GAIA'S HOPE

HUMANITY'S NEXT FRONTIER

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MEET THE TEAM

Kashyap Patel | Project Lead

"What is now proved was once imagination." Hi, my name is Kashyap Patel, and I am a Grade 12 AP student studying at Central Peel Secondary School. Growing up, I was, and still am, fascinated by technological advances. With a passion for robotics and innovating along with creativity, I look forward to building my career as a successful mechanical engineer.

Mashraful Choudhary | Vice Project Lead

My name is Mashraful Choudhury and I am a Grade 12 AP student at Central Peel Secondary School. Some things I enjoy include: hiking, making music, and learning about how our species came to be. I hope to pursue a career in the human sciences in the future. I aim to be able to connect my creative passions and career passions one day.

Ruhaim Ali

My name is Ruhaim and I am currently an AP student at Central Peel Secondary School. My interests include baking, biking and discovering new ways to enjoy the little things in life. I'm currently interested in the fields of mathematics, chemistry and biology, and I wish to pursue a graduate degree in a branch of natural sciences.

Mehtab Cheema

My name is Mehtab Cheema and I am a Grade 12 AP student at Central Peel Secondary School. My hobbies include reading, boxing, and weight lifting.
I am very passionate about innovation and problem solving so I help young individuals solve problems through the power of code. One of my role models is Steve Jobs because he was able to innovate the world through the power of technology. I aspire to become an engineer so I can innovate the world with my creations.

Anant Duggal

"So what?" one of my favorite quotes, that pushes your own capabilities. Hey, I'm Anant Duggal, a Grade 12 AP student at Central Peel. I'm extremely passionate about Artificial Intelligence, sparking STEAM in the youth within the GTA, game development, and leadership opportunities alike. I aspire to continue my passions and specialize with a Master's in Engineering.

Tanvir Gahunia

I am a Grade 12 AP student at Central Peel. My interests include physical fitness through working out, helping others through tutoring, and hitting the slopes for snowboarding. I also have a passion for mathematics and aspire to become a computer engineer in the future.

Kushal Patel

I am a Grade 12 AP student attending Central Peel Secondary School. My hobbies include swimming, camping, and playing sports. I enjoy studying math, and hope to be an engineer.

Pragalva Sharma

My name is Pragalvha Sharma and I am currently an AP Student at Central Peel Secondary School. Beyond the classroom, I am dedicated to self-improvement through my interests in fitness, investing, and blockchain technology. My passion for finance, computing and business fuels my aspiration to become an entrepreneur and bring innovative ideas to life through entrepreneurial ventures.

Greatful for this amazing team who put their 100% in creating this report. Their immense hard work and dedication towards this project, along with team support was the tool to achieving our shared goals.

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EXECTUTIVE SUMMARY

The race of giants in Greek mythology provided the inspiration for the name Titan. They were offspring of Gaia and Uranus. Titan's abundance of natural resources makes it humanity's hope for supporting human life. The name of the settlement is inspired from these facts. This paper will cover the structure, government, lifestyle, and energy of Gaia's Hope. Gaia's Hope will be cylindrical in shape, and will be constructed of insulating materials to protect the 10,000 inhabitants from the harsh conditions of space. Additionally, artificial gravity will be created through centripetal force which will create the fictitious centrifugal force. Sustainability and recycling are among the fundamental principles of the civilization that we want to install in everyday life. To maintain sustainability and to continuously improve the society, we will utilize every resource available to us, from sewage to transportation to the air citizens breathe. The Republic of the settlement will be a special fusion of democratic and authoritarian rule. As the highest authority, NASA will offer the direction, resources, and knowledge required to make sure the colony is successful. However, via their elected representatives, the people will have a say in the government. These representatives will serve as a conduit between the general public and NASA, communicating the wants and requirements of the populace to the government. Gaia's Hope will be powered mainly with nuclear fusion, but will also be dependent on wind energy, solar power, and kinetic energy. The necessary fuel can be extracted from Titan itself. The secondary source of power will be solar power. Gaia's Hope will provide hope for future human colonization of space,and open the door to endless possibilities.

1. PLANET AND SPACE

1.1 Why Titan?

It may be some obscure moon orbiting Saturn at first glance. However Titan has been one of the top candidates for supporting human life for decades. For good reason as: it is host to an abundance of resources, has great potential for use of energy sources, and is surrounded by other moons and solar objects that can be utilized. These qualities are especially important for a space settlement aiming to be home to a huge number of people.

1.2 Resources found on Titan

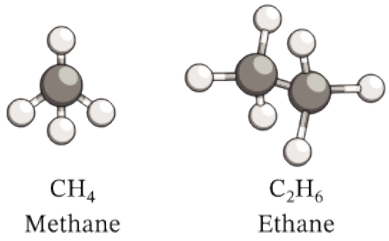


Figure 1.2.1: Structural Model of Methane and Ethane
Credit: Nagwa

Figure 1.2.2: Silicate rocks
Credit: 911 Metallurgist

A large amount of resources and materials will be brought from Earth to help sustain the settlement. However, It will not be able to function for long without supplying it with resources found on Titan. One of the major resources is the abundance of hydrocarbons. These hydrocarbons are typically found in the form of ethane and methane in lakes and rivers. Although the hydrocarbons are in this form, they can be used as fuels and raw materials for productions of goods. Although the settlement will not run off purely hydrocarbon fuels, other items on the station will use these fuels. For example, fuels for heating, cooking, and electricity.

Mining is also a hopeful possibility on Titan. The core of Titan is made of water-bearing silicate rocks. These rocks can be used for different purposes on the settlement. The biggest things these rocks can provide are micronutrients to plants that grow on the settlement.

Directly under the surface of Titan, ice and liquid water can be found. Water is probably the most important resource that the settlement will need. It is used for a wide variety of things. Agriculture, industry, and electricity all require water in some form to effectively function. Additionally, humans and other living beings require water to sustain themselves. This abundance of water beneath the surface of Titan is extremely beneficial and makes it so easy to support life on Titan.

1.3 Potential Energy Sources on Titan

One of the most important aspects of making a settlement is the method by which it will run. Titan has strong winds which can be utilized using technologies like windmills to harness its energy. The wind power will be converted into mechanical power and help with tasks such as pumping water and generating electricity.

Another important energy source is the previously mentioned water supply underneath the surface of Titan. The flowing water found on Titan can be used to power hydropower plants. This in turn would generate the necessary energy required to power different appliances on the settlement.

Solar power is another possible power source on Titan. Although the moon gets 0.01% of the solar energy from the Sun, studies have found that if solar panels are placed on 10% of Titan's surface area it can support a population as large as the United States. Due to this fact, solar power is still a great possibility on Titan.

1.4 Surrounding Space Bodies

Titan has a lot to offer not just on and but also around it. It is one of 83 moons that orbit Saturn. The settlement will be large enough for a significant population to live comfortably, however the space can be better utilized if supplies are stored elsewhere. The moons and nearby celestial bodies can be storage grounds for materials and resources.

The celestial bodies around Titan also consist of similar materials as Titan does. For example, Ganymede also has ice underneath its surface and silicate rocks similar to Titan. These similarities allow the settlement to have multiple duplicates of moons like Titan in close proximity which means resources will be readily available.

2. STRUCTURE

2.1 Design Overview

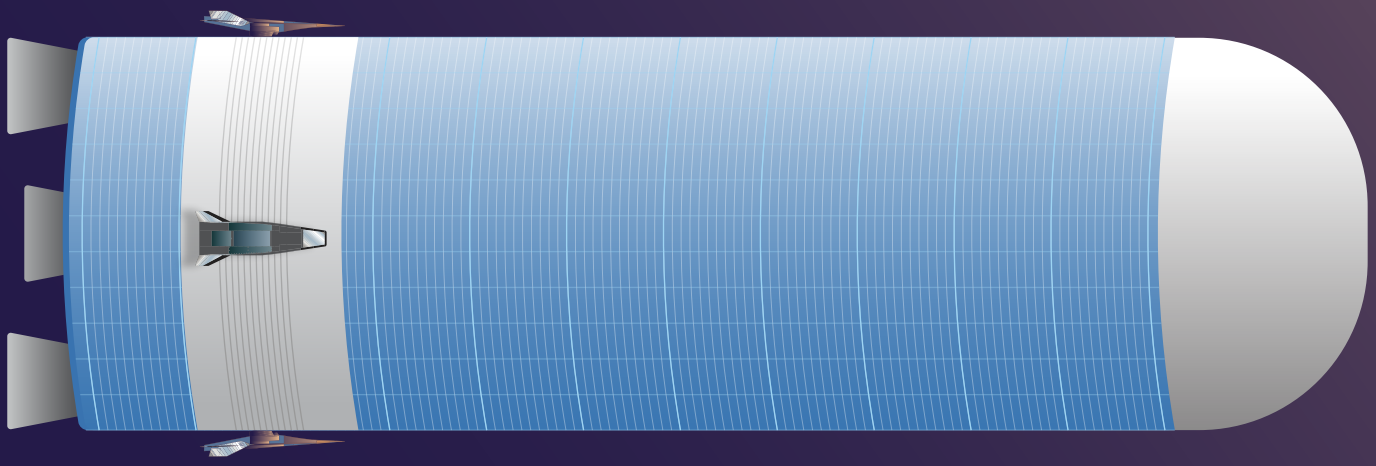


Figure 2.1.1: Outer design of Gaia's Hope

The majority of the cylindrical space settlement would be covered in solar panels to maximize the energy generated. With a loading built into the space settlement, would allow access to resources from Titan. The large dome at the front of the structure would allow protection from direct collisions with space debris.

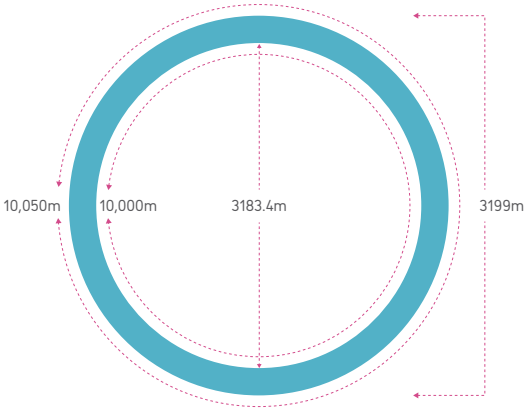


Figure 2.1.2: Dimensions

2.2 Materials

To protect residents against the harsh temperature of space, the materials used in the construction of the space settlement must provide proper insulation. For this reason, the Multi-Layer Insulation (MLI) blanket system, used by NASA in the ISS, will be incorporated on Gaia's Hope. The MLI will be made by layering Dacron, Mylar and Kevlar 30 times, as seen in Figure 2.2.1. In addition to the MLI, a thick layer of silica gel-based aerogel will be used to provide extra thermal insulation. The dome at the front of the spacecraft, in addition to the MLI, will be made using the stuffed whipple design to protect against direct collisions with space debris. The stuffed whipple will consist of a bumper made of the aluminum alloy 7068 due to its strength to weight ratio and its ability to withstand harsh conditions such as temperature and vacuum environment. Following the bumper, six

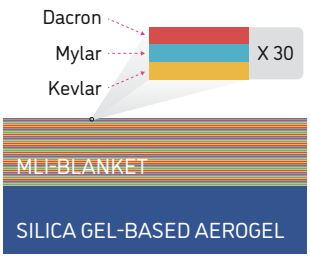


Figure 2.2.1: MLI-blanket design

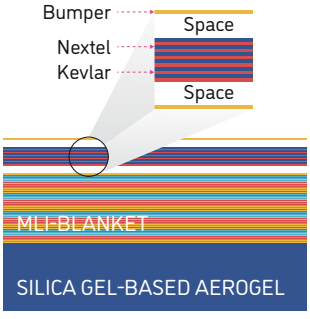


Figure 2.2.2: Stuffed-whipple design

layers of Kevlar and six layers of Nextel will be used as the stuffing, similar to the ISS. Another bumper layer will be added as backup. It is important to know that between the bumpers and the dense layer formed by the kevlar and nextel, there will be some space. The space is important to let the broken off debris, from the collision with the bumper, distribute its impact with the stuffing inside.

