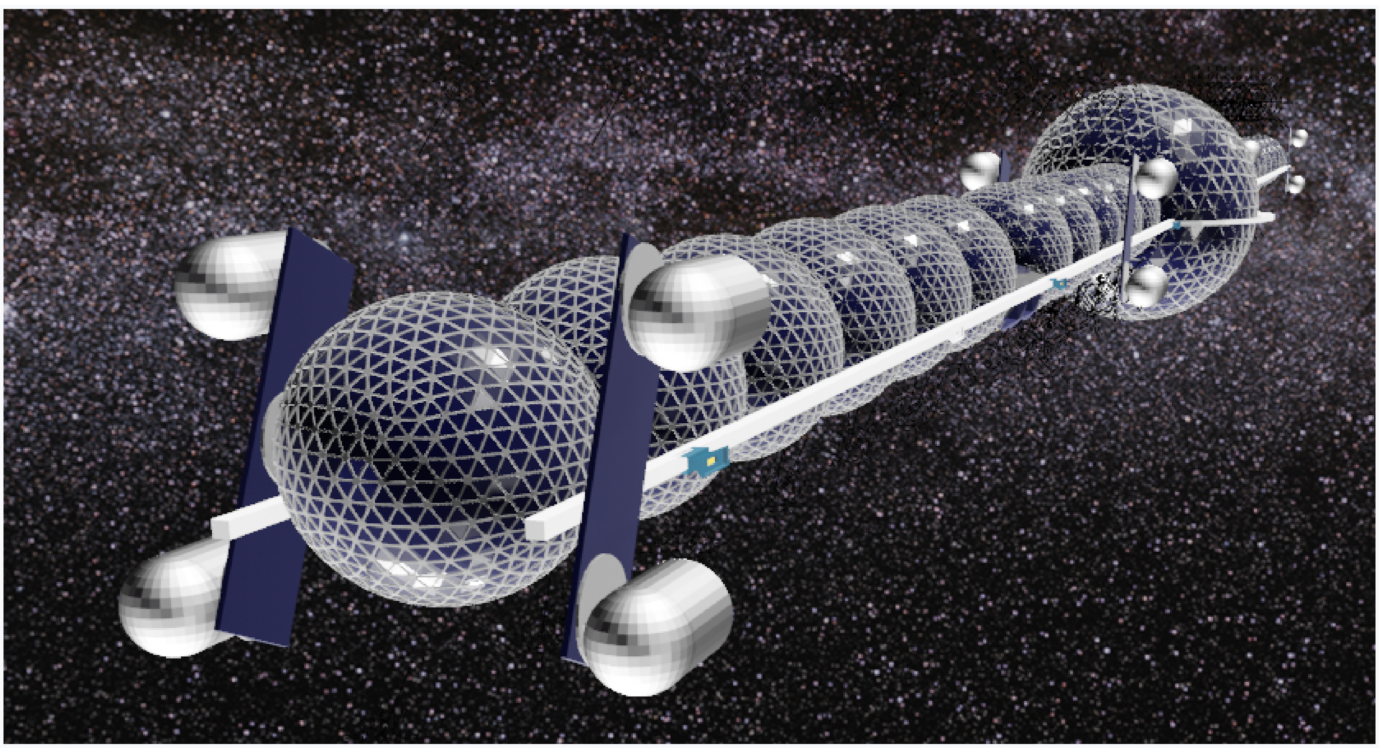
PROJECT 'CARAVAN'

Author: Oybek Gulyamov



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"...Rise of the Dark Ages. During this period, the first conquerors of the solar system take timid steps to colonize near space. People have already settled on two planets: the Moon and Mars, but this is only the beginning. Courageous dreamers risk their lives to finally get out of the shackles of the animal past and rush to the interstellar future. At this time, the first solar federation of its kind is being created. Her duties include the control of the peace and prosperity of humankind in space and on the planets. Only 100 years remain before the first flight to the nearest star...."

(C) School course on the history of space exploration. Three hundred twelve years after the collapse.

Authors: G. V. Anderson

D. E. Gallier

INTRODUCTION

'Caravan' - a type of interplanetary station from the time of the solar system's development. The NASA agency developed the project from the early 2090s to the mid-2110s to continue the Sphere-type stations, which were intended to study the extended stay of a person outside the Earth's magnetic belts and develop some life support technologies. The philosophy of the subsequent project was to try to populate the tight space with completely independent stations, test the system for intercepting and destroying asteroids, and study the satellites of the gas giants and their subsequent colonization. The project united 132 countries, more than 170,000 enterprises and companies and became the beginning of a new milestone in the history of humankind.

The data based on which the document below was compiled was found on the planet "Earth," ancestral to humanity, now according to the intergalactic index: HPP-611-EU, under the program for restoring the historical heritage of the dark ages. This report, titled "Project Caravan," consists of three chapters.

Chapter 1: Awakening. It is devoted to the general external and internal arrangement and the selection of materials for the first copy of the station, the manufacture of parts, protective panels, and power sources. Also, at that time, was described the latest technology for assembling a station outside the Earth. This procedure was intended for more excellent opportunities for implementing this type of station in the future. The expression "outside the Earth" meant the surface of other planets and the possibility of building in space.

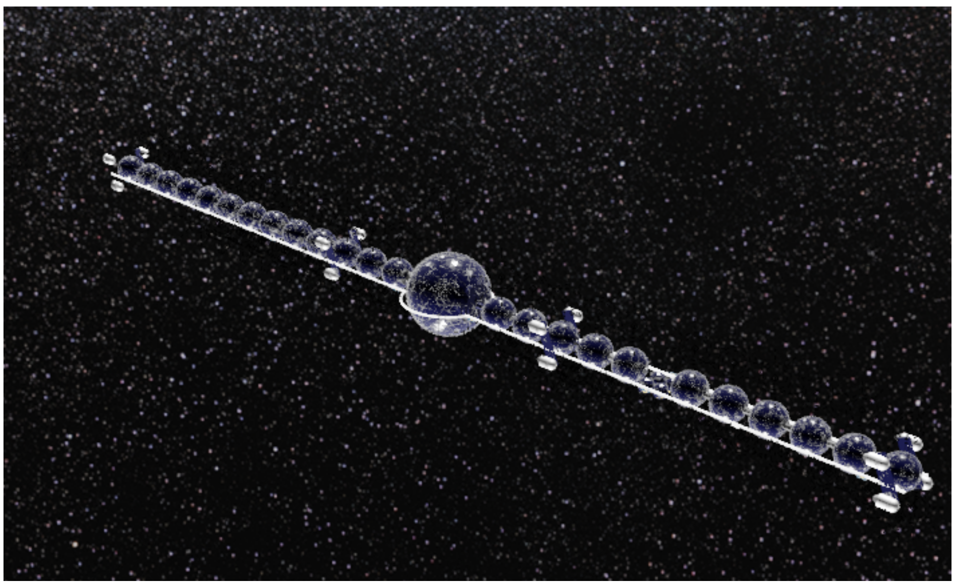
Chapter 2: The Uprise. This part is devoted to life at the station and the emotional aspect of being in space. It discusses the issues of orbital mechanics, the extraction of the necessary resources using chemical reactions, the solar wind, the devastation of asteroids to support the crew's life, and the restoration of fuel levels. The issue of minimizing crew stress using various techniques was discussed.

Chapter 3: The Expansion. The last part of the document took up the colonization and arrangement of new exo-planetary enterprises for rehearsals to construct similar stations outside the solar system. It mentions the landing spheres, their construction, performance, and operation. These spheres were intended as the founders of a new station assembly workshop or a research center. They included the necessary range of instruments in determining the suitability for production and, in addition, could become a full-fledged laboratory.

CHARTER I:

AWAKENING

An ordinary station of the "Caravan" type represented a chain of geodesic spheres and different functionalities. The capabilities of these stations were fantastic. They could fly to any, even the most distant, point of the solar system, colonize and study it. Also, a distinctive ability was autonomy. The record flight lasted 53 years, seven months, and eight days without outside support. This project has become a logical continuation of the previous project, "Sphere."



Each chain unit is called a "Super Sphere" and has its number and letter. For example, "Super Sphere" 10C comes tenth from the beginning and is a cargo sphere (C for cargo). Each "Super Sphere" (starting now referred to as SS) is two-layer, outwardly of the same type, has a diameter of 120 meters, a lock passage in front, and a receiving hole in the back. To increase the chain's strength, used two supports in the form of fastened titanium pipes, stretched by two beams through the entire length of the station from both sides.

THE SHIELD PANELS

The shape of the geodesic sphere was chosen for the following reasons:

-Protection from hazardous radiation.

Radiation will be a significant risk factor when traveling to other celestial bodies. Outer space beyond the Earth's orbit is dangerous to human health. The primary sources are the solar wind and especially rays of non-solar origin, coming from the side of the galaxy, from which the Earth's atmosphere and magnetosphere protect us. There are three types of rays: Alpha, Beta, and Gamma rays. Their penetrating power varies greatly. That is, if we can protect ourselves from Alpha rays with a thin layer of gas, then a sheet of paper can save us from Beta rays. However, Gamma rays can be protected only by a thick layer of metal or concrete.

The crew could use liquids such as fuel, drinking water or, waste to stop them. Some celestial bodies, such as Titan, would expose astronauts to lethal radiation levels during the day at >5000 mSv, while other planets would expose astronauts to less radiation (e.g., Venus). When viewed in the context of an astronaut, one 30-month round-trip to Mars (~6-month one-way flight with 18 months of work and living on the surface) would put a 25-year-old woman at the limit of her career, while the same person could be on the Moon (which has about the same annual radiation as Mars) for about four years. Simply put, the flight time, and therefore the duration of the radiation determines the risk and consequences.

For the sake of complete protection of the crew from doses of radiation, was developed the Shield Panel technology. When constructing a geodesic sphere, it forms voids between the structural elements. In these spaces, with the help of composite ties, Shield Panels modules were placed. These modules were responsible for protection against temperature extremes, cosmic radiation, and micro-asteroids.

The outer layer provided the dissipation of heat that came with sunlight. For this purpose, ultra-high temperature ceramics (UHTC) were chosen, particularly hafnium carbide. At the time of the development of the stations, this material had the highest heat resistance. It was applied to the steel plate and the surrounding surface, 0.5 cm thick, in a double layer, except for the last SS, which accounted for the main onslaught. An additional three coats were sprayed there, which avoided overheating in the long run. The plate supported some tools or other structural elements since the heat-insulating material did not have the proper strength properties.

However, in addition to excessive heat, another danger lurks in space in the form of micro asteroids. Micro-asteroids are solid particles that exist between planets. Their size ranges from clusters of a few molecules to grains a few tenths of a millimeter in size. At first glance, it is safe to encounter them, but typical collision velocities are 7.9 km/s for space debris in Earth orbit and 10-25 km/s for meteoroids at various stages of flight. Larger particles can penetrate the outer protection of the spacecraft and damage its internal equipment. The kinetic energy is so tremendous that a relatively small particle the size of a matchbox can destroy the integrity of an unprotected module. Given the enormous power of micro asteroids and other space debris, it is easier to dissipate the energy than counteract it with a thick metal plate.

Therefore, to protect stations of the "Caravan" type, Kevlar plates were used. Kevlar KM2 has very high strength qualities and is excellent for shock absorption. Ultimately, engineers developed a three-layer Kevlar plate with 10 cm gaps filled with aerogel. The aerogel served as an auxiliary means of protection. When hit with space debris, it dispersed the impact on the surface area of the entire Kevlar plate, thereby increasing the effectiveness of protection.

Behind him was a fuel tank that held about 11,000 liters of fuel had a side length of 8.5 meters and a thickness of 30 centimeters. To not allocate a separate sphere for fuel and improve radiation protection,

fuel cells were placed in the Shield Panel. Each was connected by a heat pipe to a valve so that the risk of leakage was minimal.
The third layer made up the bulk of the protection from cosmic radiation. To protect against the harmful effects of radiation on the human body, as in the previous 'Sphere' project, developers used compressed waste.
It could be compressed feces in polyethylene, non-recyclable garbage, concentrated urine, or drinking and industrial water. This layer had to contain the radiation alone because sooner or later, the fuel supply in a particular area ran out until replenished stock. Each layer was pierced with tiny metal threads through which electricity was passed to maintain the temperature.
The last layer was a 2 cm thick protective steel cover. The hermetically sealed body could contain the liquid if any layer leaked fuel or waste due to damage until the repair crew arrived. In the case of the inner side of the "minor" sphere, engineers on the board could use this cover as a mounting for bearings and other tools. On the inside, the edges of the modules were in close contact. There were practically no gaps between them, as it was essential to ensure smooth rotation of the residential part.
By the way, Shield panels were effortless to repair. Each layer was secured with removable clips and could be removed from the inside to the outer steel plate. In addition, fuel tanks could be filled with some kind of liquid or liquefied waste to improve radiation protection.

-High strength properties.

The SS unit consisted of two geodesic spheres. The "major" sphere covered the "minor" sphere that was smaller. This arrangement was chosen to improve station safety and offload some systems. Moreover, geodesic spheres are generally one of the most durable structures. This design has a high bearing potential since the entire load is distributed over many structural elements. Thanks to this shape and the scheme of a nesting doll of two spheres, it became possible to install a Shield Panel of any mass simultaneously and build rotating station modules inside. The crew had no reason to worry about sudden bursting spheres due to overloads.
The 'Edem' project should be mentioned here. It was a botanical garden, which consisted of several connected geo-domes. Inside them, all conditions were created to maintain flora and fauna worldwide. It might be cold outside, but it was always tropical weather inside. Gulyamov Oybek, chief engineer and inspirer of the 'Caravan' project, said: "I want people to perceive these domes not just as multifunctional protection, but also as a barrier between a prosperous life and the deadly cold of space. This shield, forged by living creatures from the Earth, must bear the face of courage and eternal search. He must show the whole Universe that humanity is more than one planet…".

-Ease of assembly.

