
Project
VENA

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Management Summary

Prologue

The temperature rose, crops failed, famine spread. Our planet was practically out of resources that not only kept humankind alive, but also companies growing. Markets were in an absolute state of crisis. Businesses, one by one, found themselves on the verge of bankruptcy, the resources they needed for further production were practically non-existent. However, there was a new field of competition: biggest private companies all over the world now had easy access to space travel and exploration, so they used their own probes and rovers to discover another planet to consume the resources of. This was the new space race, a repeating cold-war. Leaders had gone far enough to even propose buying land on extraterrestrial objects, whether it be asteroids, moons, or planets. The highest demand was for Mars. Some were crazy for its abundance of iron, while others showed high demand for minerals like titanium, nickel or aluminum. Businessmen were blinded by their greed and desire to prove their superiority over rival companies, so they mostly ignored what other planets may have in hand and centered around solely on the invasion of Mars.

Professor Albert, a young scientist who still had faith in the future of humankind, was devoid of a greedy desire to establish dominance over other companies and businesses with his discoveries and innovations. He worked day and night for future generations, out of pure belief in the idea that humankind could save the only planet that they had in hand. He knew that the answer laid in the mysteries of the planet Venus, so he focused his research on investigating what Venus had to offer, and what mistake its ancient inhabitants had made to ruin it to this extent.

After a few years, instead of a mere interest sparked by curiosity, his research turned into a devotion, a life goal that he was committed to complete. He would work day and night to complete his visionary project to encourage humankind to further investigate the mysteries of Venus and save their own world from having to face the same fate. He believed

that if the rich resources of Venus were to be extracted and used in the right way, Venus had a lot to offer for the future generations. In the same way, this would imply that the end of the world, which was clearly arriving soon, may not actually be *an end.* If a settlement could be established around Venus, making use of plenty of its resources and hosting thousands of inhabitants, so could our planet have a lot to offer even after the damage done could not be reversed.

He was hopeful, and he had faith, but this was surely not a thing he could do all alone. He was in desperate need of recognition, however people were too busy to pay attention to a solution that actually offered hope- most civilians had already accepted the fate of apocalypse, and leaders were still greedily going after material gains and land on planets that would offer nothing but loads of money. Professor Albert felt truly powerless in all of this mess, but he knew what had to be done.

He decided to sit down and write down a report aiming to propose all the ways in which the planet Venus could be beneficial not only to humankind, but also for the planet Earth. If life could exist around Venus, that would mean that it could also exist around the future, dissipated planet Earth. His report, as he expected, went unrecognized in the world of science. Other scientists did show him their approval and appreciation for his good will, however nobody believed in the possibility that a project so far-reaching could actually be accomplished in a state of such chaos.

His project was documented in a file, which he kept in his office. Soon enough Professor Albert passed away, and his work faded away into the mists of time.

Years later, the population of the world had decreased tremendously. Opposite to what was anticipated, those people of power actually started to hold on to any ounce of hope that could potentially keep humankind alive, because it was realized that the end was way too near to chase after any additional financial gain. Each day, more and more powerful businessmen were willing to invest in a project that offered hope, out of pure worry for the futures of themselves and their own children. Due to the search for such a solution being in

high demand, when Professor Albert's file was re-discovered, it drew great interest. It was accomplishable, realistic, but most importantly it offered hope. It showed the world that this end could be made into a beginning.

Project Vena is the original settlement proposed by Professor Albert.
It is the project that united all world leaders around a single humane emotion- which is hope.

Resource Extraction

Contrary to popular belief, Venus is a planet that has a variety and abundance of elements that are required to create a sustainable space settlement. In order to understand the distribution of elements in Venus, first the surface and basic structure of Venus should be understood.

Upon the observations of Russian Venera landers and Magellan orbiter's radio scans upon the surface of Venus, the surface of Venus consists of 65% of rolling plains while the rest consists of highlands and mountains (Blackman). Besides these, the observations demonstrate that these rolling plains are made of basalt while there are volcanic cones present as well. Apart from volcanic cones, many volcanic calderas and mountains are present in many parts of Venus, which are surrounded by lava flows. Although none have been observed until today, the presence of rolling plains and the presence of volcanic mountains indicate the existence of an active volcanic system inside Venus (NASA Solar System Exploration).

Taking these and the fact that Venus has a similar density and mass to Earth into account, the distribution of elements inside of lava; thus, the volcanic rocks such as basalt would be similar, if not exactly the same. Our primary source for resource extraction will be basalt extraction for several reasons. The first reason is the fact that Venus is coated by rolling plains which are made out of basalt, which makes it widespread on the surface of

Venus while the second reason is the minerals and elements the basalt includes and finally, the third reason is basalt mining being sustainable thanks to the probable active volcanism on Venus.

Basalt is a volcanic rock that is rich in several minerals; mainly consisting of olivine, pyroxene, and plagioclase while also including minerals such as quartz while the percentage of these minerals can change from rock to rock. By decomposing these minerals into elements, most of the elements which are required to continue sustainability inside of Project Vena are obtained.

Olivine is a silicate mineral which has the formula of (Mg,Fe)2SiO4, where magnesium and iron atom can vary depending on the rock. On the other side, pyroxene is a mineral with the formula of XYZ2O6, where X can be Mg, Fe, Mn, Li, Ca, Na whereas Y can be Al, Fe, Cr, Ti, Mg, Fe, Mn and lastly, Z can be Si, Al, Fe. Lastly, plagioclase has the formula of NaAlSi3O8 or CaAl2S2iO8. By using leaching and hydrolysis methods, all silicate-based minerals(with the exception of quartz) including olivine, pyroxene, and plagioclase these minerals can be weathered; thus, separated into metal cations, soluble silica, and clay minerals because of their mostly ionic nature. Hydrolysis is a process that causes the minerals to get weathered over time via the usage of carbonic acid(H_2CO_3). As an example, iron olivine reaction with carbonic acid can be demonstrated as:

$Fe_2SiO_4 + 4H_2CO_3 \rightarrow 2Fe_2^{+} + 4HCO_3^{-} + H_4SiO_4$

In this reaction, the formation of iron ions, bicarbonate, and silicic acid can be seen. After these materials are separated via the froth flotation method which will be mentioned in the later parts, silicic acid(H4SiO4) can be separated into water and silicate(SiO_2) since silicic acid is a weak acid. This reaction can be demonstrated as:

$H_4SiO_4 \rightarrow 2H_2O + CO_2$

The remainder bicarbonate can be used to produce electrolytes if required or to produce carbonic acid by protonating the compound with H+ ion to ensure the self-sustainability of the process.

Unfortunately, the procedure of decomposing plagioclases is a harder process. Although calcium and sodium ions are easy to extract from the mineral, obtaining other precious elements such as aluminium is much harder than the process of extracting iron from olivine. The reaction can be illustrated as:

$CaAl_2Si_2O_8 + H_2CO_3 + ½O_2 \text{ —-> } Al_2Si_2O_5(OH)_4 + Ca_2^{+} + CO_3^{-2}$

To obtain alumina from kaolinite(Al2Si2O5(OH)4), two more steps should be followed. The first step is a step called calcination. Calcination is the name of the process where the substance is heated in high temperatures to remove undesirable substances or volatile substances. When kaolinite is calcinated, two other substances, metakaolinite and water is produced. This process can be demonstrated as:

$Al_2Si_2O_5(OH)_4 \text{->} Al_2O_7Si_2 + 2H_2O$

This process allows the compound to be activated and prepares it for the process named leaching. It should be also noted that the temperature calcination was done and duration of the calcination affects the total amount of alumina obtained. It was observed that a temperature between 600 degrees and a duration of 1 hours gave the best results, with a rate about 84.9% (Erdemoğlu et al. 391). After the calcination process, the leaching process is reached. In the leaching process, similar to hydrolysis process, metakaolinite is leached inside of an acidic water. To achieve that, strong acids such as H_2SO_4, HNO_3, HCl and H_2SO_3 are used. Upon commencing the leaching, metakaolinite reacts with hydrogen inside the acid to terminate the reaction. This can be demonstrated as:

$Al_2O_7Si_2 + 6H^{+} \rightarrow 2Al^{3+} + 2SiO_2 + 3H_2O$

As it can be seen from that reaction; silicate, water, and metal ions are created.