2.3 Gravity

Long term exposure to zero gravity can be harmful to humans, causing loss of muscle and bone mass. For this reason, gravity would need to be artificially generated, through the use of centripetal force, which would in turn create a fictitious force known as centrifugal force. Similar to how a human feels an outward push while taking a sharp turn in a car, by rotating the space settlement at the right velocity, an effect like artificial gravity can be generated. Inorder for good health, humans need a minimum of 15% to and can survive up to a maximum of 900% of Earth's gravity . To stay on the safe side, Gaia's Hope will produce a gravitational acceleration of 9.7 m/s^2. This would allow for vertical buildings to be made, as approaching the center of the settlement would cause people to experience a greater force (as the radius of their speed would decrease). The formula to find the rotational speed can be derived from the formula, $a = v^2 / r$, where a is the centripetal acceleration (which in this scenario equals the acceleration due to gravity), v is the velocity of the spin, and r is the radius. With the inner circumference being 10,000m, the radius, as per the formula $C=2\pi r$, equates to about 1591.55m. Therefore, $9.7 = v^2 / 1591.55$ solving for v, the space settlement needs to spin at a velocity of roughly 124.25 m/s.

2.4 Architecture

The overall architecture of the space settlement is designed to maximize efficiency, and lower costs and maintenance. As seen in Figure 2.4.1, section A represents the dome, which will house data servers and will be protected by a 1 meter dense layer of shielding. Levels labeled with B will be known as residential levels, where the citizens will be staying. Level C would support the government building, navigation room, and industrial buildings. This level will also be in charge of waste management, air and water production, the nuclear reactor, and energy storage. Level D will be the loading dock, where the flight crew will board space crafts to gather materials from Titan. The final level, E, will be the engine room and will also hold fuel for space travel.

> **"Keep it simple and focus on what matters."**
>
> - Confucius

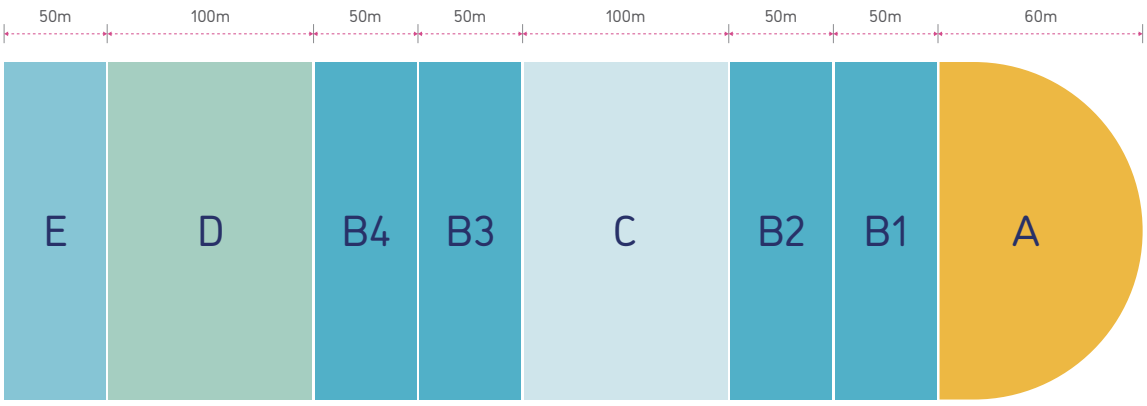


Figure 2.4.1: Level distribution of the space settlement

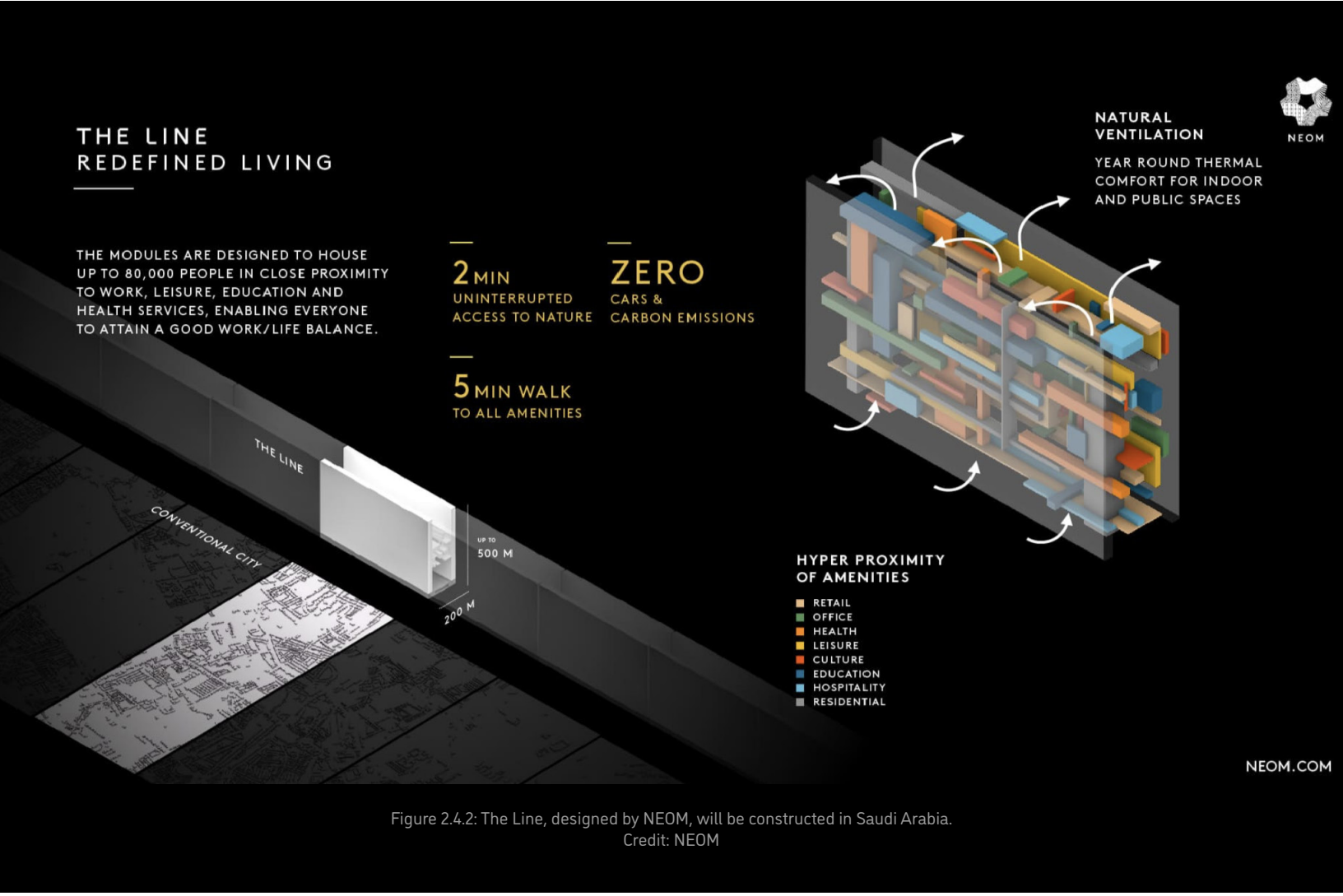


Figure 2.4.2: The Line, designed by NEOM, will be constructed in Saudi Arabia.
Credit: NEOM

The residential levels will be designed based on a simpler version of The Line, a project designed by NEOM, that will be taking place in Saudi Arabia (shown in Figure 2.4.2). Similar to this concept, each residential level will be divided into 10 districts, stretching a total of 1000 meters in length. The districts are labeled based on the significant building belonging to that section. These buildings include educational establishments (E), movie theaters (T), police stations (P), Bank (M), and hospitals (H). All residential levels will have two of each significant building in districts opposite to each other, hence they will be labeled as 1 or 2, following their district letter. Since each district will have two residential apartments, the apartments will be labeled as 1 or 2 as well. Hence, to give someone an address of where you live, you would follow the code: Residential level- District letter and number - Apartment number - Floor - Room.

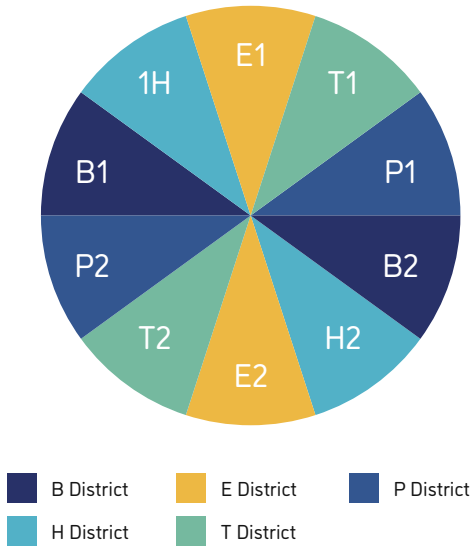


Figure 2.4.3: Distribution of districts in each residential level

Example: B1-E2-1-5-6 would be the address for someone living in residential level B1, in the second educational district, apartment 1, floor 5, room 6.

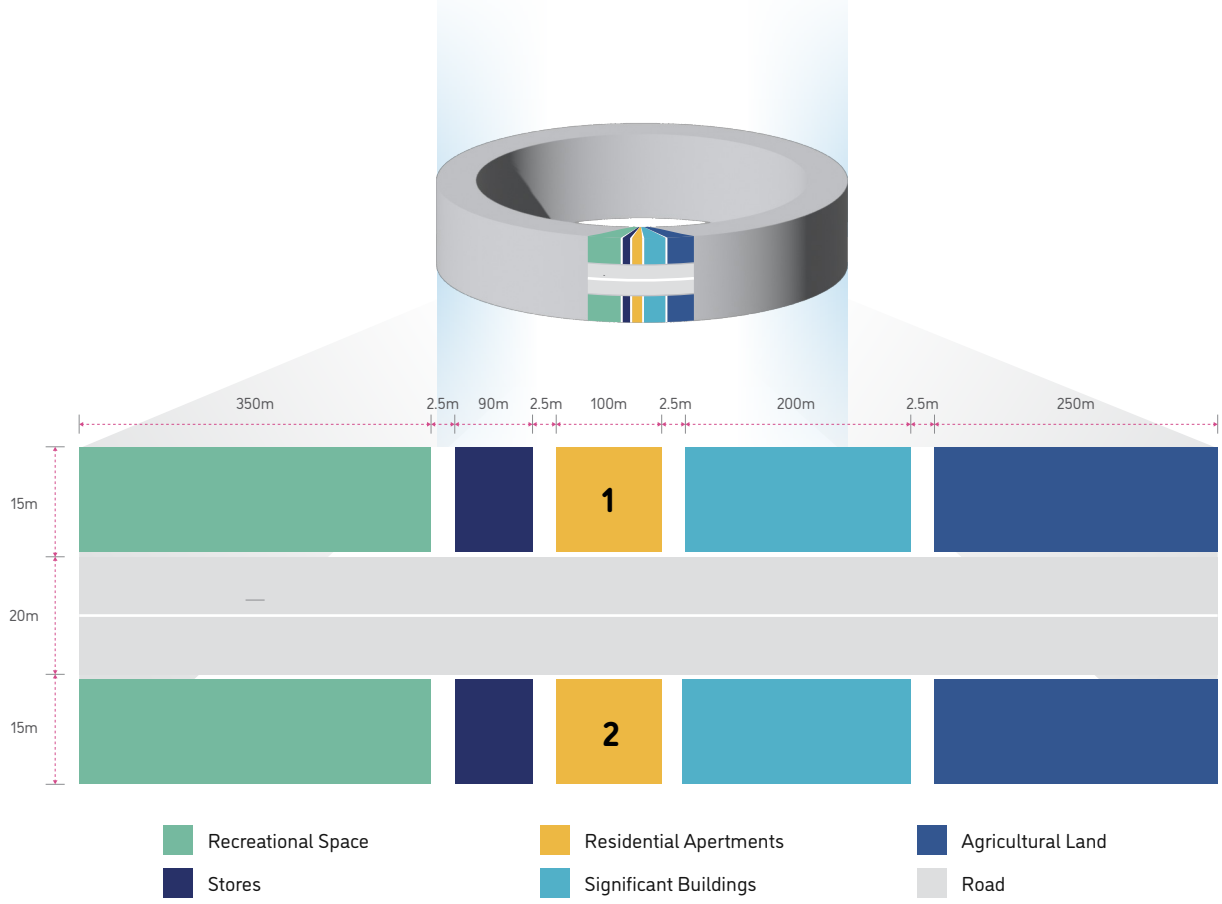


Figure 2.4.4: Distribution of areas within each district (length and width are not to scale)