Caravan-type stations are very flexible in terms of construction. They are capable of being assembled in space, on the planet's surface, followed by independent take-offs, which will be discussed later. This possibility became a reality thanks to the exact shape of the geodesic sphere. Two types of structural elements can be distinguished: Adapter and Tube. The materials can be very different, but most use composite materials (carbon fiber) and titanium.
From the moment of discovery until the 'Caravan' project, titanium has been classified as a rare element. However, it should be considered rare because titanium was a new element, relatively recently mastered

by man. According to its prevalence in the Universe and on our planet, titanium cannot be called a rare element. It is found in the spectrum of the atmosphere of stars of various types. Robotic spacecraft recorded the presence of titanium on Mars and Venus in substantial quantities in lunar rocks. On our planet, titanium is found in all types of rocks of the Earth's crust, in the seas and oceans, in the atmosphere, and even in plants and tissues of living organisms. Intense fluctuations in the content of titanium are noted in the meteorite substance of space: with a low average percentage of the number of titanium atoms in meteorites (thousandths and ten-thousandths of a percent), sometimes are found extensive accumulations of titanium dioxide (up to 2-2.5 wt.%). It may suggest intercepting asteroids to extract such a vital metal, which will also be discussed later.

Now consider the prevalence of titanium on the planets of our solar system. On those parts of its surface that were investigated by the Soviet automatic interplanetary stations Venera-13 and Venera-14, the titanium content in the rocks of the planet Venus turned out to be very high. As is known, these two stations reached Venus in March 1982. They landed in two of the most typical geomorphological provinces of the Venusian surface: Venera-13 on a hilly hill, Venera-14 in a low-lying area with a relatively smooth relief. The interpretation of the data obtained showed that the rocks of Venus are close in composition to the alkaline basalts of the planet Earth: at a higher place in the Venera-13 landing area, the rocks are similar to the leucite and alkaline basalts of the trap formation, at a lower, approximately 1000 m, area, where Venera-14 landed, the rocks of the planet correspond to oceanic basalts and tuffs.

	‘Venus-13’	‘Venus-14’		‘Venus-13’	‘Venus-14’
	«Венера-13»	«Венера-14»		«Венера-13»	«Венера-14»
SiO_2	45,1 ± 3,0	48,7 ± 3,6	MgO	11,4 ± 0,2	8,1 ± 3,3
TiO_2	1,59 ± 0,45	1,25 ± 0,41	CaO	7,1 ± 0,96	10,3 ± 1,2
Al_2O_3	15,8 ± 3,0	17,9 ± 2,6	Na_2O	2,0 ± 0,5	2,4 ± 0,4
FeO	9,3 ± 2,2	8,8 ± 1,8	K_2O	4,0 ± 0,63	0,2 ± 0,07
MnO	0,2 ± 0,1	0,16 ± 0,08			

TiO2 in Venusian basaltoids contains 1-2%, higher than its average content in the Earth's crust but somewhat lower than in lunar rocks. Recalculations of the chemical analysis data of Venusian rocks for the normative mineral composition show that they are composed mainly of calcium and potassium feldspars, olivine, and pyroxene. Up to 2-3% contain ilmenite, with which titanium is associated in Venusian rocks. Characteristically, they do not assume, as in the rocks of the Moon and the Earth, the presence of pure titanium oxides (minerals of the rutile type), and all-titanium is associated with iron-titanium oxides. The high titanium content in Venusian rocks is actual proof of the wide distribution of this great metal in our Universe. Titanium also turned out to be a very characteristic element for lunar rocks. Academician A.P. Vinogradov, who led the study of the Moon and planets in the 1960s and 1970s, noted that all lunar rocks are significantly enriched in titanium compared to brittle ones. For example, tholeiite basalts of the Earth, identical in composition, contain only up to 4.5% TiO2, while lunar basalts contain up to 7-12%. Various analyzes of the lunar soil have shown that it contains 5-12% TiO2. According to the American mineralogist J. Frondel, who studied the rocks delivered to Earth by Apollo 11, they contained 20% ilmenite, or about 10% titanium dioxide, that is, practically this spacecraft landed, according to our earthly concepts, in a titanium mine. A.P. Vinogradov found that lunar rocks contain on average about 1% titanium, and the rocks of the Earth's crust - only about 0.45%, that is, titanium on Earth is two times less than on the Moon. These values were obtained from the results of the expeditions of the American Apollo spacecraft. As a rule, the starting material for the production of titanium and its compounds is a titanium dioxide with a relatively small amount of impurities. In particular, these can be the same rutile concentrate obtained during the enrichment of titanium ores or the so-called synthetic rutile or titanium slag obtained during the processing of ilmenite concentrates. To obtain titanium slag was needed to reduce ilmenite concentrate in an electric arc furnace. While the iron is separated into a metal phase (cast iron), unreduced titanium oxides and impurities form a slag phase. Rich slag is processed by the chloride or sulfuric acid method.

THE TITAN

The production of products from titanium and its alloys has several technological features. Due to the high chemical activity of molten titanium, it is melting, casting, and arc welding are carried out in a vacuum or an atmosphere of inert gases.

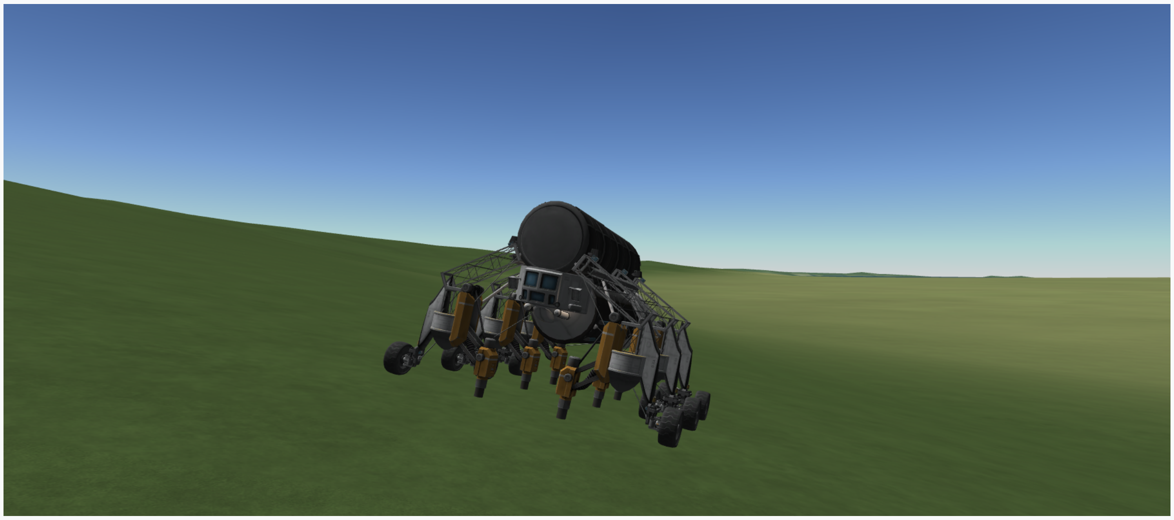
Titanium ore concentrate is sulfuric acid or pyrometallurgical shell. The product of sulfuric acid treatment is titanium dioxide TiO2 powder. The ore is baked with coke and treated with chlorine using the pyrometallurgical method, obtaining a pair of titanium tetrachloride TiCl4:

$$TiCl_4 + 2Mg \quad 2MgCl_2 + Ti$$

TiCl4 vapors formed at 850 °C are reduced with magnesium:

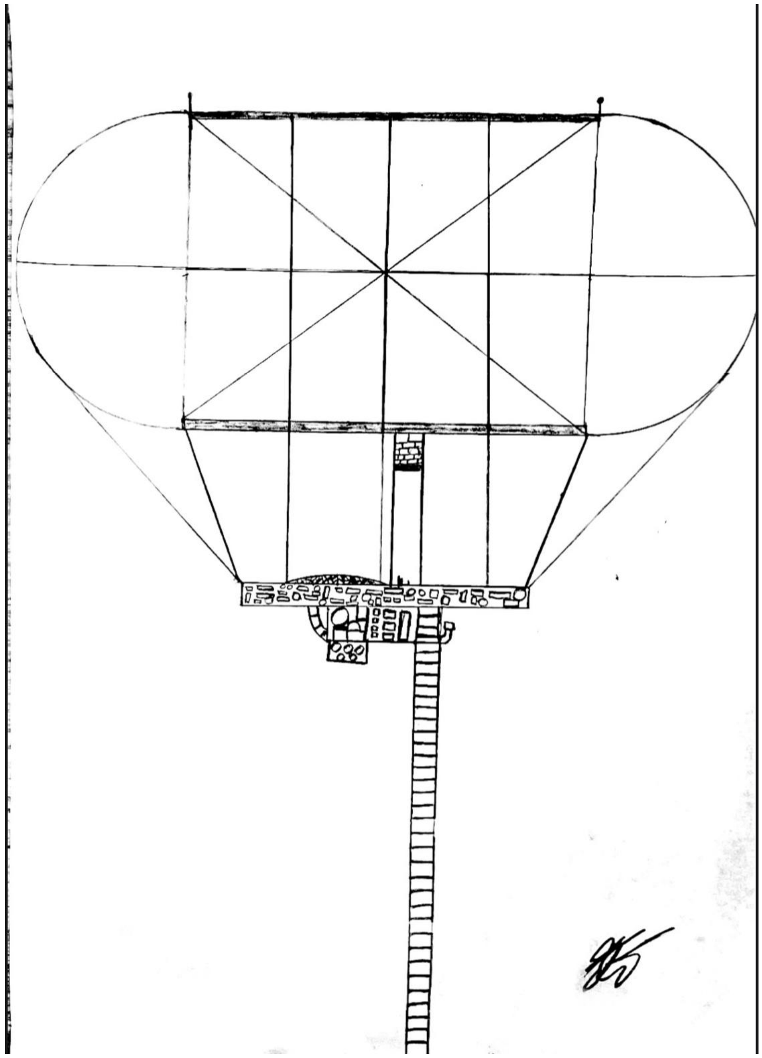
$$TiO_2 + 2C + 2Cl_2 \quad TiCl_4 + 2CO$$

However, for the past humanity, this was the beginning of a new era in metallurgy for the past humanity: exometallurgy. Crawlers have been developed to extract, partially process, and separate pure titanium and other metals to manufacture such alloys as VT3-1, VT6, and VT6S. They were used to manufacture structures for stations of the "Caravan" type.



Crawler "Yukon" on Earth.

If researchers found a quite rich deposit of titanium and other rocks, they founded a plant to produce stations "Caravan" on this place. Nevertheless, usually, crawlers transported them to a collection point on a specific planet. There were from 1 to 8 such points where assemblers produced parts of the stations. The rest of the planets could build launch complexes adjacent to factories and shipyards for assembling stations. However, in terms of Venus, everything was more complicated. As we know before, there is quite a lot of its titanium and other materials for alloys on Venus. Nevertheless, these materials need to be processed, and parts must be made on the surface and put into a reference orbit ready for assembly. For such a large-scale procedure, engineers of the late 21st century developed flying factories of the "Can you believe I exist?" type. These were flat platforms on balloons. It was an integrated plant, a metallurgical enterprise, and a launch complex located on a plate with a diameter of 1.5 km. Since the pressure, temperature, and density of the atmosphere of Venus are very high. It became possible to launch such massive objects on balloons to a height of up to 7 km. Having collected the necessary material, Crawlers took it to the elevator that connected the platform to the surface. All the material went up to the enterprises and shipyards to turn into all the necessary parts on the freight elevator. Further, the carrier rocket, discussed below, was packed into a launch vehicle and launched directly from the platform. Unfortunately, this rocket was not subject to return, so it had construction as simple as possible.



Concept art of Ron Nelson Jr., General Engineer of the Extraterrestrial Mining Department. Varieties of these stations were possible on the surface of all planets in different modifications. The Moon is the lightest celestial body, to which the necessary materials can be delivered or mined there for the construction of this enterprise. However, in the picture above, this enterprise is equipped with a balloon, a freight elevator, a rocket launch site, and correction engines, thanks to which the station does not blow away in strong winds.

In terms of carbon fiber, it is usually obtained by heat treatment of chemical or natural organic fibers, in which mainly carbon atoms remain in the fiber material. This processing consists of several steps. The first step is the oxidation of the original fiber in the air or a special chamber at a temperature of 250 °C for 24 hours. As a result of oxidation, ladder structures are formed. Oxidation is followed by the stage of carbonization - heating the fiber in nitrogen or argon at temperatures from 800 to 1500 °C. Then, graphite-like structures form as a result of carbonization. The heat treatment process ends with graphitization at 1600-3000 °C, taking place in an inert environment. Carbon fiber sheets are glued together with epoxy resin and compressed with a press for pipes or adapters. Next comes the process of cutting the desired shape and polishing. Although such parts had to be strengthened with titanium rods, the final product was lighter. Nevertheless, given the complexity of manufacturing and the need for secondary materials in resin, titanium was generally preferred. However, combinations were also possible in separate SS's made of carbon fiber or titanium.
During the material selection, their properties of compression/expansion with temperature changes should also be considered. Suppose this parameter of materials is practically not considered in ordinary life

because the temperature difference rarely reaches 40 degrees Celsius during different seasons, then in space. In that case, absolute zero is observed on the dark side and tremendous heat on the other. Fortunately, the engineers avoided the overheating problem by coating almost the entire station's surface in contact with the Sun with ultra-high temperature ceramics. Namely, half of the last SS and the middle strip of the geodesic sphere of the rest of the SS. The rest of the surface remained unprotected since the station was turned on one side to the Sun.
Now, let us calculate the approximate compression of the part with a volume of 0.5 cubic meters. According to the formula for volumetric thermal expansion,

$$\beta = \frac{V1 - V2}{V1 \cdot (T2 - T1)}$$

It means that knowing the coefficient of volumetric expansion for the desired brand of titanium/carbon fiber, their initial volume at the initial temperature, we can calculate the final volume. In our case, the temperature increment delta-T is negative, resulting in a loss of internal energy and subsequent compression. Titanium and its alloys are of considerable interest for use at low temperatures. It is confirmed by many studies of the properties of titanium and its alloys. For example, in the handbook on low-temperature properties of materials, the properties of titanium alloys are given according to 40 articles and reports. The high plasticity of titanium compared to other metals having an hcp lattice (Zn, Mg, Cd) is explained by a large number of slip and twinning systems due to the small ratio c/a = 1.587. The high cold resistance of titanium and its alloys is connected with this, which played into our hands. To obtain the desired value, we derive the difference in volumes:

$$V1 - V2 = \beta \cdot (V1 \cdot \Delta T)$$

Volume thermal expansion coefficient of titanium and its alloys β=0.000024. Let us say delta-T is -300 degrees Celsius. Then,

$$V1 - V2 = -0.0036 \text{ cubic meters.}$$

As we can see, the maximum difference is 0.0036 cubic meters. Depending on the alloys or the purity of the final material, the part was made, considering possible compression and further unsuitability for use. This time, all the properties of the materials were carefully checked so that the same incidents would not happen again, as during the repair of the station "Sphere" No. 3 in 2051.