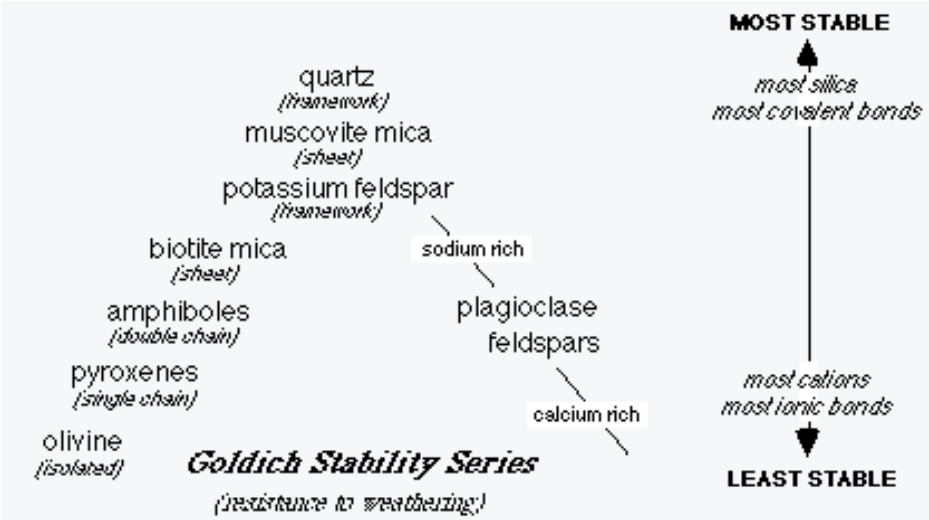


Figure 1. The stability of some minerals. (Source: http://www.columbia.edu/~vjd1/weathering.htm)

In order to shorten the processes, the concentration of acids and the water temperature can be increased. As a result of the hydrolysis and leaching processes, all silicate-based minerals can be separated into:

1. Solid clay
2. Soluble silicate
3. Metal ions

Even though metal ions and soluble silicate are found inside acidic water, there are several ways to separate from acidic water. The method we decided to use a method called froth flotation. Froth flotation is a method where hydrophilic and hydrophobic materials are separated from each other with the help of compressed air. Froth flotation is an effective method because besides helping separate the ionic metals and silicate, it is also helpful while separating other minerals, metal ores and waste management (Deliyanni et al.).

Besides these, in the mountainous and high-altitude regions of Venus, a phenomenon named Venus snow occurs. It is the concentration of lead sulfide and bismuth sulfide in mineral form. Extracting these elements may be helpful for settlement since lead can be used for radiation shielding and bismuth is used in fire alarms and certain medicines.

Lastly, gamma-ray scans made by Vega 1 and Vega 2 capsules of the Soviet Union illustrated that in certain parts of Venus, radioactive elements such as thorium, uranium, and potassium were found in abundance (Surkov et al. 46). Uranium and thorium are crucial parts of the settlement since the main source of energy for our settlement are going to be fission energy, which requires the usage of thorium and uranium.

Here is a list of primary elements and compounds that are going to be obtained from all these processes:

ELEMENT/COMPOUND	THE USAGE
Iron	Used in alloys, pipes, cables, buildings, and machinery
Magnesium	400-420 mg for men and 310-320 mg for women are needed by the body; Used in aluminium alloys, computers, and cameras because of its lightweight
Silicate	
Oxygen	A necessary element for respiration, required for burning, used in steel industry
Sodium	Used as a heat exchanger in nuclear reactors, can be used as a reagent in the chemical industry, the main element of sodium salts.
Aluminium	Used in daily life materials, transportation vehicles, tools, and as an electrical conductor since it is ⅓ the weight of copper.
Calcium	Important for bone and muscle health, used as a reducing agent for thorium and uranium.
Silicon	Is used in making some alloys, especially with aluminium and iron, used in making silicone, which is used in making waterproof sealants, used as a semiconductor in computers and microelectronics
Thorium	Used in nuclear reactors as fuel, creates more energy than uranium
Uranium	Used in nuclear reactors as a fuel
Potassium	Used in fertilizer production, the main element of potassium salts; salts such as potassium hydroxide are used in the production of detergents and liquid soaps.

Lead	Used in radiation shielding, the storage of corrosive liquids, cable sheathing, and batteries
Bismuth	Used in fire extinguishers and detectors.
Titanium	Used in spacecraft, vehicles, laptops, and tooth implants. It is an important element since it is resilient to high temperatures and weights less than steel.

Drones and Excavation Process

Since Venus's surface has extremely high temperatures and pressure, it is unreasonable to send humans to conduct the excavation processes. In order to achieve that, our team decided to design remote-controlled mining drones to achieve the resource extraction process, considering that they require no human to enter into the atmosphere of Venus.

Figure 2. The excavation drone by Yiğit Kerem Oktay (Not to scale)

Yet, because of Venus's surface conditions, designing complex drones that can endure these is arduous and requires a meticulous approach. While designing these drones, we evaluated the most important factor that had to be considered during designing these drones: pressure.

Protection Against Pressure

Considering that Earth's atmospheric pressure is 1 bar, it is not hard to estimate that about 95 bars of pressure on Venus' surface would cause drones and rovers without protection to get damaged or get unfunctional. To prevent that situation, special precautions should be taken against pressure. To comprehend these precautions, the terms stress, strain, and elasticity module(Young's module) should be understood.

Stress can be defined as the force applied to a certain area of an object and experienced by it or the internal resistance of the object against change in its shape. Stress has the formula of $\sigma=F/A$ where F is the force applied and A is the cross-sectional area of the object. In that way, the terms stress and pressure should not be confused with each other. On the other hand, strain can be defined as the total change in the dimension of the material over the initial dimension of the metal. It can be formulated as $\varepsilon=\Delta L/L$ where L is the initial length and ΔL is the change of dimension. These two terms are used while calculating the elasticity module of the material. Elasticity modulus or Young's modulus can be defined as the force exerted upon the object over the deformation of the object, which indicates the elasticity of the object. This can be formulated as $E= \sigma/\varepsilon$. Young's modulus is essential in this process since it reveals some of the important distinguishing properties of the certain object such as yielding strength, tensile/ultimate) strength, and fracture point. The table below illustrates these properties in the stress-strain curve.

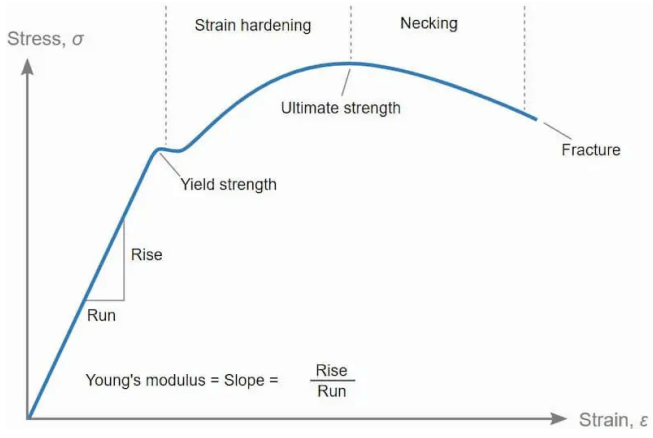


Figure 3. Andreas Velling, The stress-strain curve of metals. (Source: https://fractory.com/stress-strain-curve/)

It should be noted that every metal has an elasticity to some extent. Yield strength is the point where the plastic deformation of the material initiates and the material loses its elasticity and cannot return to its initial position when the force is removed.

Since producing high-technology space drones such as this drone is a process that is extremely costly, time-consuming, and complex; producing these drones with as much savings from the material as possible while creating drones that have long times of service time is a crucial aspect that should be considered. Because of this, the minimum and ideal thickness of the drone should be calculated. To take a reference point to achieve that, our team has elected to base their calculations on yield strength since it is the maximum point of a matter's elasticity and initial point of its deformation, which allows our calculations to be measured upon minimum values. To initiate, the total force exerted by the atmospheric pressure of Venus on the drone has to be calculated to determine the stress exerted. While doing so, the atmospheric pressure of Venus will be accepted as 95 bars.

As known, pressure applied to a matter is calculated with the formula P=F/A, where F is the force and A is the surface area. Taking that into account, in order to calculate the total force, the formula can be rewritten as F=PA. For this calculation, 95 bars can be converted onto 9.5×10^6 pascal. Upon calculating, we found that the surface area of the body of the drone equals to 30.4 m^2 with one hexagonal side being 6 m^2, and the other sides are as 4.8 m^2, 1 m^2, and 2.4 m^2 if the shape of the drone is accepted as a hexagon. Thus, we calculated that the total force exerted upon the drone's 1 hexagonal side as 5.7×10^7 N while other sides are calculated as 4.56×10^7 N, 9.5×10^6 N, and 2.28×10^7 N.

Before calculating further, the material that is going to be used in the production of these drones must be determined. For that process, a material that has a very low rate of corrosion, high strength, and cost-efficient should be utilised. For that, a titanium-aluminium alloy named Ti-6Al-4V is going to be used. This alloy has some crucial properties that are advantageous while producing drones. Compared to pure magnesium's 240 MPa yield strength, this alloy has a yield strength of 880 MPa alongside a thermal

conductivity of 6.7 W/mK. Besides these, the alloy has superplasticity features, which is a term used for materials that can withstand 200- 400% deformation in low stresses (Mosleh et al.). As an additional feature, the production of drones hypothetically be easier as well since aluminium is a more widespread element that can be obtained easier.

Since Ti-6Al-4V is the primary component that is going to be used in the production of these drones, the stress should not be bigger than 880 MPa to prevent any deformations in the shape of the drone, which could possibly result in some of the components inside the drone getting damaged in the process.