The 1000 meters length will be distributed, with 350 meters of recreational space, 250 meters of agricultural land, 200 meters for the significant building, 90 meters for stores, and 100 meters for residence, and about 10 meters for space between the different areas along with the wall thickness. All of the spaces will be multi-level, up to 8 stories high, allowing maximum use of space. The recreational area will consist of a large conservation area, a food court, sports field, arcade, virtual reality rooms which will provide an earth simulation, and a library. The stores district will consist of grocery stores, convenience stores, clothing shops, and a pharmacy. The 100 meters of length dedicated for residence, will consist of 2 buildings opposite to each other as shown in Figure 2.4.4.

Each residential building will consist of 8 floors, out of which the first 6 are dedicated for living, the seventh is for a gym, and the eight floor is a terrace. The first floor will consist of 8 rooms and a main hall, while the next 5 floors will consist of 10 rooms each. In total, there will be 58 rooms per building, with 80 buildings throughout the whole settlement. This equates to 4640 rooms. As only 3750 families will be on board the space settlement, 890 rooms will be unused, giving enough time to construct a second space settlement before Gaia's Hope becomes overpopulated.

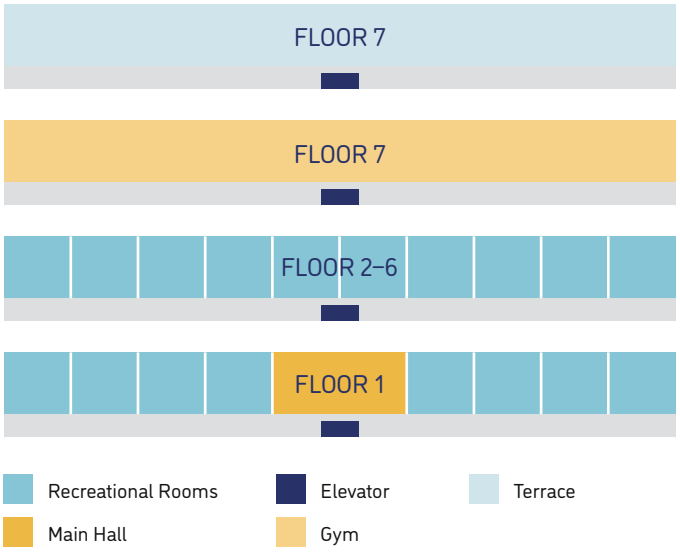


Figure 2.4.5: Layout of residential apartment

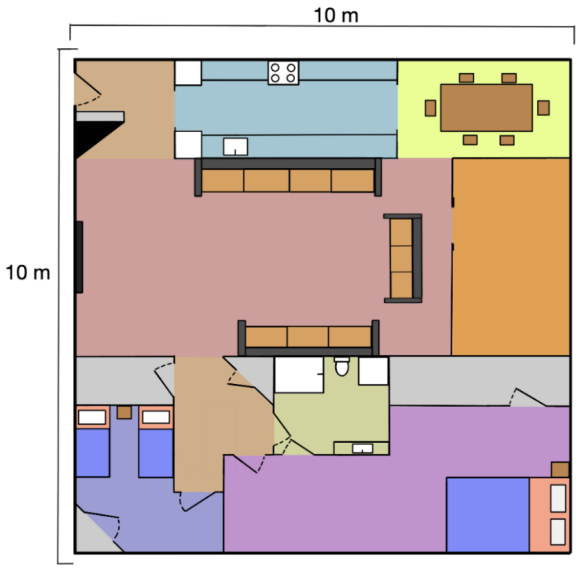


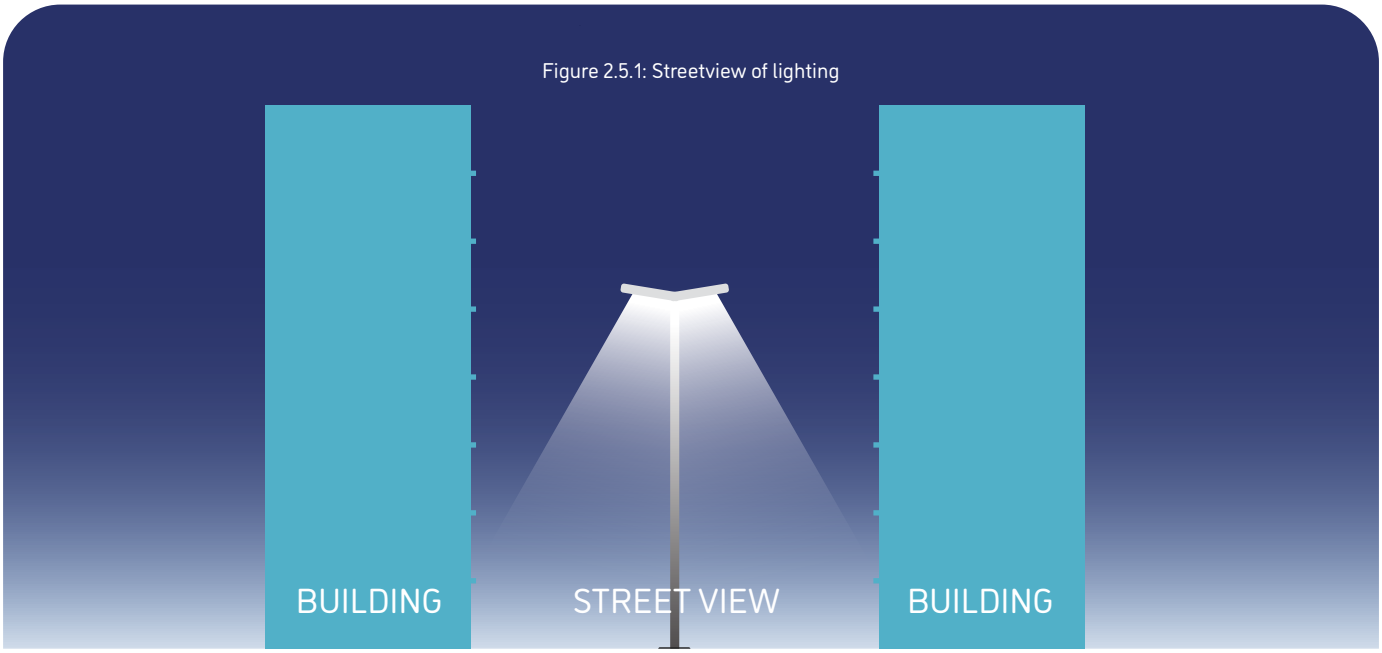
Figure 2.4.6: Floor plan of each room in a residential apartment

Each room will have a 10m by 10m living space which will be laid out as shown in Figure 2.4.6. Each apartment room will have one kitchen (teal), one dining room (lime), a living room (pink) , a study (orange) , two bedrooms (shades of purple), and one washroom (mud green). They will also have one closet in each room along with two storage rooms (gray).

2.5 Lighting

As the space settlement is a closed system, all of the light would have to be artificially made. Along with this, the space settlement will be kept hollow, so it does not seem congested for everyone living on board. For street lights, a ring system would be used with support beams to keep the structure up. This ring light system would be broken down into 6600 individual lights which would be 1.5 meters in length. Additionally, the lights will be at a 10º degree angle to maximize the area covered by the lights. The ring will be into 1320 sections with 5 lights each. To show day and night, as well as save energy, out of the 5 lights in each section, every 4 lights would dim out to show it getting darker over a 12 hour period, and would lighten up for another 12 hour period to show day time. Therefore, 1 in every 5 lights would be on for a full 24 hour period and then it will shift to the next section for the next day.

Figure 2.5.1: Streetview of lighting



2.6 Transportation

As a majority of residential needs are within a 1 km range, the bicycle would be most ideal as it not only saves energy, but also promotes a healthy lifestyle for citizens. Citizens will also have the option of riding an underground public transport bus, with the stations being under the resident apartments. There will be a total of 4 buses traveling per residential level.

Figure 2.6.1: The delivery van model created by Canoo
Credit: Canoo

For transporting goods, electric vehicles would be used, with a similar design to the delivery vans created by Canoo, shown in figure 2.6.1. The vans created by Canoo have a 200 mile range (321.87 kilometers), meaning that on a single charge, it can travel around a residential level 32 times. Aside from the range, they have a load capacity of 1543 pounds, perfect for delivering resources around the space settlement.

To import materials from Titan, jets will be used for transportation. Based on Titan's mass and radius, the velocity needed to leave the moon is 2.641 km/s. The hypersonic X-43A jet, designed by NASA, can travel at a speed of Mach 9.6, which equates to 3.29km/s. Although not designed for space, the X-43A can be redesigned to withstand the harsh conditions. The benefit of having a jet is that there is no need to create a launch pad. The construction of a simple runway will allow the X-43A to be able to leave Titans atmosphere.

Figure 2.6.2: X-43A jet developed by NASA
Credit: NASA

2.7 Construction

The space settlement would be constructed primarily in Earth's orbit, making the project cost effective, as well as time efficient. Creating the settlement at Titan would involve a lot of fuel to be wasted while exporting materials from Earth. Along with this, based on current day technologies, it takes roughly 7 years to reach Titan from Earth, hence it is unsuitable to create the structure at Titan itself.

The majority of the construction process would be done through robots which would be controlled from earth. Robots would be more effective than humans as they would not need food or water and can stay in space for as long as needed.

Once constructed, the families chosen/volunteered will be boarded, after which a course for Titan would be put on it. The navigation crew would be in charge of making sure the settlement stays on course.

3. LIFE STYLE

3.1 Overview

In the space settlement, the core values that will be embedded in the society's lifestyle includes sustainability and recycling. From sewage to the movement to the air people breathe, the space colony will make use of all of the resources to ensure sustainability and to continually build upon a self-sustaining society.

3.2 Resources

All life requires certain necessities to continue to thrive, and for the population, the settlement will continue to provide ample resources to ensure each person's basic needs are met. In terms of water, the basis of life, the civilization reuses and sanitizes water within the ship in the form of moisture in the air or tainted water, e.g, urine, sweat, and wastewater. The civilization makes use of certain machinery that takes in air, which is then cooled so that condensation can take place. From which, water vapor condenses from the air onto a surface that can collect the water, a change of states.

