330
Prosthetics & Assistive Technology Unit	140
Psychological Support & Well-being Unit	180
Ethics, Mediation & Legal Compliance Unit	110
Data Security & Information Systems Unit	140
Logistics & Resource Management Unit	170
Education & Child Development Unit	200

Autonomy:

Resource Category	Minimum Days of Autonomy
Oxygen (O2)	90 days
Water	120 days
Food (non-perishable)	180 days
Medical supplies	365 days
Spare parts & tools	180 days
Emergency equipment	90 days
Energy	≈75 days

Rotation:

- Tangential velocity: $v \approx 94 m/s$
- Angular velocity: $\omega = 1 rpm \approx 0.105 rad/s$
- Radius of the station: $r \approx 898$ m

Energy: 4.04MW of instantaneous power

II. CITIZEN SELECTION V.E.R.I.T.A.S

The selection of MARDOVI's initial population is guided by the understanding that human character cannot be fully captured through language alone. As John Steinbeck writes in East of Eden, **"Now that you don't have to be perfect, you can be good."** This principle forms the foundation of our selection process: we are not seeking flawless individuals, but those capable of **ethical choice, cooperation, and growth** when faced with uncertainty.

Rather than relying primarily on self-reported questionnaires or predictive interviews, MARDOVI's citizen selection emphasizes **observation over declaration**. In extreme and unfamiliar environments, individuals often behave in ways they could not have anticipated, regardless of honesty or intent. For this reason, readiness for life aboard the station must be demonstrated through experience rather than described in advance.

To achieve this, all candidates participate in the **V.E.R.I.T.A.S. Trial**
(Verification through Experience, Resilience, Integrity, Teamwork, Adaptability, and Self-control).

The V.E.R.I.T.A.S. Trial consists of a series of unannounced, controlled simulations that reflect realistic challenges of station life. Candidates enter these environments without detailed preparation, ensuring that spontaneous reactions, ethical judgment, and interpersonal behavior can be observed authentically. Scenarios include resource limitation, time pressure, cooperative problem-solving, and unexpected disruptions that require collective decision-making.

Throughout the trial, candidates are evaluated by a multidisciplinary committee trained to observe behavioral patterns rather than isolated outcomes. The focus lies on qualities such as emotional regulation, willingness to cooperate, response to failure, respect for others, and the ability to place collective well-being above individual advantage. Physical endurance and health are also assessed through regulated environmental stressors, with strict safety oversight.

Selection is not based on dominance, speed, or individual success alone, but on consistency of character across situations. Mistakes are expected and do not disqualify a candidate; instead, evaluators observe how individuals respond to error, responsibility, and shared challenge. In this way, the V.E.R.I.T.A.S. Trial reflects MARDOVI's broader philosophy that society is built not by perfection, but by conscious choice and mutual respect.

Component	**What It Measures**	**Evaluation Method**	**Scoring Range**	**Weight**
Adaptability	Ability to adjust to new environments, routines, and unexpected situations	Real-time simulations, unplanned scenario response	0–25	25%
Resilience	Stress management, emotional stability, recovery from setbacks	Monitored behavioral response under controlled stressors	0–25	25%
Integrity	Ethical decision-making, honesty, and fairness	Observed moral choices in dilemmas, peer and committee evaluation	0–20	20%
Teamwork	Cooperation, communication, conflict resolution	Group tasks, collaborative problem-solving, peer feedback	0–15	15%
Adaptability under Pressure	Ability to maintain performance under resource scarcity, time limits, or discomfort	Simulated emergencies, endurance challenges	0–10	10%
Self-Control	Impulse regulation, patience, and delayed gratification	Observed responses to frustration, temptation, and social conflict	0–5	5%
Total	—	—	**0–100**	**100%**

This is how the score of each candidate will be interpreted:

Score Range	**Evaluation**	**Suggested Action**
85–100	Excellent	Eligible for immediate integration;
70–84	Good	Eligible; may require targeted training in specific areas
50–69	Moderate	Conditional eligibility; must complete remediation or additional trials
<50	Insufficient	Not selected; candidate may reapply after further development

This will be considered for any position that the candidate applies for. Besides the Trial, each candidate will need to provide proof of their qualifications, each sector having a pre-destined number of positions. For example, the healthcare unit will start out with 200 open spots. The candidates which pass the trial will need to provide the following documents: A Bachelor's degree or higher in medicine, nursing, allied health sciences, or a closely related field and a minimum 3–5 years of experience in clinical or healthcare settings.

This is the chart we chose to follow regarding the workforce distribution. It has been created for a population of about 2500:

Unit / Functional Area	Core Function	Positions	Qualifications Needed
Command & Operations Unit	Governance, mission control, emergency response	**150**	Advanced training in aerospace operations, systems leadership, crisis management
Engineering & Maintenance Unit	Infrastructure, life support, power, repairs	**420**	Degree or technical certification in aerospace, mechanical, electrical engineering
Healthcare Unit	Medical care, pediatrics, rehabilitation	**260**	Medical degree or nursing license; specialization in space medicine or pediatrics
Scientific Research Unit	Biomedical, genetic, and environmental research	**330**	Master's/PhD in life sciences, medicine, bioengineering
Prosthetics & Assistive Technology Unit	Mobility aids, non-invasive implants	**140**	Degree in biomedical engineering, biomechanics, prosthetics
Psychological Support & Well-being Unit	Mental health, child development, cohesion	**180**	Degree in psychology/psychiatry; clinical or counseling certification
Ethics, Mediation & Legal Compliance Unit	Rights protection, mediation, ethical review	**110**	Degree in law, ethics, public policy; mediation training
Data Security & Information Systems Unit	IT systems, cybersecurity, data protection	**140**	Degree in computer science/IT; cybersecurity certification
Logistics & Resource Management Unit	Supplies, food systems, scheduling	**170**	Degree in logistics, operations, systems management
Education & Child Development Unit	Schooling, childcare, youth support	**200**	Degree in education, child development, pedagogy

Following successful completion of the behavioral and ethical components of the V.E.R.I.T.A.S. Trial, candidates proceed to a comprehensive medical assessment. This phase is not intended to select for physical superiority, but to ensure long-term health, safety, and sustainability within a closed space environment.

The medical evaluation includes full cardiovascular, neurological, musculoskeletal, and metabolic screening, as well as genetic and oncological risk assessments where ethically and legally permitted. Particular attention is given to conditions that could be exacerbated by confined living, limited medical evacuation options, or long-term exposure to artificial environments. Mental health evaluations continue during this stage to ensure psychological stability and stress tolerance over extended periods.

Importantly, the presence of manageable or non-progressive medical conditions does not automatically disqualify a candidate. Decisions are made based on treatability, resource impact, and long-term risk management rather than exclusionary standards.

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Final mentions:

- Participation in the V.E.R.I.T.A.S. trial is determined according to established fitness-for-duty criteria. All candidates must be 65 years of age or younger at the time of selection. This requirement reflects current health and performance standards necessary to ensure sustained contribution and successful adaptation to long-duration space life, and is not intended as age-based discrimination.
- The significant other of a qualifying candidate will not be brought abroad MARDOVI unless they manage to pass the trial. However, children of the candidates will be allowed on board because we strongly believe that the staff inside the space station will be able to provide proper care and education for the child. The only disqualifying factors will be the child not passing the medical evaluation or the existance of an at-risk behavioral background
- While MARDOVI fully upholds the individual right to freedom of belief and conscience, all residents are expected to exercise this right in a manner that respects the rights, safety, and well-being of others. When personal beliefs or practices give rise to interpersonal tension or operational concerns, the station provides structured mediation procedures to facilitate dialogue and mutual understanding.

III. ORBITING LOCATION

When we began to think about choosing the location of our space station, we took into account the following aspects: orbital stability, distance from Earth, crew safety against meteorites, and benefits in terms of resources. Our options were between placing the station in orbit around a planet, or placing it at one of the Lagrange Points. In the end, we have concluded that positioning the station at one of the Lagrange Points would be suitable due to the stability they provide. The more stability we ensure, the less fuel we will lose compared to what we would have lost while orbiting a planet.

1) What are the Lagrange Points?

Lagrange points (L1–L5) are special positions in space where objects placed there tend to remain in place. They indicate the positions where the gravitational attraction of two large bodies equals the centripetal force required for a space station to move along with them.

2) Which two-body system will we choose for the Lagrange Points?

After researching the systems we could choose from, only two options remained suitable for our case: Sun–Earth and Earth–Moon. By carefully analyzing these two possibilities, we concluded that the Sun–Earth system is the best option.

First of all, the cost of transporting materials will become cheaper and the transportation itself will be much more efficent, since we will be pretty close to Earth. Secondly, the Sun is a primary source of solar energy, which will help us illuminate the station through a fiber-optic system by capturing solar light. *(More information is provided in Chapter V, LIFE SUPPORT, Section 5.2 Lighting.)*

3) At which Lagrange Point will the space station be placed?

In order to determine the optimal position for our space station, we analyzed each Lagrange point.

We immediately ruled out the L3 point, since it is symmetric to Earth with respect to the Sun and is practically impossible to station there. The L1 and L2 points are positions in space that do not provide orbital stability.

If we were to place our space station at one of these points and it were slightly displaced from its trajectory, it would eventually change its orbit and require constant station-keeping maneuvers.

Thus, only the L4 and L5 options remained. These are relatively stable regions that offer both logistical and energy-related advantages. For example, since both provide orbital stability, the energy and fuel required to maintain the orbit are low. However, our space station needs protection from potential space debris, which is provided only by the L5 point. Therefore, our station will be placed at the Lagrange Point L5 in the Sun–Earth system.

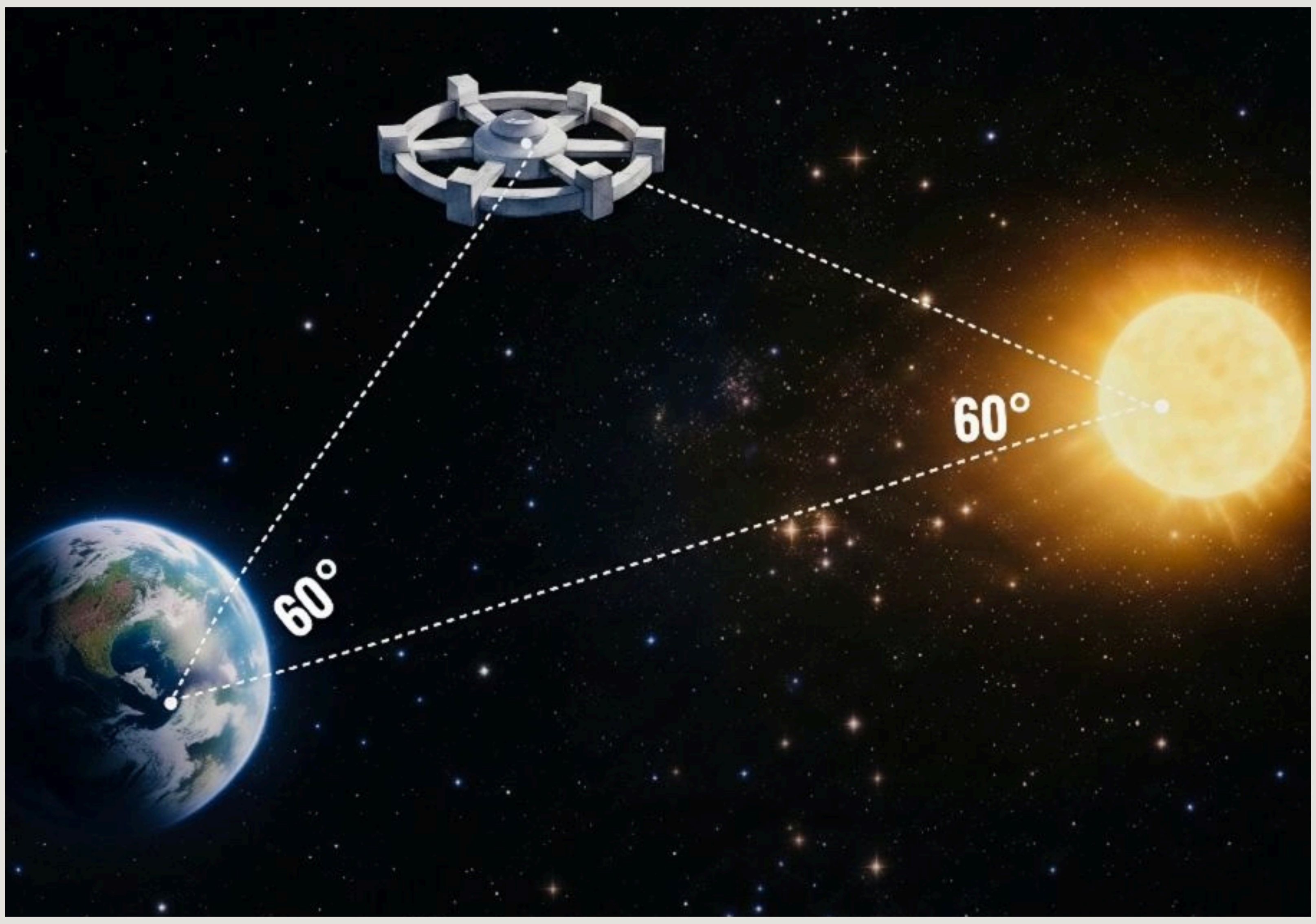


fig. 1-a concept illustration of the position of our station.

IV. STRUCTURE AND HOUSING

4.1 Main Structure

The structure of MARDOVI station is ring-shaped with a central nucleus, similarly to an orbital station. It has a circular form with a frame containing six consecutive rectangular modules, each with its own function: 2 living modules, 2 research modules, 1 cargo module, and 1 multifunctional module.

The circular length of the station is approximately 5655 m (with the radius from the center of the station to the outer ring being approximately 900 m).

The modules on the ring are rectangular with dimensions of 72 × 72 × 120 m. Between each of the modules are connecting tunnels, which contain a public transport system (rail-based) circulates, carrying people from one module to another, as well as pedestrian corridors surrounded by green spaces, bike lanes, and areas for relaxation, meditation, and spiritual recharging.

These arched rectangular connecting tunnels have dimensions of approximately 870 m in length, 35 m in height, and 30 m in width, and their connection to each module is made exactly at the center of the module, in between the districts.

The nucleus of the space station has the shape of a straight circular cylinder, at the top of which is a slightly convex straight circular cone resembling a dome. The core of the station has dimensions of approximately 120 m in height and a radius of 250 m. Between the station's core and the modules on the outer ring, there are other rectangular connecting tunnels that serve to transport people quickly from one place to another via a fast and secure means of transport, 'the rail system' , as well as pedestrian corridors with green spaces and relaxation areas, such as parks or bicycle lanes .

These straight rectangular connecting tunnels have dimensions of approximately 600 m in length, 35 m in height, and 30 m in width, and their connection to the core and modules is made in the same way, at the center of each.

Public transport (for both passengers and cargo), operating between the modules of the space station and the station's core, consists of automated electric trains with a maximum capacity of approximately 200 passengers.

A train's speed will be of about 30–40 km/h, which results in a travel time of approximately 1 minute and 30 seconds (for the 870 m tunnels) and about 1 minute (for the 600 m tunnels). Compared to the time required to cover these distances on foot, public transport is approximately 9 times faster. *(e.g. walking 870m takes the average person around 10 and a half minutes.)*

In each tunnel, there will be two trains departing simultaneously from opposite ends. The trains operate continuously, with a 5-minute pause between runs.

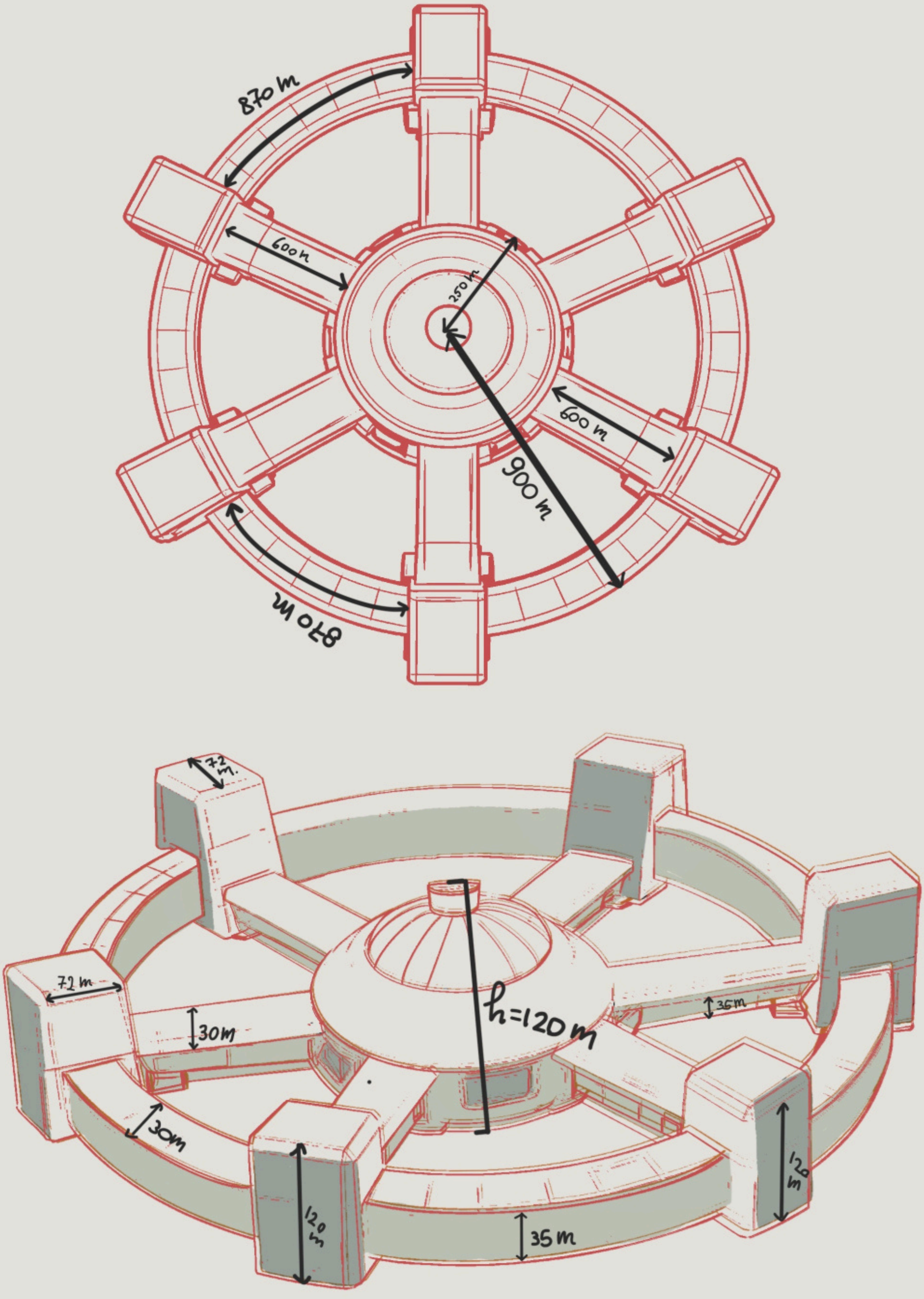


fig. 2- station structure and measurements. Images are self-made using procreate.