THE ENGINES AND FUEL

From the even chain of the station's silhouette, the station's engines stand out, allowing it to take off from the surface without atmospheric planets and reach the required speeds using the minimum amount of fuel.

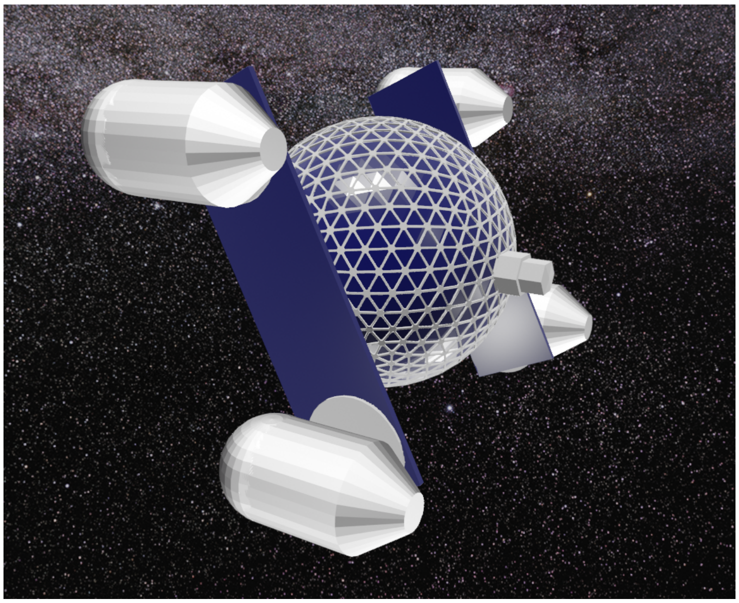
These engine nacelles are giant magnets that accelerate matter with the help of magnetic fields. The so-called reverse funnel scheme. This method was used when using hadron colliders and thermonuclear reactors. When the substance is only injected from the dispenser, with some preliminary velocity, into the accelerator module, it still has too little energy, and it must be accelerated to obtain the necessary momentum for the accelerated movement. It was carried out in a special accelerating section like a klystron or other mass accelerator. The klystron is a bizarrely shaped special chamber that vaguely resembles the empty microwave used in particle accelerators. In this section, a powerful standing electromagnetic wave is excited, the frequency and phase are carefully coordinated with the passing matter: when the next mass of fuel flies into the accelerating section, a forceful electric field pushes it forward. In our case, a modified multicavity klystron is installed in the engine to achieve higher efficiency by reducing the signal power required at the input of the amplifier to control the electronic fuel flow. However, our klystron did not have a collector module. This engine layout made using a small propellant mass to achieve colossal momentum.
According to Newton's third law,

$$P = M \cdot v$$

The equation above means that the momentum increases in proportion to the increase in the mass of the ejected material or its speed. Aircraft designers of the second half of the 20th century faced this conclusion because it was necessary to increase the momentum of turbojet engines to increase their efficiency. They decided to add a second circuit to the engines, a colossal fan that threw an enormous mass of air. It was rotated by burning a small amount of fuel in the combustion chamber of the primary circuit and made it possible to achieve air mass to fuel ratios of 11/1. Thus, engine designers cheated the fuel crisis of the late 20th century by using oil only as a secondary source of momentum.
In our case, instead of increasing the mass of fuel, rocket scientists of the late 21st century decided to increase the speed of the ejected substance. Otherwise, it would be very costly to put hundreds of tons of fuel into orbit would be very costly. It can also be possible to make a correlation with the Gauss gun. The Gauss gun consists of a solenoid. Inside there is a barrel (nozzle). At one end of the nozzle, a ferromagnet dispenser is carried out. When an electric current flows in the solenoid, an electromagnetic field arises, which accelerates the substance, "drawing" it into the solenoid. For the most excellent effect, the current pulse in the solenoid must be short-term and powerful. As a rule, to obtain such a pulse, electrolytic capacitors of large capacity and with a high operating voltage are used. The parameters of the accelerating coils, projectile, and capacitors must be coordinated so that, when the projectile approaches the solenoid, the magnetic field induction in the solenoid is maximum but drops sharply as the projectile approaches. It is worth noting that there are different algorithms for dispersing the mass, in our case, the fuel. Unfortunately, Gauss guns have too low efficiency, leading to an engine based on the klystron. However, in terms of fuel, they are similar. A liquid ferromagnetic substance, the so-called ferrofluid, is required. These are ferromagnetic particles suspended in a solvent like water or organic solvents like alcohol or ether. To ensure the stability of ferromagnetic particles, they are associated with a surface-active substance, which forms a protective shell around the particles and prevents them from

sticking together due to van der Waals or magnetic forces. Citric acid can be used as a surfactant. Despite the name, ferrofluids do not exhibit ferromagnetic properties since they do not retain residual magnetization after the disappearance of an external magnetic field, which is a plus in terms of storage practicality.

Nevertheless, surfactants in the composition of a liquid tend to decompose over time (about several years), and eventually, the particles stick together, stand out from the liquid and cease to influence the reaction of the liquid to a magnetic field. It is easier to take fuel for a shorter period but refuel during the flight or convert some fuel tanks to store citric acid. Also, ferrofluids lose their magnetic properties at their Curie temperature, which depends on the specific material of the ferromagnetic particles, surfactant, and carrier fluid. However, for iron and many other ferrofluids, this temperature exceeds the boiling point of water by hundreds of degrees, and therefore there was no need to worry.



The regular and complete operation of the funnel circuit engine requires conditions such as vacuum, the extremely low temperatures, and a tremendous amount of energy. Suppose the first two problems were not observed since, in outer space, the temperature reaches -273 C, and the density of the environment does not exceed one atom per cubic cm. Regarding planets without a relatively dense atmosphere, It was needed to wait until late at night and take off when the minimum temperature is reached. However, the third is not so simple.

THE SOURCE OF ENERGY

Space is full of energy, whether it is the radiation of the Sun or the energy hidden in the rocks of various celestial bodies. Nevertheless, in the case of using a magnetic-accelerating engine, for its operation and stable acceleration of the substance, much energy is needed to operate the klystron resonators. At the end of the 21st century, two suitable types of energy generation were known to humankind: nuclear and thermonuclear energy, respectively. The first one fell off. The nuclear reactions that gave heat faded away with time, unforgivable for an autonomous, independent station. The second option remained, one SS allocated only for the energy source.

Controlled thermonuclear fusion differs from traditional nuclear energy in that the latter uses a decay reaction, during which lighter nuclei are obtained from heavy nuclei, but the reverse process occurs in the former. The fusion reaction is as follows: as a result of thermal motion, two or more relatively light atomic nuclei approach each other so close that the strong short-range interaction that manifests itself at such distances begins to prevail over the Coulomb repulsion forces between equally charged nuclei, resulting in the formation of nuclei of other, heavier elements. The system of nucleons will lose a part of its mass equal to the binding energy, and according to the well-known formula E=mc^2, when a new nucleus is created, significant energy of strong interaction will be released. Atomic nuclei, which have a small electrical charge, are easier to bring to the desired distance, so the heavy hydrogen isotopes deuterium and tritium are the best fuel for a controlled fusion reaction. Other mixtures may be easier to manufacture; their reaction can be better controlled, or more importantly, produce fewer neutrons.

Moreover, since the neutron flux generated by fusion (for example, in the deuterium-tritium reaction) carries away a significant part of the power, the so-called "neutron-free" reactions were of particular interest since the successful industrial use of such fuel meant the absence of long-term radioactive contamination of materials and reactor design. It, in turn, could positively affect the crew's health and the overall cost of operating the reactor, significantly reducing the cost of take-off requirements, decommissioning, and disposal.

$$\mathrm{D} + {}^{3}\mathrm{He} \rightarrow \mathrm{p} + {}^{4}\mathrm{He} + 18{,}353\ \mathrm{MeV}.$$
$$\mathrm{D} + {}^{6}\mathrm{Li} \rightarrow 2\,{}^{4}\mathrm{He} + 22{,}4\ \mathrm{MeV}.$$
$$\mathrm{p} + {}^{6}\mathrm{Li} \rightarrow {}^{4}\mathrm{He} + {}^{3}\mathrm{He} + 4{,}0\ \mathrm{MeV}.$$
$${}^{3}\mathrm{He} + {}^{6}\mathrm{Li} \rightarrow \mathrm{p} + 2\,{}^{4}\mathrm{He} + 16{,}9\ \mathrm{MeV}.$$
$${}^{3}\mathrm{He} + {}^{3}\mathrm{He} \rightarrow 2\,\mathrm{p} + {}^{4}\mathrm{He} + 12{,}86\ \mathrm{MeV}.$$
$$\mathrm{p} + {}^{7}\mathrm{Li} \rightarrow 2\,{}^{4}\mathrm{He} + 17{,}2\ \mathrm{MeV}.$$
$$\mathrm{p} + {}^{11}\mathrm{B} \rightarrow 3\,{}^{4}\mathrm{He} + 8{,}7\ \mathrm{MeV}.$$

During the development process, the problem of producing Helium-3, a stable isotope of helium, arose. Engineers have made many suggestions about the possibility of using helium-3 as a future energy source. Unlike most nuclear fission reactions, the fusion of helium-3 atoms releases large amounts of energy without causing the surrounding material to become radioactive. Since it is scarce on Earth, the bulk of Helium-3 was mined on the Moon and other planets. The abundance of helium-3 on the Moon is more prosperous than on Earth since it was built into the upper layer of regolith by the solar wind over billions of years, although its abundance is still lower than in the solar system's gas giants.

Materials on the Moon's surface contain helium-3 at concentrations of 1.4 to 15 ppb in sunlit areas and can contain up to 50 ppb in permanently shaded areas. Many people, beginning with Gerald Kulczynski in 1986, have proposed scrutinizing the lunar surface, mining lunar regolith, and using helium-3 for fusion. Due to the relatively low concentrations of helium-3, any mining equipment must handle enormous amounts of regolith (more than 150 tons of regolith to produce one gram of helium-3), and some proposals have suggested combining helium-3 mining with giant mining and development. As mentioned above, the lunar rock is rich in titanium oxides, which were also needed to construct the station. Cosmochemist and geochemist Ouyai Ziuan of the Chinese Academy of Sciences, who was in charge of China's 21st Century Lunar Exploration Program, has repeatedly stated that helium-3 mining will be one of the main goals of the program. "Each year, three space shuttle missions could deliver enough fuel for all the people in the world," he said. During a fusion reaction, in which 1 ton of helium-3 reacts with 0.67 tons of deuterium, energy is released, equivalent to burning 15 million tons of oil. Consequently, the population of our planet of the lunar resource of helium-3 (according to the maximum estimates) could be

enough for about five millennia. Given the above data, it will not be difficult for crawlers on the Moon to simultaneously extract a small amount of Helium-3 for the Karavan stations' operation and titanium.
There are two principal schemes for the implementation of controlled thermonuclear fusion:

1. Quasi-stationary systems, in which plasma is heated and confined by a magnetic field at relatively low pressure and high temperature. For this, reactors in the form of tokamaks, stellarators, and mirror traps are used, which differ in the magnetic field configuration. The ITER reactor, which had the configuration of a tokamak, belonged to the quasi-stationary reactors.
2. Impulse systems. In such systems, controlled thermonuclear fusion is carried out by short-term heating of small targets containing deuterium and tritium by super-powerful laser beams or beams of high-energy particles (ions, electrons). Such irradiation causes a sequence of thermonuclear microexplosions.

Of the two options listed above, nuclear physicists chose the first one. At the station's construction, the quasi-stationary system of fusion reactors was studied much better than the pulsed system. In addition, humanity already had experience using such a system on Earth, making it possible to work out all possible points of failure and develop a plan to eliminate problems.
Developers decided to allocate two SSs for the reactor compartment because of limitations in operation caused by the dimensions of the reactor compartment.
A fusion reactor requires many office spaces personnel and support systems to function correctly.
For example, the CODAC control system consists of the following subsystems:

- five independent servers (each with its storage device)
- six independent local networks:
- Terminals
- Controllers
- Sensors

The reactor also includes fuel systems, cooling systems, a vacuum system, a power supply, and waste storage. Most parts of all auxiliary systems were located in the next SS.
ITER was a 60-meter structure with a total weight of 23,000 tons. The diameter of the outer 'major' sphere is 120 meters, but the inner diameter of the 'minor' sphere is about 105 meters. It suggests that, purely theoretically, we could place such a reactor together with auxiliary systems in the Super Sphere. However, it is worth remembering that an uninterruptible power supply is required from the power source in space, where additional repairs may not be possible to carry in the same station. In addition, ITER was a more experimental product and was not supposed to produce enough energy to operate engines, life support systems, and other vital systems. As mentioned, such a reactor weighs more than 20,000 tons. However, each additional ton in space costs a lot of effort and money. In addition, we cannot build infinitely heavy reactors because, like any design, the double geodesic sphere has its load limit. Therefore, when developing the SRISTR (Special Resources-Independent Space Thermonuclear Reactor) reactor, the following restrictions were set:

-TOKAMAK diameter: 80 meters
-Height: 30 meters
-Volume: 987000 m^3
-Weight (including auxiliary systems): 8,000 tons

As we can see, the mass is relatively small for such a colossal reactor and its outbuildings. The rated power was about 3000 megawatts. It was sufficient for operating all station systems, the operation of engines, and the recharging of autonomous modules simultaneously.