Figure 3.2.1: Proposed storage system fo reserves of water to be left in storage until needed for emergency situations.
Credit: collectSPACE

Additionally, the civilization will possess a large emergency reserve of 2 million gallons of untouched water left for any emergency situations, as shown in Figure 3.2.1. Moreover, Titan is believed to house immense resources that would prove to be more than useful in a space civilization. This includes large amounts of fresh water which is believed to exist as a liquid underneath potentially hundreds of meters of icy crust. To reach the immense resources of Titan, a drill specialized for destroying ice will be used. The process of extraction of the resources of Titan will be an ongoing process as the settlement enters orbit. It is expected that the civilization continues to research, develop and work towards the use of specialized equipment to weaken and efficiently break through the ice to produce a shaft or tunnel; from which the subsurface may be accessed.

To ensure a steady level of oxygen in the civilization, the simple electrolysis of water will allow for the society to

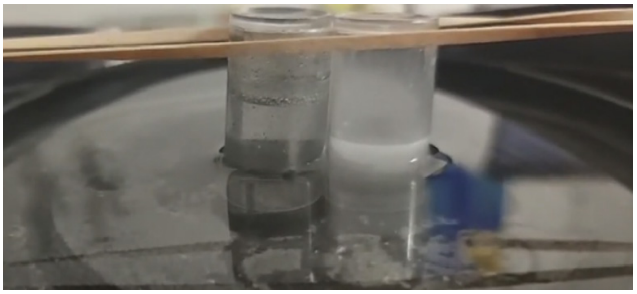


Figure 3.2.2: Process of water electrolysis
Credit: Demonstration conducted by Kashyap Patel
https://youtu.be/fhaZ5CUFOYU

continue to meet its basic needs by splitting the oxygen from the hydrogen in water. Figure 3.2.2 showcases the actual process of the electrolysis of water, with oxygen gas being produced in the left container and hydrogen being produced in the right container.

$$2H_2O \longrightarrow 2H_2 + O_2$$

The aerobic respiration of the different aerobic organisms on the ship will result in the following reaction:

$$6O_2 + C_6H_{12}O_6 \longrightarrow 6CO_2 + 6H_2O$$

The CO2 produced by the plants, animals and civilians in the civilization can be combined with the previously produced hydrogen gas (H2) to produce water and methane, as shown the following reaction:

$$CO_2 + 4H_2 \longrightarrow 2H_2O + CH_4$$

The resulting water produced will be reinvested into the initial hydrolysis process to create a sustainable method of production of oxygen for the population. Moreover, the production of methane will also allow for the production of fuel, by cooling the methane below its critical temperature of -82.3°C; producing liquid methane, which is a fuel source for the liquid methane engine.

Additionally, the implementation of green areas and vegetation would work as a natural method of providing oxygen in turn for carbon dioxide, whilst actively working to improve the air quality within the civilization. This would obviously take place because of the process of photosynthesis within the plants:

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

To maintain the air quality and purity, the ship will contain several integrated air filtration systems that make use of strong fans to intake wind through a filter to remove contaminants, dirt, dust, impurities and so forth. In manufacturing settings, the air filtration systems will make use of stronger fans and disposable, long-term HEPA filters to ensure at least 99.7% of airborne contaminants are removed in these settings of high prevalence. In all other areas, the air filtration units will make use of reusable air filters that are meant to be cleaned in a timely manner, they will not be as effective as the HEPA filter, however, they will be able to last a much longer time. Additionally, it is expected that other areas will not be as affected by air contaminants and will therefore not require extreme air purification.

In the case of the society's source of nutrition, the diet will be completely based on vegetables and fruits. We plan

Figure 3.2.3: New form of indoor farming that is being further researched by NASA.
Credit: NASA

on the regular maintenance of agriculture of fruits and vegetables that were deemed best fit under the given conditions: efficiency, growth under environmental conditions, and nutritional value. For example, the civilization would grow onions, peas, lettuce, wheat, potatoes, cabbage, and so forth. Underground storage plant organs have been observed to meet the criteria quite often, so several foods under those categories will continue to be maintained in the civilization. Large areas will be dedicated for agricultural growth; their conditions will be heavily monitored to ensure ample conditions for food growth, catered to each specific plant. These would include the levels of soil moisture, soil acidity, availability of nutrients, required symbiotic relationships with other organisms, and so forth.

Additionally, a larger center will be kept for the research on safe genetic modifications, cross breeding, and other agricultural-based research to help further the agenda of providing the best foods for consumption. These areas will be home to the research conducted on examining the DNA and potential for different plants in providing different functions that can range from providing nutrition to producing other worthwhile materials, for example, a more eco-friendly form of cotton. These repositories will contain both the plants used for agriculture as well as the countless other plant species that were present on Earth. Moreover, the seeds and DNA for all the different plants of the Earth will be stored in these research centers to save the biodiversity that was established over millions of years on Earth by ensuring the different species of plants are stored in a sustainable manner.

Despite a lack of focus, the civilization will also upkeep several small-scale farms.. The use of these farms are not commercial or meant to feed the entire population, rather, provide the several resources available from different animals as well as helping contain some of the biodiversity that is present on Earth. For example, these farms would provide eggs, dairy products, wool, and so forth. Moreover, the small amounts of food produced in the form of meat products could be used to help maintain the actual farms, for example, using the bodies of primary consumers could be used to feed carnivores and omnivores.

The society will reach its recommended daily doses of vitamins and minerals through the use of a balanced diet by providing several inexpensive food options that would be naturally available and unprocessed. A plant-based diet has continued to be proven just as effective as one filled with sources of red meat; they can provide generally the same amount of nutrients and protein. Additionally, different supplements will be provided to the populace to ensure that sufficient amounts of the required vitamins and minerals are consumed. For example, tablets that

boost vitamin D levels provide the same abilities with the body's use of vitamin D; going further as to also prevent the risks of skin cancer from sun exposure.

In the case of death, the civilization aims to be as sustainable as possible and to make use of any and all resources available. As such, everyone is a registered organ donor and their bodies will either be used in 1 of 2 ways. The first being donated to sciences, to further fuel the research and education of the population. The second being the use of microorganisms to cultivate the bodies into an artificial fertilizer that can be used to create a cycle that inserts the nutrients back into the vegetation grown. In the civilization, different views surrounding the treatment of bodies after death are understood, however, in the civilization, sustainability is one of the very core values and the aim is to not waste any resources in possession.

3.3 Daily Activities & Schedule

In the civilization, every civilian will be working 4 days a week with 8 hour shifts. An article by The Guardian states, "Microsoft tested out a four-day work week in its Japan offices and found as a result employees were not only happier – but significantly more productive" (Paul, 2019). This experiment by Microsoft proves that the 4 day work week will boost productivity and mood in the work environment which will make civilians, and company owners happy. In the 8 hour shifts, employees will be given a mandatory 30 minute break. There will be different rotations on those 4 days and all parts of civilization are to be manned at all times. All civilians will get 2 weeks of vacation time. Since civilians will be from various cultures and will have various cultural celebrations, 10 holiday days for cultural/religious reasons will be given to civilians on the space settlement.

With the 4 day work week, citizens will have more time to be physically active. Civilians will be provided with adequate areas that will allow them to be physically active. There will be parks, gyms and recreational areas in residential levels. Civilians will be provided access to nearby wellness centers which will specialize in exercise and physical therapy. Citizens will be encouraged to exercise regularly and maintain a steady sleep schedule. Centers which specialize in sleep will be available for citizens if they believe they are lacking quality sleep.

3.4 Recreation & Mental Health

Recreation will be heavily promoted throughout society as it has many benefits. Recreational activities will help improve a citizen's physical and mental health, and will give various community members the opportunity to connect with others. Civilians will have accessibility to many recreational activities ranging from sports to reading. Coaching centers for sports will be available so civilians can find new hobbies to pursue or improve their skills. If citizens would like to pursue their recreational activities without coaching, recreation centers will have designated times in which citizens can practice. Various clubs/organizations surrounding recreational activities will be present as well so citizens are more inclined to join. On the website wellbeingpeople, it is mentioned that, "Being a part of a community that revolves around your hobby also gives people a sense of belonging" (Clarabut, 2020). Some examples are reading clubs, basketball clubs, women's soccer clubs, etc. Other than sport areas, recreation centers will incorporate meditation rooms, reading rooms, and gaming rooms.

Although improving physical health is great, one must not forget about mental health. The World Health Organization states, "Around 20% of the world's children and adolescents have a mental health condition" (World Health Organization). The statistic by the Canadian Mental Health Association proves that many people need to improve their mental health. To help improve citizens' mental health, there will be meditation classes. Meditation classes are helpful as it is an activity that benefits a person's emotional well-being and overall health. Therapy classes will be available at an affordable price which can help many people deeply understand their problems. Mental health centers will be available all around residential areas and mental health will be prioritized in workplaces as well. The centers will also specialize in popular mental health issues such as depression, anxiety disorders, schizophrenia and addiction management.

3.5 Healthcare

A public healthcare system will be in the reign of the civilization, where each citizen is insured. In the settlement, public health will remain a core value and priority to uphold. The "health" of the general public can be described as the life expectancy and quality of life of the general population. The implementation of any viable factors that are found to be able to efficiently and effectively improve the "health" of the population will be considered. In the civilization, we work towards ensuring each and every individual recipes adequate health care options to pursue as well as the ability to make use of technologies available to increase accessibility, for example, mechanical mobility vehicles for those who may be physically impaired.

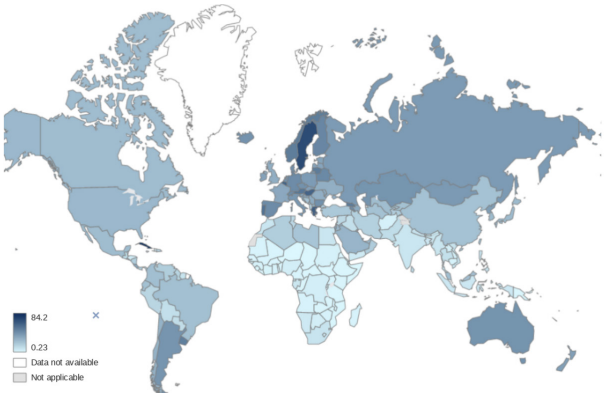


Figure 3.5.1: Map depicting the Medical Doctors per 10000 people for different countries.
Credit: RitaE

The healthcare system will be made to insure a minimum rate of 50 hospital beds per thousand people; meaning a total of 500 hospital beds made available to the 10000 person population. Additionally, the civilization would maintain an extra 250 hospital beds in the case of an emergency resulting in mass hospitalizations. The hospital bed to hospital ratio is more than 10 times that seen in the countries with the highest rates of hospital beds per thousands people (The World Bank, 2019). In terms of physicians, society has and will maintain a minimum of 15 physicians per thousand people; resulting in a total minimum of 150 physicians, which can range from general concerns to specializations in areas such as neurology. This ratio of physicians per 1000 people also continues the trend of outdoing that of the highest rates in the current settlement (The World Bank, 2019). Keep in mind that the healthcare system in the civilization will also require the work of several nurses, physician assistants, and other occupations that have not been specified.

It is also important to mention that in the civilization, each and every person is registered as an organ donor, so in the event of death, any viable organs will be made available to anyone who requires it. This is simply because of the importance of retaining resources of the civilization and to ensure that people in the civilization do not face the common issues associated with healthcare on Earth; from a lack of access, long organ wait lists, health inequalities, shortages and so forth. In the civilization, upkeeping the health of the entire population will be a strong priority.