The MARDOVI space station is constructed from a combination of multiple material layers that have a direct impact on the level of radiation inside. Lightweight metals, such as aluminum, are necessary for structural strength; however, they do not provide optimal radiological protection. When energetic particles strike materials with a high atomic number, their nuclei fragment, generating secondary radiation in the form of neutrons and gamma rays, which can increase crew exposure.

In contrast, hydrogen-rich materials, such as polyethylene or water, have small nuclei and interact much more efficiently with charged particles, gradually dissipating their energy and producing significantly fewer secondary radiations. Due to this mechanism, hydrogen-rich materials offer superior protection.

Water is considered one of the best shielding materials, as it simultaneously fulfills the role of a vital life-support resource and a radiological shield, and can be strategically distributed throughout the station's structure. For standard protection, the walls should have a thickness equivalent to 15–30 cm of water. For shelter rooms intended for emergency situations, such as solar flares or intense solar storms, a greater thickness is required—approximately 40–60 cm of water equivalent. These spaces must also be equipped with essential supplies, allowing astronauts to remain safe for the duration of hazardous events.

Therefore, the wall thickness of the spacecraft is approximately 30–40 cm (constructed from water, polyethylene, aluminum, Nextel, and Kevlar), while the walls of the shelters against solar storms have a thickness of approximately 70 cm.

Thermal insulation is an essential element in the design of a space station, since outer space is characterized by extreme temperature variations and the absence of an atmosphere. In space, heat transfer cannot occur through convection, but only through radiation and conduction, which exposes the station's structure to temperatures above +120 °C when illuminated by the Sun. The main solution adopted is the use of Multi-Layer Insulation (MLI), consisting of approximately 25 thin reflective layers made of materials such as aluminized Mylar, separated by insulating spacer layers.

These layers reflect most of the thermal radiation and significantly reduce heat loss, while also having low mass, an essential aspect for launch. MLI is a technology that has already been validated and used on the International Space Station, satellites, and other space missions. Passive insulation is complemented by an active thermal control system, which includes external radiators to dissipate excess heat, cooling fluids circulating through the station's structure, and electric heaters used to maintain minimum temperatures in critical areas, especially during eclipse periods.

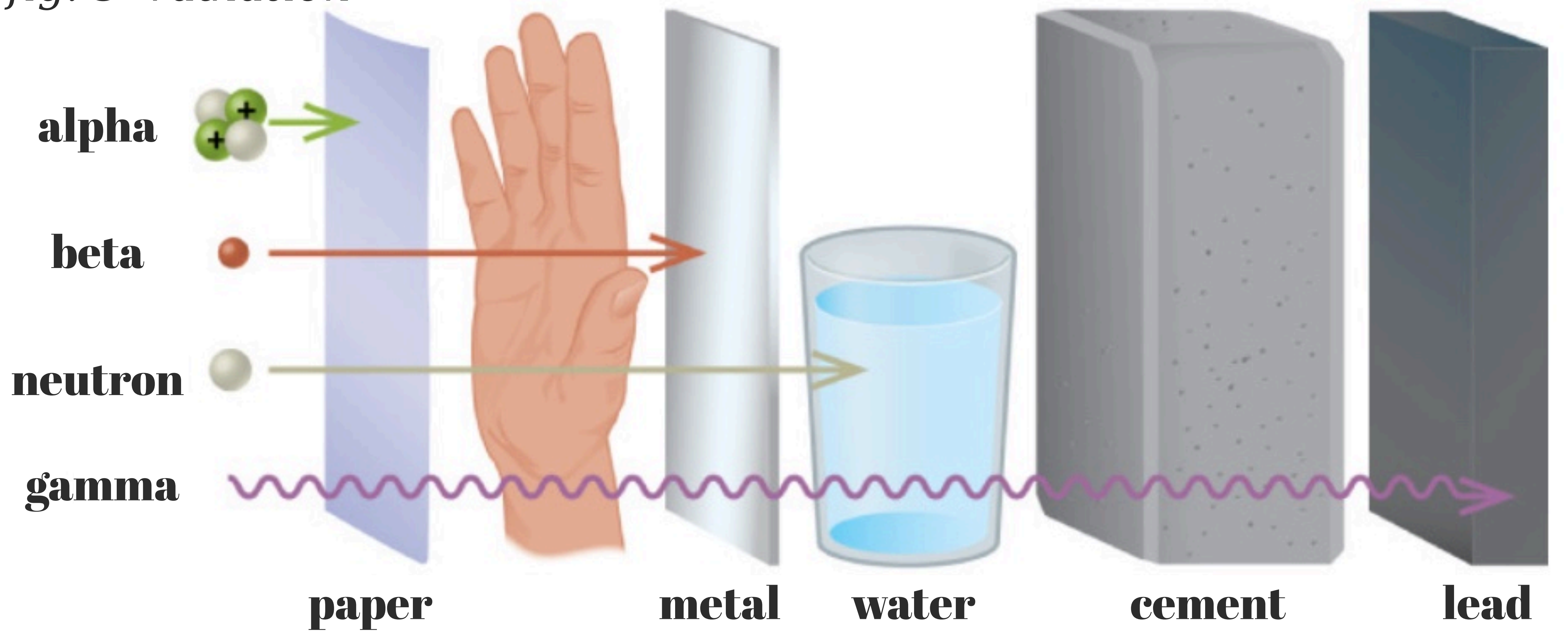
4.2 Shielding

Cosmic radiation represents one of the most serious and constant threats to the safety of astronauts in space. Unlike the terrestrial environment, where the Earth's atmosphere and magnetic field provide an effective natural shield, in outer space humans are directly exposed to high levels of radiation, with potentially severe short- and long-term health effects.

A recent study published in **the Journal of Medical Physics** proposes an integrated framework for the radiological protection of space crews and highlights the complexity of this risk. According to the authors, cosmic radiation is not uniform but forms a so-called "mixed field," composed of particles that vary greatly in energy and nature. This field includes gamma radiation, electrons, protons, and heavy ions, each having different penetration capabilities and distinct effects on the human body. It is precisely this diversity that makes radiation protection a major challenge for engineers and physicians involved in space missions.

Space radiation can be classified into several main categories, depending on its source. Galactic cosmic radiation (GCR) originates outside the Solar System and is generated by extremely energetic events, such as supernova explosions. It is constantly present in the cosmic environment and consists mainly of protons, electrons, and heavy ions, such as carbon, oxygen, or iron nuclei. Due to their very high energies, these particles are extremely penetrating and contribute to the long-term exposure of space crews.

fig. 3- radiation



Another important type of space radiation is represented by solar particle events (SPE), which are generated by intense solar activity and occur suddenly during solar flares. Although they are less frequent than galactic cosmic radiation, SPEs can produce extremely high radiation doses over a very short period of time, posing the most dangerous immediate threat to crews. In addition, the interaction of these particles with the structure of a spacecraft or space station can generate secondary radiation, such as neutrons and gamma rays, which can amplify the total radiation level inside if construction materials are not properly chosen.

When radiation becomes too intense, the crew must be sheltered in a space that most space stations have, called a storm shelter. The storm shelter is an essential element in the architecture of a habitable space station, designed as a special compartment intended to protect the crew during solar storms. It is not a permanently used space, but a temporary refuge, activated exclusively in situations of extreme risk. Its placement is at the center of the station, so that the distance from the outer walls is maximized, reducing the direct penetration of energetic particles. Additional shielding is achieved by surrounding the shelter with water tanks, food supplies, batteries, and other dense equipment, all serving as passive radiation shields. In the event of a major solar event, rapid retreat of the crew into the storm shelter can reduce the absorbed radiation dose by up to 70–90%, making the difference between survival and lethal exposure.

The following images (fig. 4,5,6 and 7), created by us using 'homestyler', represent the interior of the storm shelter rooms. We have also attached a QR code for live 3D viewing of the rooms (! Important note: the website tends to load slowly, so we recommend being patient when viewing the 3D models):

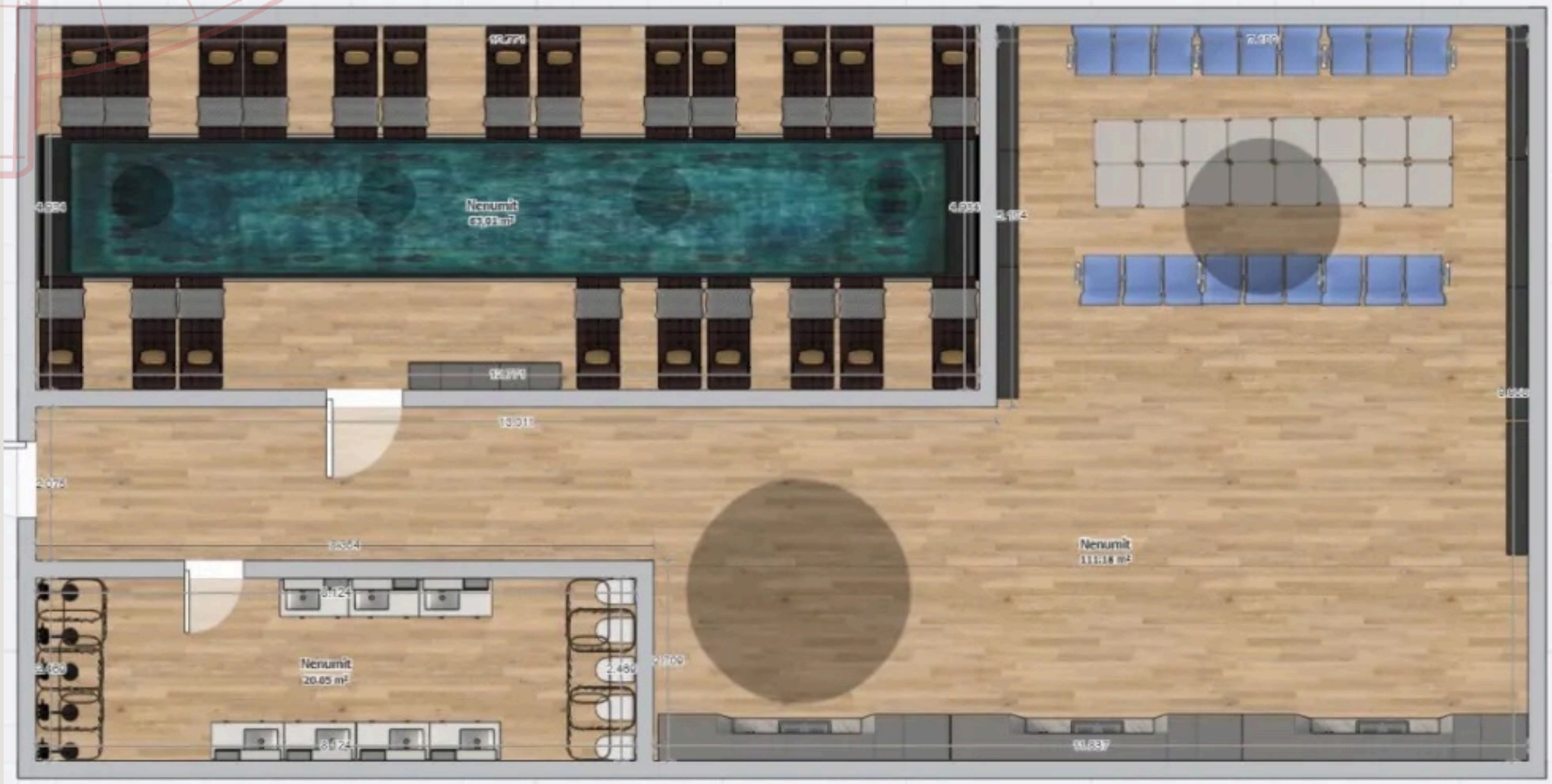


fig. 4

fig. 5

fig. 6

fig. 7

storm shelter rooms QR

Each storm shelter is designed to store enough materials and supplies for short-term comfortable living. There are going to be scheduled routine checks of each shelter to ensure that they can keep everyone safe in the unfortunate event of a solar storm.

4.3 “Stacking” Housing method

The MARDOVI space station is designed to sustain a permanent population of up to approximately 2,500 inhabitants, requiring a highly efficient yet human-centered approach to spatial planning. To achieve this, the station adopts a vertical urban organization known as the stacking housing method, in which residential neighborhoods are arranged one above another. This method allows MARDOVI to maximize usable space while preserving clear functional zones, walkability, and a strong sense of community similar to that of Earth-based cities.

The residential population is primarily housed within two identical habitation modules, together accommodating around 2,400 people. In addition to these, seven smaller residential blocks are located within the central core of the station and house approximately 100 inhabitants, mainly individuals working in the surrounding agricultural sector near the command center. This distribution ensures that essential workers remain close to their primary workplace while still benefiting from full residential infrastructure.

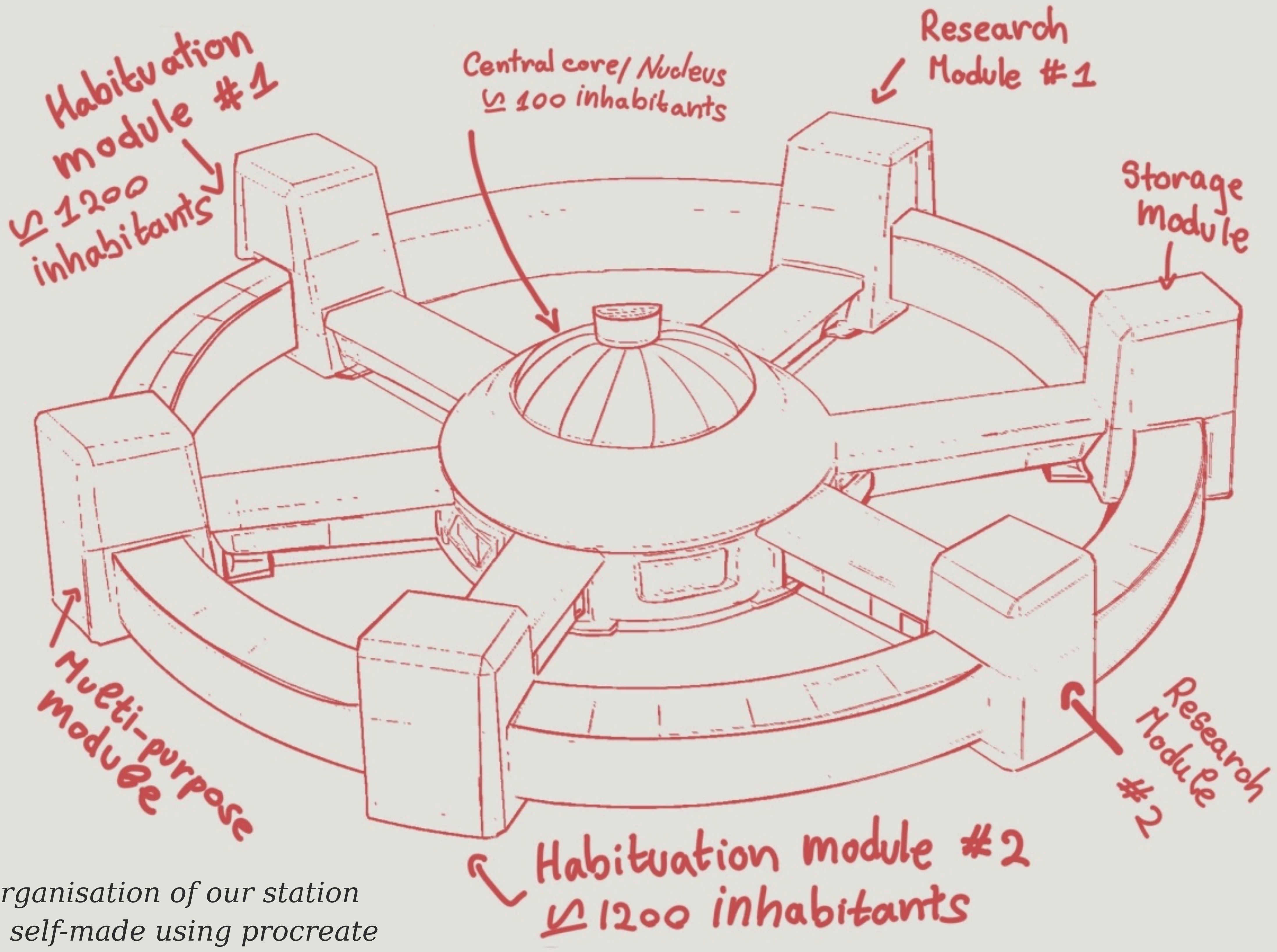


fig. 8-organisation of our station
image is self-made using procreate

Each habitation module is composed of six vertically stacked residential neighborhoods, each designed for approximately 200 residents. Every neighborhood functions as a semi-independent living unit, providing housing, services, and communal spaces within a clearly defined volume. The housing layout within each neighborhood is deliberately diverse, accommodating families, couples, and individuals in proportions that reflect a balanced population structure.