The principle of plasma confinement is based on the interaction of charged particles with a magnetic field, namely, on the spiral rotation of charged particles along the magnetic field lines. However, magnetized plasma is very unstable. As a result of collisions, charged particles tend to leave the magnetic field. Therefore, powerful electromagnets are used to create an effective magnetic trap, which consumes a tremendous amount of energy, or superconductors are used. With that said, our reactor would never have started on its own. There is much energy in space, but to absorb, for example, solar energy and convert it into electricity, substantial solar panels would be required. It was required to light a thermonuclear reactor already assembled. In the case of planets without an atmosphere, where the stations could independently take off into the desired orbit and accelerate to the second cosmic speed, they could use huge solar panels, nuclear power plants, or identical thermonuclear reactors to start the reactor.
Rockets were launched into low Earth orbit on planets with an atmosphere, such as Earth, and delivered everything needed. The station was powered by a thermoelectric generator operating on the Seebeck effect before the reactor's launch. Seebeck effect - the phenomenon of the occurrence of EMF at the ends of series-connected dissimilar conductors, the contacts between which are at different temperatures. The Seebeck effect is also sometimes referred to simply as the thermoelectric effect. As already mentioned, the temperature difference between the bright and dark sides is vast in space. It is absolute zero on one side of anybody, but on the side facing the Sun, the temperature can rise to 100 degrees.
The partisans used this method to recharge the batteries of the radios. The Seebeck installation was built into the kettle, with a liquid placed inside and a flame kindled. It turned out conveniently: the soup was cooked, and the batteries were recharged. The unassembled station did not require much electricity, so one generator for one SS unit was enough. However, when it came time to start the reactor, larger units came into play. The station-rector was involved in the work. It was a SS with a diameter of 180 meters, controlled remotely. It looked like a station of the "Sphere" type, but a nuclear reactor occupied the main volume with a capacity of 1200 megawatts. Regularly replaced fuel allowed such a "Sphere" to operate for long. The algorithm of actions was as follows:

1. SS-reactor changes its orbit to meet the Caravan-class station.
2. Rapprochement and connection with a special plug to the gateway transition between the service SS and the TOKAMAK.
3. The process of starting thermonuclear reactions in a TOKAMAK.

4. Transfer of fuel and oxidizer from special tanks to the cigarette lighter station. It was decided to combine the launch and refueling processes to reduce the number of unnecessary steps in the algorithm of actions.
5. Detachment and withdrawal maneuver
6. Acceleration of the SS-reactor to achieve a higher orbit.

It is noteworthy that such stations were not tied to one planet. Cases were known when SS-reactors, with an additional fuel module, could accelerate to the second space velocity and then slow down at the desired planet. The fuel module was reusable and reused if necessary.

THE GLUE

There is no doubt that reliable fastening of parts to each other is the key to the success of any space mission. Different types of fasteners have their advantages. However, it is possible to draw a correlation between the strength of the fastener and its mass. It is not surprising. The more massive the part, the heavier and more reliable it is. However, in space, such an approach is unforgivable. Therefore, it was decided not to fasten pipes, adapters, and other parts with rivets or welding but to glue them. Epoxy resins are suitable for bonding a wide range of materials. These are adhesives in different viscosities, cure rates, metal-filled and non-metal-filled, designed to meet high-performance requirements for various applications in assembly processes. It is resistant to high and low temperatures, water, and chemical agents. Bonding of metal is not inferior in reliability and strength to welding. At the same time, gluing metal to metal is faster, easier, and cheaper than welding. Glued metal structures are resistant to vibration and mechanical stress. Also, glue allows connecting metal and other materials, such as metal and plastic or wood parts. Epoxy glue has a unique property: it can be filled with different materials, such as ceramic or metal shavings. It increases the strength of the joint and gives the adhesive base the qualities needed in a particular situation. However, for it to seize, it needs to be heated. Double-sided adapters were used to fasten parallel tubes. It was done with a cylindrical heating pad, which covered the part's surface into which the tubes were inserted and heated up to 200 degrees. This procedure was carried out before spraying ultra-resistance ceramics.

The station is subjected to heavy loads due to various maneuvers. These can be orbit corrections, acceleration to the desired speed, evasive maneuvers from various large celestial bodies. When considering each SS individually, two lines of support tubes can be seen to maintain structural integrity during maneuvers or other types of loading. These support structures consist of titanium or carbon fiber tubes connected by double-ended adapters for convenience.

THE ROCKET

'Every grandiose space flight starts from the Earth' - so many science fiction writers of the 20th century used to say. Nevertheless, to become a multi-planetary species, humanity needed great opportunities:

flexibility and versatility. The geodesic sphere perfectly suited these requirements. Easy to assemble with maximum volume and minimum surface area. Regardless of where the "Caravan" type station was assembled, the procedure was the same.

Let us consider two cases: an assembly in space and a non-atmospheric planet. In the first case, all the material was mined and reworked into parts on the surface. Next, the launch vehicle delivered the parts into orbit. So that there was no need to launch rockets many times, a carrier was needed that could deliver a large load at a time. Also, there was a need for reliability and partial reusability. For this purpose, the "Sea Dragon" project, curated by Robert Truax in the 1960s, was well suited. Truax's main idea was to create a cheap heavy launcher, now called the "big stupid launcher." The rocket had to independently launch from the ocean or a converted platform suspension with a minimum of support systems to reduce the launch cost. A system of large ballast tanks is attached to the bottom of the first stage engine to keep the rocket upright. In this orientation, the payload on top of the second stage was slightly above the waterline for easy access. To reduce the cost of the rocket itself and at the same time make it possible to build it outside the Earth, Truax planned to build it from cheap materials, in particular, 8 mm steel sheets. The 'Sea Dragon' rockets were built at a shipyard on the seashore and towed to the launch site. In the case of an extraterrestrial assembly, It was hung on cables in a wide launch shaft. The rocket launched up to 550 tons of payload into a low reference orbit.

THE ROTATION

While in space, the human body is exposed to many risks. Spaceflight-induced molecular, cellular, and physiological changes have been shown to induce changes in many modalities of the human body, including the cardiovascular, musculoskeletal, hematological, immunological, ocular, and neurological systems. The Twin Study, a multi-year study of the human response to spaceflight, has provided detailed and comprehensive molecular and cellular maps of the human response to radiation, microgravity, isolation, and stress. These data revealed epigenetic, gene, inflammatory and metabolic responses to spaceflight. Previous studies have demonstrated numerous complications caused by human spaceflights, such as cardiovascular changes, loss of bone and muscle mass, eye dysfunction, risk of malignancies, hematological problems, and behavioral changes.

According to NASA, there are five main hazards of human spaceflight: radiation, gravity, distance (from Earth), hostile enclosed environment, and isolation. It can be challenging to separate these hazards from one another when studying an astronaut's response to space flight, but all hazards must be considered and adequately assessed before each mission. For example, distance from Earth (or a future base) forces astronauts to be more self-sufficient due to increased communication latency and a limited supply of non-renewable goods. Radiation damages DNA, RNA, proteins, and lipids and increases oxidative stress in cells. Although the health effects of acute radiation exposure have been comprehensively studied, much less was known about the effects of chronic exposure on astronauts on long missions outside of Earth orbit when the station was developed. Microgravity shifts fluid toward the head, causing disadaptive changes that stress blood vessels and the heart. In addition, other studies have shown that the resulting increased intracranial pressure can cause papilledema, which can lead to choroidal folds, a condition termed spaceflight-associated neuro ocular syndrome or SANS. Reduced gravity also leads to muscle atrophy and bone loss. Difficulties with prefrontal functions have also been found, including decision making, attention, concentration, and spatial working memory. Problems with mood, depression, anxiety, and irritability have been documented. In general, there is a negative effect on neurocognitive functions.

As we can see, artificial gravity is necessary for autonomous long-range flights. Stations can create artificial gravity in many ways, such as rotating individual modules. The circuit works thanks to centrifugal and centripetal forces that balance each other. Imagine a disk rotating uniformly about a vertical axis with an angular velocity. There is a part on the disc in the radial direction on which a ball and a spring are put on. One end of the spring is connected to the ball, and the other is hooked to the disk axis. Relative to the rotating disk, the ball with the spring is at rest. With uniform disk rotation, tangential forces and acceleration are absent, and the spring tension force acting on the ball in the radial direction is equal to the product of the ball mass and the normal (centripetal) acceleration.

Since the rotating module is stepped, it looks like a children's pyramid. Each part needs its speed. The smooth rotation of the modules is achieved with the help of electric motors that transmit their work through rubber wheels mounted on the inner surface of the "minor" sphere. However, It was not necessary to create gravity equal to Earth's. It is more rational to create an artificial gravity equivalent to the gravity of Mars. It significantly reduced the load, increased the station's life, and at the same time, so far, has saved the crew from ailments caused by microgravity.

$$a = \omega^2 \cdot R$$

Using this formula above, we will calculate the required angular velocity and the number of revolutions for the required artificial gravity.

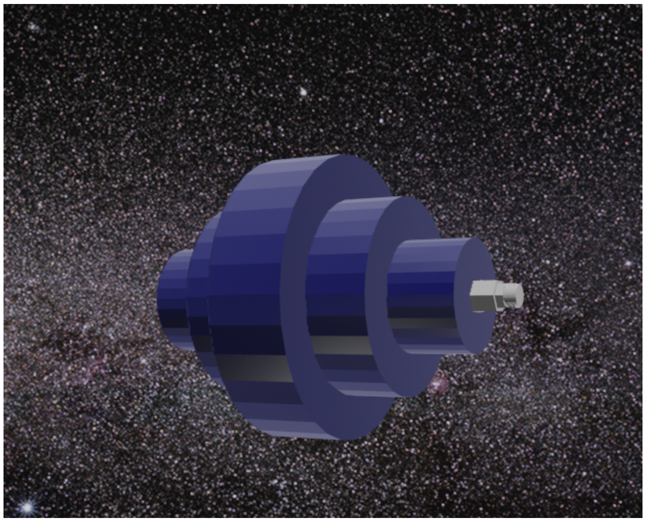
$$\omega = \sqrt{\frac{a}{R}}$$

If the radius of the largest habitation unit is 48 meters and the desired acceleration is 3.72 m/s^2,

$$\omega = \sqrt{\frac{3.72}{48}} = \sqrt{0.0775} = 0.278\, rad/sec$$

It means that to achieve an acceleration of 3.72 m /s^2, the required angular velocity will equal 0.278 rad/sec. So, the frequency of revolutions per minute should equal 2.65 rpm.

However, when an object rotates in zero gravity, a torque is generated, which, without a proper counterweight, will begin to rotate the same axis to which it is attached. It means that we must result in the torque of one module and the other so that the station does not rotate decently. Thus, the living compartments of half of the SS rotated in one direction, the other in the opposite direction, respectively. Thanks to the central axis, this technique has become feasible and practiced.



However, inside each SS, there were four cast-iron flywheels, each weighing 1800 kg. They were added for two reasons: First, in the motors' failure that keeps one of the modules spinning, the flywheels will compensate for the excess torque while being repaired. Secondly, despite the coherence of the mechanisms, there were some precessions. In this case, flywheels were ready to work, which extinguished excess rotation.

The last problem was the Coriolis force. Different human body parts experience different accelerations because they are located at different distances from the center. It turns out that the head will lag behind the whole body. In addition, the legs would tend to the floor more strongly than the head. It would affect the functioning of the cardiovascular system and would be disorienting when moving along the direction of rotation. However, a solution was found. To cope with the lag of the head, it was necessary to somehow compensate for the tilt. For this, shoes with unevenly high heels would be perfect. However, wearing high-heeled shoes increases the risk of ankle injuries because it affects balance: the higher the platform or heel, the higher the risk. However, this was not to be feared. This shoe looked more like an elephant's foot. However, the angle should not be higher than 10 degrees to minimize the load. Such shoes were versatile because it was possible to raise the end of the foot to move in the direction of rotation of the module. Alternatively, increase the walking angle in the living compartment of a smaller radius. The solution to the difference in acceleration in different body parts was even more straightforward: compression stockings. They squeezed most of the legs and did not allow blood to drain into the lower body.

THE REPAIR

There were 15 meters between the 'major' sphere and the 'minor' sphere. It was left to store all the necessary repair units, parts, and tools. Also, it was easy to repair anything in such a large space.

There were also machines for making new protective layers from waste. The process of manufacturing a new layer went like this: feces were taken, and the first pressing apparatus was filled with them. It reduced the thickness of the mass of feces and gave them the shape of a triangle. After 15 minutes, the material was taken out. Before pressing, the thickness was about 60 centimeters; after the press, the thickness decreased to 40 centimeters. Excess liquid was pumped out and processed for human consumption. Already pressed and shaped, it was transferred to the last unit for polyethylene coating. After that, the finished protective layer was inserted into its triangular place and fixed with epoxy glue. It had to be torn off each time to remove the old protective layer.

Five repair teams could work simultaneously with extensive damage to the outer sphere. Spare parts for repairs were stored in small containers epoxy glued to a steel plate. Also, a place was found for additional fastening between the two spheres. These were ordinary beams to increase strength. However, there was not much space between the inner surface of the minor sphere and the habitation modules. Although the distance was also decent: 9 meters, there were also mounts, the central axle, and acceleration electric motors that took up space. However, at the same time, the minor sphere had to be repaired much less frequently.

Nevertheless, only two brigades could repair it simultaneously if the minor sphere was touched. In addition, during the repair, the rotation of the residential modules was stopped, and the crew of this SS was evacuated. To move between the spaces of the Spheres, a gateway on the central axis was used. It could be used to seal any SS or serve as a sealed passage between the spaces of the spheres. The axle itself was cylindrical, but the receiving opening and the airlock itself were hexagonal to replicate the shape of the SS. At its two ends, there were receiving holes for attaching the first 72 fundamental titanium tubes of the major and minor spheres. Adapters were inserted into them, pipes were inserted into them, and it continued till the end.