Upon doing so, we can calculate the minimum thickness inside the drone. Since 880 MPa equals to $8.8x10^8$ pascal, the minimum cross sectional areas can be calculated as following:

$8.8x10^8$ pascal = 5.7×10^7 N / ym^2 $y \approx 6.5 \times 10^{-2}$ m^2
$8.8x10^8$ pascal = $4.56x\ 10^7$ N/ ym^2 $y \approx 5.4 \times 10^{-2}$ m^2
$8.8x10^8$ pascal = 9.5×10^6 N / ym^2 $y \approx 1.1 \times 10^{-2}$ m^2
$8.8x10^8$ pascal = 2.28×10^7 N/ym^2 $y \approx 2.6 \times 10^{-2}$ m^2

Upon calculation, we found the rates between the areas, thus the sides of the empty space and the wall. They all had a constant rate of approximately 99.4% between the sides. Thus, we decided that the drone should have a thickness of at least 1.44 cm. Because of the error margin, we decided to produce our drones with a thickness of 2 centimeters per side.

Architecture

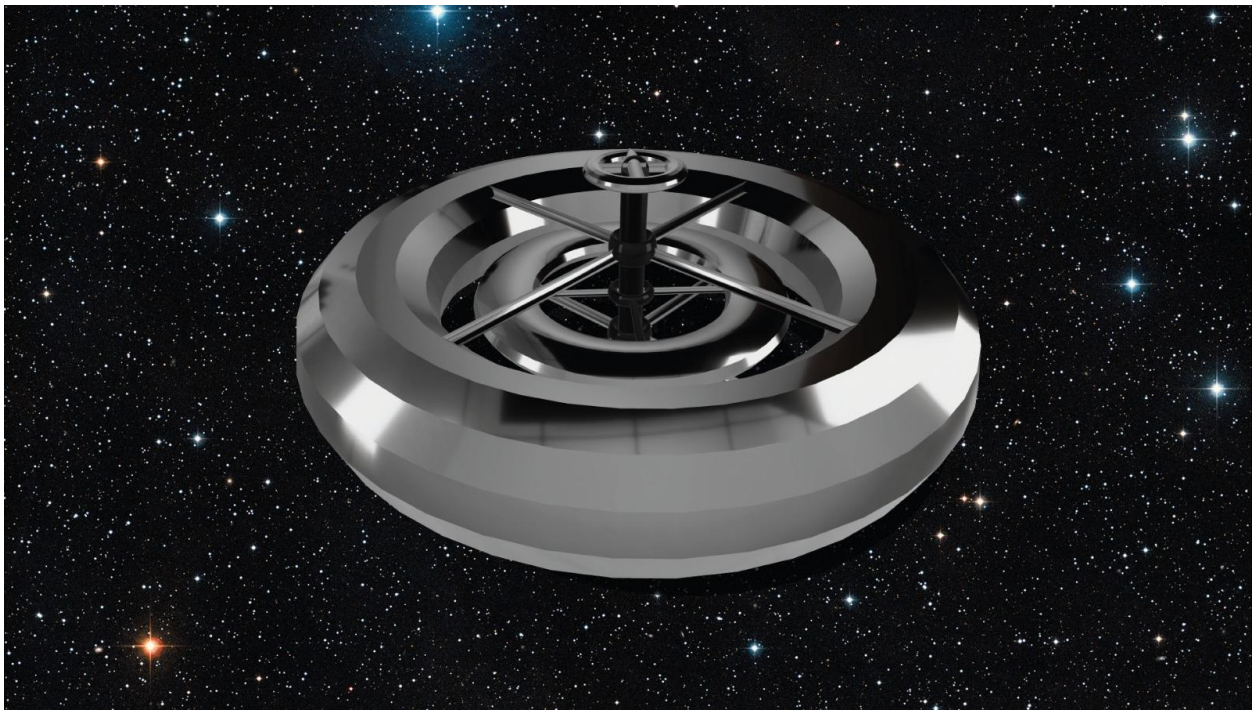


Figure 4. Settlement's outer structure by Yiğit Kerem Oktay.

Energy and Power Distribution

Introduction - Thorium Powered Molten Salt Reactors

In our space settlement, we have chosen to utilize nuclear fission as our main energy source. We have decided that the implementation of power plants called "Thorium Powered Molten-Salt Reactors" will provide our settlement with large amounts of on-demand energy. An important aspect is that nuclear systems provide a desirable option for space missions that require on-demand power in space environments where solar power or sunlight is absent. Additionally, molten-salt reactors hold a reduced risk of meltdown compared to conventional Light-Water Reactors, and also are an affordable source of electricity, and will occupy a very small area for construction. Molten Salt Reactors (MSRs) are one of the systems retained by Generation IV International Forum for

the development of new nuclear energy systems. They have proven to show enhanced safety and reliability, high efficiency of fuel use, and reduced waste generation. Additionally, the required fuel, Thorium, can be found abundantly in Venus rocks, which will be extracted with the use of our settlement's drones specialized for this task.

How do these power plants work?

Molten Salt Reactors are nuclear fission reactors that use liquid fuel rather than a solid form of fissile elements, which are used in Light Water reactors (as uranium fuel in solid rods). These solid rods in LWR's have to be continuously kept cool with coolants such as liquid water to avoid a meltdown, yet the MSR's complete this process a lot more differently. The main method used with the MSR is that the fuel, whether it be Thorium, Uranium or Plutonium, is dissolved in the coolant salt (high temperature liquid salts like fluoride or chloride) and is used as both the fuel producing the heat and the coolant to transfer and/or remove the heat. This is a safety advantage for the power plant, since it allows continuous extraction of the fission products. This means that fission products can be removed or added while the plant is in operation, therefore a shut down isn't necessary for refueling (on-line fuel processing). MSR's do not require high pressure, and since they aren't cooled by water either, the possibility of a steam explosion is impossible. These low required pressures ensure safer operation as well as reduced size and costs of reactor building. Additionally, since the salts are at atmospheric pressure, a leak in a tube doesn't automatically result in an expulsion. The most important safety measure taken due to the liquid fuel is the "drain tank mechanism" which is an emergency system that allows the fuel to be passively drained and cooled in the case of potential overheating.

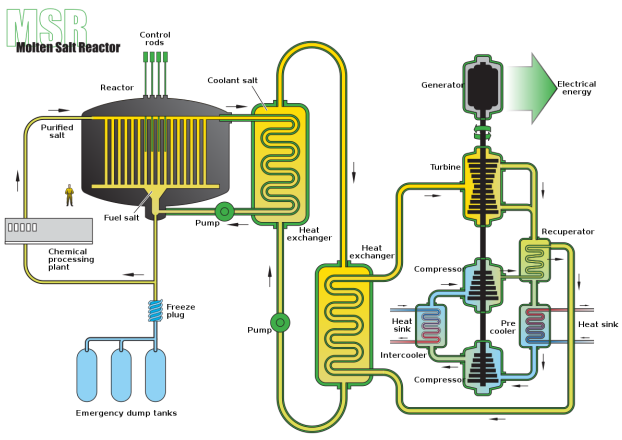


Figure 5: Molten salt reactor diagram
https://www.iaea.org/newscenter/news/molten-salt-reactors-iaea-to-establish-new-platform-for-collaboration

This is what the traditional (1970s single fluid graphite moderated molten salt reactor) looks like. The reactor core is where the fuel-salt mixture goes through fission. This is where heat is generated, which is then transmitted by the heat exchangers to water, producing steam. This steam drives a turbine which then produces electricity. The emergency dump tanks are activated when the frozen plug of salt melts, allowing the fuel-salt to drain into the emergency dump tanks.

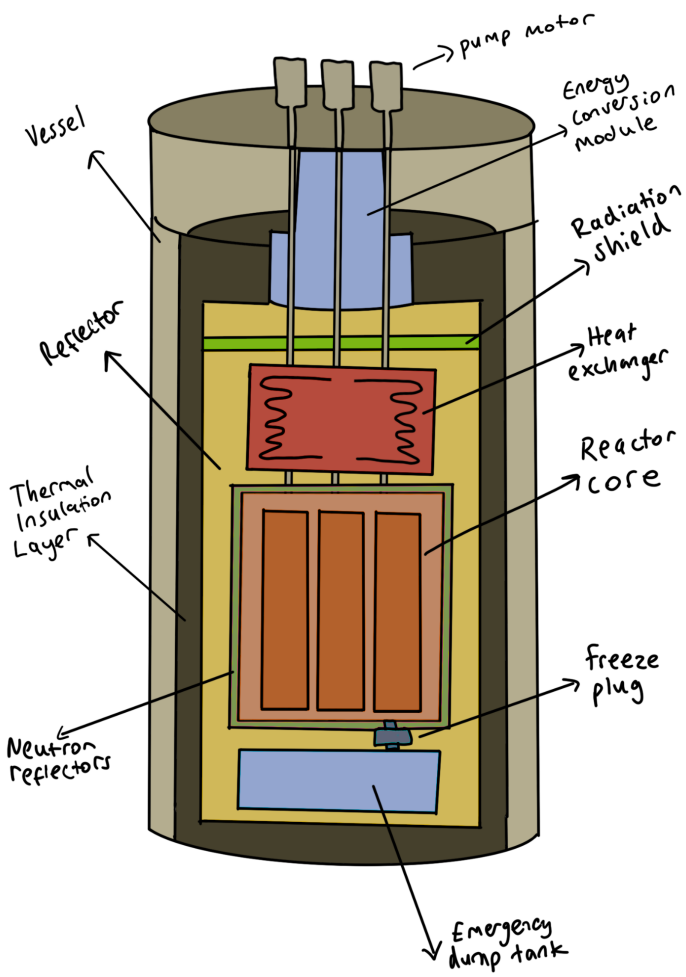


Figure 6. A molten salt reactor (MSR), illustrated by İrem Eroğlu

Our system will be fundamentally similar to the system described above, however will have some altered aspects so that it can be a better fit for space applications, considering qualities like additional safety mechanisms, smaller modeling and architecture, further waste recycling methods and simplified/less massive core and heat exchanger designs.
As a structural material for the outer vessel of our reactor, we will use Silicon Carbide (SiC). It has been speculated that SiC is an appropriate material for components in space fission systems at even very high temperatures. SiC is additionally very lightweight with a density of 2.55–3.25 g/cm3. In order to maintain a power system with a low specific mass, which is crucial due to the high cost of putting a heavier object into