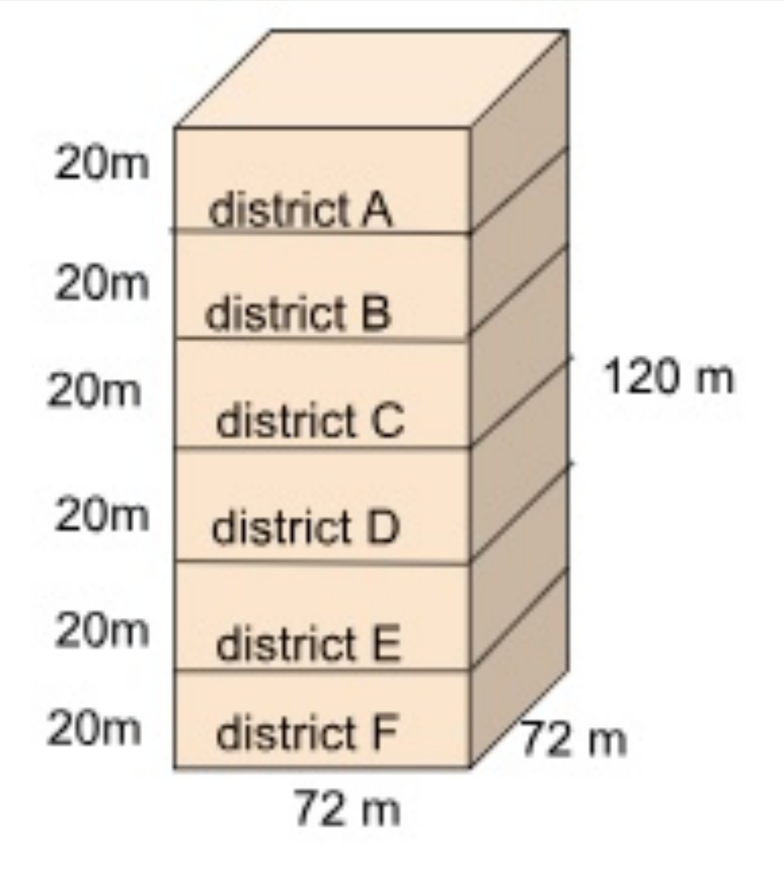


fig. 9- district measurements

The following images were created by us using 'homestyler' (fig. 10-21). For each level, we have prepared QR codes for those who wish to view the 3D models of the buildings. Each code will be attached near one of the images (Imporant mention: the site tends to load slowly, so we advise patience when viewing the 3D models).

Family housing is provided through two-story houses designed to offer comfort and privacy comparable to terrestrial living standards. The ground floor contains an entrance hall, living room, kitchen, and secondary bathroom, while the upper floor includes a main hallway, a parents' bedroom, a children's bedroom, and a primary bathroom. Each house has a usable surface area of approximately 180 square meters, a ground footprint of 111 square meters, and a height of around 6 meters, making them suitable for long-term habitation and family life.

ground floor layout:

ground floor QR

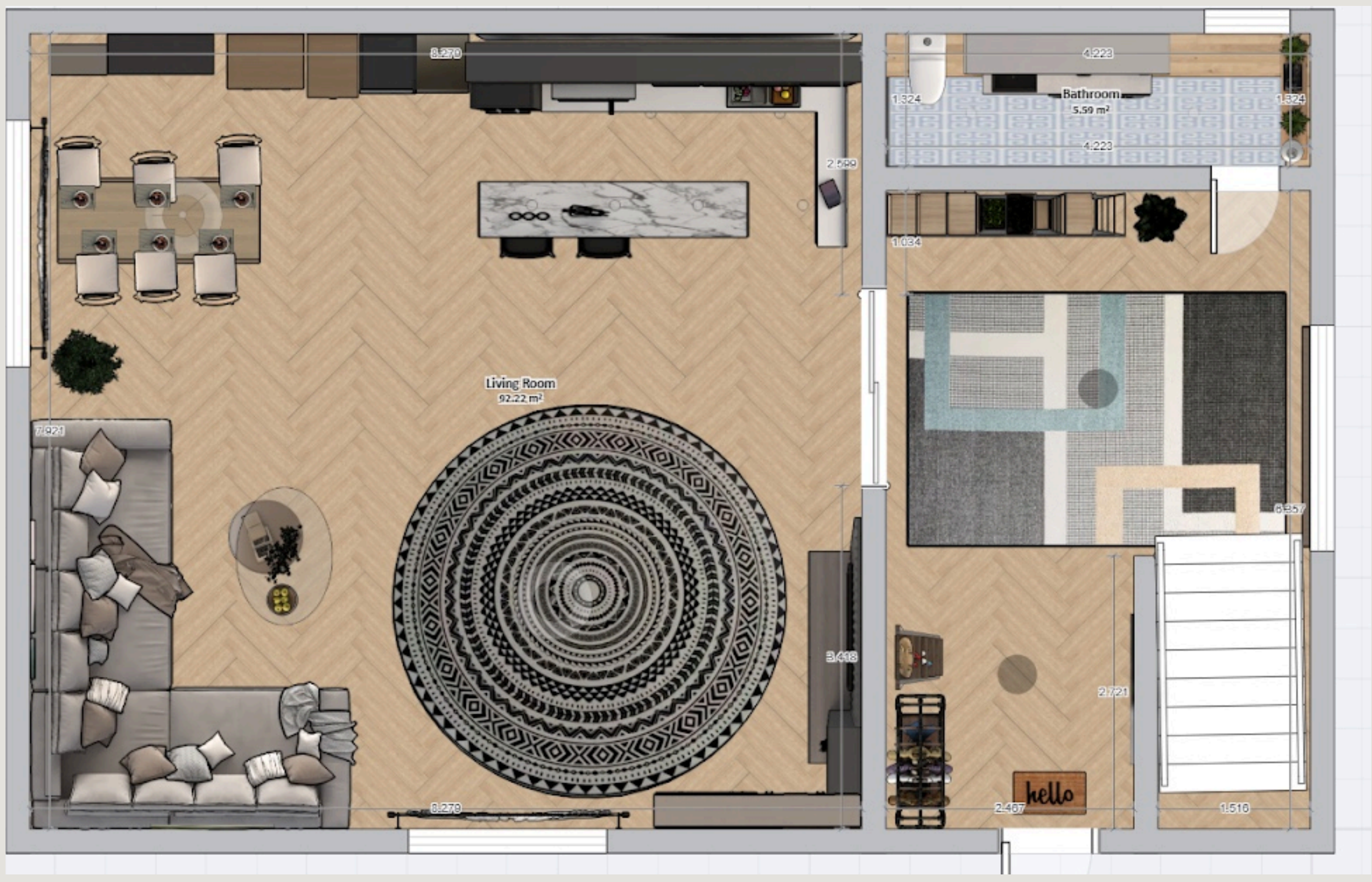


fig. 10

fig. 11

fig. 12

upper floor layout:

fig. 13

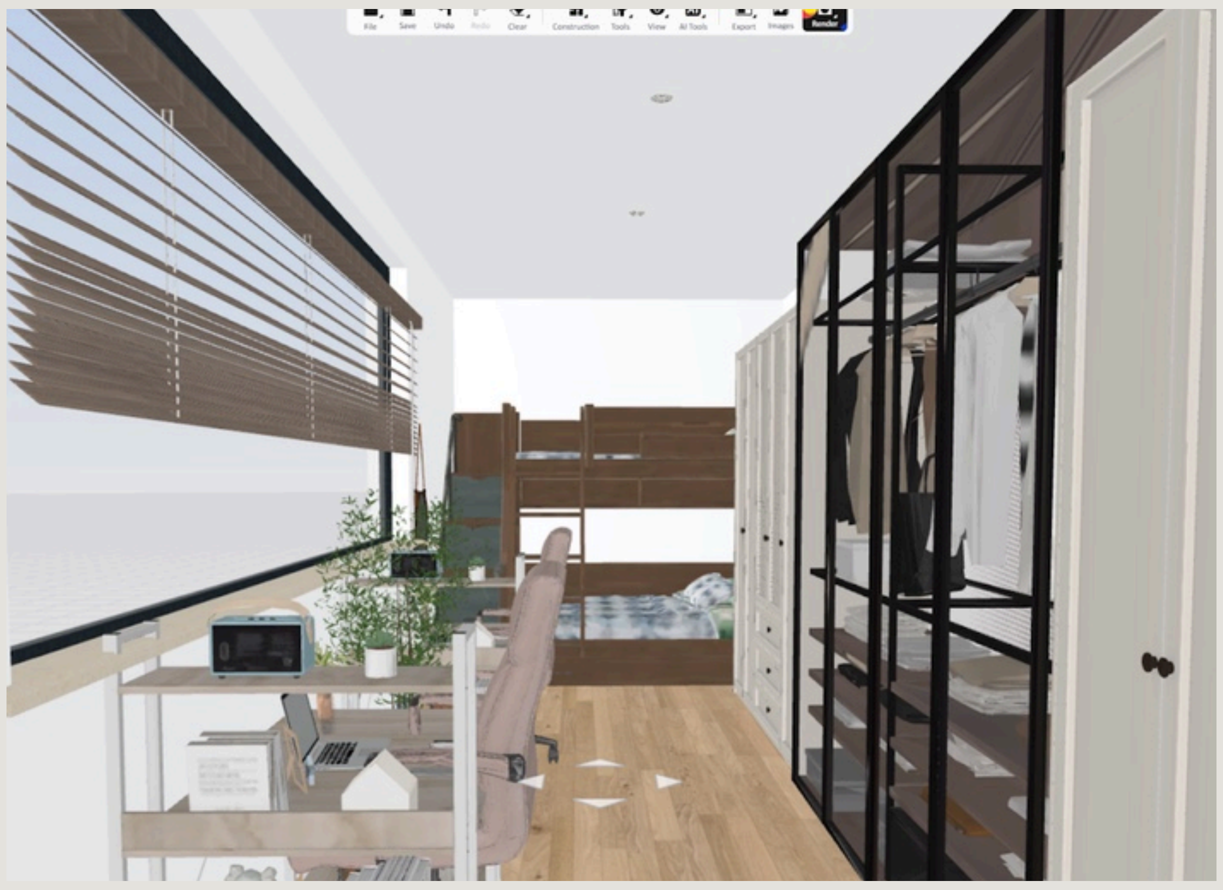


fig. 14

upper floor QR

fig. 15

In addition to houses, each neighborhood contains seven apartment buildings, which provide more compact living solutions. Each apartment building rises four stories high, with residential units distributed across floors to balance density and accessibility. The usable surface per floor ranges between 120 and 150 square meters, with an additional 30% allocated to shared circulation spaces, such as stairwells and elevators. As a result, each building has a ground footprint of approximately 200 square meters and an overall height of around 12 meters, fitting seamlessly into the vertical structure of the habitation module.

Standard apartments consist of a main hallway, bathroom, bedroom for two occupants, and a combined living and kitchen area, totaling approximately 60 square meters of usable space.

apartment layout:

fig. 16

apartment QR

fig. 17

fig. 18

Studio units are designed for young residents or individuals living alone and include a hallway, bathroom, and a single multifunctional room serving as bedroom, living area, and kitchen, with a usable surface of around 30 square meters.

studio unit layout:

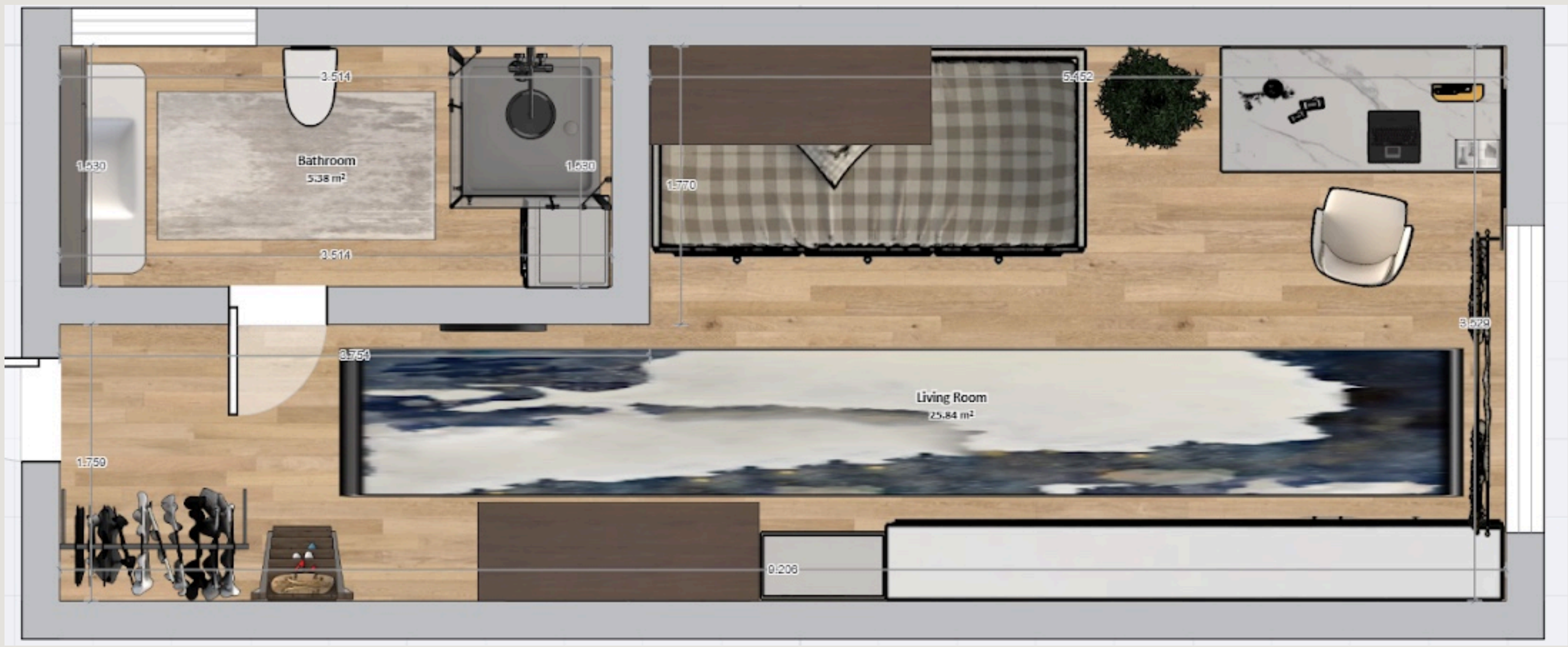
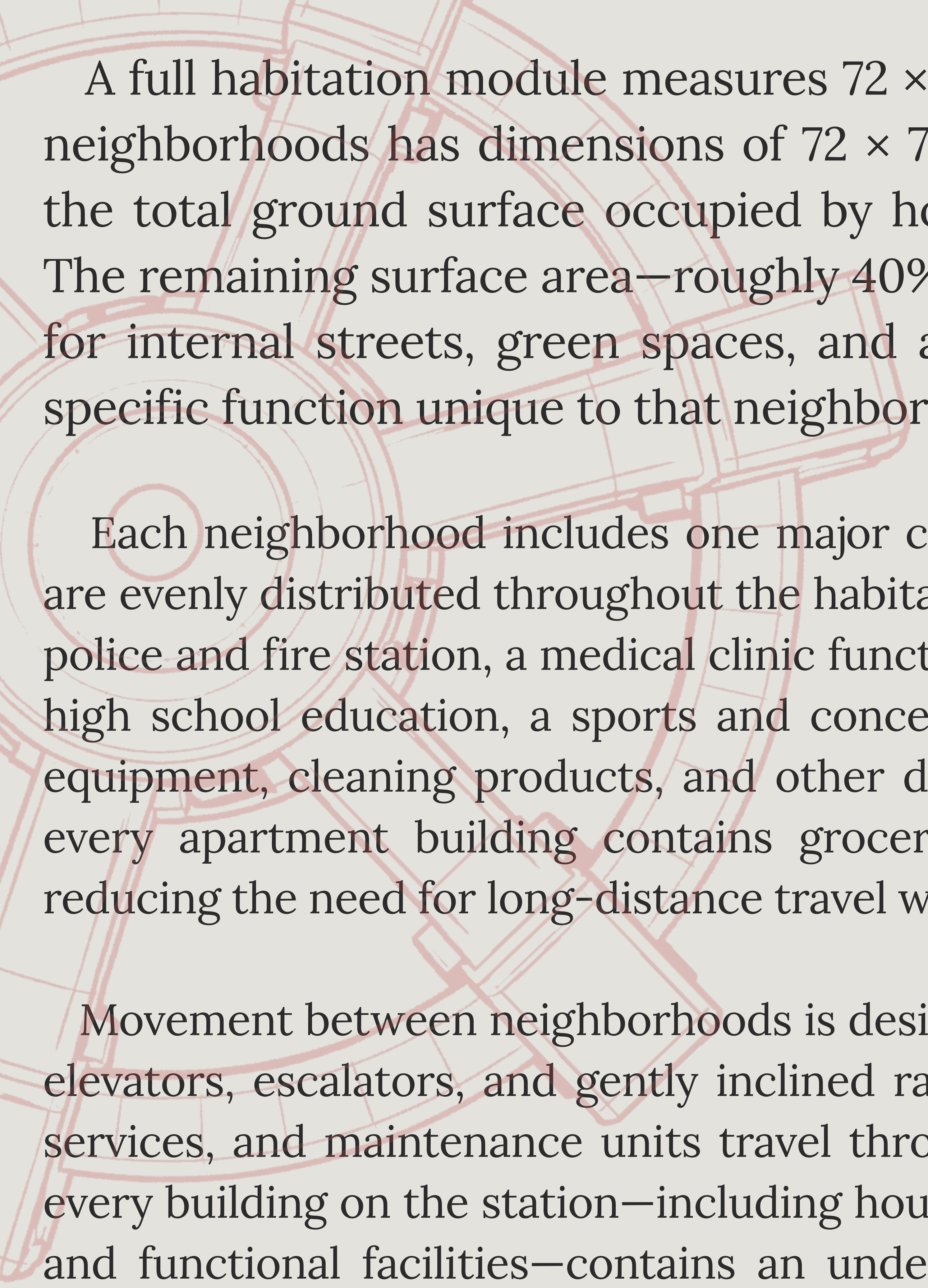


fig. 19

studio unit QR

fig. 20

fig. 21



A full habitation module measures 72 × 72 × 120 meters, while each of the six stacked neighborhoods has dimensions of 72 × 72 × 20 meters. Within a single neighborhood, the total ground surface occupied by housing is approximately 3,600 square meters. The remaining surface area—roughly 40% of the available footprint—is intentionally left for internal streets, green spaces, and a dedicated communal building that serves a specific function unique to that neighborhood.