3.6 Education

Education is a very significant aspect of a functioning society. Education will be publicly funded from pre-school through university. The space settlement will provide an adaptive curriculum which will be modified for the unique environment and challenges of living in space. STEM subjects will be the core of the curriculum and hand-on learning opportunities will be provided. Teachers with experience in STEM fields would be brought onto the space settlement to help teach the STEM subjects. Technology will be incorporated greatly in the curriculum as well. Virtual augmented reality will be used to enhance learning experiences. Every University will virtually provide the same opportunities, education and preparation for the workforce following graduation. Public funded universities will be more focused on skills for the ministries on the space settlement. Universities will also be virtual to help save space and money. By doing so, there will be enough employment opportunities for future generations. If a job is in low demand, marketing strategies will be used to push that career into the younger generation. To make the job more appealing, the salary will be increased as well since there is a low amount of specialists in that field. Students will be encouraged to prioritize their physical and mental health while studying hard in schools. There will be various student organizations so students can feel included.

3.7 Population Overview

Our targeted overview for the starting population of the civilization includes a total population of 10000 peoples, in which, there are two major groups of people:

1. 2500 Young Couples (Approximately 5000 people)
2. 1250 Small Families - 3-4 people per family

The purpose of this breakdown of the general population is to ensure that there is great potential and optimization for the civilization to continue its ability to grow in a sustainable manner. The brightest candidates will be brought that present the greatest outlook for future generations and maintenance of the required population. In the civilization are 4640 rooms; from which, each couple and family would receive one of the rooms. The remaining 890 rooms would be used for the purposes of population growth and cultivation. The reason for selection for young couples and small families is to maximize the occupancy of space by people by sharing rooms by relations. In terms of priority, younger candidates would be put at an advantage due to their greater ability to adapt and time they have to grow; this is especially true for people selected to complete more labor intensive tasks in the civilization. However, in terms of further research and development, people will be selected on the basis of knowledge, experience and age; taking into account the benefits of time spent in each field.

Additionally, in the population we hope to prioritize a majority of families or couples that have specializations in fields that are necessary for the further developments and bare requirements of civilization. For example, this would include medical personnel, engineers, plant life researchers, educators, astrophysicists, mechanics, and so forth. We also plan to allocate an adequate amount of seats of the civilization to families, couples and individuals that may not have a major academic specialization but show promise in their abilities, work ethic and mindset to help the upkeep of the civilization in terms of the more general aspects of labor. For example, to maintain cleanliness, to run different stores or dispensaries, proficiency in the skilled trades, and so forth.

4. GOVERNMENT

4.1 Form of Government

The settlement's Republic will be a unique blend of democratic and authoritative governance. NASA will serve as the highest authority and provide the necessary guidance, resources, and expertise to ensure the settlement's success. However, the citizens will have a voice in the government through their elected representatives. These representatives will act as intermediaries between the citizens and NASA, relaying the concerns and needs of the citizens to the governing body.

The president, elected through popular vote, will be the face of the government and the primary decision-maker. They will be responsible for ensuring that the government operates in a fair and just manner, serving the best interests of the citizens. The president will also work closely with NASA on Earth, ensuring that resources are used in a timely and efficient manner. This close collaboration between the government and NASA will help to mitigate potential problems and promote quick decision-making, crucial for the success of a new community.

The Republic aims to promote fairness, the common good, freedom, and prosperity for all citizens. It recognizes that the success of the settlement depends on the well-being of each individual and strives to create a society where everyone has equal representation and opportunities. The government will work to provide the necessary resources and infrastructure to support the citizens, creating a thriving community that benefits everyone.

In conclusion, the Republic is designed to balance the needs of NASA and the citizens, creating a government that operates efficiently and fairly. By electing representatives and a president, the citizens have a voice in the government, ensuring that their needs and concerns are addressed. The government aims to promote fairness, the common good, freedom, and prosperity for all, creating a thriving community that benefits everyone.

4.2 Addressing Concerns

The goal of this form of government is to create a just society that prioritizes the well-being of all its citizens. However, there are concerns that the concentration of power in the hands of the authorities can lead to abuse and undermine the principles of a fair and equitable society. To mitigate these risks, strict restrictions and requirements have been put in place for those in positions of authority. This includes a mandate for all non-emergency decisions to be reviewed and approved by NASA, a trusted and neutral body. This helps ensure that all decisions made by the authorities align with the goals of promoting fairness and the common good. The lack of other settlements in the area means that there are limited external security threats. This allows the government to focus on ensuring internal stability and fairness, without having to devote resources to external security. Finally, the government recognizes the importance of transparency and accountability in fostering trust

and confidence among its citizens. To achieve this, the government is implementing a blockchain-based system for tracking and recording its financial activities. This system allows citizens to view the use of government funds in real-time, promoting greater accountability and transparency.

Elections will take place every four years to provide citizens with the chance to hold their elected officials accountable. The four-year term is established to balance the need for stability and progress with the need for accountability and representation. A rigorous policy will be put in place to enforce the alignment of elected officials with the government's views and to respond to public discontent. The policy allows the government to impeach elected officials who are out of step with the party's goals and objectives, either through a majority vote by the group of elected officials or in response to widespread public unrest. This policy is crucial in ensuring that the government remains representative of the views and needs of the citizens. It ensures that elected officials are working for the greater good and are held accountable for their actions. By providing regular opportunities for citizens to vote, the government remains responsive to the changing needs of society.

4.3 Civilian Rights

Our government will establish the Planetary Charter of Rights and Freedoms to safeguard the basic human rights of all citizens residing in the settlement on Titan. This document will serve as a cornerstone of individual freedom and liberty, guaranteeing fundamental rights through its comprehensive provisions. The Planetary Charter of Rights and Freedoms represents a commitment to creating a society that prioritizes human dignity and equality. It serves as a framework for ensuring that all citizens have access to the basic rights and freedoms necessary for a fulfilling life.

Please note that this document serves as an initial outline and is subject to refinement and revision.

All individuals in the settlement, regardless of their status, are entitled to the following rights:

Fundamental Rights and Freedoms

Everyone has freedom of

1. Religion and Beliefs
2. Thought, Opinion and expression including freedom of communication through technology
3. Peaceful Protest and Assembly
4. Participation in society - that being economic or social

Election Rights

Everyone has the right

1. To vote in elections that form the legislative assembly ruling over the planetary settlement.
    a. No legislative assembly shall continue for longer than four years without undergoing another fair election process
        i. With the exception of special circumstances and approval from NASA

Equality Rights

Everyone has the right

1. To be treated as an equal before and under the law.
2. To equal protection from and by the government
3. To equal access of the law without discrimination, in particular of race, gender, national, physical disability...

Legal Rights

Everyone has the right

1. To Life, liberty and security.
    a. One may be deprived us the right to liberty via decision by a judicial court out of an Act of Justice
2. To be secure from reasonless detainment, imprisonment and searches.
3. Under detention or arrest, to have legal council of their choice
    a. They must be informed of their offense with no unreasonable delay
    b. They must have a trial within a reasonable time
    c. They must be treated as innocent until proven guilty by a judicial court
        i. If acquitted of an offense, may not be tried for it again
        ii. If guilty of an offense, may not be tried for it again
    d. They must not be denied bail without a just cause
4. To not be subject to any cruel or unusual punishment or treatment
5. To special accommodation for communication such as an interpreter if required

Mobility

Everyone has the right

1. To remain in and leave the Planetary Settlement
    a. With an exception in case of special circumstances or approval from NASA
2. To move freely in public space
3. To take residence in allotted areas
4. To pursue a livelihood

Enforcement

Everyone has the right

1. To hold a trial demanding fair remedy by a court or competent jurisdiction if rights and freedoms in this chapter have been violated and infringed

This document may be cited as Planetary Charter of Rights and Freedoms.

4.4 Ministries

Ministry of Economics

The Ministry of Economics will be responsible for monitoring the economic state of the settlement, ensuring fair and legal market interactions, and promoting stability and fairness in the society. The Ministry will work to prevent fraudulent activities and enforce severe penalties on those found in violation. Additionally, the Ministry will continuously seek opportunities for economic growth and development, striving to maintain the overall prosperity of the settlement and its citizens. By working towards a stable and fair economic environment, the Ministry of Economics will play a crucial role in ensuring the long-term success of the settlement.

Ministry of Transportation

The Ministry of Transportation will be at the forefront of driving the settlement's transportation sector towards new heights of excellence and efficiency. By closely working with transportation workers and the energy team, the Ministry will be able to tackle complex challenges and bring about sustainable solutions that align with the settlement's vision and goals. With an eye on the future, the Ministry will also foster a culture of innovation and creativity in the transportation sector, encouraging new ideas and technologies to emerge. This way, the Ministry will play a key role in advancing the settlement's transportation capabilities and ensuring that its citizens enjoy the benefits of a safe, efficient, and reliable transportation system.

Ministry of Education

The Ministry of Education will be responsible for managing the curriculum, activities, and other educational institutions in the settlement. They will work to ensure that the school system prepares children for the workforce and will collaborate with the Lifestyle team to ensure a bright future for the society. The Ministry will also ensure that all educational institutions meet high standards of quality and effectiveness

Ministry of Safety

The Ministry of Safety will play a critical role in maintaining a secure and safe environment for the citizens of the settlement. In addition to working with engineers, the Ministry will also collaborate with emergency services and law enforcement to create a comprehensive safety plan. The Ministry will continuously assess and evaluate the effectiveness of safety measures, and make necessary improvements to ensure that the settlement remains secure and protected. Through proactive planning and coordinated efforts with key stakeholders, the Ministry will strive to create a safe and secure settlement for all its citizens.

Ministry of Health

The Ministry of Health will play a crucial role in ensuring the health and well-being of the settlement's citizens. In addition to collaborating with medical unions, the Ministry will also be in charge of implementing and enforcing health policies and standards. The Ministry will also be responsible for maintaining a robust healthcare infrastructure, which includes adequate medical facilities, equipment, and personnel. By promoting a healthy and safe environment, the Ministry of Health will contribute to the overall growth and prosperity of the settlement.

4.5 Finance and Economy

Tokenizing currency through cryptography and blockchain technology represents a pivotal moment in the civilization's advancement along the Kardashev scale and brings numerous advantages to society. The implementation of cryptocurrency enhances the security of assets through the utilization of secure cryptographic protocols and increases liquidity by enabling easy buying and selling of digital assets. By leveraging blockchain technology, transactions can be processed more efficiently, as they no longer require traditional financial intermediaries.

This technology also reduces costs by eliminating the need for third-party verification and streamlining record-keeping processes. The nature of cryptocurrency offers improved risk management, reducing the impact of any single point of failure. This helps to create a more secure and resilient financial system that benefits all members of society.

On the planet Titan, transactions will be revolutionized by the use of the $Gaia token. Utilizing cryptography technology, $Gaia serves as the primary currency, offering secure and cost-effective exchanges between inhabitants. . The use of blockchain technology enables individuals to engage in transactions directly with each other, without the need for a centralized authority. This innovative approach to financial transactions has the potential to increase financial inclusion by providing individuals with greater access to financial services. It also reduces the cost of conducting transactions, helping to create a more accessible and affordable financial system for everyone.

Moreover, the implementation of blockchain technology holds the potential to elevate transparency and accountability in the economy. By documenting all transactions on a publicly accessible ledger, it becomes much more challenging to conceal illegal activity or engage in deceitful practices. This is a crucial step in creating a stable and secure financial system and can help to prevent economic crises. Furthermore, the transparent nature of blockchain technology can foster trust in the financial system as all parties have access to the same information. This leads to increased confidence in the stability of the economy, and helps to create a more positive environment for investment and growth.

Our nation will start with a centralized currency system, with issuance and control in the hands of a central authority. However, as $Gaia gains wider adoption, the currency may transition towards decentralization. To promote transparency, government financial activities will be made publicly accessible to all citizens, while preserving the privacy of individual transactions by only making them accessible to the government. $Gaia will be an inflationary token where new coins are mined as a reward for supporting the network. The rate of token generation decreases over time, balancing inflation for stability and growth.