orbit, such materials with lightweight properties must be used. This material can also maintain its physical

strength under very high doses of radiation. As the molten salt for our reactor, we will use lithium-beryllium fluoride (FLiBe) salts with thorium fluoride. This molten salt can effectively breed U-233 from Th-232 in line with the Thorium fuel cycle (Th-233U). Based on the Thorium/Uranium fuel cycle, thorium 232 cannot be used as a nuclear fuel before it is transformed into Uranium 233, which occurs through the process of absorbing more neutrons. A chain fission reaction is not as easily started in Thorium as it is in Uranium- extra neutrons must be accelerated to decay Thorium into Uranium 233 first. This eliminates the possibility of an uncontrolled chain reaction, thus a nuclear disaster. It ensures the safety of the reactor.

Parts of the reactor

The neutron reflectors help reflect neutrons back into the core, and prevent them from escaping. A graphite radial blanket surrounds the core to prevent neutron leakage and thus result in positive feedback coefficient.

The reactor core is where the nuclear reactions occur within the fuel salt (lithium-beryllium fluoride (FLiBe). This fluid entirely fills the interior of the core, and for means of simplicity, there is not a lot of internal structure. This increases efficiency since neutrons aren't lost into parasitic absorption of internal structure. When on-line refueling is necessary, new fuel is pumped into the core with the help of the pump motors.

After heat is generated in the core, the fluid then flows into the heat exchanger where it is cooled. This heat exchanger aims to keep the temperature drop as much as the temperature rise in the core. It works to transfer heat from the reactor core to the energy conversion module, where the nuclear heat is turned into electrical power for everyday use.

The heat exchanger is put behind a radiation shield as shown in the figure, since the molten salt fuel is highly radioactive and can fission outside the core.

The insulation layer helps with the heat insulation generated from the fission activities inside the core.

The frozen valve (freeze plug) melts once the temperature at the core reaches a specific critical temperature, thus allowing the molten salt to drain into the emergency dump tanks and cool it down. This results in an emergency shutdown, which highly reduces the risk of any sort of a nuclear disaster.

The energy conversion module, with the usage of a thermoelectric generator, changes the nuclear heat into electrical energy. This generator uses the heat produced by fissile material into electrical energy, and utilizes the Seebeck effect to generate voltage.

Structural information about the reactor

Since our main aim with this reactor is to include elements that are specifically suitable for space missions, architectural and structural aspects such as size, mass, density and type of material also serve this purpose.

Radiation shield : Lithium Hydride (LiH)
Outer vessel : Silicon carbide (SiC)

Core Diameter X Length (cm)	40 X 80
Vessel mass (kg)	80
Reflector mass (kg)	100
Fuel mass in the core (kg)	350
Power range	10MWe to 15MWe

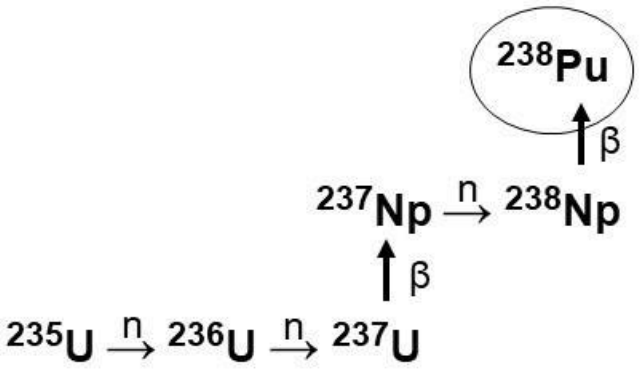
Removal of gaseous fission products (like Xe-135 and Kr-83) from the core

During the generation of nuclear fission energy in our molten salt reactor, some radioactive isotopes of gases such as xenon, krypton, and helium are released, as well as other gases that are produced during the nuclear reaction. These are called volatile fission products,

and they can have large neutron poisoning effects. A neutron poisoning occurs when a substance (such as the ones aforementioned) starts absorbing neutrons in the vicinity of a reactor core. This can have undesirable outcomes since neutron poisons may prevent or disrupt the fission chain reaction. The stream of such gases produced during fission is called an off-gas stream, and it must be carefully controlled and removed before it is released into the environment. For this reason, we will be using an off gas system which will use hydrogen as a purging gas to remove gaseous fission products out of the core.

Molten Salt reactor waste & recycling

The thorium-uranium fuel cycle used in our reactor can produce U-235 as a byproduct of the nuclear reaction. When this U-235 is to absorb more neutrons without fissioning soon decays into Plutonium-238, as shown in the cycle:



Plutonium-238 is, thus, a waste product of the nuclear reaction in the MSR that can be extracted from the fuel. This isotope will help us power the engines of our resource extraction drones, through the usage of Radioisotope Thermoelectric Generators.

Figure 7. Uranium 235 decays to Plutoium 238
https://www.acs.org/education/whatischemistry/landmarks/plutonium-238-production.html

What are Radioisotope Thermoelectric Generators? (RTG)

According to the World Nuclear Association, Radioisotope Thermoelectric Generators (RTGs) have been the main power source for US space work since 1961. RTG's are flight-proven systems, and can provide heat or electricity for decades under even very harsh conditions. Since they are widely used in the field of space exploration and have very low shielding requirements, they excel in that field. According to WNA, again, so far over 45 RTGs have powered in excess of 25 US space vehicles including Apollo, Pioneer, Viking,

Voyager, Galileo, Ulysses, Cassini and New Horizons space missions, all of which have been successfully conducted. To ensure a stable and consistent power supply for specifically the engines (motors) of the settlement and its component parts, we will make use of RTGs which will get their continuous supply of Pu-238 from the waste generated in the central molten salt reactor.

Pu-238 is non fissile and cannot be used in fission reactions. Its natural decay results in generation of high amounts of heat, which is then transferred to one side of the thermocouple used within the RTG. A large temperature difference between the fuel and the atmosphere is what helps the thermocouple generate electricity. The thermocouple here, similar to conventional thermocouples, makes use of the Seebeck effect which creates electricity when its two separate metal ends are subjected to a great temperature difference.

The RTG has a quite compact and durable design, has no moving parts, and is highly resistant to harsh environments in outer space.

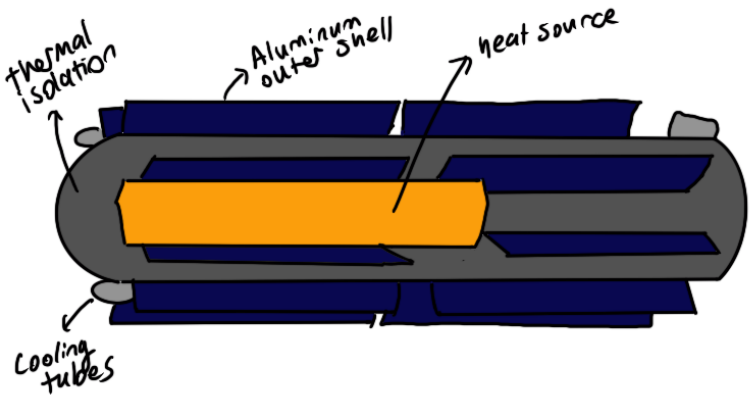


Figure 8. RTG design by İrem Eroğlu

We will be using the electricity from these batteries to power the engines of the resource extraction drones, which will carry out resource extraction on the rocks of planet Venus.

The batteries will use the temperature difference between the heat produced by the decaying of Pu-238 and the cold environment of space. The batteries will mostly be refueled while the drones are outside of Venus's atmosphere, or at rest while interlocked to the exterior of our settlement. Once the plutonium 238 is extracted from the reactor waste and fueled into the

RTG batteries on the drones, energy production will be carried out separately in each drone, either while interlocked on the settlement or hovering outside the atmosphere of planet Venus. The drone will use all of its stored electricity while completing its tasks on the surface of Venus, and refuel with the thermocouple system once the battery starts to run out.