Each neighborhood includes one major communal facility, ensuring that essential services are evenly distributed throughout the habitation module. These include a cinema, a combined police and fire station, a medical clinic functioning as a small hospital, a school for middle and high school education, a sports and concert hall, and a mini-mall offering clothing, sports equipment, cleaning products, and other daily necessities. Additionally, the ground floor of every apartment building contains grocery stores, pharmacies, and basic service shops, reducing the need for long-distance travel within the station.

Movement between neighborhoods is designed to be efficient and inclusive. Pedestrians use elevators, escalators, and gently inclined ramps, while public transport vehicles, emergency services, and maintenance units travel through dedicated transit ramps. For safety reasons, every building on the station—including houses, apartment blocks, laboratories, storage areas, and functional facilities—contains an underground shelter designed to protect inhabitants during solar storms.

Located between the two habitation modules is the functional module, which also follows the stacking housing method and consists of six vertically arranged levels of identical dimensions. This module hosts facilities essential to the entire station, including the government headquarters, large hospitals covering all medical specializations, police and fire departments, universities, extensive food courts, shopping centers, and large areas dedicated to relaxation, sports, and entertainment. Throughout the functional module, green spaces, parks, and indoor gardens are integrated to improve air quality and psychological well-being.

Transportation within the functional module mirrors that of the residential areas, relying on elevators, escalators, and urban transit ramps for both pedestrians and vehicles. In addition to high-speed train connections between modules, a landscaped roadway with green areas connects the habitation modules to the functional core, reinforcing the sense of continuity across the station.

At the center of MARDOVI lies the station nucleus, which contains the main command center. Surrounding it is a multi-level agricultural zone dedicated to crop cultivation and animal farming. Within this area are seven residential blocks assigned specifically to agricultural workers responsible for food production. These blocks are supported by nearby shops and institutions, ensuring that agricultural workers enjoy the same quality of life as all other inhabitants of the station.

V. LIFE SUPPORT

5.1 Artifical Gravity

In space, microgravity has many negative effects upon our bodies and humans must train if they decide to embark on a space station with 0g. The effects of microgravity are:

- In 0g, many people experience “space sickness”, because in the inner ear we have a vestibular organ that helps us balance on Earth. Here, this organ sends information about gravity to the brain, but in microgravity, the input from the vestibular organ varies.
- On Earth, gravity pulls bodily fluids into the lower part of body. In 0g, the bodily fluids are pulled upwards in the upper part of the body. But after a while, they(the fluids) balance out.
- After spending a lot of time in space, the muscles and the bones, mainly in the legs and in the lower back, begin to weaken. In 1g, gravity always acts upon you, and you constantly use your lower-body muscles, but in 0g, without any force acting upon our body, the muscles start to weaken, and the bone mass decreases.

To counteract these effects, we will create artificial gravity with the help of centripetal acceleration by rotating the space station. To calculate the radius of the station, we will be using the centripetal acceleration to be 1g and the angular velocity to be 1rpm (1 rpm≈0.10471975511966 rad/s, the formula being rpm=rad/s* 60/(2*π); a= centripetal acceleration, ω=angular velocity, r=radius of the station). To calculate the tangential velocity we will use the same angular velocity and the radius v= tangential velocity which is measured is meters/second)

By using this formula $a = \omega^2 \times r$, we calculate the radius $r=a/\omega^2$ and by replacing a and ω, we get r≈ 895 m and by using this formula $v = r \times \omega$, we will find the tangential velocity, which is 93.6467 m/s.

Based on the rpm of the station, humans need to adapt to the artificial gravity, but everyone will need to adapt at their own pace:

Rotations per minute	The training needed
Up to 2 rpm	Not much training is needed, but humans could experience motion sickness
Between 2 and 4 rpm	Little training is needed for inhabitants and visitors
Between 4 and 6 rpm	Little training is needed for inhabitants, but for visitors it would require more training
Up to 10 rpm	Inhabitants and visitors would need specific training
Over 10 rpm	The training would be very hard

The space station is rotating once per minute, and the citizens of MARDOVI Station will need some training because there could be certain effects such as motion sickness. The majority of people will adapt in about a few days or weeks, so there will a period of accommodation. An advantage would be that the pressure from the head would be lower than the pressure at the legs, which would be like on Earth. (and the Coriolis Force will not be so strong and could go unnoticed.)

More about the Coriolis Force:

-The Coriolis Force is an inertial force that acts upon objects within a rotating frame of reference, such as the Earth or our space station. While the space station is rotating, an object inside the station that is thrown will take a curved path instead of a straight one and it can make citizens experience motion sickness.

Humans do not observe the effects of the Coriolis force while the space station has an angular velocity below 2 rotations per minute(2 rpm). Because our space station rotates once per minute, the Coriolis force will be unnoticed most of the time.

5.2 Lighting

In a space station, lighting plays a vital role both in crew comfort and in the efficiency of work carried out in laboratories and living spaces. We have selected three main types of lighting, each meant to serve a specific purpose on MARDOVI.

The first type of lighting consists of variable-spectrum LEDs, used mainly in research laboratories. These LEDs allow adjustment of color temperature and light intensity, mimicking the natural light cycles on Earth. During the day, the light can be bright white, promoting concentration and productivity, while in the evening the color temperature shifts toward warmer tones to encourage relaxation and sleep. The advantages of this system include energy efficiency, durability, and the ability to be customized according to the needs of each area. Although it requires an advanced control and programming system to precisely synchronize the lighting with the circadian rhythm, the benefits it brings to health and productivity make it indispensable in workspaces.

fig 22- light varation

The second type of lighting is the fiber-optic system for capturing sunlight, intended for living spaces such as crew cabins and relaxation areas. This system collects natural light from outside using mirrors and lenses, then transmits it into the interior of the station through optical fibers. It provides the natural light needed to maintain the crew's psychological well-being and helps regulate biological rhythms without directly exposing the station to solar radiation. Although the installation of this system is complex and its efficiency may vary depending on the station's position relative to the Sun, it reduces electrical energy consumption and offers a significant benefit in terms of the crew's mental health.

For the interior walls of MARDOVI, a combined solution was selected, integrating programmable circadian lighting with a fiber-optic system for capturing sunlight. The optical fibers collect natural light from outside, using mirrors and lenses, and transmit it into the interior, giving the crew access to natural daylight, which is essential for mental well-being and the regulation of biological rhythms. In addition to the daylight delivered through the fibers, the walls are equipped with a circadian lighting system that automatically adjusts both light intensity and color temperature throughout the day.

When natural light is insufficient, the programmable system simulates natural day–night cycles by gradually changing the light's tone—from cooler, bluish hues in the morning that enhance alertness, to warmer tones in the evening that promote relaxation and sleep. This combination balances natural and artificial lighting, creating a comfortable interior environment tailored to the crew's biological needs.

During nighttime hours, a very low-intensity lighting system is used to ensure minimal visibility without disturbing sleep.

Although this integrated system requires complex technical infrastructure and a moderate amount of energy, its benefits for crew health, circadian rhythm regulation, and overall productivity make it a key element in spacecraft interior design.

By combining these three types of lighting, the space station provides an optimal, comfortable, and efficient environment for both work and daily life, adapting illumination to the biological and operational needs of each area of the station.

5.3 Air

For an ideal air on our station, we will try to create the best environment for MARDOVI's inhabitants.

To make this possible, we need to know the components of the air from our Planet, which is made up of: 78,08% N_2, 20,95% O_2, 0,93% Argon, 0,038% CO_2 and 0,002% others.

Nitrogen, the first element of the Earth's atmosphere, is essential because it helps produce amino acids, proteins etc. and it occupies 78% of the Earth's Atmosphere.

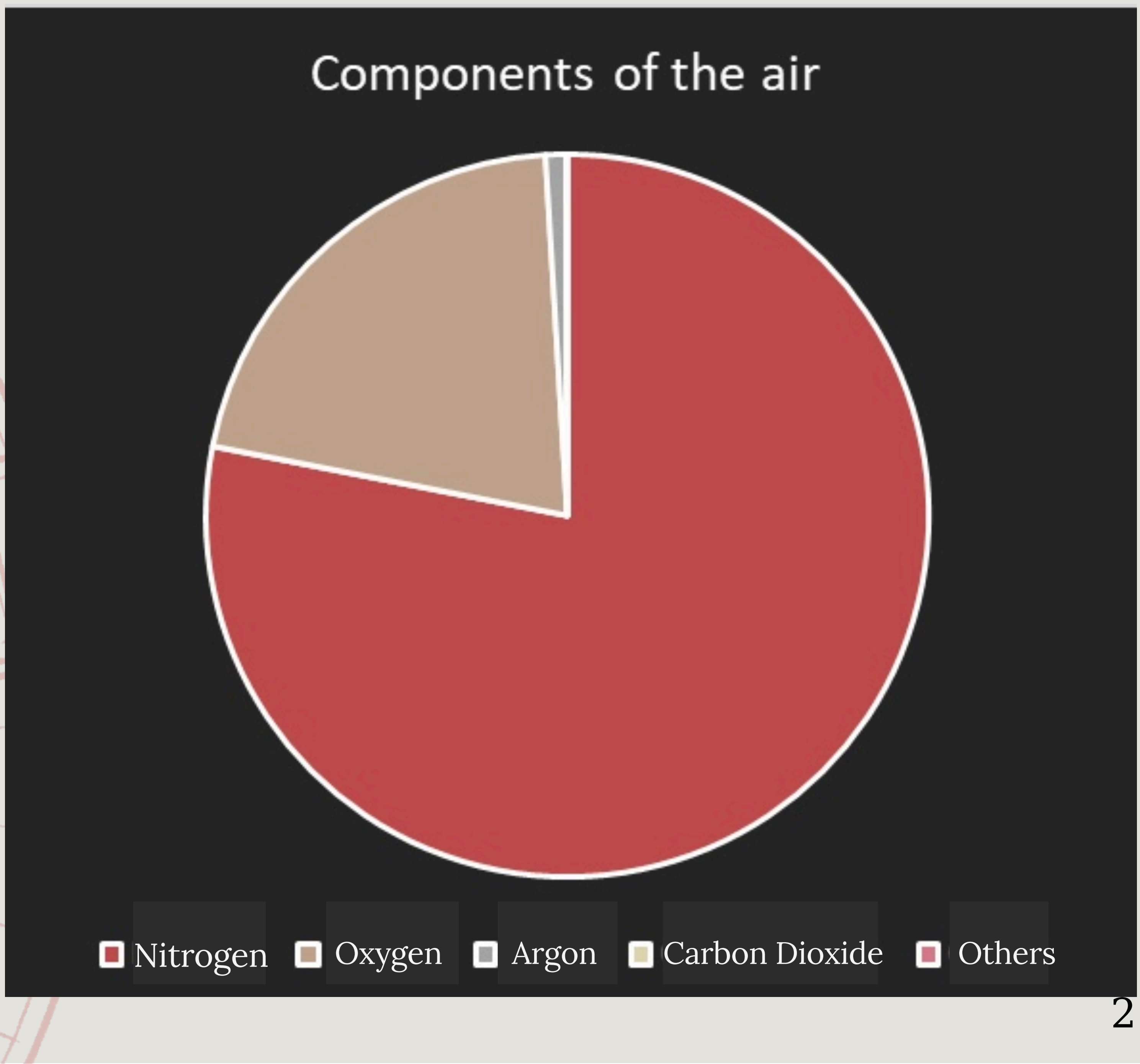


fig 23- air components chart is self-made

The roots of the plants absorb it by ammonium or nitrate. Nitrogen is primarily used by plants and it is not used by humans and animals.

Oxygen, the second element of the Earth's atmosphere, it's the most essential element for humans and animals and is used for cellular respiration. To be comfortable for our citizens, the percentage of oxygen will be between 20% and 22,5% to prevent any side effects that may happen. Potential side effects include:

- Over 24% oxygen percentage would create a risk for combustion and, also, higher percentages of oxygen would be deadly over a long time for humans.
- Between 15% and 19% oxygen levels/percentage, humans have a reduced capacity for physical activity and could cause pulmonary and circulatory problems.
- Between 10% and 15% oxygen levels/percentage, the pulse and the respiration increases, resulting in humans having poor coordination and getting tired very fast
- Under 6% oxygen levels/percentage is deadly for humans.

Carbon Dioxide, found in very small percentages, is essential because plants use it to perform photosynthesis and create energy and release oxygen in the atmosphere. If the percentage surpasses 2-5%, it may become deadly for humans.

After this research, we decided that the composition of the air on our station will be 21,24%O_2, 78,73%N_2, 0,03% CO_2 and the percentages will change because of our inhabitants, but we will control them to make sure the levels of the elements do not exceed their limits by using the Environmental Control and Life Support System(ECLSS) that is used on the ISS.

The Water Recovery System, the Air Revitalization System, and the Oxygen Generation System are the three important components of the ECLSS. To clean the air in the station and to eliminate carbon dioxide and other trace contaminants, the Air Revitalization System is used. Carbon dioxide is eliminated by using zeolites, which are like a spongy mineral and have tiny pores that capture CO_2. This CO_2 moves in the newly absorbent beds and the molecules, and after it's heated up, it releases the trapped gas and takes in more. The excess carbon dioxide, with hydrogen produce methane and water by using the Sabatier Equation($CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$). There could be traces amounts of Carbon Monoxide(CO) and that could react with the hydrogen and create methane and water ($CO + 3H_2 \rightarrow CH_4 + H_2O$). The water from those 2 reactions could be collected and taken through a process called water electrolysis, resulting in hydrogen and oxygen with the help of the Oxygen Generation System.

The methods of obtaining these gases are as follows:

To transport nitrogen in the space station, we decided to transport it as liquid nitrogen which boils at -196 degrees Celsius(77.15K) and becomes a gas if the temperature exceeds this value. To transport it, we will use the Cryogenic storage tanks, which are vacuum-insulated, to minimize the heat exchange and to help maintain the temperature below -196 degrees Celsius. This tank has two metal layers separated by a vacuum to prevent heat loss and is built from stainless steel or aluminium to ensure that it could withstand extreme temperatures. They are equipped with pressure-relief valves and other safety systems.

As for oxygen, there are multiple ways to achieve transporting it. Firstly, we will transport a certain quantity of oxygen with the help of Cryogenic storage tanks keeping liquefied oxygen, which boils at -183 degrees Celsius. A second method would be by using water electrolysis with a help of a direct current separating the hydrogen from the oxygen($2H_2O \rightarrow 2H_2 + O_2$). Another method would be represented by the plants on MARDOVI and the oxygen released by them during photosynthesis.

Temperature and humidity:

On our space station, the average temperature will be between 21-24 degrees Celsius while the thermal control is active, the thermal insulation helping us with the temperature changes staying minimal.

Humidity levels within the space station will be carefully maintained between 40% and 50% for optimal comfort and functionality. When temperatures exceed 20°C, it is recommended keeping humidity levels at a maximum of 60%. Hygrometers will be installed to accurately monitor the concentration of water vapor in the air. To achieve our humidity goals, we will use dehumidifiers to reduce excess moisture and maintain the desired levels, while humidifiers will also be available to introduce moisture when necessary. This system will ensure a balanced atmosphere good for both the crew well-being and equipment performance. If the humidity level is too low it can cause chapped lips, dry skin, dehydration, heightened allergy symptoms and skin conditions like eczema. If the humidity level is too high it can cause hyperthermia, decreased energy levels, asthma symptoms and even impact sleep quality. Therefore maintaining a constant and decent humidity level is a priority.

Thermal Control System

To prevent the overheating and ensuring components remain at acceptable temperatures, we will be using the same system that is used on the ISS, the Active Thermal Control System **(ATCS)** that collects heat, transports it and rejects it with the help of cold plates and heat exchangers, both being cooled by ammonia loops. ATCS is made up of the Internal Active Thermal Control System(IATCS), External Active Thermal Control System(EATCS), Early External Active Thermal Control System(EEATCS) and the Photovoltaic Thermal Control System(PVTCS).

- The **Internal Active Thermal Control System** consists of a series of loops designed to circulate water throughout the module. This system effectively captures excess heat generated by the electronic devices and equipment. The collected heat is then routed to the Interface Heat Exchangers, where it is transferred to the EATCS. The system features two separate loops: the Low Temperature Loop (LTL) and the Moderate Temperature Loop (MTL). This segmented design effectively manages thermal loads, facilitating easier heat load control and ensuring redundancy if any equipment malfunctions. The LTL operates at a chilly 40° F (4° C) and serves specifically to systems that require cooler temperatures, including the Environmental Control and Life Support System (ECLSS) Common Cabin Air Assembly (CCAA) and select payload experiments. On the other hand, the MTL runs at a nominal temperature of 63° F (17° C), providing the primary cooling for systems like avionics and various payload experiments.
- The EATCS is the main permanent heat rejection system on the space station. It operates using a special type of ammonia that doesn't contain water, which makes it effective for its ability to absorb and release heat over a wide range of temperatures. One of the key benefits of this ammonia is that it remains liquid even at very low temperatures, freezing at just -107 degrees Fahrenheit (-77 degrees Celsius) when there is normal air pressure. This system has two independent loops and in case one fails, EATCS works at a reduced capacity.

The EEATCS is a modified version of PVTCS. The EEATCS has two separate cooling loops called ammonia cooling loops (ACL). These loops work together to move heat away from the Interface Heat Exchanger (IFHX). The EEATCS will be used until the permanent EATCS is up and running. Once the permanent EATCS becomes active during the mission, the EEATCS will be switched off.

- The PVTCS consists of ammonia coolant, two pump flow control subassembly(PFCS), a Photovoltaic radiator(PVR) and eleven coldplates. The coldplate subassemblies are essential to the IEA's structural foundation. The woven fins on the coldplate and the electronic boxes of the Integrated Equipment Assembly(IEA) orbital replacement unit (ORU) transfer heat from the electronic boxes to the coldplates. The key component of the thermal system is the PFCS. In addition to controlling the temperature of the ammonia coolant in the thermal control system, it includes all the pumping capacity, valves, and controls required to move the heat transfer fluid to the heat exchangers and radiator.