5. ENERGY

5.1 Choosing an Energy Source

There are many potential options to choose from when considering energy sources for the station. However, to make an informed decision, it is important to analyze the pros and cons of each option.

Source	Pros	Cons
Solar	- Renewable - Well-established technology - No emissions	- Titan is far from the sun; reduced efficiency - There are periods of low sunlight; energy storage would be needed
Nuclear (Fission)	- High energy density - No emissions - Not reliant on natural factors such as sunlight	- Requires significant infrastructure to be built and maintained - Safety concerns; meltdowns - Nuclear waste disposal
Wind	- Titan has strong winds in its upper atmosphere - No emissions	- Wind speed on the surface is minimal
Chemical	- Abundance of liquid methane and ethane - No emissions	- Logistics of transporting large amounts of fuel to the space settlement - Safety concerns
Kinetic	- Renewable source - No resources used	- Not efficient for large energy production

Table 5.1.1- Pros and cons of potential energy sources for the settlement.

Upon analyzing the pros and cons of various energy sources, it was determined that the space settlement will be run mainly by nuclear fusion, solar power, and wind power. The space settlement will also be using kinetic energy as back up.

5.2 Nuclear Power

The primary source of power on the settlement will be nuclear power. The nuclear reactor will utilize nuclear fusion, rather than fission.

Nuclear fusion is the process in which 2 lighter nuclei combine to form a heavier nuclei and release massive amounts of energy. Plasma, a hot, charged gas composed of free-moving electrons and positive ions, is the state of matter where fusion events take place. Plasma has special features that make it different from solids, liquids, or gasses. Fusion can produce 4 times the energy per kilogram of fuel than fission.

Fusion fuel is plentiful and easily accessible on Earth. Most fusion reactors require deuterium and tritium, isotopes of hydrogen. Deuterium can be found in sea water. About 1 in every 5000 hydrogen atoms in the sea is deuterium. Tritium can be extracted from titanium. The compact fusion reactor onboard the settlement, inspired by Lockheed Martin, will require about 12 kilograms of fuel per year. The settlement can carry a substantial amount of fuel, and more fuel can be acquired from Titan. Titan's underwater ocean of liquid water can be utilized to obtain deuterium. It is estimated that one out of every 6420 hydrogen atoms is a deuterium isotope, meaning that deuterium can be extracted from the ocean. "Heavy water," water in which deuterium substitutes for hydrogen, is separated from regular water using chemical exchange processes, and electrolysis is used to obtain deuterium gas. Tritium is produced naturally through cosmic rays interacting with atmospheric gas, specifically nitrogen. Atmospheric nitrogen interacts with a fast neutron:

$$^{14}N + {}^{1}n \longrightarrow {}^{12}C + {}^{3}H.$$

Nitrogen is plentiful on Titan, 95% of Titan's atmosphere is composed of nitrogen.

The reactor will be compact. It is estimated that the reactor will be 7m in diameter, and 18m long. Nuclear fusion will take place inside the reactor in a small magnetic container, releasing energy in a controlled way to generate power. Additionally, nuclear fusion does not produce long-lived nuclear waste, and there is minimal risk of a meltdown. Fusion can only happen under extremely specific operational conditions; otherwise, the plasma would spontaneously end, lose all of its energy very rapidly, and burn out before the reactor sustains any significant harm.

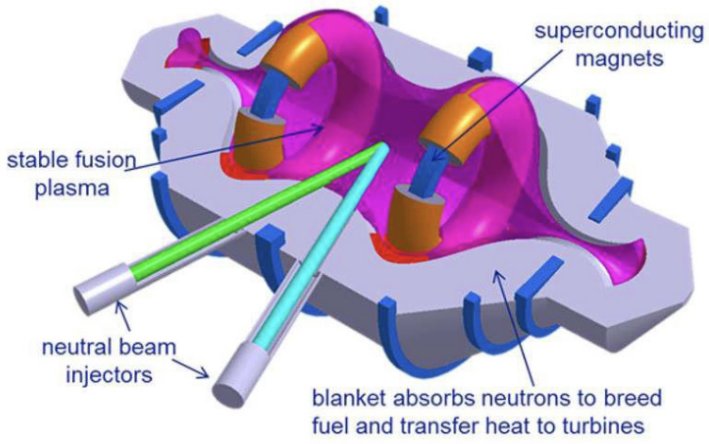


Figure 5.2.1: Lockheed Martin's Compact Fusion Reactor
Credit: Lockheed Martin

5.3 Solar Power

The primary source of power on the settlement will be nuclear power. Solar power will act as a secondary source of power to meet the energy requirements of the space settlement.

Titan receives about a hundredth of the solar flux reaching Earth; this is due to Titan's large distance away from the sun (9.54 AU). At the top of Earth's atmosphere, the average solar energy is 1400 J/m²s. At the top of Titan's atmosphere, the average solar energy is 14-17 J/m²s, which is approximately one tenth of the average solar energy at the top of Earth's atmosphere. Thus, the efficiency of the solar panels used on the settlement is extremely vital.

Panels with high concentration photovoltaic (CPV) cells will be used. Sunlight is focused onto small and highly-efficient solar cells using curved mirrors. Panels with CPV cells can achieve up to 46% efficiency. High concentration photovoltaic (HCPV) systems concentrate sunlight into the intensity of 1000 suns or more. A high-capacity passive heat sink will be required to counteract temperature related electrical performance and life expectancy losses.

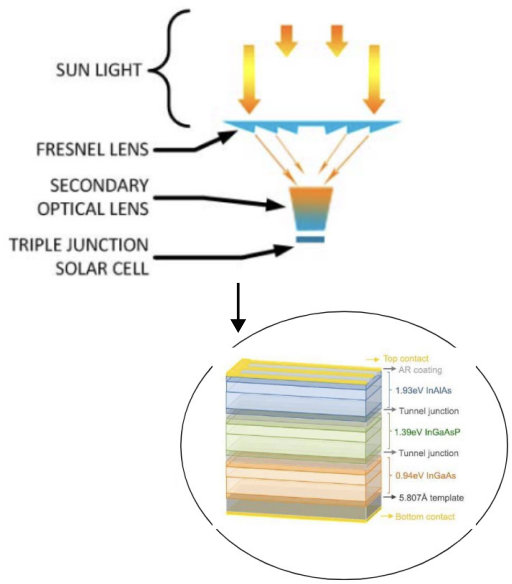


Figure 5.3.1: HCPV systems and multi-junction solar cells to be used on the settlement.
Credit: Marina S. Leite, et al and Solartron Energy

To further increase the efficiency of the solar panels, multijunction solar cells will be used. When light is absorbed by solar cells, electrons in the semiconducting material are knocked loose. Those loose electrons flow through the p-n junction, creating an electrical current. This current is then caught and transferred to wires. The one p-n junction in single-junction solar cells controls the flow of energy produced when sunlight strikes a semiconducting substance. There are several p-n junctions in a multi-junction solar cell that can cause an electrical current to flow, thus increasing the efficiency of the solar panels.

5.4 Kinetic Energy

As a source of backup power, kinetic energy will be collected and stored for emergencies. One method of collecting kinetic energy involves the use of kinetic flooring. The concept of kinetic floors involves the use of tiles which produce electricity when a force is applied. On average, each tile is 75 cm by 75 cm and they will be equipped in all residential buildings, totaling 821,280 tiles. In addition to this, sidewalks and stores will also consist of kinetic tiles. In total, an estimated 1,500,000 tiles will be used throughout the space settlement.

5.5 Wind Energy

Wind speeds on Titan's surface are minimal - about 0.3 m/s². However, at an altitude of 120 km, wind speeds are approximately 120 m/s². Thus, airborne wind turbines will need to be utilized to maximize power output. These wind turbines would need to reach the altitude of 120 km above the surface, where it would need to be built by advanced composites, such as carbon fiber reinforced polymers, and stainless steel designed to resist corrosion, due to the harsh environmental conditions.

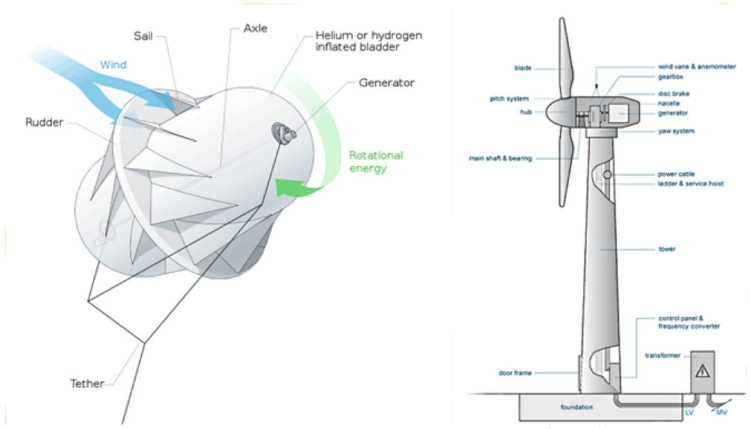


Figure 5.5.1: Aerostat wind turbines
Credit: Dhinesh Kumar

An aerostat is an innovative aircraft that harnesses wind energy in the upper atmosphere of Titan by leveraging the principles of buoyancy and aerodynamics. By using hydrogen gas, obtained through the electrolysis of water from Titan's underground ocean of liquid water, the aerostat creates lift that allows it to float effortlessly in the air. The aerostat harnesses wind energy through buoyancy, using a lighter-than-air gas filled cylindrical balloon to generate lift and float in the upper atmosphere. The cylindrical balloon at the center of the aerostat is surrounded by an aluminum tube that rotates, generating the Magnus effect and providing stability. The wind vane stabilizer and tether cable also play important roles, helping to regulate airflow and transmit the electrical energy produced by the aerostat's generator to the space station. The generator will then convert the rotational motion to electrical energy, where the tether cable will carry the electricity to the space station.

5.6 Power Needs

According to NASA, about 110 kW is produced in the International Space Station (ISS) for up to 6 astronauts. Therefore, about 18 kW is required per person. The space settlement will house 10,000 people, hence 180,000 kW is required. However, the space settlement utilizes a variety of different technologies and is a much larger and complex structure compared to the ISS; thus, to be on the safe side, 270,000 kW will be generated.

The settlement will utilize one compact fusion reactor. The reactor will produce 100 MW. The rest of the energy will be supplied by the solar panels, kinetic tiles, and wind turbines.

The available space for the solar panels is 3.5 x 106 m². Solar irradiance is a measurement of solar power, and is around 14-17 J/m²s at the top of Titan's atmosphere (see section 5.3 for more details). When performing calculations, the average solar irradiance will be used (15.5 J/m²s). The efficiency of the solar panels to be used on the settlement will be around 46% (see section 5.3 for more details). The following calculations were done to estimate the total power generated by the solar panels:

Total Power Output (W) = Total Area (m^2) · Solar Irradiance (J/m^2s) · Efficiency
Total Power Output = $3.5x10^6 \cdot 15.5 \cdot 0.46$
Total Power Output = 24955000 W = 24955 kW ≈ 25000 kW
The solar panels will produce about 25,000kW.

In terms of kinetic energy, the daily output will vary as it is subjected to human effort. Each tile produces 2 W per step and the average human takes 3000 steps per day. With a population of of 10,000 individuals, the energy produced can be calculated as follows:

Total Power Output (W) = Population · Avg. Steps · energy per step
Total Power Output = 10000 · 30000 · 2
Total Power Output = 60000000 W = 24955 kW ≈ 60000kW
The kinetic tiles can produce up to 60,000 kW on average.