THE ASSEMBLERS

As mentioned above, assemblers were also displayed when the axes for the future station were displayed. They had four arms to improve mobility and speed up the assembly process. These assembler robots did not possess legs, heads, and a lower body in general. The central processor, hydraulic systems, thrusters, gyroscope, and power source were stored in a separate compartment at the rear. They rarely used engines. Usually, they, like spiders, clung to the structural elements of the station and so moved to the right place.

If the damage was superficial, that is, the heat-resistant layer was knocked down, from 3 to 5 assembler robots came into play, which they usually took with them for damage cases on the scale of entire SSs. EVA was easily accessible through the Landing Sphere Hangar, but the assemblers did most external damage. In their arsenal, they had a welding machine, a supply of steel plates, and a heat-resistant ceramic sprayer. There were also some titanium pipes to restore the supports between chain units.

The issue of providing electricity to these robots was acute. It was possible to provide everyone with a small nuclear reactor, which would provide the required amount of energy for a sufficiently long period. However, the crew would have to take them on board so that they do not leave orbit and pollute a large area with radiation. Moreover, this is a considerable mass in addition and space wasted in vain. Each picker weighed 340 kg and measured 8 meters in length and 2 meters in height with fully extended arms. In total, there were from 40 to 70 of them. They used their reserve fuel to de-orbit and burn up entirely in the atmosphere at the end of their mission. So, there could be no talk of a nuclear reactor. Solar panels? Too bulky and impractical. It is possible to store energy in pre-inflated gas, passing through a turbine. However, this method will not give such excellent efficiency compared to a nuclear reactor. So, only the batteries remain.

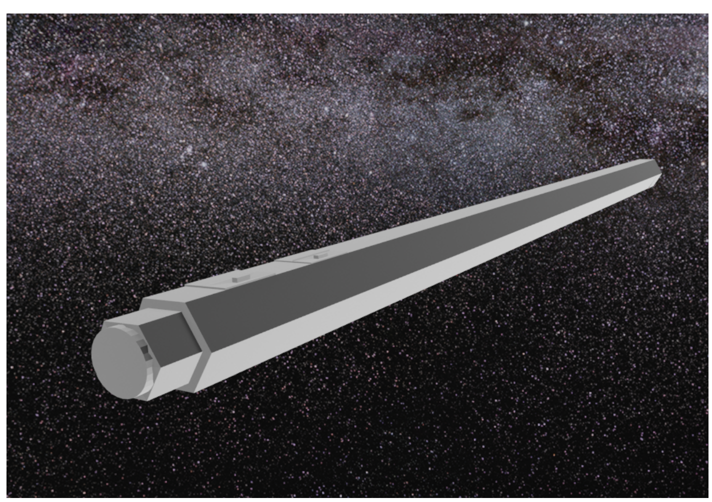
The real problem with the longevity of lithium metal batteries is the gradual growth inside them of so-called dendrites, tiny, rigid tree-like structures. Lithium metal has a very high energy density and can therefore be used to produce ever lighter and more energy-intensive batteries. However, the dendrites overgrow, so the average life of such batteries is short. The solution to this problem was specially developed thermotropic liquid crystal ionic electrolytes, together with additives and a piezoelectric separator that created an electric field, which could stop the growth of dendrites. Also, the European research project SENSE, whose goal was to create a so-called "generation 3b" lithium-ion battery with a composite anode of silicon and graphite and an NMC single-crystal cathode containing nickel compounds manganese, and cobalt, gave its solution. The study aimed to increase the specific energy intensity of the battery, which made it possible to increase the stored charge, improve the technology of fast battery charging and reduce the use of rare metals. Combining the two technologies, engineers of the late 21st century have received huge capacity and durability batteries. On average, these robots were equipped with batteries with a capacity of 910 A / h with a voltage of 36 volts. The battery was housed in a small, pressurized, temperature-maintained compartment for extended life. The assembler moved to one Seebeck installation when the battery was discharged and charged.

THE ASSEMBLAGE

Until the installation of thermal protection, the structure slowly rotated. The principle was the same as during the flights of the Apollo mission. The heat evenly heated all parts of the unfinished station until it reached the dark side, where it cooled down.
The algorithm for assembling the station in orbit was as follows:

1. The axes delivery.

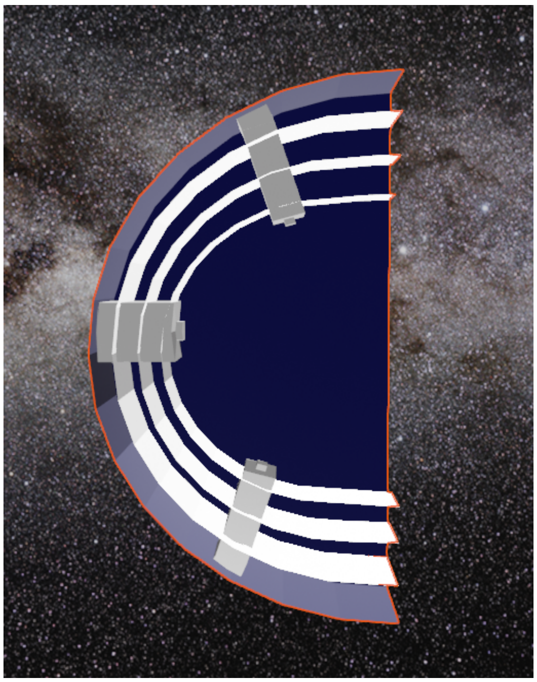
The first structure to be withdrawn was the central axis of the station. Rotating residential modules, geodesic spheres "minor" and "major" were attached around it. In front was a gateway bulging out of the geosphere, with another receiving module for the CC gateway in the back. Also, it served as a kind of corridor between the spheres and could be hermetically sealed by bulkheads in an emergency. The axes of each SS were displayed and fastened into a single chain. The length of each axis was equal to 140 and a width of 15 meters, respectively. The only exceptions were the lead SS, which did not have an airlock in front, and the last sphere, which contained a fusion reactor. It did not have an axis since two minor and major spheres were erected around the rector, who was also delivered in parts. In the case of assembly in orbit, each axis was launched in 3 stages on the Sea



Dragon launch vehicle. Modules of a 15-floor building were divided into four more parts and completed in the cargo compartment. Upon reaching their destination, they were fastened together like train cars with the help of their shunting modules and assembler robots. Thus, all axles were brought out and fastened into a single chain, from 1200 meters to 4.5 kilometers long.

2. Delivery of parts of rotating modules.

The assembly was similar to the construction of panel houses in the USSR and the GDR during the reign of Khrushchev and Brezhnev. Panels measuring eight by 6 meters, repeating the arc in shape, were already delivered with thermal insulation, a layer of sealant, electrification, and some interior decoration. All that was needed was to secure them carefully in the right place. The bearings were first attached to the axis's surface to install the residential module's ceiling. Next, sidewalls were placed, which were fastened to the ceiling with epoxy resin, later bulkheads were placed between the side plates and the compartment's floor. Bulkheads were of horizontal and vertical type. The vertical ones were intended to separate the individual cabins of the crew members and other premises from each other. There were three horizontal bulkheads. Each shared one floor from another. However, only in the largest module were there three floors. There were two in the middle residential module, and in the small one, only one. It was done because of the smaller space and the strengthening of the Coriolis force. The ground floor contained private rooms and public spaces. They were placed on the first floor to minimize the Coriolis mentioned above force because it is in such places that people move hay more often. By the way, it was on the first floors that the treadmill and the visited area of the sphere-reserve were located. The second floor was intended for offices. It was customary to do a warm-up every 50 minutes at work, but otherwise, there was less movement, so the Coriolis force was not so noticeable. The third floor was allocated for office space and warehouses. To reduce wear, reinforcing plates were attached to the outside of the habitation module, which was in contact with the booster wheels. Then they were sealed and were ready for operation.



3. Assembling the Sphere "minor."

The assemblers installed more than 1000 pipes, and adapters fastened the reinforcing beams delivered by the launch vehicle in 2 passes. Beams were also installed to reinforce the connection between the major and minor spheres. Also, all auxiliary systems were installed at this stage, such as communications and equipment of a separate area for life support systems.

4. Delivery and installation of Shield Panel.

After assembling the bare structure in minor, about 400 modules for a smaller sphere were delivered by a rocket in 5 approaches. The assemblers installed them in place and fastened them with plastic ties. Thin plastic ropes were wrapped around the module's attachment point and heated up. They pulled together and firmly attached the Shield Panel to the structural elements. At the same time, other assemblers from the inside fixed motors and wheels on long beams.

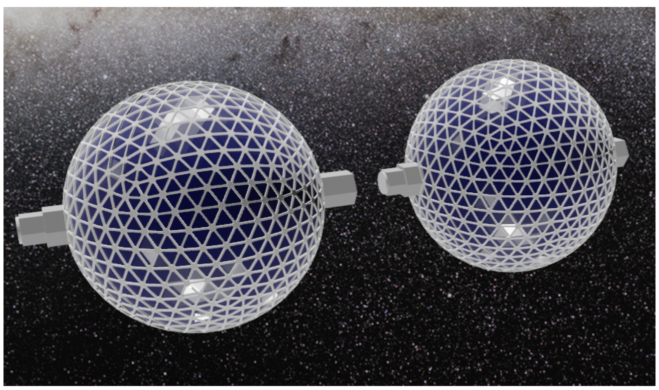
5. Assembling the Sphere "major."

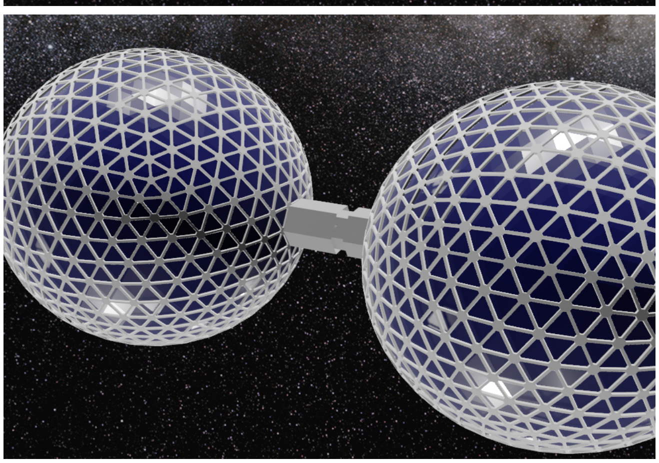
Building a bare structure from titanium pipes and adapters continued but were already on a major scale. The same machines for the manufacture of new layers of protection from waste repair tools were also delivered.

6. Delivery of a new batch of Shield Panel.

This time, more than 500 modules were already delivered in 8 approaches. In general, the modules were located on a platform with a maneuvering system, which made it possible to deliver them to the assembler robots, which installed them in the right place.

7. Installation of engines.





They were mounted on a huge round hinge with a diameter of 15 meters on both sides. It made it possible to change the angle of the main beam at the ends of which motor gondolas were located. It became necessary to make station maneuvers more flexible. However, the motor gondolas at the ends were also hinged so that the jet of the front engines did not touch the structural elements and the engines at the back. The disassembled main hinge was the first to be launched into orbit. It was divided into triangular parts like a pizza, and they, in turn, into three more parts. Thus, the two main hinges were delivered in 4 passes, followed by the assembly by robots. The next step was the removal of the main beams, 150 meters long, also in 10 disassembled approaches. It is worth noting here that in the case of the main hinges and main beams, the maneuvering system of the platform on which the parts were delivered was more involved in the process of installation in its rightful place. The assemblers only fastened the disassembled parts together. The main and auxiliary hinges of the motogandol were set in motion by a system of electric motors. The main engines of the main hinge were attached even before installing the hinge itself. The same is true for auxiliary motors. The electric motors were attached after installing the main beam, then the hinge and motor gondolas.

Additionally, the hinge and the motogondol were pulled together with the same plastic ropes for better fastening. The motor shaft was not directly connected to the motor itself. Power was transmitted through a downshift gearbox with forward and reverse gears. It was located inside the Major Sphere, and the shaft passed through the previously removed 2 Shield Panel modules. It was about 8 meters wide and 3 meters long, respectively. The base of the shaft to which the shaft itself was attached was epoxy reinforced with the adjacent Shield Panel. The rim of the main hinge was fixed and was not connected to the rotating part since additional titanium beams were attached to it.

8. Delivery of landing spheres.

We will come to their structure and mission a little later, but their storage was in the place of the missing sphere. Two main beams and an axle for the crew's passage were carried out, but otherwise, a space of 120 meters was formed. One landing sphere had a diameter of 50 meters, so up to 4 such landing spheres were placed in the hangar.

On this, the assembly of the station ended. The assemblers went out of orbit, and a reactor sphere flew up to the station. After the launch of the fusion reactor, the crew was delivered to the station along with furniture and necessary equipment. Various materials for experiments, food, water, oxygen, and filters, were also delivered to the station. On the dark side, she turned in the right direction with the help of flywheels and began her journey.

CHARTER II:
THE UPRISE

THE TRANSFER

In orbit, things are different. In order to accelerate, the crew must start the brake engines, but to reduce speed, the crew will need to fire the main engines. Orbital mechanics explain this oddity. Without it, humanity would not be able to go beyond the bounds of the globe. There are several definite orbits in space: LEO, heliocentric, geocentric, and Lagrange points. All of them serve as the endpoint for many launched spacecraft. However, in our case, the stations had to arrive on the way constantly. It "stops" near some celestial body for a short period. To get out of the shackles of the Earth and begin the journey, the ship needed speed. Or rather, the so-called escape velocity. The name speaks for itself: this is the minimum value of the speed at which the object can escape from the influence of the gravitational field of the celestial body around which it moved in orbit.