5.4 Energy

Electrical energy is a very important component for any space station. It enables life-support systems, temperature control, communications, and navigation equipment to function. If a space station did not have a safe and constant source of energy, it would not be able to operate at all.
The main source of energy for our space station is solar panels. These use high-quality photovoltaic cells that can convert energy emitted by the Sun into electrical energy. The solar panels are mounted on mobile structures that can be oriented in such a way as to maximize the amount of solar energy received throughout the orbit.

The station will be equipped with high-capacity lithium-ion batteries, which store the excess energy produced by the solar panels, ensuring the functionality of all systems on the space station. The station has an intelligent energy management system that prioritizes absolutely essential systems (such as temperature control, communications, and life-support systems) in situations of energy crisis.

As an additional backup solution, fuel cells can be used. These produce energy through the reaction between hydrogen and oxygen. A significant advantage of this method is the generation of reusable water.

By combining the energy production and recycling methods mentioned above, we can obtain an efficient solution for the energy used by the space station, allowing it to operate safely and continuously throughout the entire mission.

To estimate the total energy consumption of the space station, we considered the maximum number of people on board, namely 2,500. We assumed an average energy consumption per person, which includes lighting needs, personal equipment, and support systems, while the station operates continuously 24 hours a day. Therefore, the total energy consumed can be calculated using the following formula:

$$E_{\{total\}} = N_p times\ P_{\{per,person\}\ times} t$$

-$\boldsymbol{N_p}$ is the number of people, $\boldsymbol{P_{\{per,person\}}}$ represents the average energy consumption per person in WATTS, whereas $\boldsymbol{t}$ is the time in hours.

$$E_{\{total\}} = 2500 \times 300 \times 24 = 18{,}000{,}000\ \{\ Wh\} = 18{,}000\ \{\ kWh\ per\ day\}$$

5.5 Water Obtaining

To obtain water on our space station, and especially in space, we will use the same method that has been practiced for many years on the ISS (International Space Station), developed by NASA, called the Water Recovery System (WRS). This system is a complex recycling process that transforms urine, sweat, humidity from the air, shower water, breath vapor, and wastewater from cleaning systems back into potable water.

The WRS has two main components: the Urine Processor Assembly (UPA) and the Water Processor Assembly (WPA).

The UPA is a key part of the Water Recovery System, turning crew urine into potable water for meal preparation and even oxygen generation. The UPA performs multiple processes: first, it uses vacuum distillation and a rotating drum to separate water vapor from urine. The vacuum lowers the boiling point, allowing water to evaporate at lower temperatures. To remove remaining impurities—such as salts, urea, and ammonia—a filtration system chemically treats the water using substances like hydrogen peroxide (H_2O_2) and phosphoric acid (H_3PO_4).

The brine, a concentrated water solution of common salt ($NaCl$), is the leftover fraction from urine processing. Dry, warm air is blown over the brine through a special membrane to evaporate the remaining water. A filter then separates contaminants from the vapor, and finally, the purified water vapor is condensed into potable water. This process allows the WRS to achieve 98% efficiency.

The WPA is responsible for purifying water recovered from all sources, including urine, sweat, and humidity. This process is more complex, as it ensures that the water is safe to drink. First, volatile organic compounds (VOCs)—carbon-based chemicals that vaporize at room temperature and are harmful if ingested—are filtered through a series of filter beds. Remaining organic compounds are then broken down in a catalytic oxidation reactor. Hydrogen peroxide (H_2O_2) is used to eliminate any residual organic impurities.

To remove other salts and ions, such as magnesium and calcium, that may accumulate, ion exchange technology is applied. In the final step, a small amount of iodine is added to purify the water before it is stored in large tanks for use by the crew.

5.6 Agriculture & Food

Food procurement represents one of the greatest challenges of life on a space station. On MARDOVI station, the growth of resources plays an essential role in ensuring a stable and healthy life for the community. In an environment lacking natural soil and normal gravity, space agriculture is more difficult, but it is designed to reproduce Earth-like conditions as closely as possible, so that people can adapt more easily to life in space. The purpose of these systems is not only food production, but also maintaining a balance that offers the community a connection to terrestrial life. Through these methods, we aim for a long-term lifestyle on the MARDOVI station.

Raising animals on a spacecraft requires high costs as well as significant resources. It becomes complicated when considering potential diseases, their adaptation to space, and the surface area they would occupy. For these reasons, we decided to reduce the number of animal-based foods in an individual's diet on our station and place greater emphasis on protein sources.
This is what a typical citizen's diet would look like, consuming around 1,550 kcal per day from main meals. It is important to note that this is the basic menu for citizens, but calorie intake may vary from one individual to another.

Breakfast: 432–471 kcal

- Instant oats – 50 g — 190 kcal
- 2 boiled or poached eggs — 154 kcal
- Skimmed milk powder (or dehydrated plant-based milk) – 20 g — 70 kcal
- Fresh fruits and vegetables grown using the aeroponic system (strawberries, raspberries, blueberries, or cucumbers, tomatoes, and peppers), optional:
    - 100 g strawberries — 33 kcal
    - 100 g raspberries — 52 kcal
    - 100 g blueberries — 57 kcal
    - 100 g cucumbers — 12–15 kcal
    - 100 g tomatoes — 18 kcal
    - 100 g bell peppers — 20–30 kcal

Lunch: 550 kcal

- Dry quinoa – 70 g — 250 kcal
- Lentils (hydrated and boiled or pre-cooked, canned or dry + water) – 100 g — 120 kcal
- Olive oil – 15 g (1 tablespoon) — 130 kcal
- Fresh vegetables grown using the aeroponic system (peppers, carrots, spinach), optional:
    - 100 g spinach — 23 kcal
    - 100 g carrots — 41–44 kcal
    - 100 g bell peppers — 20–30 kcal

Dinner: 440 kcal

- Whole wheat pasta – 60 g — 210 kcal
- Sauce made from freeze-dried tomatoes + garlic powder + herbs (rehydrated) grown using the aeroponic system — 50 kcal
- Dehydrated tofu – 50 g — 110 kcal
- Dehydrated cheese – 50 g — 30 kcal

Optional snack: 150 kcal

- Mixed nuts and seeds (10 g almonds, 10 g sunflower seeds, 10 g cashews) — 150 kcal

The daily minimum total would be approximately 80–90 g protein, 150–160 g carbohydrates, 45–50 g fats, and 20–25 g fiber—sufficient to support a person in daily activities.

PRODUCT | TOTAL QUANTITY – 7 days | ESTIMATED PRICE (USD)

- Instant oats – 350 g – $1.40
- Eggs – 2 cartons – $6.98
- Milk powder – 140 g – $2.79
- Quinoa – 500 g – $4.19
- Lentils – 700 g – $2.33
- Olive oil – 100 ml – $2.10
- Whole wheat pasta – 420 g – $2.79
- Vegan cheese – 50 g – $1.16
- Dehydrated tofu – 350 g – $6.98
- Mixed nuts and seeds – 210 g – $4.19

The estimated total cost is $34.91 per person.
Weekly, the total cost per individual amounts to $34.91.
Total monthly cost for all citizens: 34.91 × 2,500 × 4 = $349,100.
Total monthly consumption:
16 kg per person × 2,500 people = **40,000 kg (40 tons) per month for all citizens.**

In this diet, we have integrated as many foods as possible that can be grown on the station using the aeroponic system, while the remaining foods can be brought from Earth using Bulk transport, the recommended solution for the station's location at L5.

Bulk-shipped food can be stored in double-walled tanks that also serve as radiation shields for the station. The optimal frequency of Bulk transport, in order to minimize launch costs and docking maneuvers at L5, is infrequent transport in massive quantities, which is the most efficient method. A spacecraft such as Starship could transport between 100–150 tons per flight. For the estimated 480 tons per year needed by the MARDOVI station, 3–4 Bulk transports per year would be required, meaning once every 3–4 months. The estimated cost, based on SpaceX Starship targets, to transport around 120 tons in a single launch would require on-orbit refueling, meaning between 5 and 7 tanker launches just to propel the spacecraft toward the L5 station location would be from 500 mil to 1 billion for a single launch and annualy.

- Minimum estimate:

500,000 x 4 = $2 billion

- Maximum estimate:

1,000,000 × 4 = $4 billion

**These costs cover imported products only and do not include crops grown via* the aeroponic system.

The AEROPONIC system

The aeroponic system for growing plants is a modern technology used to produce food in controlled environments. In this system, plants are not grown in soil, but are supported by a special structure, made of polystyrene in this case, while their roots remain suspended in the air. These roots are fed through the periodic spraying of a nutrient solution rich in essential minerals needed for plant development.

Aeroponics allows plants to receive an optimal amount of oxygen while preventing mold, which leads to faster and healthier growth. In addition, the light required for photosynthesis is provided by special LED lights, which offer the appropriate light spectrum for development while consuming little energy. Furthermore, this system uses less water than traditional agriculture, because the nutrient solution is recycled. Due to its efficiency and precise control of conditions, the aeroponic system is ideal for the MARDOVI station, where space and resources are limited.

Food production represents one of the greatest challenges of life in space. On the MARDOVI station, the cultivation of plants and the raising of animals play an essential role in ensuring a stable and healthy life for the community. In an environment lacking natural soil and normal gravity, space agriculture is designed to reproduce Earth-like conditions as closely as possible, allowing people to adapt more easily to life in space.

In conclusion, the combination of carefully selected crops, animal farming, and supplementary medicinal plants ensures a sustainable and efficient life-support system for the space station. By producing food, essential nutrients, and natural medical resources on board, the station reduces its reliance on supplies from Earth and increases long-term self-sufficiency. This integrated approach supports the health, well-being, and productivity of the crew while ensuring continuous operation throughout extended missions.

The purpose of these systems is not only the production of fresh food, but also the maintenance of a balance that provides the community with a connection to terrestrial life. Through these methods of raising animals and growing plants, we aim for a long-term lifestyle on the MARDOVI station.

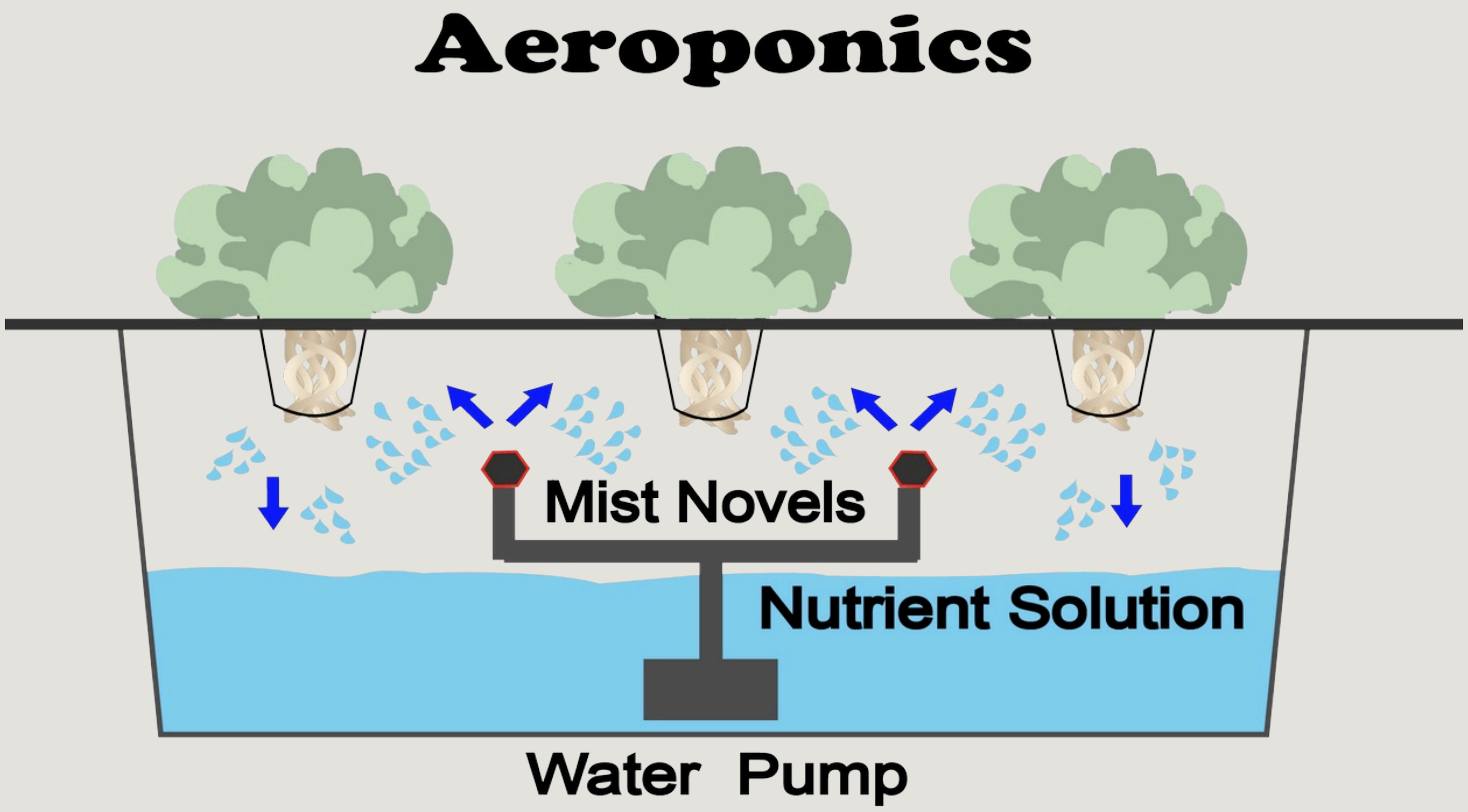


fig 24- aeroponic system

5.7 Storage Units

We decided to organise the storage units on MARDOVI within a special Storage Module designed on the same scale as our Housing modules to accentuate the station's need to support a population of around two thousand inhabitants over long periods of isolation. Instead of relying on a single warehouse, this module is composed of multiple closely connected storage structures arranged along the internal corridors, in order to allow efficient movement of goods.

Each storage structure is built vertically, with multiple levels dedicated to different categories of supplies, similar to our housing system. Upper levels are typically used for lightweight, frequently accessed items such as packaged food, clothing, and supplies to stock the stores on our station, while lower levels store heavier or more sensitive resources, including technical equipment, spare parts, and emergency supplies. Certain levels are fully climate-controlled to preserve pharmaceuticals, medical equipment, and perishable goods, while sterile sections are reserved for laboratory and healthcare materials. Those sections will also be monitored even more closely than the others.

All storage units are integrated into an inventory system that continuously monitors supply levels, expiration dates, and usage rates across the entire station. This will help us easily keep track of each item on board. Items are logged upon arrival and assigned to specific levels and compartments. Automated transport systems, similar to the ones inside our space station, and dedicated logistics corridors connect the storage district to residential areas, laboratories, hospitals, and operational sectors, allowing resources to be distributed on a regular schedule or rapidly deployed in emergency situations.

To ensure reliability and resilience, supplies are distributed across multiple units rather than concentrated in one location. This layered and compartmentalized design reduces the risk of large-scale loss due to technical failure, contamination, or structural damage.

We enforce regular check-ups of each storage unit to ensure it's safe and well-stocked.

To ensure long-term survivability during extended isolation periods or emergency scenarios, the Storage Module is designed around clearly defined categories of critical resources, each with a mandatory minimum level of autonomy measured in days of supply. These thresholds are calculated based on the full population capacity of the station and are continuously enforced by the central inventory management system.

If stock levels for any critical category fall below the predefined minimum, automated alerts are triggered and resupply, rationing, or internal redistribution protocols are activated. This approach ensures that MARDOVI can remain operational and self-sufficient even in the event of delayed resupply missions or partial system failures.

The minimum days of autonomy for each critical resource:

Resource Category	**Examples**	**Minimum Days of Autonomy**	**Storage Notes**
Oxygen (O_2)	Compressed O_2 tanks, chemical oxygen generators	90 days	Stored in reinforced, pressure-controlled lower levels; integrated into life-support systems
Water	Potable water, emergency water reserves	120 days	Dual-use storage tanks with radiation shielding; linked to recycling systems
Food (non-perishable)	Freeze-dried meals, protein sources, supplements	180 days	Distributed across multiple levels to avoid single-point failure
Medical supplies	Pharmaceuticals, trauma kits, antibiotics	365 days	Fully sterile sections with enhanced monitoring
Spare parts & tools	Life-support components, electronics, mechanical parts	180 days	Heavy-load lower levels, categorized by system criticality
Emergency equipment	EVA suits, fire suppression, backup power units	90 days	Rapid-access compartments near logistics corridors

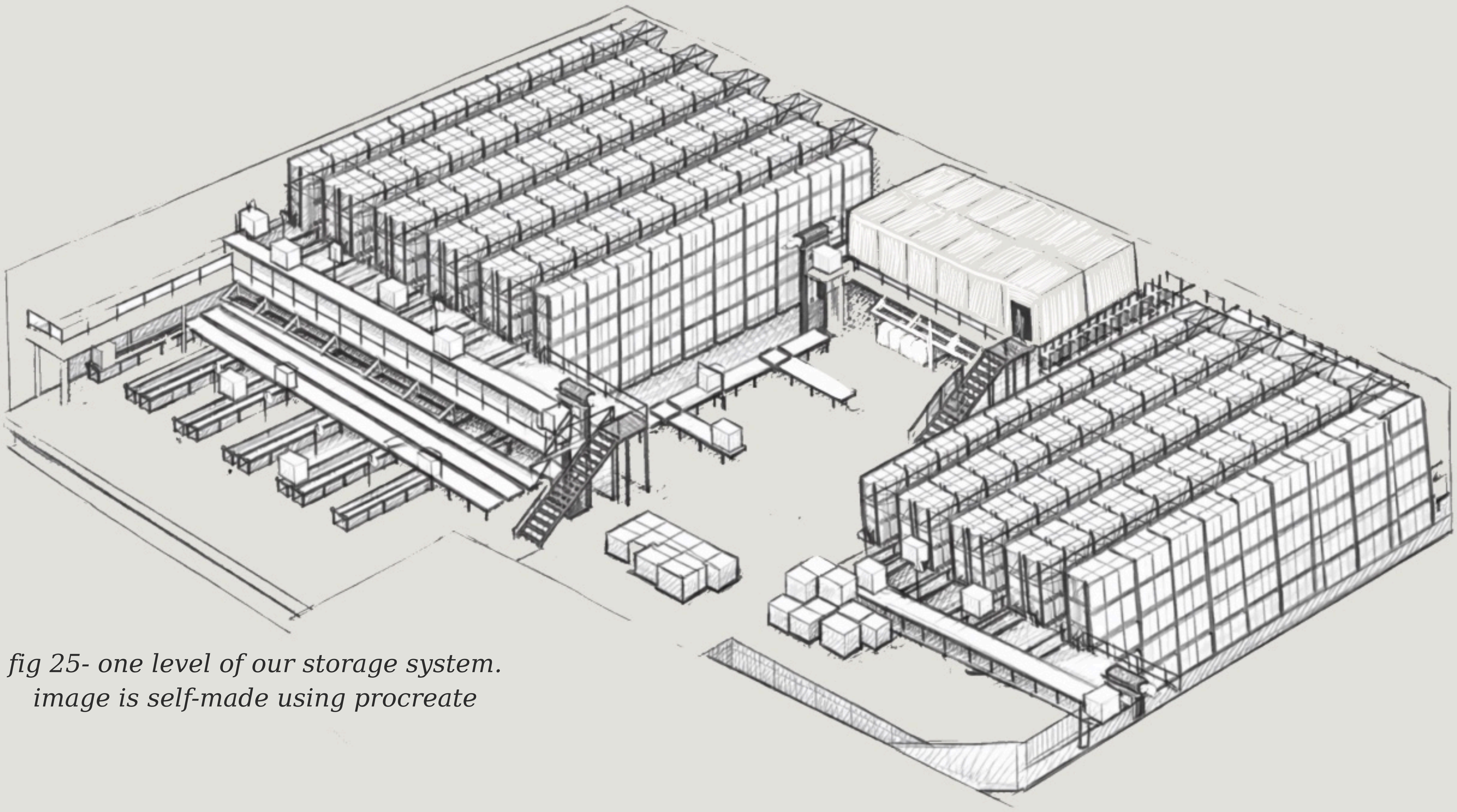


fig 25- one level of our storage system.
image is self-made using procreate

5.8 Death Protocol-Alkaline Hydrolysis

Once a death is confirmed by medical personnel, the body is documented and identity verified according to station records. The decedent's previously stated preferences for post-mortem disposition are consulted. Next of kin or designated representatives are notified, and a respectful period of observation or ceremony may be arranged consistent with station safety standards.