The power produced by the turbine can be calculated using the following equation: $P = (½) \cdot \pi \cdot r^2 \cdot \rho \cdot v^3 \cdot \eta$. The radius (r) is the length of the blades on the turbines; it will be 60m. The air density (ρ) in Titan's upper atmosphere is 0.0019395 kg/m^3 as the air density of Titan is 50% denser than Earth's which is 0.001293 kg/m^3. The wind speed (v) is about 120 m/s in Titan's upper atmosphere. The efficiency (η) is estimated to be around 37.5%. Wind turbines are usually 30%-45% efficient, and the average of this range is 37.5%.

$P = (\pi \cdot r^2 \cdot 0.00193953 \cdot v^3 \cdot \eta)/2$
$P = (\pi \cdot 60^2 \cdot 0.0019395 \cdot 120^3 \cdot 0.375)/2$
P = 14214027.8904 W =14214.0278904 kW ≈ 14214 kW

Each wind turbine will produce about 14,214 kW. Six turbines will be used to generate the necessary amount of power needed to keep the settlement running. As time progresses, and the amount of energy required increases, more turbines will be added.

5.7 Rocket Fuel

Chemical Propellants are commonly used to deliver specific impulse values ranging in a continued timeframe of usage of around 175 up to 300 seconds. Although, it is noted that the most energetic chemical propellants are theoretically capable of specific impulses up to about 400 seconds, ideally.

Therefore, high values of impulse are derived from high exhaust-gas temperatures simultaneously with exhaust gas having a very low molecular weight. In order to be efficient, a propellant should have a large heat of combustion to yield high temperatures and should produce products within a combustion reaction with elements such as hydrogen (ideal as it's the lightest), carbon, oxygen, fluorine, alongside lighter metals such as aluminum, beryllium, and lithium.

The second criterion is density which is important which accounts for a greater amount of fuel to be stored in a smaller volume. This is crucial as it affects the amount of fuel that can be stored in a given volume. High-density fuels allow for more fuel to be stored in a smaller space, which allows for cost-effectiveness, reducing the size and weight of the rocket, whilst allowing the rocket to be more powerful and capable of traveling greater distances. Likewise there are numerous factors to consider when looking within fuels it is equally important to also consider the type of fuel.

5.8 Rocket Fuel Types

Rocket Fuels are essential parts towards sustaining the aerospace transportational aspect, in order to optimize their own unique properties and characteristics for their intended purposes.

The first type of solid propellant is referred to as a double-base propellant, which consists of nitrocellulose and nitroglycerine along with small amounts of additives. It does not have a separate fuel and oxidizer, as the molecules break apart and reorganize upon ignition to release large amounts of energy.

The second type of solid propellant is known as a composite, where separate fuel and oxidizer chemicals are intimately mixed within the solid grain. The oxidizer is usually ammonium nitrate, potassium chlorate, or ammonium chlorate and often makes up a significant portion of the propellant mix. Hydrocarbons such as asphaltic compounds or plastics are used as fuels. The fuel must not only perform well, but also provide the necessary form and rigidity to the grain as the oxidizer does not have significant structural strength.

One advantage of solid propellants is their minimal maintenance and instant readiness. However, highly energetic solids may require controlled storage conditions and may present handling difficulties in large sizes as the rocket must always be carried fully loaded. It is crucial to protect the grain from mechanical shocks or abrupt temperature changes that may cause cracking.

Liquid chemical rockets, on the other hand, typically use two separate propellants: a fuel and an oxidizer. Common fuels include kerosene, alcohol, hydrazine and its derivatives, and liquid hydrogen, while nitric acid, nitrogen tetroxide, liquid oxygen, and liquid fluorine are some of the commonly used oxidizers. The best oxidizers are liquefied gasses such as oxygen and fluorine, which are only in liquid form at very low temperatures, making their use in rockets challenging. Most fuels, with the exception of hydrogen, are liquids at ordinary temperatures. In general, liquid propellants have higher specific impulses compared to solid propellants, but require more complex engine systems to transfer the liquid components.

Utmostly, Titan requires a propellant that can ideally be abundant around Titan, whilst being economically sound for the settlement to reach its ideal efficiency.

There are many potential options to choose from when considering fuel sources for the station. However, to make an informed decision, it is important to analyze the pros and cons of each option.

Fuel	Comparisons
Liquid Methane vs Liquid Hydrogen	1. While Hydrogen is the most efficient chemical rocket fuel by weight, it's extremely voluminous – requiring extremely large tanks. a. Also offsets the efficiency of the fuel itself 2. Hydrogen is extremely expensive to harvest, store, and transport in large quantities 3. Liquid Hydrogen must be maintained at extremely cold temperatures, while that is fine with Titan, it must be separated from the oxidizer within the tank on the way to engines, which increases complexity and weight eroding the theoretical advantages of the fuel 4. Moreover, the boiling points of Liquid Hydrogen are low – meaning that it's too fast. This means tight orbital transfer windows or carrying extra fuel to widen the windows – reducing efficiency Liquid Methane is almost just as weight-efficient as hydrogen and almost as clean. However, it's much denser which can be made even denser by chilling it below its liquefaction temperature – something not possible with Hydrogen. It's also significantly easier to harvest, store, handle, and smaller tanks are needed to maintain fuel efficiency
Liquid Methane vs Kerosene	1. Methane engines have a far greater impulse than Kerosene, which provides for greater mass of both the fuel and the engine 2. Methane is far easier to handle and store, which means the settlement can hold more 3. Methane is much cleaner burning than Kerosene, eliminating problems with carbon deposits causing dangerous hot spots and blockages which greatly reduces the need for overhaul before reuse. 4. Liquid Methane, can be made anywhere in space that power and common raw materials are available – and is extremely abundant on the surface and within the frozen lakes of Titan 5. The boiling point of oxygen and methane are close enough you can easily prevent one freezing the other with a little insulation. That's not the case with hydrogen (which will freeze oxygen) or kerosene (which will be frozen by it). These problems can be addressed with other fuels, but at the cost of extra weight.

Table 5.8.1- Choosing the ideal fuel

5.9 Proposed Decision

Liquid methane is a key component of Titan's atmosphere and surface. The oxidation of this methane plays a significant role in the evolution of Titan and contributes to the chemical composition of its atmosphere. In this essay, we will explore the various processes that drive the oxidation of liquid methane on Titan, including reactions with atmospheric gasses, exposure to ultraviolet radiation and energetic particles, and geological processes. We will also examine the chemical reactions that occur during the oxidation of methane, and their contributions to the formation of organic compounds in Titan's atmosphere and surface.

The oxidation of methane on Titan is a complex process, driven by a combination of atmospheric chemistry and geological processes. In the atmosphere of Titan, methane reacts with nitrogen and hydrogen, producing a suite of hydrocarbons and other organic compounds such as ethane and acetylene. These reactions are driven by the breaking apart of methane molecules by ultraviolet radiation and energetic particles from the sun, which initiate chemical reactions. The formation of these hydrocarbons contributes to the thick and hazy atmosphere of Titan, which obscures its surface from view.

Trace amounts of dissolved oxygen and other oxidizing agents present in Titan's atmosphere may also play a role in the oxidation of methane. The oxidation of methane in the presence of oxygen results in the formation of formaldehyde and other organic compounds, which can then participate in further chemical reactions, leading to the formation of more complex organic molecules. This process may contribute to the formation of prebiotic compounds on Titan, which are considered essential building blocks for life as we know it.

In addition to atmospheric processes, geological processes such as cryovolcanism may bring methane in contact with oxidizing materials on the surface of the moon. During cryovolcanism, molten or partially molten materials, including water, ammonia, and methane, are expelled from the interior of a moon or a planet, and solidify on the surface. The contact of these materials with oxidizing materials on the surface can result in the oxidation of methane and the formation of other organic compounds.

In conclusion, the oxidation of liquid methane on Saturn's moon Titan is a complex and ongoing process, driven by a combination of atmospheric chemistry and geological processes. The reactions between methane, nitrogen, and hydrogen in the atmosphere, exposure to ultraviolet radiation and energetic particles, and geological processes contribute to the formation of hydrocarbons and other organic compounds in Titan's atmosphere and surface. These processes play a significant role in the evolution of Titan and may contribute to the formation of prebiotic compounds, making Titan an important target for future studies of the origins of life in the universe.

6. UNMANNED AERIAL VEHICLES

6.1 What are they?

Advances in space exploration can further be progressed through the advancement and implementation of Unmanned Aerial Vehicles (UAVs). With the establishment of UAVs look towards establishing a settlement near the moon Titan, the use of UAVs offers numerous possibilities for improving life in space.

6.2 Uses on the Settlement

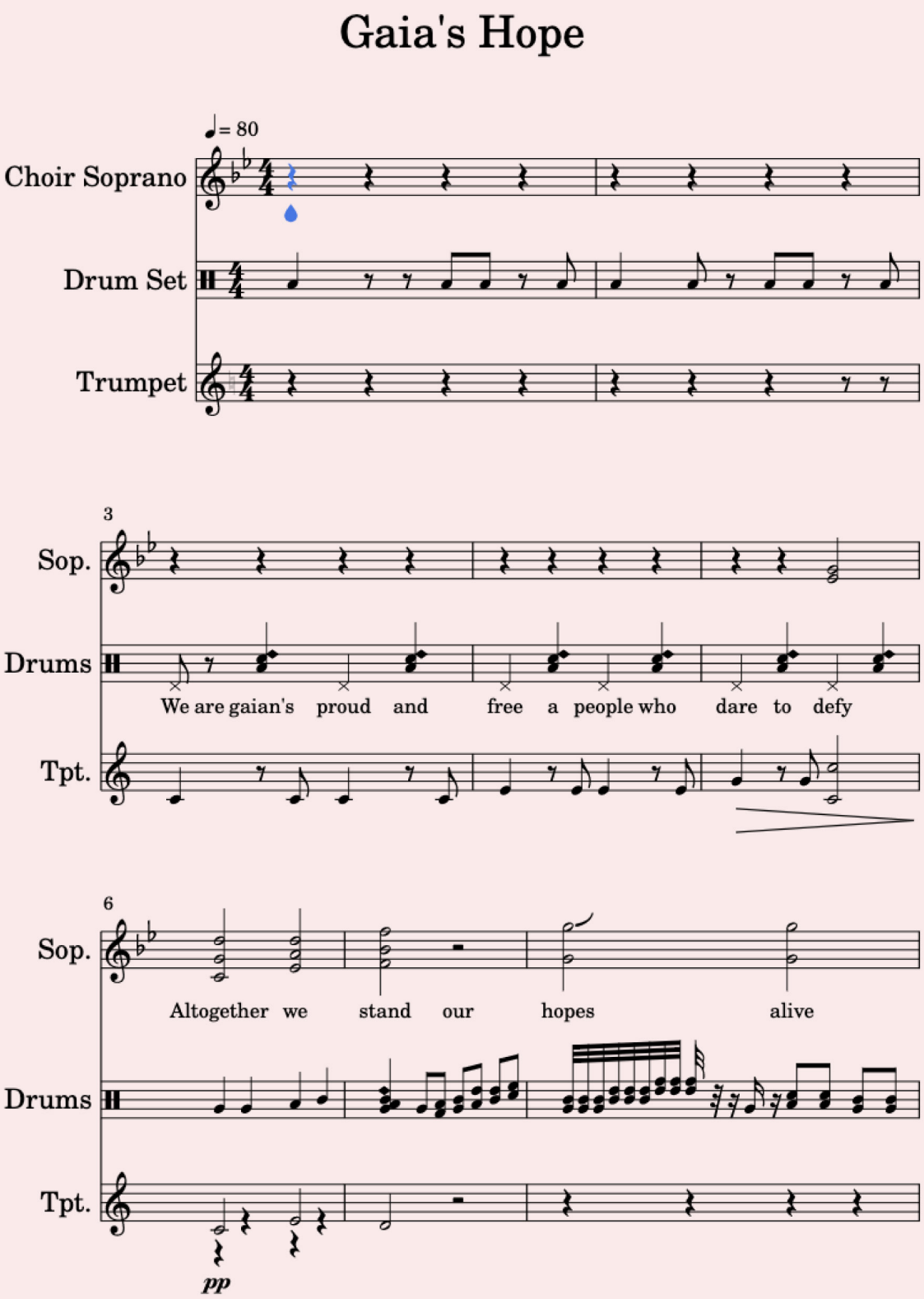
Figure 6.2.1: Drone Show
Credit: Canadian National Exhibition