The escape velocity formula is:

$$v \geq \sqrt{\frac{2GM}{r}}$$

For the Earth, it is equal to 11.2 km / s. Of course, it depends on the initial height of the station. Usually, the orbit height during the assembly process did not exceed 260 km. It was necessary to make frequent support impulses not to fall, but this made it possible to deliver more cargo. Transfer orbits are usually elliptical orbits that allow spacecraft to move from one orbit. They usually require an engine burn at the beginning, a burn at the end, and sometimes one or more burns in the middle. There are the following types of transfer orbits:

- Hohmann's transfer orbit.

It is an elliptical orbit to transfer between two circular orbits of different radii around a central body in the same plane. Requires a minimum delta-v.

- The bi-elliptic transition.

It may require less energy than the Hohmann tranfer if the orbit ratio is 11.94 or greater but achieved at the cost of longer travel times than the Hohmann tranfer.

- With low-thrust engines (such as electric propulsion).

If the initial orbit is supersynchronous with the final desired circular orbit, then an optimal transfer orbit is achieved by a continuous thrust in the velocity direction at apogee. However, this method takes much longer due to the low thrust.

All options are good in one way or another. However, the first two are the best. The first option is suitable for flights to nearby planets. These can be missions to Jupiter, Saturn, and their satellites. Hohmann's crossing provides minimal delta-v flow rates.
Nevertheless, a variant of the Bi-elliptical transition was used during long missions to the outer gas giants. It took more time than Hohmann's transfer, but there is never much fuel. Each saved ton makes it possible to continue the flight and expand the boundaries of the Universe even wider.
Let us analyze the case of a flight to Saturn on April 23, 2129:

Each following calculation will be based on the Vis-Viva equation:

$$v = \sqrt{\mu(\frac{2}{r} - \frac{1}{a})}$$

The first step we need to take is to find the speed of the parking orbit. We will make the Sun the central celestial body from which our calculation will be repelled in the following calculations. Therefore, the speed of such an orbit is equal to the speed of the Earth in its orbit around the Sun:

$$v_{\text{park}} = 29,78\ km/sec$$

Next, we must find the orbital parameters of the transfer orbit. First, it is necessary to find the semi-major axis of the transfer orbit. To do this, we can take the average value of the semi-major axes of the target orbit and the parking orbit:

$$a = \frac{(\, target + park\,)}{2} = 751586478\ km$$

Now we can find the velocity at the periapsis of this transfer orbit.

$$v_{\text{trans-P}} = 33,919\ km/sec$$

$$\Delta v_1 = v_{\text{trans-P}} - v_{\text{park}} =$$

$$= \ 33,919\ km/sec - 29,78\ km/sec =$$

$$= \ 4,139\ km/sec$$

This first activation will put our spacecraft into a transfer orbit. Next, we need to calculate the velocity at the apocenter of the transfer orbit:

$$v_{\text{trans-A}} = 4,417\ km/sec$$

Now we have to calculate the speed of the target orbit:

$$v_{\text{target}} = 9,9\ km/sec$$

Now we can calculate the Δv for the insertion burn and the total Δv:

$$\Delta v_2 = \ v_{\text{target}} - \ v_{\text{trans-A}} =$$
$$= 9,9\ km/sec \ - \ 4,417\ km/sec \ == \ 5,483\ km/sec$$

$$\Delta v_{\ total} = \ \Delta v_{\ 1} + \Delta v_2 = \ 9,622\ km/sec$$

However, by the time of the approach, the inclination of the orbit had to be changed to match the inclination of Saturn's orbit. The difference is 2.488 degrees. The orbital velocity at the point of arrival to Saturn will be approximately equal to 9.9 km/sec, so:

$$\Delta v = \ 9.9\ km/sec \ \cdot \ sin(2.488) \ = \ = \ 0.42976\ km/sec$$

Therefore, the total delta-V was about 10 km/sec. The station flew up to the planet after about 5.75 years and found itself in its gravitational field. Further, landings on the moons with the help of landing spheres were possible. At the time of landing by people on the moons of Saturn, the station made turns around.

The rotational speed in the orbit of Saturn at an altitude of 1250000 km, which is 1200000 km above its actual surface, is:

$$v = \sqrt{\frac{GM}{r}} = \ 5.57\ km/sec$$

That is the identical speed of the movement of Titan around the orbit. It was convenient since Titan was the main subject of study and often landed on it.

However, in the case of assembly on the surface, it was necessary to spend fuel on launching into orbit. To do this, the hinges rotated the engines to a vertical position to start the take-off mode. It was distinguished by a change in mass proportion to velocity in the momentum formula. This time, the mass of the ejected matter was given more preference than its speed. It was done so that the fuel jet would not disturb the surface and not damage the station during take-off. The acceleration was minimal because the station was designed to fly in zero gravity, and take-off was huge for all structures. Therefore, the first kilometer of altitude passed with an acceleration of about 1.5 m/s^2. In 37 seconds, it reaches a vertical speed of about 55 m/s. Next, it takes off along a parabolic trajectory to an altitude of 40 to 90 km, depending on the case, and enters a low reference orbit—next, Hohmann's transfer and journey to other planets.

THE ROBBERY

During a long flight to Saturn or other distant celestial bodies, supplies were needed for all this long time. However, it was not possible to take on such a huge amount of supplies that could sufficiently satisfy the appetites of the crew. Therefore, it was necessary to extract resources independently in some cases. Luckily, enough energy was left—for example, mining from asteroids. Asteroids are directly useful in a wide variety of sciences. The least altered asteroids, "carbonaceous" asteroids, carry messages 4.5 billion years old from a period of only a few million years, during which the pre-solar nebula condensed into planets. Asteroid material can tell us about this process and why there are ores in the Earth's crust, given that gold and other heavy metals must have sunk into the core when the Earth was molten.

Furthermore, it could show us whether the water in our oceans was formed from asteroids and comets that collided with the Earth shortly after forming the Earth's crust or whether it could lift the veil of mystery over the question of the origin of life. However, besides the research interest, we were driven to get something useful to extend the flight. In particular, the following main types of asteroids can be observed:

- Class C - carbon, 75% of known asteroids.
- Class S - silicate, 17% of known asteroids.
- Class M - metal.
- Class E - the surface of these asteroids contains a mineral such as an enstatite and may resemble achondrites.
- Class F - generally similar to class B asteroids, but without traces of "water."
- Class V - Asteroids of this class are moderately bright and quite close to the more common S class, which are also mainly composed of stone, silicates, and iron (chondrites) but differ in S by a higher content of pyroxene.

This system relies on color indices, albedo, and characteristics of the spectrum of reflected sunlight. Most of all, asteroids of classes F, S, and V will suit us. However, approaching asteroids is not an obligatory part of the beginning of the flight. In principle, it is easy to load cargo for half of the flight. After flying to the same Saturn and landing some of the landing spheres on the surface of its satellites, the stations usually "turned around" and slowed down until they crossed the asteroid belt. Along the way, they tracked one of the classes of asteroids from afar, using spectrometers and other instruments, made some corrections in orbit, and settled down near the asteroid. After that, one of the converted landing spheres flew up to the surface and took soil samples in different places. After analyzing its composition, the mining sphere began to dig up the soil and collect the necessary material—for example, silicates. After mined, they were processed aboard the same already docked sphere and prepared to return to space. An international team of researchers led by the University of Glasgow, including those from the Curtin Space Science and Technology Center (SSTC), have found that the solar wind, made up of charged particles from the Sun, mostly hydrogen ions, creates water on the surface of dust particles transported to asteroids. The current theory is that water was brought to Earth in the last stages of its formation on C-type asteroids; however, the previous testing of the isotopic fingerprints of these asteroids has shown that they do not, on average, match those found on Earth, and this means that there was at least one other unaccounted source. The study suggested that the solar wind created water on the surface of tiny dust grains, and this isotopically lighter water likely provided the rest of the water on Earth. This new solar wind theory is based on a careful atom-by-atom analysis of tiny fragments of an S-type near-Earth asteroid known as Itokawa, samples collected by Japan's Hayabusa space probe and returned to Earth in 2010. It means that the crew could either mine some of this material that has been solar bombarded with hydrogen atoms or expose their own to the solar wind to get water. By the time of the sunset of the "Caravan" project, stations of a new generation were put into operation. The unfulfilled assumption of Joseph Shklofsky became a reality.

"Our world-class atomic probe tomography system here at Curtin University has allowed us to study in incredible detail the first 50 nanometers of the surface of Itokawa dust grains, which we found to contain enough water that, if increased, would be about 20 liters per every cubic meter of rock," said Professor Bland. Considering the filter's capacity installed at the station, these 20 liters from each cubic meter could circulate in the station's ecosystem for a long time. By the time the launch vehicle launched the first batch of parts, all the Shield Panels had already been prepared. As mentioned above, waste tanks could be filled with many liquids or wastes. In most SS, it was dried feces. However, to allocate a separate SS for the water tank, about 35% of the Shield Panel was filled with drinking water instead of a protective layer. In this case, as mentioned above, the temperature maintenance system was activated permanently. After all, the fuel tanks were often filled, and when freezing, the water expanded. This amount of water was enough for use in cooking, the functioning of the botanical garden, and the daily shower. Of course, the water has been recycled many times. The filtering process looked like this: urine moved through a pipe to a vessel of impressive size, comparable in size to a huge refrigerator. The vacuum pump sucked out excess air from the container and, due to a decrease in pressure, the boiling point of the liquid inside the vessel dropped. The urine began to boil and give off water vapor, later condensed in another vessel for re-distillation. After three boiling cycles, ultraviolet irradiation, and mineralization, the water was completely ready for drinking. However, dirty water after a shower does not undergo the last stage of purification. On the other hand, the concentrate could have been used to protect against radiation or be thrown away.

In the case of recycling water coming from taps or a shower, recycling reached a new level. The fact is that no one took a huge supply of soap, shampoo, shaving gel, and other stuff. The water that washed off all the listed hygiene products boiled away, and soapy water concentrate was extracted from the residue, from which liquid soap was later made, shampoo concentrate, which was processed into a cleansing liquid, and shaving gel, which was reborn into a paste to facilitate the process of hair removal. Of course, such products were lower in

efficiency than their original versions, but they still kept hygiene normal. The process itself was based on the difference in the densities of such media. With the help of a centrifuge, the different components of the used water concentrate were separated more clearly and were pumped out separately using a thin tube.
In addition to water, iron was mined on asteroids to produce ferrofluid as a fuel. Also, inorganic salts were mined for the Common ferrofluid surfactants
for future fuel. In our case, citric acid. It was obtained by fermentation with molds of the genus Aspergillus niger and some carbohydrates extracted from plants.
Below are the most popular routes of "Karavan" stations:

-Earth-Saturn-Asteroid Belt-Jupiter-Mars
-Earth-Mars-Asteroid Belt-Saturn-Jupiter-Earth
-Moon-Asteroid Belt-Saturn-Neptune-Jupiter-Earth
-Earth-Asteroid Belt-Saturn-Neptune-Pluto-Uranus-Saturn-Asteroid Belt-Earth

It should be noted that some visits, such as Mars or Earth, are "tourist" points or points of gravity maneuvers. Also, when flying to the far part of the solar system to Neptune, Uranus, or Pluto, the stations were equipped with additional "Cargo" SS, which were filled with food, some parts for possible repairs, or a place to store the extracted material. The mined material was transported along the highways passing through the locks. There was also the question of children on such a long flight. Should the crew of the Caravan-type stations have been able to have children? No. First, it is dangerous. Some radiation still passed through the shielding, and therefore the embryonic period would be accompanied by developmental problems. Due to the reduced gravity, the child will not have the opportunity to develop fully. Thus, until the start of the next project to create more favorable conditions for childbearing, it was forbidden to have children outside the Earth's magnetic fields.
In order to better imagine the chances of catching an asteroid and starting to extract resources from it, a table will be given showing the number of asteroids N greater than the diameter D:

D	100m	300m	500m	1km	3km	5km
N	25000000	4000000	2000000	750000	200000	90000

As we can see, there are quite a few celestial bodies to be excavated. There are three main groups of distribution of asteroids in the solar system:

1. The asteroid belt, including the large asteroids Ceres and Pallas.
2. Asteroids of Jupiter - "Trojans," "Greeks," and Hilda's group. These asteroids accumulate at Jupiter's Lagrange points L5, L4, and L3.
3. The Kuiper belt.

Although the third option remained unacceptable until 2152, the remaining two were popular with returning stations. For example, on October 4, 2129, Station No. 4, "Enterprise," after completing the expedition to Jupiter, spent five whole months near the asteroid "Marine." During this process, the crew completely cut off communication with the Earth or other communication points in the middle of the solar system and went on an extended vacation. NASA was already preparing a rescue mission because it was not easy to see the station behind the asteroid, so experts were preparing for the worst. However, the crew made sure to find them as hard as possible. This incident was the second space riot in the history of astronautics. After a long wait, the crew got in touch right at the time of their funeral. Surprisingly, they did not even say a word. It was like nothing happened. However, this case did not remain unaccounted for during subsequent missions. During their stay near the asteroid belt, the crew was given six months of vacation. It reduced the likelihood of such incidents.

THE BREATHING

However, water could not be dispensed within space. Oxygen is the second most important resource in space. Nevertheless, there was a way to get it. From 2000 to 2024, the Russian oxygen generation system (OGK) Electron-VM operated at the International Space Station (ISS). SGC received oxygen for crew breathing by electrolysis of water with the circulation of an alkaline electrolyte (KOH solution with a concentration of 25% by mass) through the cathode and anode chambers of the electrolyzer, with further separation of the gas-liquid mixture (GLM) in static separators on porous diaphragms and catalytic purification of oxygen. At a standard cell supply current of 10–64 A, It produced 25–160 l/h of O2 and 50–320 l/h of H2 (here and below, the volumes are given for normal conditions). The SGK was not carried out, except for the inclusion for 5 hours every six months during storage. However, from experience, It must be noticed. It almost did not turn off. In the electrolysis cell, between two nickel sheet current leads, there was a hydrogen chamber with a cathode and an oxygen chamber with an anode, each in the form of a package of three grids. The chambers were separated by a diaphragm of porous asbestos cardboard 0.5 mm thick. In the package on the side of the current lead, a large-mesh mesh formed cavities of the chamber. In the package on the side of the diaphragm, two fine-mesh nickel grids formed an electrode, while on one grid, which adjoined the diaphragm, a layer of nickel was additionally applied by the electrochemical method so that a porous structure was formed on the surface.