MARDOVI's primary method for disposition is controlled molecular decomposition via **alkaline hydrolysis**, an established alternative to burial or flame cremation that breaks down organic material efficiently in a sealed environment. In this process, the body is placed in a specially designed stainless-steel chamber equipped for elevated temperature and, when necessary, pressure. A solution composed predominantly of water and an alkaline agent such as potassium hydroxide is introduced into the chamber. This highly alkaline solution, when heated, accelerates the breakdown of proteins, fats, carbohydrates, and other organic tissues into their basic chemical components — amino acids, peptides, sugars, and salts — through a chemical reaction similar to hydrolytic decomposition. The process typically runs for several hours until all soft tissues have been dissolved and only inorganic material remains.

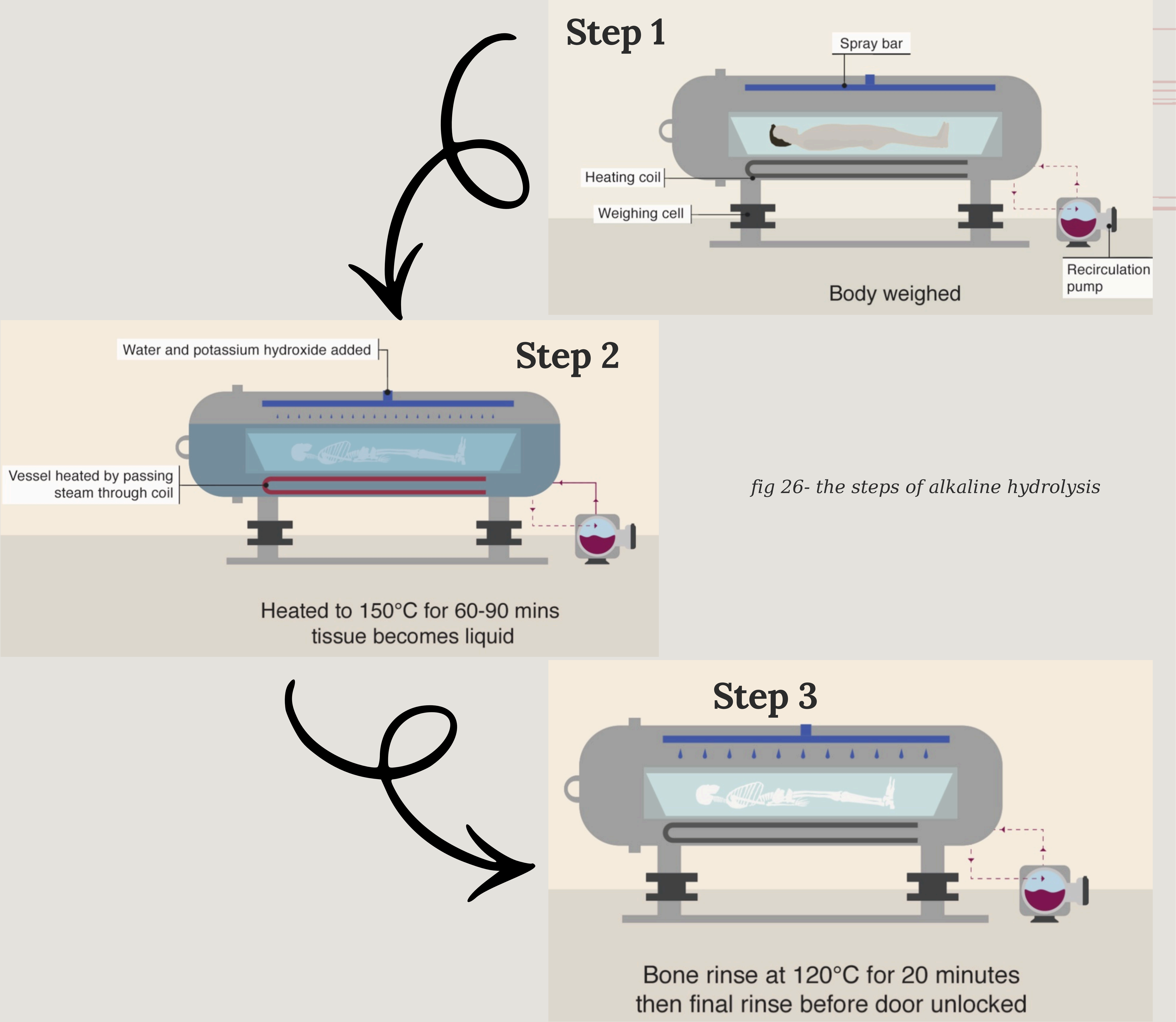


fig 26- the steps of alkaline hydrolysis

This process produces two main byproducts:
The first is a liquid waste that is sterile and contains no DNA. It consists of dissolved organic compounds and mineral salts. Before reintegration into station recycling systems, the pH is adjusted to safe levels and processed , ensuring it meets environmental and life-support standards without risk of contamination.

The second byproduct is a solid, non-organic residue, mostly made out of bone minerals and any implants or prosthetic materials. These solids are collected, rinsed, and mechanically dried before being pulverized into a fine powder similar in texture to cremation ash. This sterile powder may be handled according to the person's wishes. It can be preserved in sealed containers, urns, or used in permitted non-biological ways. All such uses must comply with ethical oversight and safety protocols.

The alkaline hydrolysis process consumes energy, but it is carefully managed to fit within MARDOVI's overall power system. The process is usually scheduled during periods of lower station-wide energy demand to avoid overloading the system, and most of the electricity comes from renewable sources such as solar panels and recycled energy from the station. During the reaction, the system generates heat, which is not wasted: it is captured and redirected to help preheat water for daily use and to assist with temperature control throughout the station, reducing overall energy loss.

The liquid byproduct produced by the process is initially highly alkaline and contains dissolved organic compounds. Before it can be reused, it is chemically neutralized to bring its pH to safe, environmentally compatible levels. Once neutralized and filtered, the solution is sent into the station's closed-loop recycling systems, where it is processed as part of water recovery and nutrient management. This ensures that the materials from the body can be safely returned to the life-support system for non-biological reuse, such as irrigation for aeroponic crops or other closed-loop functions, without any risk of contamination.

VI. RESEARCH LABORATORIES-

6.1 Biosensor Implant

Part I: Scientific Background and Research Challenges of FOP

Fibrodysplasia Ossificans Progressiva (FOP) is a rare genetic disorder characterized by the progressive formation of bone in soft tissues such as skeletal muscles, tendons, ligaments, and connective tissue. This process, known as heterotopic ossification, leads to irreversible joint immobilization, severe physical disability, and, in extreme cases, even an early death. Because this illness affects approximately 1 in 2 million individuals, FOP is notably difficult to study from both a clinical and research perspective.

One of the major challenges in FOP research is the unpredictable nature of disease flare-ups. They're episodic inflammatory events during which soft tissues become swollen, painful, and inflamed, with time transforming into bone. These flare-ups can be triggered by minor trauma, muscle strain, injections, surgical procedures, or sometimes even occur spontaneously, without any particular cause. Because flare-ups are not easily predictable, researchers often lack precise information regarding when and where pathological ossification begins.

Currently, disease progression and flare-ups are mostly monitored using medical imaging techniques, such as CT scans, MRI's , and X-rays.Unfortunately for us, these methods present plenty of disadvantages. CT scans and X-rays expose patients to repeated doses of ionizing radiation, which is undesirable, especially since FOP is a chronic disease. MRI, while safer, is expensive, time-consuming, and not always accessible, especially on a space station like MARDOVI. Imaging techniques also tend to only detect changes once the ossification has begun. Until then, it is nearly impossible to detect inflammation or other changes.

This makes it difficult for researchers to accurately identify the onset of flare-ups, correlate molecular and environmental triggers with disease progression and most importantly, study early pathological changes before irreversible ossification occurs

Part II: Proposed Implantable Inflammation-Detection System and Biological Rationale

To address these challenges, we propose a minimally invasive implantable biosensor system designed to detect early inflammatory changes in muscle-adjacent tissues in individuals with FOP. The primary purpose of this device is early detection and monitoring, enabling improved and easy patient management as well as more precise research and data collection.

Part III: Device Concept and Research Integration

The implantable device would be placed close to vulnerable muscle groups, without penetrating contractile muscle fibers, in order to minimize tissue trauma. It is important to note that FOP individuals can suffer severe flare-ups even from the slightest injection, so making this device as non-invasive as possible is ideal.

The implant would continuously monitor physiological markers associated with inflammation, such as localized temperature changes, altered tissue stiffness, or biochemical indicators of inflammatory activity. Upon detecting abnormal values consistent with an inflammatory flare-up, the device would transmit this data to a computer program, designed for researchers to keep track of each patient present on MARDOVI, and the progression of their illness.

Here is how inserting the device would happen, in a few simple steps:

1. **Patient and site preparation**
- The area near the vulnerable muscle group is cleaned with antiseptic.
- Local anesthesia is applied to reduce pain and minimize tissue trauma.

2. **Device preparation**
- Sensors (for temperature, tissue stiffness, and CRP-like inflammatory markers) are enclosed in a biocompatible casing.
- The device is sterilized using autoclave, plasma, or chemical sterilants.
- The exterior is coated with antimicrobial material to further reduce infection risk.

3. **Implantation procedure**
- A small, precise incision is made adjacent to the target tissue, without penetrating contractile muscle fibers.
- The device is inserted into the space next to the muscle, minimizing trauma and avoiding triggers for flare-ups.
- It is gently secured to prevent shifting.

4. **Risk management**
- Immediate infection risk is low due to thorough sterilization and antiseptic preparation.
- The sealed, biocompatible casing prevents microbial contamination and immune reactions.

- Post-procedure monitoring is performed to detect any early signs of inflammation or infection.

5. **Data transmission and power**

- Sensor data is transmitted wirelessly via encrypted low-power radio frequency, avoiding interference with other systems.
- The device operates at very low power (sub-milliwatt) and is powered by a micro-battery or energy-harvesting system.

6. **Monitoring and maintenance**

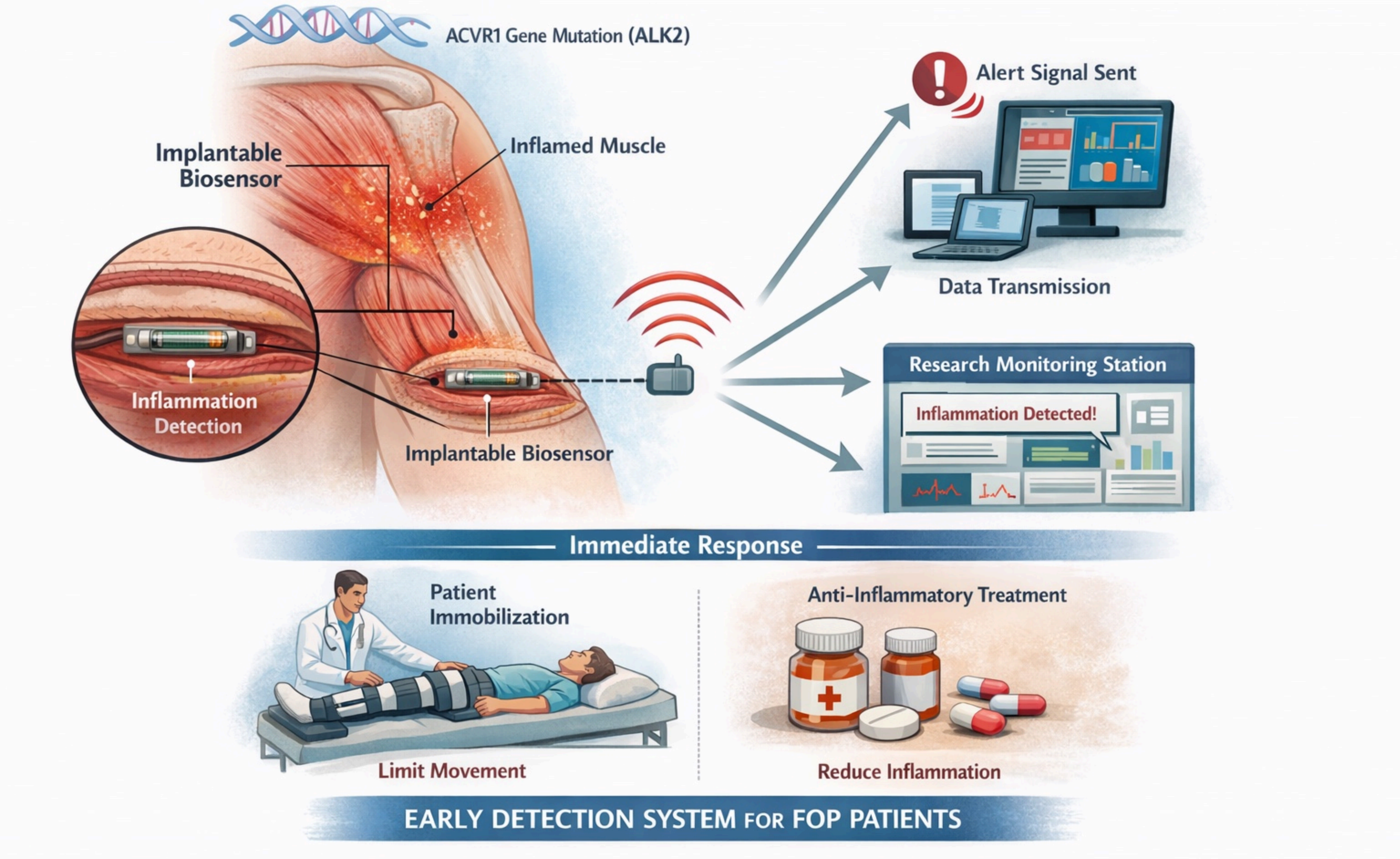
- Device function can be checked externally without removing or opening the implant.
- Calibration or adjustments are done non-invasively.

All implanted devices would be connected to a centralized research monitoring program, allowing clinicians and researchers to observe disease activity in real time. This system would enable:

- Continuous longitudinal monitoring of patients
- Early identification of flare-up onset
- Reduced dependence on frequent imaging techniques

If a patient is advised to receive the implant, the procedure is entirely voluntary and requires informed consent before any device is placed. The patient is fully informed about the purpose of the implant, the potential risks and benefits, and any alternative monitoring options. Participants retain the right to withdraw at any time, and the device can be safely removed if requested. All data collected by the implant is encrypted, anonymized, and securely stored, with access strictly limited to authorized medical and research personnel.

fig 27- a concept illustration of our biosensor implant.



The chart below summarizes key biomarkers relevant to the study. It highlights their clinical significance, measurement methods, and associated conditions.

Biomarker	Measurement Method	Monitoring Frequency	Desired Accuracy
Temperature	Micro thermistor / thermal sensor	Continuous (real-time)	±0.1°C
Tissue Stiffness	Piezoelectric / elastography sensors	Continuous / hourly	±5%
CRP-like markers	Microfluidic biochemical sensor	Every 6 hours	Detect 10–20% change from baseline

Clinical Response to Detected Inflammation

Once a flare-up is detected by the implant, the immediate clinical response would focus on minimizing further disease progression. One of the most important interventions in FOP management is activity restriction.

Patients would be immobilized as much as possible in the affected region to reduce stress, microtrauma, and inflammation. Excessive movement during flare-ups is known to accelerate the ossification of the muscle tissue, and because a lot of research has yet to be made, immobilising the patients is the only available method we have.