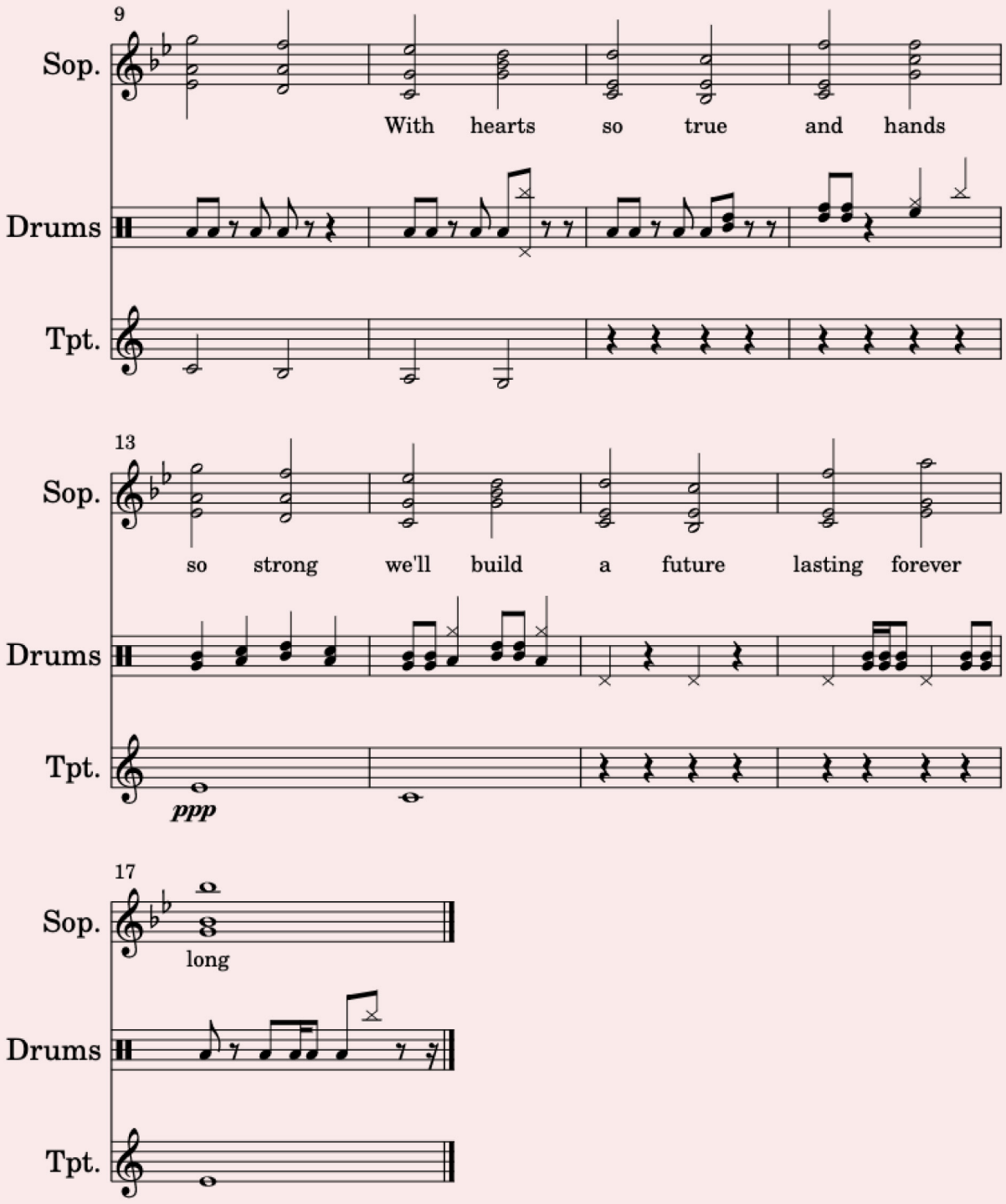
One of the primary uses of UAVs would be for repairs. The UAVs can be equipped with tools and equipment necessary to carry out routine maintenance and repairs of the settlement's infrastructure. This can help ensure any issues are addressed promptly. Another important use of UAVs in the settlement would be for cleaning. UAVs can be used to clean the exterior and interior surfaces of the settlement, removing any dust or debris that might accumulate, such as on the solar panels for high efficiency. This will help to keep the settlement looking clean, and maintain a healthy living environment for inhabitants. UAVs can also be used to watch over security breaches. UAVs can also be used for entertainment purposes, particularly during religious events. For example, UAVs can be programmed to create a simulated fireworks display to celebrate special occasions, something that would be impossible in the harsh environment of space. This will help to provide the inhabitants with a sense of normalcy and unity.

6.2 Uses on Titan?

Advancements in UAV technology have made it possible to use these versatile machines on the moon Titan. One of the key ways UAVs can be used is for exploration of hidden or hazardous areas. UAVs can access areas that may be too dangerous for human explorers. UAVs can survey hazardous or difficult-to-reach areas, providing valuable data and insights into the surrounding environment. This can help to enhance the safety of human explorers and support their efforts to understand the conditions on Titan. Another way UAVs can be utilized is for scanning underground levels for water and liquid methane. These essential resources are crucial for the survival and development of the settlement, and UAVs can play an important role in locating and extracting them. With advanced sensors and imaging technology, UAVs can survey the underground environment, providing valuable data and information about the distribution of these resources. UAVs can aid in the development of ideal environments to land, harvest resources, and develop energy sources like wind. With their ability to survey large areas, UAVs can help to identify the most promising sites for resource extraction and energy development.

7. NATIONAL ANTHEM




9
Sop.
With hearts so true and hands
Drums
Tpt.
13
Sop.
so strong we'll build a future lasting forever
Drums
Tpt.
ppp
17
Sop.
long
Drums
Tpt.

CONCLUSION

To conclude, the space settlement will orbit the magnificent moon of Saturn called Titan, which hosts resources such as hydrocarbons and liquid water which will allow the space settlement to function sustainably. Around Titan, there are various space bodies which can be used for storage of materials and resources, and can be used for their resources since they have similar resources compared to Titan. The space settlement will be a cylindrical space settlement with a design that maximizes energy acquisition and protects the residents from the harsh environments of space. The inhabitants of the settlement will be living comfortably with residential needs being within a 1km range, and comfortable home space for each. Oxygen will be acquired for the space settlement using simple electrolysis and nutrition will be brought to citizens using the various agricultural crops that will be grown on the space settlement. The importance of physical and mental health will be heavily promoted and citizens will have access to opportunities which will allow them to connect with others. The starting population will consist of 10,000 people which will consist of 5000 young people in a relationship and around 5000 people in a small family. The government will aim to have a strict balance between democratic and authoritative governance, where the primary focus will be to address citizens' concerns, protect civilian rights, innovate finance through the use of cryptography and create government ministries to take care of civilian facilities. There will be ministries revolving around the necessities of a society to make sure that the civilization runs smoothly. The space settlement will be powered on nuclear fission, wind power, solar power, and kinetic tiles. Through the usage of unmanned aerial vehicles, exploring the surface of Titan will be made much easier. Additionally, the UAVs will also allow for better maintenance of the space settlement externally, such as removing space debris from the solar panels. Gaia's Hope is the name of both the settlement and the national anthem. Named after the great Greek god Gaia, this anthem hopes to capture much of her power and authority. It is meant to motivate the thousands on the settlement who have embarked on this brave new crusade.

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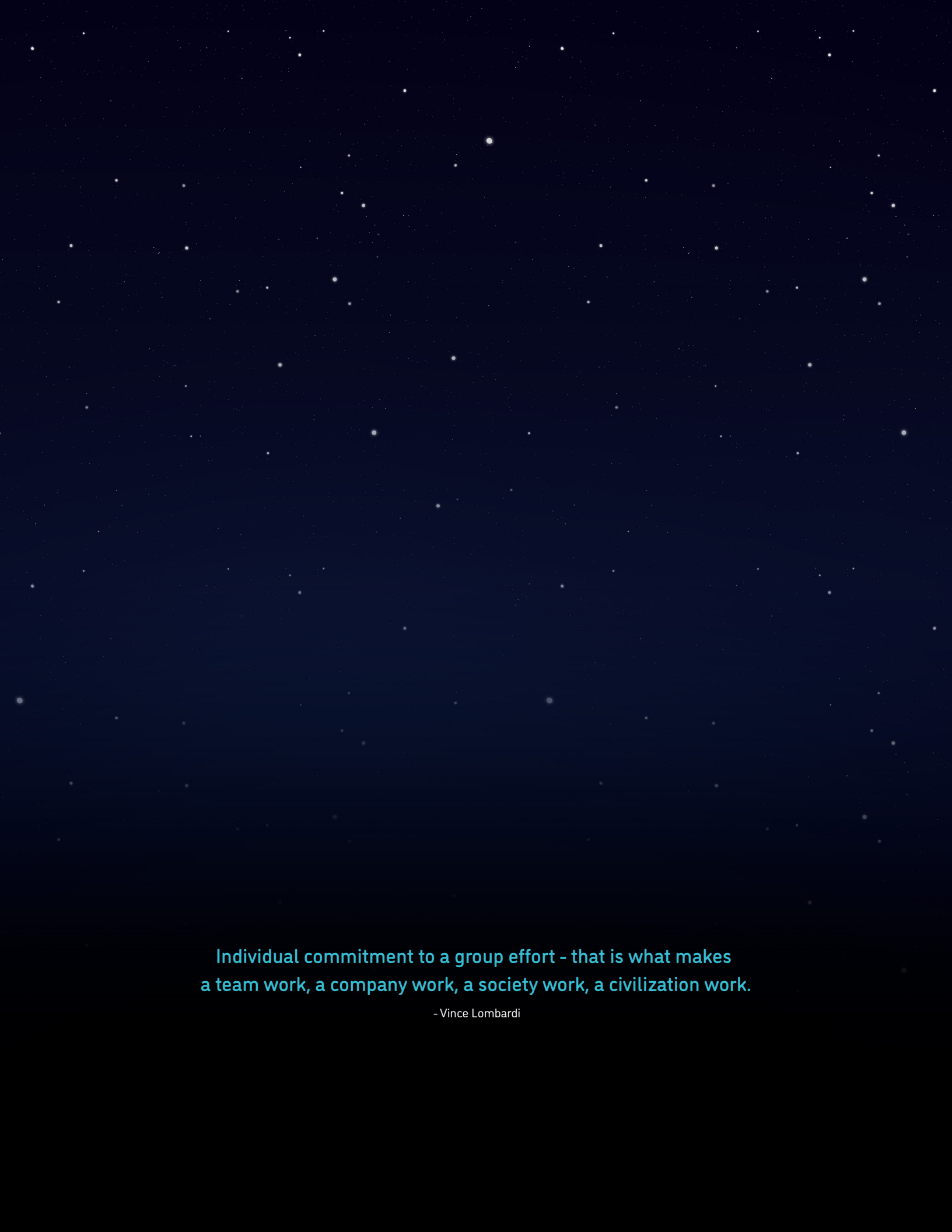
Individual commitment to a group effort - that is what makes
a team work, a company work, a society work, a civilization work.
- Vince Lombardi