Shielding

Defense Against Meteoroids and Orbital Debris

According to Kerr Mesh double-bumper shield: A low-weight alternative for spacecraft meteoroid and orbital debris protection,

A mesh double-bumper (MDB) shield will be covering the settlement to provide high-strength protection against meteoroids and orbital debris while carrying less weight. The shield will include the first bumper in the form of aluminum wire mesh, followed by a standard second bumper shortly after a small distance, a layer of robust fabric, and a back wall.

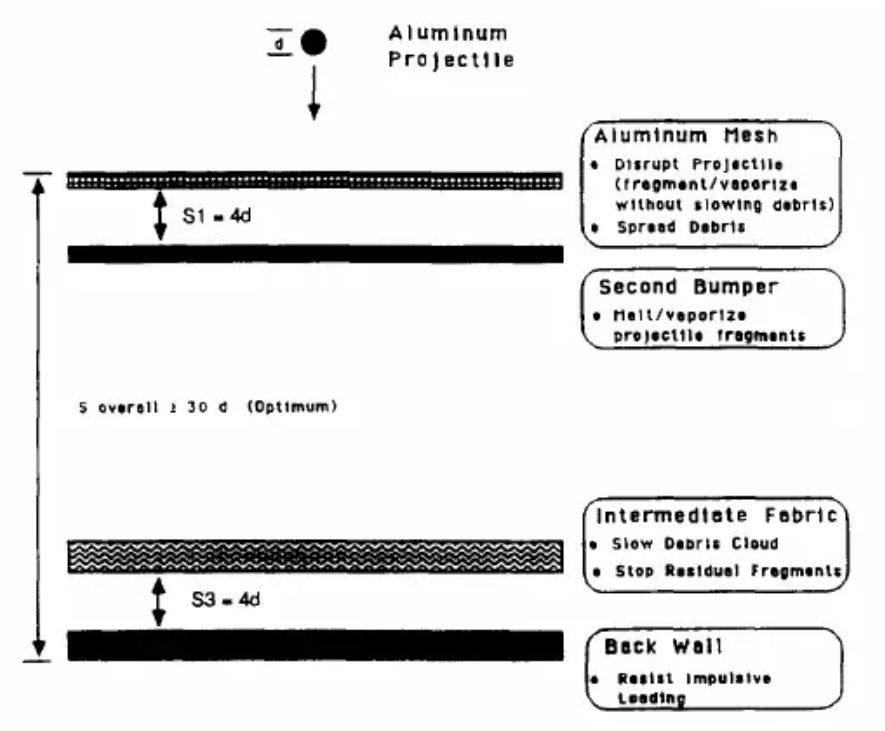


Figure 9. MDB Shield (Christiansen, 1990)

The first buffer will make sure that the hazardous material is broken up into small pieces by the stacked wire mesh in square patterns on top of one another. The impact will be boosted by having the mesh thicker where the wires meet. On the hand, the effect of small pieces that can pass through the wire mesh without being damaged will be lessened in the second bumper which is continuous; moreover, the pieces that are detached by striking the wire mesh here will be further pulverized by a second shock or melted/evaporated by increasing their heat. Remaining pieces of debris will pass through the fabric layer to be significantly slowed down or completely stopped. Nextel, a ceramic fabric made of alumina-boria-silica fibers that shock and deconstruct the debris, decreasing its potential risks, and kevlar made of aramid fibers to lessen the impact as much as possible will be used together to form the fabric interlayer (Johnson Space Center Ares). If there are still solid fragments that are effective after passing through the fabric interlayer, the back wall will prevent them from reaching inside of the settlement.

Radiation Shielding

According to Laster Radiation shielding in space exploration,

Radiation prevention is also vital for the settlement. In this instance, an improved form of electrostatic shielding will be utilized. Instead of establishing an area charged with one sort of charge on the hull, zones charged with different types of charges will be generated at the opposite ends of the spacecraft in order to protect the settlement from the potential danger of both negatively and positively charged particles in space. This will avoid the hull from being damaged by creating an area loaded by only one type of charge that attracts opposing loads as well while repelling similar loads.

By converting the settlement into an electret that is permanently polarized without requiring any extra mass or energy, this technique will also provide additional protection through the magnetic field it generates.

Self Sufficiency

Production of Water

Water is one of the most essential elements to preserve life in a settlement. The sustainability of water resources is so crucial for the human body in terms of maintaining homeostasis, transporting nutrients to the cells, and protecting the tissues, spinal cord, and joints. Water is mostly known for being used for drinking, cooking and cleaning, but despite these uses; water is also required for commercial, agricultural, and industrial use. A continuous and a balanced water cycle is necessary, since the lack of water resources may result in a huge adversity and chaos, which would threaten the settlement's future.

Venus is a planet that has a variety of resources and elements to be processed. It is commonly acknowledged that Venus' atmosphere is composed of toxic gasses such as Carbon Dioxide, Sulfuric Acid, etc. Approximately between 50-70 kilometers, there is an abundance of Sulfuric Acid (H_2SO_4). When the sulfuric acid is diluted, it is possible to obtain water out of it.

The ions present in dilute sulfuric acid are H^+ and OH^- that comes from the water, and H^+ and SO_4^{2-} that comes from the sulfuric acid. The cathode attracts the H^+ ions, whereas the negative ions attract the anode. As a result, OH^- ion loses electrons.

- ➔ At the cathode: $2H^+ + 2e^- \rightarrow H_2$
- ➔ At the anode: $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

A similar way to obtain oxygen and hydrogen in order to form water is to electrolyze Carbon Dioxide (CO_2) and Hydrogen sulfide (H_2S). The extracted oxygen and hydrogen elements' covalent bond would be broken with the provision of energy, and then combined to form water as a result.

- ➔ $2CO_2 + \text{energy} \rightarrow 2CO + O_2$

Carbon Monoxide that is formed as a result of this reaction can further be used as a fuel in engines, or as heterogeneous catalysts.

Another way to produce water is to react with the naturally abundant acids and bases found in Venus. Sulfuric acid occurs naturally in volcanes, and other acids such as CO2, HCl, and HF also are present in Venus' atmosphere.

Ammonia (NH3), is a key component that has been identified both by the Venera 8 and Pioneer Venus probes. NH3 dissolves in some of the sulfuric acid cloud droplets. This neutralizes the acid and stores the dissolved SO2 as ammonium sulfite ions. The vertical SO2 abundance anomaly can be explained by the SO2 being trapped in the clouds and then released below the clouds when the droplets warm up and settle down to higher temperatures. The source of NH3 is unknown, although it might be biological; if so, the most energy-efficient NH3-production also produces O2, explaining the finding of O2 in the cloud layers at about 10 ppm of its atmosphere.

Ammonia can be reacted with the other acids that are found in the atmosphere of Venus. With the neutralization (acid-base) reaction, water and salt will be formed. Filtration could be used for the water that is obtained as a result of these reactions. The salt can then be traded or stocked for industrial use.

Stable Climate

Venus's current climate is dominated by an effective carbon dioxide-water greenhouse effect as well as the radiative qualities of its cloud cover. Both the greenhouse effect and clouds are sensitive to changes in the amount of water vapor and sulfur gases in the atmosphere. Planetary-scale processes, involving volatile transport and sequestration, influence these abundances through time, driving climate change.
The pressure 50 kilometers above Venus's surface is the same as the pressure at sea level on Earth, which is one bar. Venus has an atmospheric pressure of 92 bars on its surface, which is equivalent to the pressure at a one-kilometer depth of an ocean on Earth. The dominance of carbon dioxide in Venus's atmosphere results in high pressure and a surface temperature of roughly around 455°C.

The heat radiated from Venus is trapped in the greenhouse gases of Venus's atmosphere, resulting in very high temperatures. Without the greenhouse effect, the equilibrium temperature on Earth would be around -18°C, which is not ideal for life. Accordingly, the greenhouse effect has elevated the temperature to 16°C, resulting in the current conditions.

The optimal room temperature is between 19-22 degrees celsius. It is very essential to stabilize the temperature in our settlement to keep it habitable for our residents, which will make it easier for them to feel at home and welcomed in the settlement. The temperature balance is a priority not only for the comfort of our citizens, but also for ensuring that the electronic devices are operating properly in the settlement.

Thermal equilibrium will be established within the spaceship with a Thermal Control System. The temperature will be controlled under two main ways: Passive heat control, which involves multi-layered insulation for shielding, as well as radiators, heaters, and surface coatings to help maintain the temperature steady. Active thermal control, which is divided into three stages: heat collection, conveyance, and rejection. We are going to control the temperature through both external and internal systems. The collecting phase requires the Internal Active Thermal Control System, which is a closed system that transports waste heat to the outer system. Water is going to be used in this process because it is a fluid that is an effective thermal transmitter. It is also non-toxic, and keeping it within the facility will not create any threat to the residents. Furthermore, we will not discard the waste heat generated by the systems since we want to colonize the settlement in the most efficient way possible in order to make it more sustainable and practicable. As a result, we will design a circulation system that uses water to cool the systems. After the heat exchange between the water and the machines we use in the settlement, the water will be warmer, and this will not affect the working principles of the machines. The warmer water could be used for bathing and cooking as well.