Further, a combined catalyst of Pt (87 wt %) and Pd (13 %), which is the same for the cathode and anode, was deposited onto a package of three grids by the electrochemical method (with the preservation of the porous structure). All construction details (grids, current leads, diaphragm) were tightly pressed against each other, without free space between them. Rubber end gaskets ensured the tightness. To supply the electrolyte and remove the GLS, the cells were connected in parallel with collectors, which were located in gaskets and current leads. The flows in the H2 and O2 chambers of the cell were crossed, relative. Similar devices with improved characteristics were installed on the Caravan-type station. It was possible to obtain 400 liters of oxygen per hour. The released hydrogen was burned, the heat was used to heat the station premises, and the resulting water was mineralized and served to the crew as a drink.

However, human life in space must maintain a certain pressure and composition of the surrounding gaseous medium, constantly replenish oxygen, and remove carbon dioxide. However, special filters with mixed matrix membrane technology also served to clean the air from carbon dioxide in addition to trees. The blended membrane is highly selective, and due to the efficient distribution of metal-organic framework (MOF) additives, permeability losses are minimal. The nanosize of MOFs increases their dispersion over the polymer matrix, which negates the formation of micropores around the particles. Moreover, amination - the introduction of the amino group NH2 into the molecules of organic compounds increases their interaction with the polymer matrix, which leads to an increase in the rigidity and selectivity of the entire composite material. Moreover finally, one more task that had to be solved during air conditioning in space was cleaning the air from the smallest dust particles crumbs of debris. This task was already carried out by adsorption or carbon filters, which absorbed all toxic impurities and unpleasant odors.

Humidity is also important. If the air is dry, it will affect the crew's health. Nevertheless, if the system overdoes it with humidity, it can cause the growth of colonies of bacteria and fungi. Therefore, as the best option, which would prevent most respiratory system diseases and not cause additional ones, a value of 45% was chosen as the golden mean. However, the humidity reached 75% in some areas in the forest sphere.

In the American ships Mercury, Gemini, Apollo (except for the Shuttles), a pure oxygen atmosphere with a pressure of 260-280 mm of mercury was used. Such a solution simplifies the tasks of designers since it reduces the requirements for the strength of ship structural elements and makes it possible to reduce its weight. However, the oxygen composition of the "air" forces the astronauts to breathe pure oxygen in the spacecraft for about two hours before the launch and to release the pressure from the cabin when the spacecraft is put into orbit. However, this method is explosive, so it did not suit us. Engineers can create an atmosphere similar to the Earth inside the ship. In terms of comfort, this is the best solution. However, when the spacesuits are pressurized (and this is necessary for the event of a violation of the tightness of the spacecraft and, as a result, a sharp drop in pressure in the cabin), a large pressure drop is created: inside the spacesuit is about 760 mm of mercury, outside - zero. Under these conditions, the astronaut becomes practically immobilized. The solution was to reduce the pressure and switch to pure oxygen breathing, which is technically very difficult. However, this is perhaps the only problem. The second obvious problem - increasing the ship's weight - has a downside, which means a significant plus for the crew because the radiation protection in ships with the Earth's atmosphere is much better due to the increase in the thickness of the ship's shell. On long flights, this was crucial.

During such flights, the stations had to correct the convergence somehow. Of the orientation systems, there were only flywheels. Nevertheless, since the main engines were located on hinges and could also regulate the momentum, they were used as orientation engines.

THE APARTMENT

The crew spent their main time at the workplace and in their cabins throughout the flight. It was essential to choose the correct interior and materials to improve the performance and feel of the squad. The ordinary personal cabin had the following scheme:

It has a total area of 64 sq. meters. The apartment did not differ in any way from an ordinary Earth apartment, as it allowed the crew to cope with stress. Nothing reminded the man that he was in space. Engineers did not want to save on personal space because a cramped room is the cause of negative emotions. The highlight was the bathroom. Each one was individual. It allowed for two showers a day. The first is icy in the morning. The second is hot in the evening. It invigorated in the morning, relaxed in the evening. The water was filtered and poured over the same person the next day. In addition, representatives of almost all religions were present on board, which meant that some, like Muslims, had to take frequent ablutions to read the prayer. With an individual bathroom, the process of washing was more straightforward. Of particular interest was the toilet. A vacuum disposal system was used, like toilets on airplanes. It made it possible not to wastewater and not load the filters. Waste, such as urine, was turned into water, and the concentrate went to the reserve for possible repair of the protective layer of the Shield Panel. Feces also suffered such a fate, but only a part of their volume. The other was either ejected, and a new constellation, "Feces," appeared in the Earth's sky, or experiments were carried out to release biogas and fertilizers. The second option was more welcomed since there were not enough nutrient solutions for the whole flight.

As a rule, everyone could choose the position or color of the furniture, but there were also mandatory parameters. For example, there was an obligatory presence of a corner of nature in each cabin. It was an artificial waterfall with a landscaped area around it. Above it stood bright lamps to provide light. Also, it helped with the fight to absorb carbon dioxide.

THE COMFORT

Researchers and scientists have proven that a person's emotional state affects the perception of color. However, mood can be adjusted with color. Color causes a corresponding reaction of a person, and in a certain way, forms his emotions and, therefore, his mood. Color perception is highly dependent on lighting. So, Japanese scientists have calculated that the streets must be painted in at least 20 colors and shades for a person's everyday life in a city. Every street is like a little rainbow. The Russian scientist and doctor V. M. Bekhterev betrayed particular importance to color as a treatment reserve; he dreamed of building a hospital where color would cure nervous diseases. This color calmed and helped me forget how far away the house was. However, besides blue and its shades, other colors were used. There was also the opportunity to draw drawing on an especially deduced area.

Each color causes subconscious associations. The Swiss psychologist Max Luscher found that a specific color evokes quite certain emotions in a person. For example, yellow-red tones create a feeling of excitement activity. Blue-gray color tones, on the contrary, have a calming effect. Black - depresses, green - soothes, yellow - creates a good mood. The designers have excluded dark colors from the interior based on the rules above. Basically, in private apartments and recreation rooms, colors from the blue and green parts of the spectrum were used. The workspace was yellow, orange, and shades of purple. Food stations used the red parts of the spectrum. In space, as nowhere else, it is necessary to "play" with changing and suggesting the emotional state.

The group situation also acted on the crew. People behave differently in a strange company compared to the company of their close friends. Among the first, it is difficult for a person to express his opinion, as he is afraid of being misunderstood. However, in the case of being in the second group, the possibilities expand much more. Therefore, people were determined in groups of 5 people a year before the start. These groups needed to bond to the point where each of them felt comfortable and safe in their company.

However, there were also exceptions. It is not necessary for an individual to need friends for peace of mind. For example, introverts prefer being alone.

Everyone knows that human life directly depends on temperature, external and internal. For a comfortable existence in everyday life, for example, at work or home, it is crucial to create an optimal regime around yourself. The comfortable air temperature around allows the person not to get hung up on external factors, concentrate on the current activity, relax, rest, sleep, communicate. Indeed, if a crew member constantly experiences discomfort due to high / low air temperature, he will not relax or work normally. In a confined space, the person needs to get rid of all irritating factors not to create even more stress for his body and mind. Room temperature has a huge impact on various aspects of our daily lives. So the temperature from 20 to 25°C is the most favorable for a comfortable human existence. This answer can be obtained from many biologists and doctors.

Moreover, the air temperature indicator applies only to offices or common areas. The temperature in private cabins is 2-3°C colder than the minimum limit mark. However, there was a minimum temperature in the warehouse: 5 °C. It is not harmful to boxes with things and various devices to freeze. To improve sleep and mimic the changing seasons, the temperature varied with the time on Earth. For example, during Winter, the temperature dropped to 14 °C. It was always colder early in the morning or late at night than in the middle of the "day." It also helped psychologically. In addition, it was possible to save on electricity during lower temperatures.

THE FORREST

In addition to a corner of nature, there were other places at the station where one could remember the Earth. The Forest Sphere is a unique station unit. With a diameter of 200 meters, this module was a huge space filled with vines, trees, and small streams. There were bred colonies of ants, worms, hedgehogs, and parrots. Also, vegetables and legumes, such as coffee, were grown. However, the area was relatively small, about 1020 sq. M., thanks to genetic engineering and nutrient solutions, managed to accelerate growth and increase the fertility of plants. It made it possible to provide the crew with the necessary vitamins. However, they received useful substances not only from vegetation. The diet included vitamin pills. Significantly, the emphasis was on the consumption of vitamin D because there were no portholes at the station, and the sun could not get the crew. The climate could be changed relative to a particular zone. As Nguyen Phillips, one of the 'Hurricane' Station №6 crew members, told Mars Daily magazine:

> *"The most blissful feeling is the moment of realizing that after a hard day's work, you can lie on the cold black soil in a forest sphere for an hour. Inhaling the smell of leaves, dew, and wet moss, listening to the birds singing and the crackling of branches, you forget that you are millions of kilometers away from home…."*

Of course, such pleasure costs a lot. Zoologists and other specialists had to be hired to support the reserve. Also, it was necessary to take additional feed and care products. However, this sphere saved 439 people from suicide despite all the victims.

THE COMMUNICATION

People use languages to convey their own emotions, opinions, or ideas. In ancient times, when each nation was independent of each other, languages developed independently, which is why they are so different today. For example, the Eskimo language has more than 50 words that describe snow. However, the peoples of Africa have a maximum of one. Furthermore, therein lies the problem. At the time of the development of the stations, the official language on the territory of any international spacecraft was English. It is not surprising. It is relatively light compared to the more popular Mandarin. However, since almost all the world's peoples were present on board the Caravan stations, English would have become a welcome for many people. Many could not pronounce words correctly and be understood simply because of the peculiarity of their native language. What was needed was a language based on English, but simpler and easier to learn. Moreover, there was one: Esperanto. Created by the Warsaw linguist and ophthalmologist Lazar (Ludwik) Markovich Zamenhof in 1887, it was supposed to be the second language of every person. It was elementary to learn. Easy grammar and lack of exceptions made it accessible to everyone. This language was proposed as a way of communication within the framework of the meetings of the League of Nations, so there was no need to doubt its suitability. Using a neutral (non-ethnic) and easy-to-learn language could bring interlingual contacts to a more understandable level. In addition, Esperanto has great pedagogical value; it greatly facilitates the subsequent study of other languages.

THE FOOD

There are many ways to get nutrients. One of the most popular ways is eating. Usually, people grew vegetables or other vegetation in vast fields, and meat, a source of protein, was obtained by raising animals in spacious pastures. Everything would be fine, but there are no such spaces and resources in space. If the problem of growing and fertility of plants is solved by genetic engineering described above, then not everything is so simple in terms of animals. Of course, scientists could grow meat in test tubes or program the genes so that the animal grows faster and does not require less space. However, would it be ethical? Or, could artificial meat be just as tasty and nutritious?

The answer to these questions will be insects. For example, locusts. There are the following arguments for eating it:

-Locust is rich in protein: in the shell of the locust protein is 13-77% of the dry mass.

-Locust is rich in amino acids such as lysine, tryptophan, threonine (which, by the way, are poor in cereal proteins)

-Contains up to 9% fat by dry weight. It is a small amount, so it is excellent for those who want to "dry" the body, but these are polyunsaturated fatty acids, including essential linolenic and α-linolenic

- Locusts are easy to breed

Locusts are easy to get; there are about a billion individuals in one locust swarm in one locust swarm.

-It is an antioxidant due to the content of melanin and a sorbent due to chitosan and chitin. Bioadditives obtained from these substances can remove metals and radionuclides from the body.

One of the best contenders for being the best locust to eat was the sand locust. It has a gigantic size of 10 cm, can breed in huge colonies of millions of individuals, and has a wide range of taste preferences. Although they require a hot climate, it was pretty feasible due to the microclimate in the breeding chambers. By the way, about breeding chambers. A separate SS was allocated for breeding locusts and other insects for eating. Usually, one rotating module was allocated for one species and its related growth conditions. Termites are also a great example of nutritious insects. More than 40 nations around the world eat them. Winged termites are rich in fats and proteins, and their larvae are also easy to eat. It is possible to make butter from them by boiling them and collecting a little fat from the surface.

The third option was flour worms. The nutritional value of mealworms cannot be overestimated, and in addition, they are rich in copper, sodium, potassium, iron, zinc, and selenium. The Dutch scientist Arnold van Huys, one of the main popularizers of the mealworm diet, even published an entire cookbook with recipes from these insects and the local school of cooks: it contained recipes for rolls and other dishes from larvae. Diversity in space is always good. They were bred in ordinary plastic or metal containers that required good ventilation and low humidity. Bran, oatmeal, dry cereals, cereal residues mixed with or without sawdust were used as food. From above, they could put pieces of cotton fabric folded in several layers, sheets of thick paper or cardboard, egg grates, under which insects accumulated. However, they had to be regularly, if rarely, fed freeze-dried fruits stored from the Earth. It was not necessary to store the main food for the entire flight duration. As stated, the forest sphere provided the crew with vegetation for consumption. However, also, it provided food and insect colonies. Like banana peel mixed with cilantro, their bait was waste, but part of their diet, like oats, was grown in reserve. Also, up to 5 percent of the space was allocated for feeding animals living in the forest area.

Specifically, the reserve concentrated its capacity on potatoes. It is not whimsical, nutritious, and with additives, it can be the main ingredient of all dishes. Many stories have been about people eating nothing but potatoes for a year and staying healthy.

However, not all people eat the same way. For example, vegetarians could not eat mealworms. People who had a gastrointestinal tract disease had to go on a diet and could not eat part of the food. Nevertheless, the food supply systems of the Caravan stations were different depending on the crew. During the settlement of the reserve, the preferences of each member of the composition were taken into account. Their diets, contraindications, and intolerances were taken into account individually.

THE SENSE

We work, solve problems, and come up with ideas so as not to fade away. In space, the emotional decline is one of the worst possible events. In addition to laboratories or a reactor control center, there were branches of many large companies at the station to prevent this.