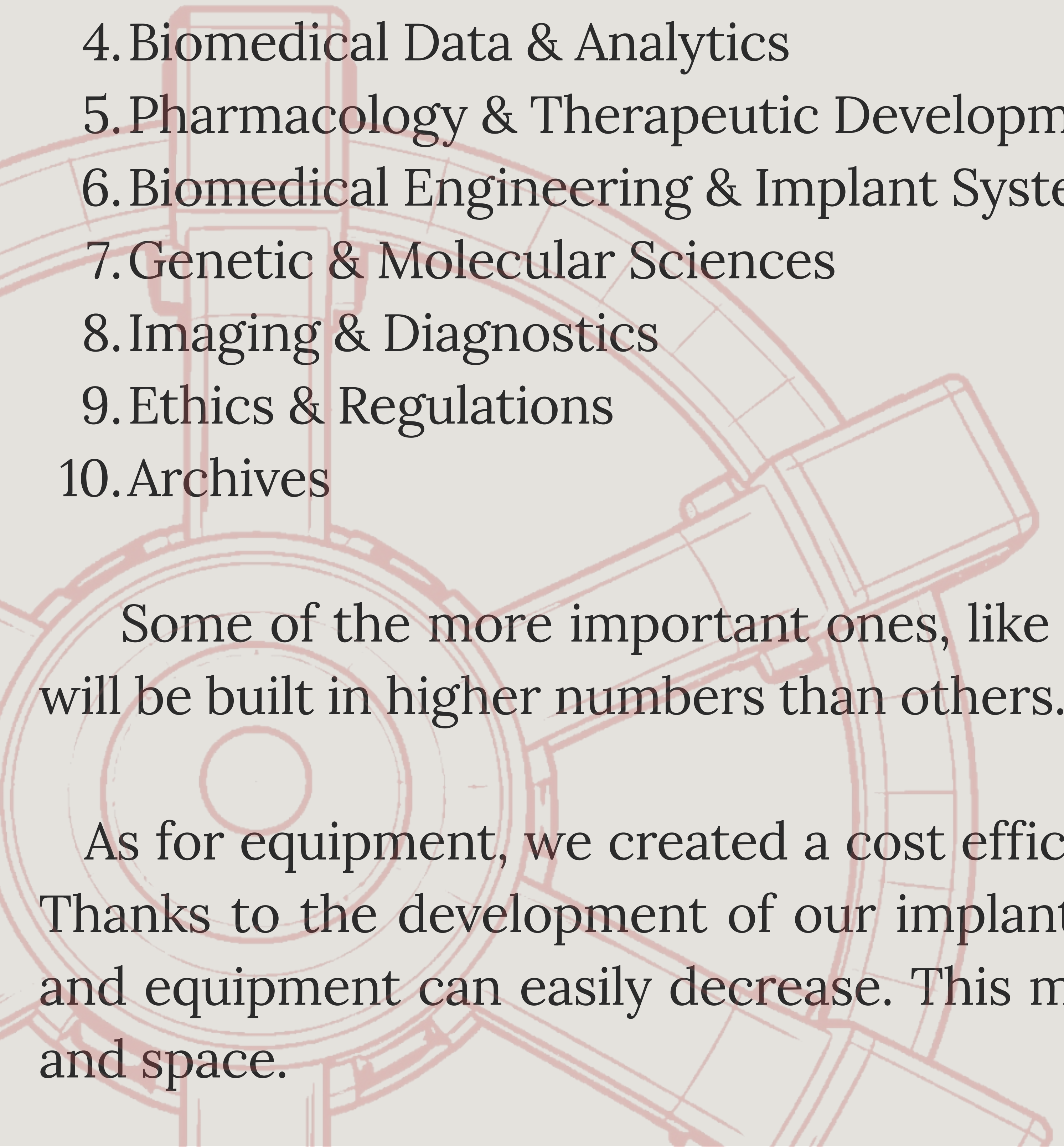
With time, we hope that physicians will be able to figure out immobilisation methods that would keep the patient both safe and comfortable. Unfortunately, such methods aren't available at the present moment.

Thanks our implant, we can now simplify the equipment necessary for research on MARDOVI. Our research modules will be organised similarly to the housing units, each being split into districts with specific requirements and duties.

6.2 Research Units

We came to the conclusion that the bare minimum for a well functioning station is at least one of each district:

1. Preclinical Research
2. Translational Human Research
3. Clinical Care & Patient Observation
4. Biomedical Data & Analytics
5. Pharmacology & Therapeutic Development
6. Biomedical Engineering & Implant Systems
7. Genetic & Molecular Sciences
8. Imaging & Diagnostics
9. Ethics & Regulations
10. Archives



Some of the more important ones, like clinical care or genetic and molecular sciences will be built in higher numbers than others.

As for equipment, we created a cost efficient strategy that saves both money and space. Thanks to the development of our implant, the number of MRI, CT, and X-ray machines and equipment can easily decrease. This means we save a great deal of money, resources and space.

With all of the funds that we save, we plan to develop a line of assistive mobility equipment for FOP patients. Our long-term goal is making the lives of those burdened with FOP less painful. Although the illness itself might be difficult to cure, we can always create mobility devices or prosthetics to help those with FOP live an easier life, with less discomfort.

Doing so sounds easy in theory, however all devices must be designed to minimize pressure, friction, and sudden movements while still providing support for mobility and posture. Otherwise, we put patients at risk of sudden flare-ups.

Materials for those prosthetics will be chosen for their lightweight, flexible, and hypoallergenic properties, often incorporating soft polymers, carbon fiber composites, or advanced foams to distribute load evenly and reduce localized strain.

Each device will need to be custom fit and designed in 3D. Our computer programs will actually be an enormous help, providing the engineers with easy access to the patients information.

Two out of six modules from MARDOVI station will be dedicated to researching. One of those two will contain laboratories, imaging units and research units, whilst the other one will focus on storing patient information, creating and improving prosthetics and archiving all studies of FOP.

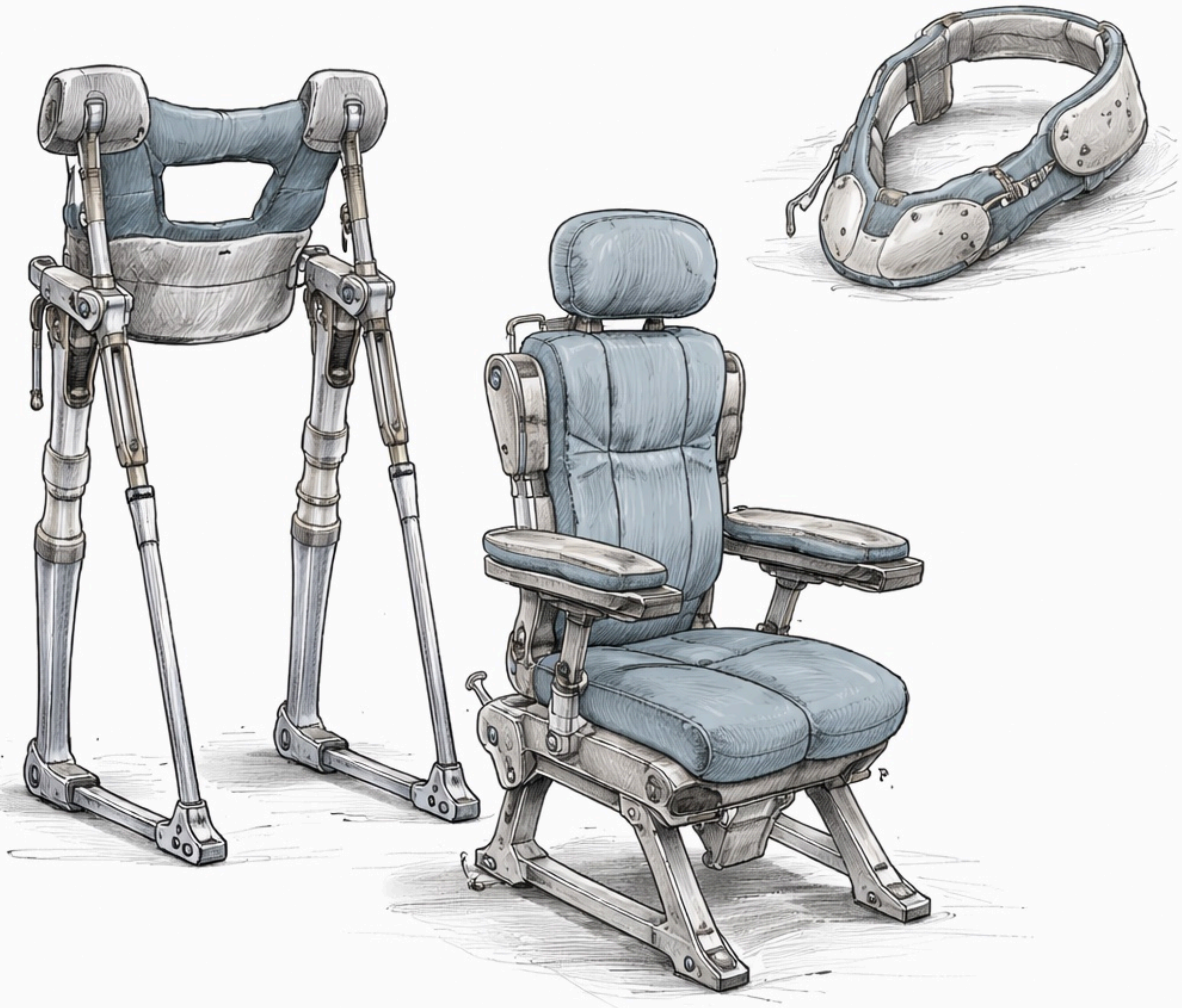


fig 28- a concept illustration of possible future prosthetics

This image provides an example of equipment for FOP patients. It contains an adaptive posture support chiar, a custom neck brace as well as a lower-limb assistive exoskeleton.

VII. INSTITUTIONS

7.1 Goverment

We founded the government of MARDOVI on a representative system inspired by two major factors which we consider essential: the ancient Greek democratic principles and the philosophy that observation precedes authority. We are guided by the idea introduced by John Berger in his work: “Ways of Seeing”, in which he affirmed that “Seeing comes before words. The child looks and recognizes before it can speak.”—Therefore regardless of age or position we are all capable of perceiving, understanding, and contributing to collective decision-making.

Each major department of the station, including food systems, scientific research, healthcare, engineering, education, and operations, will elect a small number of representatives to participate in a governing assembly. These representatives will be chosen to convey the observations, concerns, and experiences of their respective communities. Representation is based on lived experience within each sector. This ensures that decisions and changes will reflect the practical reality of things.

A distinctive feature of MARDOVI’s governance is the inclusion of youth representation. All educational institutions aboard the station will and must elect at least one young representative to the assembly. We decided to make this role exist because we believe that observation is not dependent on age or expertise. Younger individuals experience the station differently and often notice social, environmental, or ethical issues overlooked by adults. Their participation ensures that governance remains inclusive, adaptive, and grounded in human experience across generations.

Before any vote takes place, all representatives will participate in an evidence-first process in which visual data, direct observations, and measurable outcomes are presented. Only after this shared act of “seeing” does discussion occur, followed by voting.

Leadership within the assembly will be rotational and facilitative, preventing long-term concentration of power while maintaining organizational continuity.

Through this structure, MARDOVI’s government ensures that authority arises from collective observation and shared understanding. By giving voice to all sectors and generations, our station creates a governance system that is ethical, resilient, and aligned with both scientific principles and fundamental human perception.

7.2 Law & Order

Law and order on our station are founded on the same principle as before, though it is important to note that we also believe in equal human dignity and the belief that all individuals have the right to exist, work, and participate without fear of discrimination or exclusion. All of these principles are ideal and will be applied strictly onto our station.

Any form of discrimination based on race, ethnicity, nationality, gender, sexuality, religion, age, disability, or genetic characteristics is strictly forbidden. These protections are embedded in the station’s legal framework and apply to all residents, regardless of role or status. Each individual will be subject to monitoring carried out within the limits established by the **Bill of Rights** (*see page* 40) and in full compliance with applicable privacy laws. This monitoring is intended to ensure safety, transparency, and equal treatment, and to prevent discrimination or abuse within the station.

We strongly believe that if the children and following generations will be taught love instead of hatred, peace on our station will be easily maintained. The very first generation that will be brought on board is the most crucial one, and will be monitored the most.

The enforcement of law on MARDOVI will highly prioritize prevention, accountability, and restoration over punishment. An independent Order and Ethics Council will be responsible for upholding station laws, investigating violations, and ensuring that all individuals are treated fairly and impartially. This body will operate transparently and will be separate from political or operational leadership, to prevent conflicts of interest and abuse of power.

In alignment with the station's guiding philosophy that observation precedes judgment, all incidents are going to be assessed through evidence-based investigation. All decisions will be grounded in documented observations, recorded data, and verified testimony before any conclusions or sanctions will be applied. This ensures that enforcement is rooted in facts rather than assumptions, bias, or authority.

When violations will inevitably occur, our station will use restorative justice wherever possible. Our goal is to repair harm, protect affected individuals, and reintegrate community members while maintaining safety and trust. Serious or repeated offenses will be addressed through clear, proportional consequences to preserve the well-being and stability of the station.

Presented below is the Station's Bill of Rights, accessible to all MARDOVI citizens.

MARDOVI STATION BILL OF RIGHTS

- **Shield of Privacy** – All personal data, communications, and medical records are confidential and protected, access is limited to authorized personnel only.
- **Command of the Self** – Crew members have full authority to make informed decisions about their own healthcare, without coercion.
- **Seal of Consent** – No medical treatment or research activity can occur without full disclosure of risks, benefits, and alternatives, and voluntary agreement from the individual.
- **Freedom of Withdrawal** – Participants may retract consent from any medical or research procedure at any time, without affecting their standard care or station privileges.
- **Beacon of Fairness** – All disciplinary, legal, or administrative actions are conducted with transparent procedures, representation, and the opportunity for a fair response.
- **Sanctuary of Belief** – Crew members may practice, or refrain from, religious or philosophical beliefs without interference, restriction, or discrimination.
- **Equal Access Mandate** – Every crew member has equitable access to healthcare, nutrition, shelter, and emergency services, regardless of rank, role, or background.
- **Haven of Safety** – The station maintains strict environmental, occupational, and medical safety standards, minimizing hazards and ensuring proper monitoring.
- **Light of Knowledge** – Crew members have the right to timely, transparent information about station policies, scientific procedures, and health risks.
- **Cloak of Dignity** – Every individual has the right to be treated with respect, free from harassment, coercion, or discrimination, across all aspects of station life.

7.3 Entertainment

Entertainment on MARDOVI will be designed to mimic what is available on Earth, providing our residents with opportunities to relax, socialize, and pursue their hobbies in between working hours. Each module will include at least a cinema for films, plenty of spaces for music and many other cultural activities, as well as multipurpose halls for community events. Sports and physical recreation will be available mostly through common gyms and athletic areas. This will allow our residents to play games, exercise, or participate in organized activities in their free time. All of these facilities will ensure that life on the station will remain engaging and balanced, especially since all of our residents will have strict work schedules.

Life on MARDOVI will be carefully structured so that work responsibilities will not disturb or get in the way of our residents' personal time. Everyone will follow a set schedule that will allow them to ballance professional duties with ample free time. This way every citizen can get plenty of rest, socialization, and fully pursue their hobbies or personal interests. Residents will be constantly encouraged to engage in leisure activities such as sports, music, art, or cinema, to help maintain mental health and prevent burnout. By prioritizing this balance, our station will foster a community where productivity and well-being will go hand in hand, ensuring that inhabitants remain motivated, healthy, and connected.

7.4 Healthcare

To ensure the health and well-being of all inhabitants, our space station will maintain an accessible healthcare system for both routine and emergency medical needs.
Our station will include two large hospitals, one in each living module, equipped with all essential departments, including cardiology, neurology, radiology, surgery, oncology, urology, emergency medicine, and others. Each hospital will also contain an intensive care unit (ICU) and fully regulated pharmacies, where medical supplies and treatments are available exclusively through professional prescription.

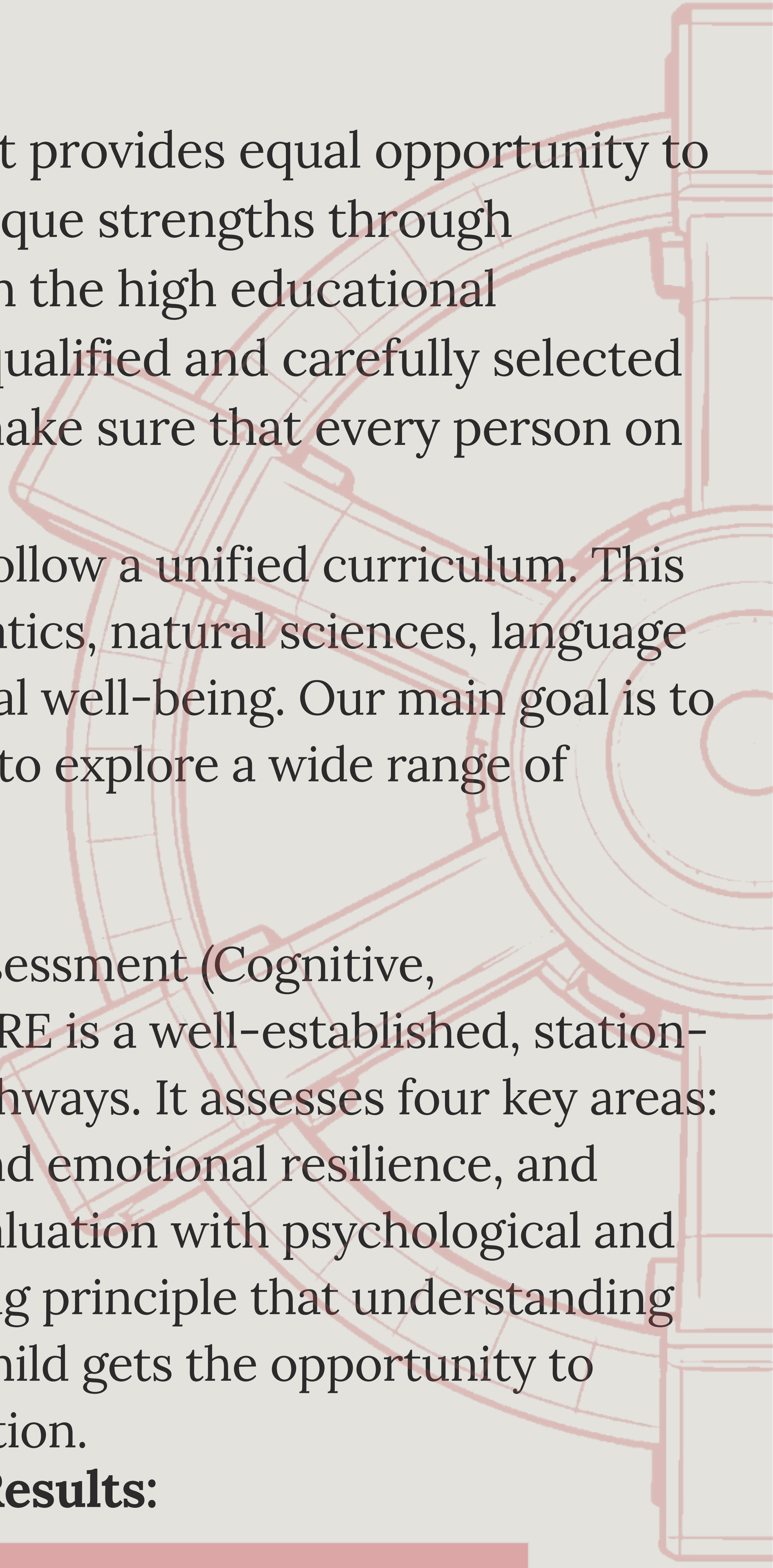
Throughout each district in the living modules, small medical clinics will be located at regular intervals to provide first aid and treat minor health issues. This way every person on MARDOVI gets rapid access to care at all times.