Relative humidity refers to the amount of water vapor that the air can contain without converting to water at a certain temperature. Other than sweating or having dry skin, if the relative humidity is too high or too low, other hazards such as germs and unwanted microorganisms may emerge in the settlement. The appropriate humidity levels should be balanced within 30-55%, in order to reduce the negative consequences.

Besides monitoring the temperature, the system that will be created will also control the relative humidity levels. The data that is collected will then be sent to sensors that detect any radical changes in the temperature and humidity, incase of an emergency.

Plant Cultivation

Considering the basic conditions for establishing a permanent settlement, it is of great importance to provide the necessary provisions for people to continue their lives. In order for citizens to have a varied and healthy diet as in the Earth, it is necessary to be able to produce food continuously on the settlement. Otherwise, a continuous interaction with the Earth in this context will be very costly and contradict the principle of the settlement being self-sufficient and sustainable. Therefore, agriculture is an important part of space settlement.

Production System

According to Shrestha and Dunn *Hydroponics - Oklahoma State University* 2017,

Since soil usage would be extremely costly considering the need to carry enough soil from Earth, it would not be wise to use it for agricultural production. In this case, a more productive alternative to soil would be preferred: hydroponics.

In hydroponics, plants are grown without soil by submerging their roots in a nutrient-enriched liquid solution. There are various benefits to keeping plants in human-made solutions intended with maximum efficiency rather than in soil:

The nutrient content and pH value that the plants need specifically can be controlled as desired, which means much higher quality product and crop yield.

By increasing the oxygen content in the plant's root zone compared to that in the soil, faster growth can be achieved.

Elimination or reduction of insects, fungi and bacteria that reduce the quality of soil agriculture, adversely affect production, and may cause significant problems in the settlement.

Agricultural labor in the soil, such as tillage, pesticide application, and weed removal, are not necessary for hydroponic systems.

Contrary to soil agriculture, the amount of water used decreases dramatically. Additionally, since water and nutrients utilized are reusable, the cost of water and nutrients is inexpensive compared to agriculture in the soil.

Application of the System

Aeroponic systems are a high-tech and effective type of hydroponic gardening that is to be preferred.

Instead of using soil or substrate, the plant is grown in the air using artificial support. While the roots, from which nutrients are obtained, hang in the growing area in total darkness, the tops, such as leaves and fruit, reach outside the growing area. As opposed to other hydroponic systems, which submerge the plant's roots in the solution, this method involves spraying the solution on the hanging roots, conserving water and nutrients. (Lakhiar et al. *Overview of the aeroponic agriculture – an emerging technology for Global Food Security*)

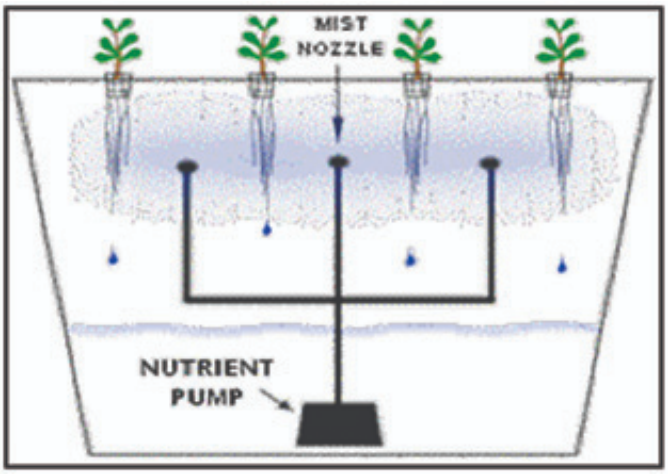


Figure 10. The Aeroponic System (*Shrestha and Dunn, 2017*).

According to Shrestha and Dunn, Hydroponics - Oklahoma State University 2017,

The timer controls the solution (nutrient) pump, allowing it to run at certain intervals. However, unlike other hydroponic systems where plants are placed directly into the

solution, the aeroponic system has a timer set to run for a few seconds every few minutes to provide the crops with enough nutrients.

Sprayed nutrient solution is also crucial as it is what primarily ensures the development of crops:

In order for the plants to supply the nutritional content they require for their growth and development using the hydroponic method, the major and micro components that must be provided to the solution can be stated as follows, along with their ionic forms and normal concentration range:

Concentration Range
Element Ionic Form mg/L, ppm

Major Elements	**Micronutrients**
Nitrogen (N) NO^-_3, NH^+_4 100 to 200	Boron (B) BO^{3-} 30.03
Phosphorus (P) HPO^{2-}_4 , $H_2PO^-_4$ 30 to 15	Chlorine (Cl) Cl^- —
Potassium (K) K^+ 100 to 200	Copper (Cu) Cu^{2+} 0.01 to 0.10
Calcium (Ca) Ca^{2+} 200 to 300	Iron (Fe) Fe^{2+}, Fe^{3+} 2 to 12
Magnesium (Mg) Mg^{2+} 30 to 80	Manganese (Mn) Mn^{2+} 0.5 to 2.0
Sulfur (S) SO^{-2}_4 70 to 150	Molybdenum (Mo) MoO^-_4 0.05
	Zinc (Zn) Zn^{2+} 0.05 to 0.50

Table 1. Ionic forms and normal concentration range of major elements and micronutrients in (most) nutrient solutions (Jones, 2005) [(Shrestha and Dunn)].

Furthermore, since plants generally need to have a slightly acidic pH, the pH level should be kept between 5.0 and 6.0. Therefore, in addition to the "recipe" for the solution in the table above, when necessary, dilute sulfuric acid can be added to lower pH while dilute sodium hydroxide (NaOH) solution can be supplied to raise pH.

Reaching and Maintaining Optimum Conditions

According to Monje et al. *Farming in space: Environmental and biophysical concerns*,

Mainly, one of the most energy-intensive systems for agriculture in spacecraft is lighting. For plants that obtain chemical energy using sunlight on Earth, the light spectral composition also regulates the photomorgenic and phototropic aspects of them.

The amount of light received by the plant is also the deciding factor of the crop growth rate and the total plant biomass obtained. Since solar radiation has no cost, even with only 1% of biomass it provides, it has been able to feed humanity for a long time. On the other hand, electricity will be used for artificial lighting, which will be required for agriculture in the spacecraft.

In this case, light emitting diodes (LEDs) can be considered advantageous. Given its long life and low level of thermal radiation, it is a possible option and the positive effects of blue and red LEDs on the growth of plants are also observed.

However, there is an even more effective alternative to LEDs. The sulfur-microwave electrodeless lamps are to be preferred.

In microwave lamps, the bulb is a spherical structure containing sulfur and argon. Argon, which is ionized by microwaves, heats and turns sulfur into gas, and when it reaches lower energy states back, it forms sulfur molecules that reveal an energy continuum.

Additional advantages that make microwave lamps functional include the following:

Unlike LEDs, the microwave lamp produces a broad-spectrum, bright sunlight-like visible light.

Microwave lamps are highly efficient in terms of electrical conversion and produce very little unwanted ultraviolet and infrared radiation. In this context, it is an ideal light source in terms of the development of plants and its efficiency in conversion to electricity.

Building a Continuous Self-Supplied System

According to Heppenheimer, Colonies in space: Chapter 9 – up on the farm - national space society 2017,

As well as the continuity of production, the use of all kinds of materials that can be utilized is significant for the continuity of the settlement. A system in which all available is evaluated and what is produced and wastes are in a continuous cycle will be promising for the settlement.

Inedible parts of harvested plants will be collected in the waste storage. The accumulated waste should be functionalized without creating pollution. Since processes such as incineration cause both the destruction of recyclable materials and pollution, more functional solutions should be applied when evaluating wastes.

Wet oxidation would then be the ideal application. The wastes are cooked for 1.5 hours by heating up to 500°C using oxygen under 100 times the normal atmospheric pressure. The result of the process is high quality sterile water containing ammonia and phosphate ash and a sterile waste gas free of “oxides of nitrogen, sulfur and phosphorus”.

Solids such as ash in the water will be filtered and used as a mineral source for plants, and the recovered water will be used for growing plants while the remaining waste gas will be used to control the level of carbon dioxide necessary for crops to grow. Thus, a continuous system of production and residues supporting each other will be established, and it will be a major step towards building a long-term and promising settlement.

Estimations On Production

According to Heppenheimer *Colonies in space: Chapter 9 – up on the farm - national space society* 2017,

In the hydroponic garden with artificial lighting, controlled temperature and high ventilation; Arizona State University's John R. Meyers achieved a yield of 15,400 pounds per acre per day. In this context, growing 500 pounds of grain per acre is a consistent goal for the settlement that has a population of 5,000 individuals.

Moreover, vegetables, another crucial agricultural product for an earth-like diet, can outperform grains in terms of production. In this context, the yield to be expected from each vegetable per acre based on the highest yield for veggies grown commercially would be:

vegetables	lbs. per acre per day
tomatoes	920
cucumbers	1000
cabbage	530
radishes	560
broccoli	315

Table 2. The expected yield from each vegetable per acre (Heppenheimer)

In addition to grain and vegetable production, it will also be possible to grow fruit trees, both for food production and for creating an earth-like environment. Various trees that are suitable for development in the temperate climate, which will be required to be provided in the settlement, such as apple, orange and peach will add a colorful and lively look to the common areas.

Society

Optimizing the Population

Population and Distribution of Genders

We believe that an equal distribution of genders in the colony is crucial to the sustainability of the colony. Even slight offsets could lead to wasted potential in growth or decrease in emotional levels due to the inability to have a partner; thus, the deviation of the population should be calculated before further calculating the population of the settlement.

Calculating Deviation

To mitigate the aforementioned, we have created a software that can automatically calculate the amount of deviation from the 1:1 ratio of boys and girls in the genders of babies born, assuming there are no other factors in their distribution. As it can be seen in the following table, the maximum and average deviation in 1000 randomly generated colonies.

Number of Newborns	Deviation	Max Deviation
1 Million	0.08%	0.36%
100K	0.25%	1.24%
50K	0.34%	1.55%
20K	0.57%	2.14%
15K	0.65%	2.79%
10K	0.83%	3.72%
5K	1.12%	4.96%
3.5K	1.40%	5.94%
2.5K	1.58%	6.80%
2K	1.72%	7.30%
1K	2.51%	10.20%
100	7.87%	36%

Table 3. Average deviation and maximum deviation (gray) versus population, using 1000 samples from each population category, by Yiğit Kerem Oktay

The calculations show a very significant decrease of deviation of genders' distributions after 100 people and 1000 people. This aligns with the Bell Curve which formulates that deviation will decrease when the sample size increases.

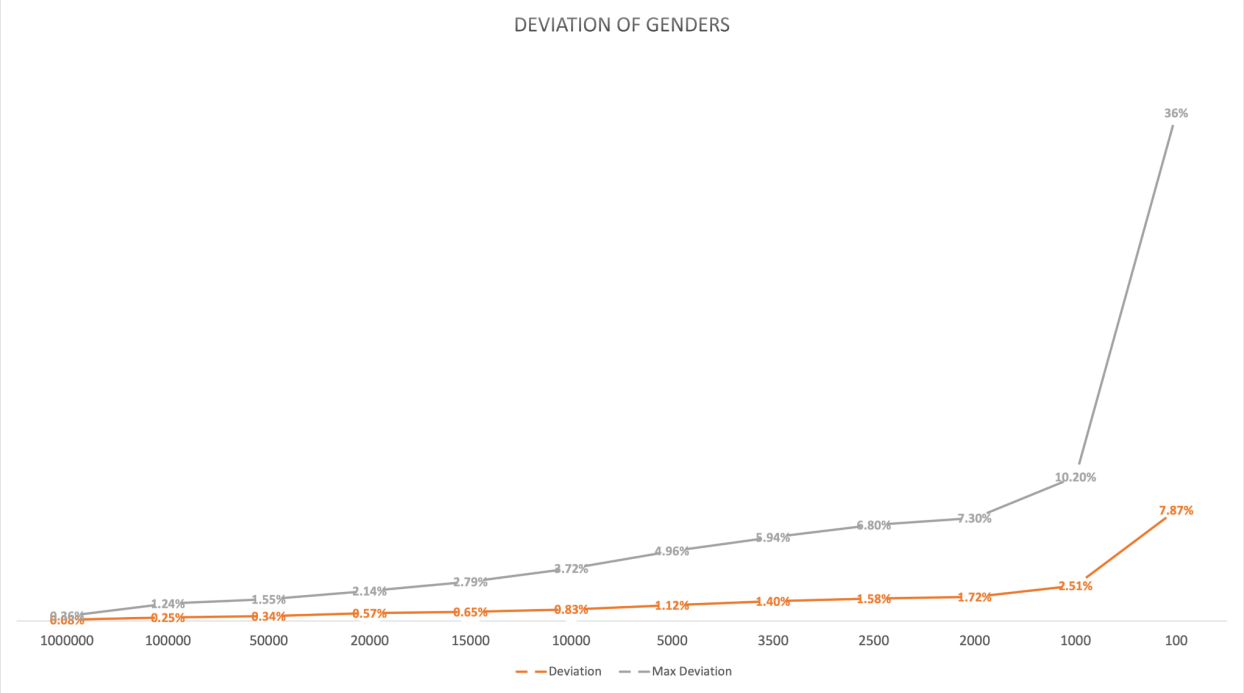


Figure 11. Graph showing average deviation (orange) and maximum deviation (gray) versus population, using 1000 samples from each population category by Yiğit Kerem Oktay.

Choosing a Suitable Starting Point

For the highest possible chance of a successful beginning, the population should be the least possible while still not compromising on productivity and sustainability. Considering the inability to reproduce is one of the biggest threats to sustainability of the colony, we should try to avoid wasting reproductive potential.

Due to this, the high amount of deviation in smaller numbers make it impossible to rely on a small population. It is however impossible to make a judgment solely based on the likelihood of both genders being roughly equal. The time it takes for a baby to reach maturity to healthily reproduce must also be taken into account.

On earth, on average only around 20 people get married out of every 1000. Due to the limited options in space, we will be leading most colonists to getting married to not risk sustainability. Assuming 80% of the population marries, we have decided it is best to have control over the reproductive activities of couples in our colony as well, limiting their maximum children to two whilst suggesting they have at least one. Having this rule noted, we went on to calculate the growth of newborns.

The genders are important for reproduction only as long as the humans are old enough to reproduce. We have considered the appropriate age for marriage 22 as per the average on earth. We expect our couples to produce babies around age 25-26. These numbers will be taken into consideration when we calculate the initial population.

With all of these considerations in mind, it was obvious that we could not have had all the initial colonists at the same age group. We assumed that people become unproductive at age 60 even if they are alive so we wanted to keep the under 60 population constant. This requires the equal distribution of all ages in the colony for maximum success.

We wish to have the least possible population with a sample size big enough to be able to ignore deviation most of the time, thus a starting population of 5000 was selected.

Below is the code that was used to calculate the deviation.

```
import numpy as np

sampleSize = int(input("Enter sample size: "))
cycles = int(input("Enter number of cycles: "))

maxDev = 0
minDev = 100
totalDev = 0

for x in range(cycles):
    random_values = np.random.randint(2, size=sampleSize)
    unique, counts = np.unique(random_values, return_counts=True)
    cts_dict = dict(zip(unique, counts))
    dev = abs(sampleSize/2 - cts_dict[0])/(sampleSize/2)*100
    totalDev = totalDev+dev
    if minDev > dev:
        minDev = dev
    if maxDev < dev:
        maxDev = dev


print("Completed "+str(cycles)+" cycles.")
print("Sample Size: "+str(sampleSize))
print("Average Deviation: "+str(totalDev/cycles)+"%")
print("Minimum Deviation: "+str(minDev)+"%
("+str(int(minDev*sampleSize/100))+" People)")
print("Maximum Deviation: "+str(maxDev)+"%
("+str(int(maxDev*sampleSize/100))+" People)")
```

Politics and Jurisdiction System

Humans are social creatures and always interact with each other. As a result of this, we believe that creating a balanced and cautious social system considering the needs of the habitants inside of the Vena is essential. To achieve that, democracy and justice are two of the most important aspects that must be addressed for more quality of life for the citizens. While doing so, the limitations of population and boundaries of the settlement must be given heed to. In order to do so, a system as in the scheme below will be formed in the settlement:

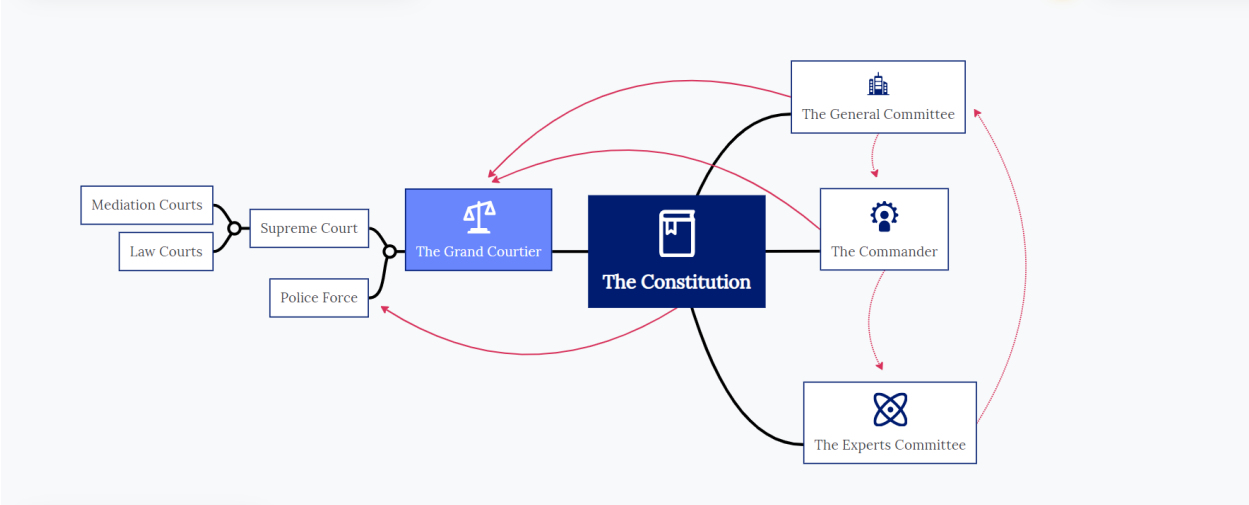


Figure 12. The politic and jurisdictional system of the settlement by Yiğithan Akkuş