Aside from treatment, MARDOVI's healthcare system will place a strong emphasis on prevention. To reduce long-term health risks, before embarking the very first generation on our station, we will determine which items to bring based on established health and safety standards. All consumables and materials are evaluated for long-term risks, including potential carcinogenic effects, and only those that meet regulatory safety guidelines are included in the supply manifest. This ensures that all provisions comply with the station's medical protocols and risk-management policies, while avoiding arbitrary or paternalistic restrictions.

All food production, storage, and distribution systems will follow strict nutritional and safety standards, prioritizing balanced diets and minimizing exposure to harmful additives or contaminants. Similarly, materials used in everyday products and living environments will be carefully selected to meet certain safety guidelines, so that the population on MARDOVI can be as healthy as possible.

Regular health monitoring and check-ups will be mandatory for all residents to allow early detection of potential medical concerns and reduce the need for invasive treatment, which isn’t very desirable on a space station. Mental health support will be integrated into the healthcare system, and we will have plenty of professionals to help our inhabitants face the psychological challenges of living in a confined and high-responsibility environment. By focusing on prevention, accessibility, and evidence-based medical practice, MARDOVI aims to create a stable healthcare model that protects its population without relying on experimental or unproven technologies.

7.5 Education || The “CORE” Assesment



We designed the education on MARDOVI in a manner that provides equal opportunity to every individual while recognizing that everyone forms unique strengths through observation, experience, and curiosity. In order to maintain the high educational standards required to become a part of MARDOVI, highly qualified and carefully selected teachers will live and work aboard the station, so we can make sure that every person on our station becomes a highly intelligent individual.

From early childhood until the age of ten, all students will follow a unified curriculum. This stage of education focuses on core subjects such as mathematics, natural sciences, language and communication, ethics, history, creative arts, and physical well-being. Our main goal is to build essential skills, encourage curiosity, and allow children to explore a wide range of interests without any early specialization.

At the age of ten, all students must complete the CORE Assessment (Cognitive, Observational, Resilience & Engagement Evaluation). The CORE is a well-established, station-wide evaluation designed to guide the future educational pathways. It assesses four key areas: cognitive skills, observational and analytical ability, mental and emotional resilience, and personal engagement or passion. By combining academic evaluation with psychological and interest-based insights, the CORE reflects MARDOVI’s guiding principle that understanding begins with observation and self-awareness.This way, each child gets the opportunity to pursue their passion, while also being useful to the space station.

Pathway Guidance Based on CORE Results:

CORE Profile Strength	Suggested Educational Pathway
High cognitive + observational scores	Scientific research, data analysis, space science
High engagement + technical reasoning	Engineering, systems maintenance, robotics
High resilience + social awareness	Healthcare, psychology, community support
High observation + creativity	Design, communication, education, culture
Balanced scores	Interdisciplinary or exploratory pathway

VIII. ECONOMY

The economy of the MARDOVI space station will be structured as a hybrid system, combining institutional coordination with individual initiative. Its primary objective will be to ensure long-term stability and efficiency in an environment defined by limited resources and logistical isolation, as the station will be located at the Lagrange Point L5. Unlike Low Earth Orbit (LEO), where frequent resupply missions are feasible, L5 will impose long communication delays and high transport costs. For this reason, MARDOVI's economic model will be designed to minimize reliance on Earth-based deliveries and will prioritize local production, recycling, and self-sufficiency.

Unlike most economic systems on Earth, where profit and market competition are central, MARDOVI's economy will focus on supporting the community as a whole. Every resident's work will be valued based on how it contributes to safety, research, and daily life on the station. Essential resources such as food, water, oxygen, housing, and basic energy access will be guaranteed to all inhabitants by the station administration, ensuring that no one's survival depends on income or status.

Access to additional goods and services will depend on personal involvement in station activities. This involvement will be measured through a civic credit system. Civic credits will be earned through professional work, research, maintenance tasks, medical service, education, or volunteering. These credits will not function as money but will serve to regulate access to non-essential items, such as extended use of equipment, specialized workspaces, advanced training programs, or recreational facilities. Their purpose will be to encourage participation in the activities held around the station.

The distribution of goods and resources will be managed by an intelligent digital system connected to the station's storage and logistics network, as mentioned in the stoarge chapter. This system will continuously track supply levels, usage rates, and overall demand. Based on this data, it will adjust distribution to prevent waste, shortages, or overuse. While supply and demand will still exist, decisions will be guided by system limits and long-term sustainability rather than free-market competition.

From a financial point of view, MARDOVI will operate using a mixed funding model. Major ongoing costs will include life-support systems, energy production, medical facilities, scientific laboratories, and general station maintenance. These expenses will be covered mainly through long-term support from governments, international organizations, and research institutions on Earth. Instead of producing physical goods for export, the station will create value through research and innovation. The main economic outputs of the station will be scientific knowledge, technological development, and specialized services. MARDOVI will produce research data in areas such as space medicine, long-term human health in isolation, rare disease monitoring, and closed-loop life-support systems.

It will also generate patents and intellectual property, including medical devices, advanced prosthetics, monitoring systems, and autonomous technologies tested in space. In addition, the station will offer research and testing services to Earth-based institutions, allowing experiments that cannot be performed under normal gravity conditions.

Sustainability will be a fundamental principle of this economic model. Most production and consumption processes will be organized in closed loops, where waste will be recycled and reused whenever possible. Repair will be preferred over replacement, and residents will be encouraged to maintain and reuse personal and shared equipment. This approach will help conserve resources and reduce long-term costs.

IX. EMERGENCY PROTOCOL

To support rapid and coordinated responses during critical situations, we decided to implement a station-wide Emergency Operations Manual accessible to all crew members. This manual outlines standardized procedures for scenarios such as power outages, life-support failures, fires, decompression events, and medical emergencies. It is available in both digital and physical formats and is specifically designed for quick reference under stress, using clear step-by-step instructions, visual indicators, and prioritized actions. The manual is regularly updated based on system upgrades, incident reviews, and crew feedback, and all residents receive mandatory training on its use.

Here are some of the possible scenarios we have taken into account:

1.Life Support System Failures : In the event of an oxygen deficiency, we have designed alarm systems equipped with sensors to detect internal hazards and alert the population in a controlled manner. This ensures that the control center is immediately informed of the issue and can transmit signals via radio waves to a ground-based station on Earth. The distance between the Lagrange Point L5 (the location of our space station) and Earth is approximately 150 million kilometers. Radio waves travel through a vacuum at a speed of about 300,000 km/s, resulting in a one-way transmission time of approximately 500 seconds, or 8–9 minutes (16–18 minutes round trip).

2.Onboard Fires: Fire behaves very differently in space than it does on Earth. To keep the crew safe, we decided to keep oxygen levels on the station low, but we still need a reliable way to put out accidental fires. For decades, space stations and submarines have used Carbon Dioxide (CO2) to bloom over fires. This works because CO2 doesn't damage expensive electronics, which we will have a lot of on our station, but it has a downside: it fills the cabin with gas that the crew can't breathe, which then has to be cleaned out of the air.
As a more modern alternative, we decided to propose a Vacuum-Based Fire Suppression system. This idea is inspired by new research from space agencies like JAXA, which suggests that instead of spraying a fire with chemicals, we should simply "suck it away." This system uses a vacuum chamber—or even the empty vacuum of space itself—to create a powerful suction. When a fire starts, the flames and smoke are pulled into a collection tank. This stops the fire instantly by removing both the heat and the oxygen it needs to burn.

This vacuum method is a smarter way to handle emergencies because it does two jobs at once: it puts out the fire and cleans the air. Instead of the crew having to wear oxygen masks for a long time while the station's scrubbers remove CO2, they can get back to work much faster. Once the fire is trapped inside the vacuum chamber, the valve is closed tight, and the mess is safely contained away from the living quarters.

We made this chart to help compare the traditional methods with the Vacuum System that we proposed:

Feature	Traditional CO2 Systems	Proposed Vacuum System
How it works	Smothers the fire with gas.	Sucks the fire and smoke away.
Air Quality	Leaves gas in the room for the crew to clean.	Cleans the air by removing smoke immediately.
Safety	Good for maintaining equippment, but hard for humans to breathe.	Very safe; keeps the cabin air clear.
Storage	Needs heavy tanks of stored gas.	Uses the natural vacuum of space.

3.Power Outage / Blackout Scenario: To prevent a complete station-wide blackout, our station will rely on a structured load-shedding and power-prioritization system. In the event of a power failure or significant energy shortage, automated monitoring systems will immediately assess power availability and system status, allowing the control center to respond without delay. The station will operate under a three-tier hierarchy of system. Critical systems, including the Environmental Control and Life Support System (ECLSS), medical equipment, emergency lighting, fire suppression, and essential communication systems, remain powered at all times through dedicated energy lines and lithium-ion battery reserves.

Essential systems, such as laboratories, internal transportation, food preparation areas, and core data-processing units, may experience reduced power or intermittent operation depending on available energy. Non-essential systems, including recreational areas, personal electronics, decorative lighting, and optional research activities, are automatically shut down first in a controlled sequence.

Power reduction is carried out gradually to avoid sudden shutdowns that could damage equipment or endanger personnel. Load shedding follows a predefined order, disconnecting the most energy-intensive but least critical systems first.

During this period, the control center will continuously recalculate battery autonomy and adjust system priorities based on crew needs, medical requirements, and repair progress.

Lithium-ion battery reserves will ensure uninterrupted power to critical systems for extended periods, providing sufficient time for diagnostics, repairs, or the restoration of primary power generation. Non-essential activities will be suspended until stable power levels will be restored, minimizing overall consumption and preserving emergency reserves. This layered approach ensures crew safety, system stability, and operational continuity during blackout events.

4.Emergency Decompression Response: In the event of rapid or slow decompression caused by a hull breach or pressure system failure, pressure and structural sensors will immediately detect the anomaly and trigger automated containment protocols. Affected modules are isolated by fast-acting bulkheads to limit air loss and prevent pressure propagation throughout the station. Crew members in compromised areas will be alerted via audible and visual alarms and instructed to secure emergency oxygen masks or pressurized suits.

Life-support systems will immediately prioritize stabilizing pressure and oxygen levels in safe zones, while the control center assesses damage severity. Emergency repair teams will be deployed when conditions allow, and medical staff will be prepared to treat hypoxia-related symptoms. This layered response ensures crew survival, limits structural damage, and maintains overall station integrity during decompression events.

“60 seconds” Emergency Protocol:

To ensure our crew is prepared for any critical situation and to eliminate delays caused by human hesitation, we have developed a dedicated protocol for the first sixty seconds following an emergency:

Scenario	Event Trigger	Automated System Response	Crew Action (First 60s)
1. Solar Particle Event	Radiation sensors detect flux.	A station-wide "Radiation Alert"is issued.	Crew immediately moves to the nearest storm shelter available.
2. Onboard Fire	Smoke or particle sensors go off.	**Vacuum Suppression** activates; intake valves open to stop the fire.	Crew must clear the immediate area to avoid possible citizens being caught in the suction zone.
3. Decompression	Pressure and structural sensors detect a sudden drop in *O2* partial pressure.	Fast-acting bulkheads trigger automatically to isolate the module, helping prevent air loss.	Any nearby crew must secure oxygen masks and move to the nearest safe zone.
4. Power Outage	Monitoring systems detect an energy shortage.	**Load-shedding** starts; non-essential systems shut down immediately.	Crew suspends experiments and checks critical life-support displays.

Risk Register:

Following the initial 60-second response, all events are logged into the Risk Register to evaluate long-term impact. Here is an example of our anticipated Risk Register:

Risk Event	Probability	Impact	Mitigation Strategy
Solar Particle Event (SPE)	Moderate	Moderate - High	Immediate relocation to the nearest storm shelter.
Onboard Fire	Low	Critical	Low oxygen levels and the **Vacuum-Based Fire Suppression.**
Rapid Decompression	Low	Critical	Fast-acting bulkheads to isolate modules and pressure sensors for immediate detection.
Power Outage	Moderate	Moderate	Three-tier hierarchy and load-shedding to prioritize Life Support (ECLSS) and medical equipment.
Life Support Failure	Low	High	Automated alarms and dual-layered communication with Earth-based ground stations.

X. BIBLIOGRAPHY

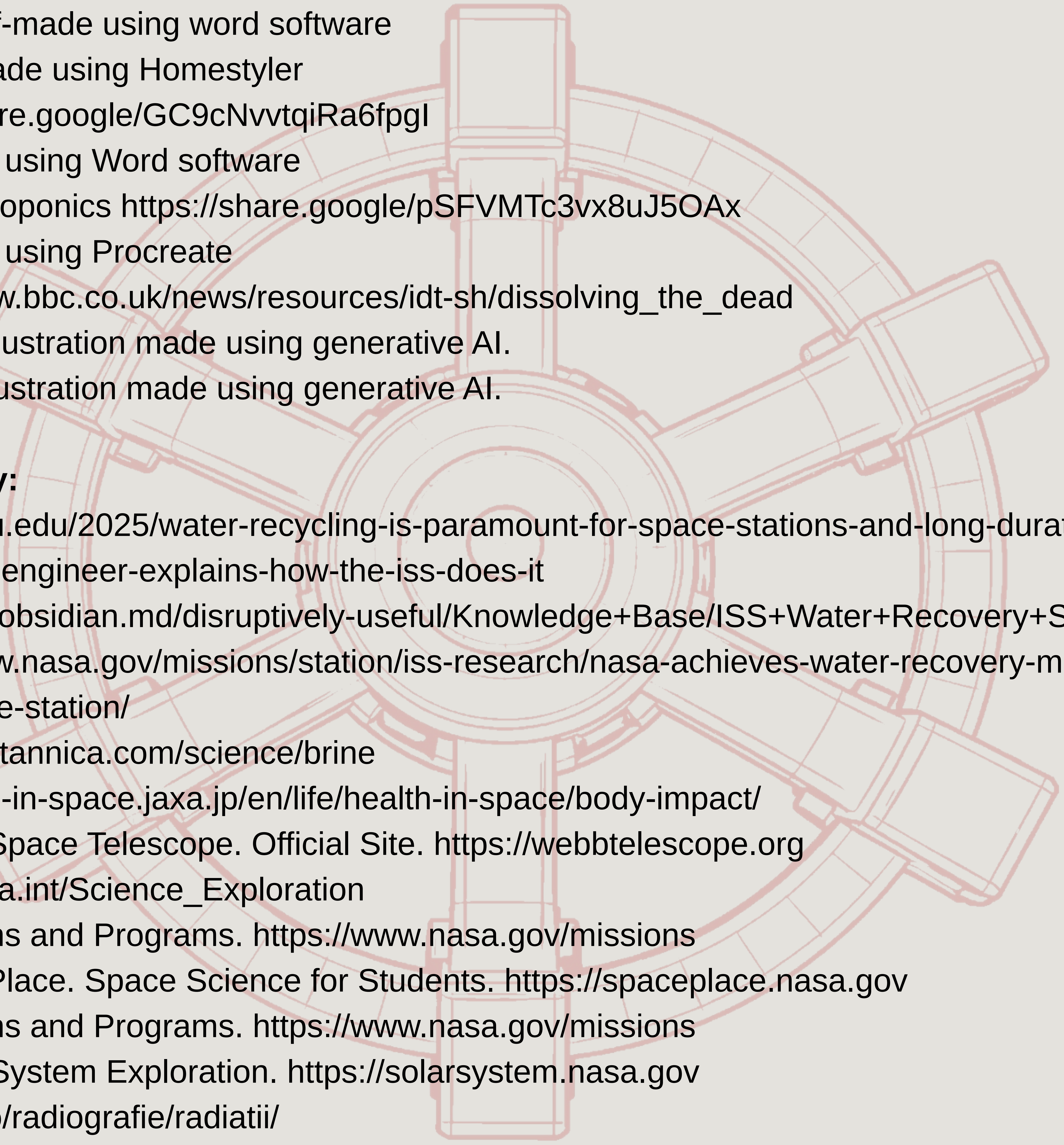


Image bibliography:
fig 1 - Concept Illustration made using generative AI.
fig 2 - Self-made on Procreate
fig 3 - https://www.scientia.ro/biologie/37-cum-functioneaza-corpul-omenesc/7420-efectele-radiatiei-asupra-organismului.html
fig 4-7 - Self-made using Homestyler
fig 8 - Self-made using Procreate
fig 9 - Chart is self-made using word software
fig 10-21 - Self-made using Homestyler
fig 22 - https://share.google/GC9cNvvtqiRa6fpgI
fig 23 - Self-made using Word software
fig 24 - Rise Hydroponics https://share.google/pSFVMTc3vx8uJ5OAx
fig 25 - Self-made using Procreate
fig 26 - https://www.bbc.co.uk/news/resources/idt-sh/dissolving_the_dead
fig 27 - Concept Illustration made using generative AI.
fig 28 -Concept Illustration made using generative AI.

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