The Constitution

The constitution of the Vena is the main cornerstone of all the juridical and democratic activities to be conducted in the settlement. The constitution will be the unfalterable beacon and symbol of justice, democracy, and people of the Vena while acting as the cornerstone of the state. The constitution will primarily mention the basic rights of the citizens, freedom of the people, basic responsibilities of citizens and officials to the state, the separation of the powers inside of the government, the main electional procedures, and the roles of the commander, General Committee, Experts Committee, and The Grand Courtier alongside with their subbranches these include. Although independent, the constitution takes inspiration from some of the other constitutions from Earth

governments, such as the constitutions of the United States of America, Switzerland, Norway, and Finland since these countries are some of the countries that has the highest democracy index and with established constitutions. The first title of the constitution, which mentions the fundamentals of the settlement, will be as the following:

THE CONSTITUTION OF PROJECT VENA

Preamble:

For the people, from the people; with a provision inherited from humankind's earliest days until today. People who have a mind of steel, people who are the hope itself. People who are the builders of the future and the last bastion of hope for the rest. People who always look forward for better, shining like a light. Thence, the manifestation of the will of people is written for the people, by themselves for a glance of future.
Glory to those who look forward; glory to Vena!

Title 1-Provision of the State:

Article 1-The Settlement:

Project Vena is a self-governing settlement with a democratic-technocratic system; the settlement is a republic.

Article 2-The Aims of the Republic:

The aim of the republic is to protect its citizens against any harm while working for their prosperity, equality, and peace.

The republic shall seek no difference amongst its citizens while treating every single one of them as equals.

The republic shall follow scientific and technological advancements in order to further expand the settlement while exploring the universe for the betterment of humankind.

Article 3-The Constitution:

The constitution is the main source to all laws, acts, and amendments that are going to be created.

The citizens of the settlement, the government, and the jurisdiction are obliged to obey the constitution and respect it in every aspect since it is the mutual creation of the upper three mentioned. No person or institution is in any case above the law.

No person or institution may ever use the constitution to oppress, control, and impose a certain belief or ideology on the people of Project Vena.

Article 4-The Separation of Powers:

The republic is divided into two branches: jurisdiction and legislation.

The jurisdiction part will be conducted by The Grand Courtier with the subbranches of police, the Supreme Court, Law Courts, and Mediation Courts. The Grand Courtier has the responsibility to ensure the appliance of the law and this constitution.

The legislation process will be conducted by The Commander, The General Committee, and The Experts Committee. All of these three institutions have the responsibility to balance the powers of each while creating new laws and managing the republic in the requirements of the people, with the authorisation of the people.

Article 5- Protection of Title 1:

Unlike the other titles inside of this constitution, the articles inside of Title 1 including this article cannot be amended or removed in any case. Certain additions can be made with a public referendum via the participation of every citizen of the settlement.

The General Committee

The General Committee will act as the parliament of the government. Initially starting with 17 representatives for reasons that are going to be explained later, The General Committee will be the main branch of government that is going to conduct the legislation process by creating laws, passing acts, maintaining the budget, and passing amendments if required. In order for a law, act, or amendment to pass from the Committee, a threshold of 55% must be passed. This number may be altered in future when the number of seats inevitably increases. The elections for the Committee will be held every four years. Every citizen that is older than the age of 18 will be able to vote in these elections to select the representatives who are going to represent and create laws for four years. The General Committee will have the responsibility to inspect The Commander to ensure the sustainability of the democracy inside the government and allow the separation of powers. The required amount of representatives will be calculated before each election, and the elections will be held according to that. The number of representatives will be found via the cube root formula. The cube root formula states that the number of seats in a parliament must be proportional to the total number of citizens. When applied, the formula below is created:

$S=(P)^{1/3}$ where S is equal to the number of seats and P is the total population(ACE Electoral Knowledge Network). The same rule can be used to calculate the seat number for parties if, in future, a multi-party system is adopted. Although there have been some counterarguments against this rule such as Laakso (355), the rule has been applied in the United States of America, Canada, the United Kingdom, and New Zealand for many years. Consequently, since the settlement will have 5,000 habitants initially, when the cube root rule is applied, 17 representatives will be present in The General Committee.

The Experts Committee

While creating the sociopolitical system of the settlement, the fact that creating the space settlement and preserving the homeostasis is crucial for the lives of the habitants must be taken into consideration. The smallest and simplest of mistakes can cause redundant damage to the structure of the settlement or cause unbearable damage to society. To prevent that, a committee consisting of experts from several topics is going to be formed.

These experts will be selected by The Commander within every selection. The experts will be responsible for preparing reports on crucial topics such as but not limited to the economic situation, agriculture, resource extraction, population control, and energy production. The Experts Committee will be given the right to recommend the creation of laws to The General Committee while having the right to overrule any decision made by The General Committee within a strictly scientific ground if the decision is detrimental to the settlement. Thanks to that, any decision that may damage the settlement will be prevented.

The Commander

The Commander is an honourable person, selected by the people themselves with elections every 5 years. The Commander can be considered to be the presidents in the Earth's governments. The Commander is responsible for approving and applying the decisions passed by The General Committee, appointing the experts to the Experts Committee, addressing and representing the citizens, and suggesting laws or bills to the General Committee if required. The president has the right to veto a decision made by the General Committee if he/she deems it to be against the Constitution or democracy itself. In that case, the General Committee and The Commander work together to amend the bill in order to find a middle ground. Overall, The Commander will represent the citizens of the settlement democratically and contribute to the execution process of the execution process.

The Grand Courtier

The Grand Courtier is the head of all jurisdictional processes. Courtier has the responsibility of ensuring equal representation, preventing injustice, and ensuring the security of the citizens. Courtier is responsible for controlling the police forces and the Supreme Court. To ensure justice and prevent corruption, the Courtier cannot have a political background but rather specialised in law and jurisdiction. The Courtier will be appointed by the Commander and the General Committee with a mutual decision. The Courtier will be bound to the constitution and the Experts Committee will have the right to

discharge the Courtier if the Courtier violated the constitution or abused its power. Overall, The Grand Courtier will be the head of jurisdiction and security to protect the rights and security of the citizens.

Police Force

Police force will be the primary component of internal security inside of the settlement. Commanded by the Grand Courtier, the police is obliged to obey and implement The Constitution and will act within the range of the directives of The Grand Courtier. Police will act equally to every citizen inside the settlement, protect them, prevent crime and any violence.

Supreme Court

The Supreme Court is the highest level of court system. The Supreme Court has the responsibility of ensuring the appliance of the constitution while interpreting the parts of it causing conflict or indecision. The Supreme Court will only overlook the cases that has no precedent or the previous cases from Law Courts if there is a false judgement making according to the Constitution. The Court will be the main enforcer of the Constitution. All the Law and Mediation Courts will be responsible with obeying and respecting the Supreme Court's decisions and apply them.

Mediation Courts

Mediation Courts will be the lowest level of the jurisdictional system. Mediation Courts will overlook after the disagreements between the citizens before they turn into cases and allowing mediation to find a mutual solution to their problem. The mediators will be people that has mastered in law with the persuasion abilities to encourage both parties to find a suitable solution. Thanks to mediation courts, many problems will be solved before they turn into cases and the juridical system work without overload. Law Courts will have the right to suggest plantaiff and sued to transfer the case to Mediation Courts if the case is a case that can be solved with cooperation.

Law Courts

Law Courts will be the primary institution for the jurisdictional process in the settlement. Law Courts is tasked with finding a solution to a case in accordance with the constitution. Law Courts will work in accordance with Mediation Courts and Supreme Court. If required, courts can give punishments to the citizens including detainment or fine depending on their crimes. The specification of these will be stated on the constitution.

Concluding Remarks

Project Vena is the artery vein of humanity: a renewed hopeand a reflection of benign human nature. It is the embodiment of hope, innovation, and belief but also a stance against greed. For future generations, a hopeful future in the orbit of the Earth's twin, Venus is awaiting where they would live for many generations to come in peace, prosperity, and serenity. Project Vena is the light in the darkness.

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Epilogue

Project Vena

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In order to submit to:

NSS Gerard K. O'Neill Space Settlement Contest

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