The range of expertise was varied. There were IT companies, institutes, some engineering companies. Also, there were many writers, science fiction writers, physicists, and mathematicians on board. According to loaded courses, there was an opportunity to improve or change qualifications right on board the station. All this made it possible for people to be engaged in a good deed and not get bored. Every "morning," the crew woke up to do their duty. To help make the impossible a reality. It inspired the crew to live. Therefore, offices or workspaces occupy up to 40 percent of the total area at the station. The remaining 40 percent went to private apartments and shared spaces, the other 20 for research or office space. Of course, anyone had the right to live

according to such a schedule that he would prefer. The main thing is that the principle "Not harm" is respected. It says that a person has the right to do whatever he pleases, as long as his actions do not harm others. In any case, the work schedule was observed,
medical examinations were observed, and briefings were attended at which the agenda, the station's state, and the crew's purpose were discussed.

THE SOULLESS

Medical Examination was handled by AI "Joseph." Analyzing the results of the last workout, the parameters of the smartwatch, and the description of well-being from the person himself, he made conclusions about whether he was healthy or should visit a doctor. The doctor was already a person, or rather a team of doctors in the hospital sphere. In principle, the equipment was enough to remove and treat cancer perform amputations or organ transplants. Naturally, there were no viruses at the station since the crew was quarantined before the flight, and the air at the station was constantly filtered. However, food poisoning has been possible in rare cases. In case of poisoning, a person was prescribed a week's rest and therapy in the medical field. However, in addition to the medical Examination, "Joseph" was constantly checking all systems and correcting them in case of deviations. In addition, "Joseph" was the most rational "member" of the crew, which allowed him to be entrusted with secret security protocols in case of an unforeseen situation. Only one case of its use was recorded on April 1, 2155, at station No. 3, "Miracle," on the way to Jupiter. In the morning, the captain was awakened by a group of people who had broken through the guard at the entrance to the head sphere. They said that there was now too little space on the station for everyday life, and they should retire all the extra ones, namely three-quarters of the crew. They were armed with sharpened drill bits, and metal bottles converted into knives. They had already lost some of their men during the assault on the head sphere, but there were still 23 men in front of the captain. However, they did not know that during their rebellion, "Joseph" realized the danger of the situation, built a maneuver to Earth, and brought all four assembly robots inside the station. After moving to the head sphere, they seized all the rebels and neutralized them for the duration of the entire flight home. As one of the crew members, Kim Seung, recalls:

> *"At that time, I was on watch and controlled the auxiliary processes of the reactor, when suddenly, through the speakers, the voice of "Joseph" announced the command to group the entire staff in the forest sphere. My heart just jumped out of my chest, I was already afraid of a catastrophe in the middle of space, and now the running security protocol only added fuel to the fire. I caught my sweatshirt out of excitement on the gap between the airlock door and the handrail, right in the middle of the transition between the spheres. I frantically began to take off my janitor overalls, but my hands trembled so much that I could not even unbutton my pants button. The situation was heating up, and I could already see the assemblers suddenly appearing, moving from the airlock to the hangar, rapidly advancing. But I had to calm down, I could not allow the robots to be delayed because of me, and I spent more than 1.5 minutes in the most vulnerable part of the station to radiation. Finally, when the pickers were already waiting near me, one of them simply tore my overalls. I felt the horrendous pain of cold metal sitting at absolute zero for months. He dragged me to the meeting place for the rest of the*

crew, where he left me. From that day on, almost all the crews of all stations and I were moved by confidence in the assembly robots. Anyway, he thought of helping me…."

Already after six months of travel, the station landed all the violators, and after replenishing the crew, it again continued to fulfill its mission. In the end, 56 people were injured, 18 of the rebels, and 38 guardsmen. All were saved from moderate and severe injuries at the station, and all were rehabilitated already on Earth. As a result, the project management decided to equip the guardsmen with traumatic pistols and stun guns for a quick defeat. The assemblers were given soft pads on their manipulators so that they do not harm them when they come into contact with people.

THE SOCIAL LIFE

Common spaces like theatres, cinemas, and restaurants were not uncommon in Caravan-class stations. It was possible after a working day to go to the hall with an IMAX projector and a favorite movie in the company of friends. All such activities provided an opportunity to experience the community's life.

However, besides entertainment, there were other activities outside of work. The sphere-gym is where everyone had to spend at least 8 hours a week. For the most part, this procedure was mandatory because of its effectiveness in dealing with stress. Physical activity improves mood and motivation. Also, they help minimize the influence of artificial Martian gravity on a person. More time was spent on the elliptical trainer. The elliptical trainer allows the person to load the muscles and heart during a run but does not stress the joints. Yoga also occupied one of the first places in the list of exercises performed by each crew member. However, the most extensive rotating module was determined for the treadmill. It was an empty residential module on which athletes could run along. Moreover, since it is essential to tilt the body forward in the running, the Coriolis force played into the hands of the athletes.

Hierarchy allows keeping order in society. In a closed space, order and discipline are essential. The lead SS was responsible for controlling maneuvers and the station's essential systems, such as life support systems. The remote control looked up at a miniature model of the station. The launch of a particular engine was carried out by screwing a miniature of a motogondol to a miniature of a hinge. Alternatively, the angle of the central hinge was determined by the angle of rotation of the miniature. The station captain observed the process, and he controlled every action. The station's bridge was more like a secret base because only a few had access to it.

On the other hand, the captain usually practically did not go beyond the head sphere. Only in case of emergency, he leaves the lead SS. However, the already mentioned space guards kept order in the rest of the station. Guardsmen on duty with salt-loaded shotguns, sleep darts, traumatizes, and stun guns could be seen in the corridors or back rooms. Also, they coordinated the crew's actions in the event of an emergency or poor-quality sleep of the latter.

CHARTER III:
THE EXPANSION

People evolutionarily sought to develop new territories, to find out what was hidden under the veil of obscurity. This trait has allowed us to exist for so long and survive in the harshest conditions. In the era of technological development, we could explore the depths of the ocean, dark caves, and spaces outside the Earth. Planets such as the Moon and Mars have been carefully examined and studied. The human foot was already confidently stepping on the surfaces of these planets. However, what is next? Flights outside the solar system were still far away, and flights to the gas giants and their satellites required new technologies. It was for such purposes that the Caravan project was created. Explore the unknown. It was paving the way to the interplanetary future of humankind.

THE PROVIDER

However, the station itself was not designed to land on planets. It served the crew as an aircraft carrier, providing everything they needed for long-term and autonomous survival in space. Therefore, landing spheres were created. These were a kind of small SS designed to transport a person to the planet's surface and back to the station. They were similar in shape but differed radically in structure. Like the Sphere-type stations, the landing spheres were equipped with solar panels on the entire free surface as a power source.

Additionally, six batteries with a capacity of 1020 Ah each were installed. The Landing Sphere was built on the principle of an egg. At first, the interior was built, then titanium tubes and adapters were used to build the construction of the geodesic sphere, and then the Shield Panel modules were installed. They were different from those that stood at the SS units of the station. The most obvious difference was the absence of a protective layer of Kevlar and aerogel.

The thickness limit of 1.3 meters went to radiation protection and fuel in their place. The proportions of the segments to the dimensions of the landing sphere itself have also changed. While hundreds of Shield Panels were used to build large SSs, the Landing Spheres took on average up to 190, making it more angular in shape. The side of the Shield Panel on the landing spheres was 4 meters. One could notice two glass panels in the lower hemisphere instead of the usual Shield Panel. These were one, and a half meter lead glasses to control and correct the landing process. Each glass was intended for one of the pilots. It gave control on both sides. Management was carried out with the help of two groups of engines: marching and indicative. The first group consisted of 12 liquid engines, three per one-quarter hull. The scheme with one main engine on the hinge was discarded for safety reasons and increased the reaction speed in an emergency maneuver. The advantages of this system were proven on August 14, 2146, during the landing of the first lander in the history of humankind on the moon of Jupiter on the surface of Callisto. As first pilot Andrew Bills recalls:

"The first minutes went smoothly. We slowed down enough and were ready to start reducing the vertical speed. However, 4 out of 6 engines from quarters 1 and 2 stopped working before the maneuver. Roger Wilson, my navigator, looked at me with a startled look. In his pupils, I seemed to see death approaching us. Realizing the possible outcome, I shouted 'Not on my shift!' and began to do everything not to die. I lowered the power of the engines from the third and fourth quarters by 40% and put them on the opposite afterburner mode. The marsh engines always had a 25% power reserve, which saved the crew in emergencies, although it completely wore out the engines in one flight. Next, I activated the lagging side's orientation thrusters to stabilize the ship during the acceleration. After an agonizing 30 minutes drive back, we entered the rendezvous line from our station No. 5, 'Soul.' It turned out that the breakaway inner layer of the metal tank got into the fuel mixture due to an unnoticed impact. We ran the fuel from the rest of the landing spheres through filters, and the metallurgical engineers from Earth changed the material of the fuel tanks ... ".

The attitude thrusters were similar to the sky crane of the early 21st century Martian rover landing system. They were also grouped into four sides in paired groups, corresponding to main engines. Fuel for LRT can burn differently in a rocket engine. Combustion of fuel in the chamber of a rocket engine is, first of all, a chemical oxidation reaction with the release of heat. Moreover, the course of chemical reactions significantly depends on what ratio of substances enters into the reaction.
However, in general terms, rocket fuel must meet the following requirements:

1. The highest heat output.
2. Minimal toxicity, stability, and low cost.
3. The most negligible molecular weight of combustion products will give a high specific thrust impulse.
4. Moderate combustion temperature (no more than 4500K); otherwise, everything will burn or burn out.
5. Minimum ignition delay period.

For the marsh engines, the fuel pair chosen was Nitrogen Tetraoxide and Aerozine-50, used during the Apollo missions. Unlike LH2 and LOX, it can be used in deep space conditions. The percentage of fuel from the total mass of entirely ready from the descent of the landing sphere reached 68%. The energy of compressed nitrogen was used as fuel for the orientation engines, and eight 150 kg flywheels were used as gyroscopes.

A boarding ladder was outside at the same level between two glazed cabins. It also took the place of one Shield Panel module and was intended for direct crew access to the planet's surface, removal of parts of future all-terrain vehicles and

rovers, and machine tools if the planet turned out to be
suitable for the development of station production on it.
Inside there was room for 12 crew members. Usually, two pilots, two navigators, 5-6 researchers, and 2-3 mechanical engineers. Navigators were needed to assist pilots in the system's manual control and control part. In general, they significantly unloaded a load of pilots when manual control was necessary. Two rovers and two all-terrain vehicles were stored disassembled in the cargo hold in the center of the landing sphere. So it was easier to take them out because they were located directly opposite the exit. Assembly robots, which were also brought to the planet's surface, also participated in the assembly of rovers and all-terrain vehicles. While rovers and crawlers could operate autonomously, all-terrain vehicles were designed for manual control only. They were needed to study the surface in the nearest area. Food supplies in the form of the same worms and dried vegetation, especially potatoes, were stored for two weeks in the event of a breakdown and a delay in take-off. However, in addition to food, the station had water supplies processed in the same way as at the station, plants, and filters for processing carbon dioxide and an oxygen generation system. Various research tools were distributed throughout the empty volume of the station, as there was no longer enough space in the cargo hold.

THE SURFACE

The cabins had a different shape from the private rooms at the station. They were cylindrical and looked more like pressure chambers. For added security, each cabin is pressurized. According to security protocol, an emergency suit should be in the cabin of each member of the landing mission under the bed. The astronaut put on a spacesuit with a supply of oxygen for 4 hours and left the cabin. If the depressurization was local, i.e., covered a separate section of the station, it was quickly liquidated with epoxy resin by the astronaut on the spot. In addition to the spacesuit under the bed, there was a screen in the cabin for consuming media content or communicating with other crew members on the station. She was right over her head. There could be posters or shelves for storing personal items on the sides, like books. However, more than 10 kg of things per person was not taken since the carrying capacity of the landing sphere was small, and the duration of the landing was counted in days. There were no common gym spaces other than the dining room, where briefings were held, and no private bathrooms.
After researching the planet's composition, finding mines, and installing workbenches, the landing sphere returned. However, Its mission did not end there. After refueling, only pilots and navigators descended back with new cargo. They launched crawlers. Some parts had already been delivered during the first flight, so the colossal crawler was delivered in two passes. Having descended, part of the crew had to help the assemblers unload parts of the crawler and fly away. In some cases, up to 4 crawlers were delivered.
The station was equipped with a subsurface radar to study the tectonic composition of the soil and a spectrometer to study the mineral composition of the surface and prepare the landing site for the landing spheres. A magnetometer for measuring the characteristics of the magnetic field, an analyzer of ions and neutral particles for fixing the solar wind and other indicators, and an analyzer of charged particles stood on the landing spheres. They were needed to determine the degree of danger of being on the surface for a long time.
Nevertheless, the primary mission was to determine the composition of the planet. If deposits of the necessary materials for the construction of stations, such as titanium, were found on it, this place was used to extract and

produce the necessary parts and further transportation to the collection point where the station itself was assembled, or the parts were sent to an assembly shop on another planet.
The spacesuits were the conductor of a person to the planet's surface. Unlike habitation modules, they cannot be covered with a layer of waste to increase protection. However, she was not needed. Radiation sickness manifests itself only with prolonged exposure to radiation. Like the momentum formula, we can increase the time and decrease the radiation, or increase the radiation but decrease the time. Of course, protection in the form of a 10 cm liquid layer was present. It also made it possible to stay up to 40 minutes on the surface of any moon or planet. Also, the difference between the spacesuits of the stations "Karvan" from previous years' models was a helmet. 15 cm lead glass completely covered the head, like a dome, giving a panoramic view. A display with all the necessary data was displayed on the front of its inner surface. Pulse, radiation, pressure, and remaining time until painful death. This information output system was similar to an OLED display: Many lasers with a particular frequency and angle shone in a specific place. Thus, the role of pixels was played by lasers, which reflected on the human eye. The orchestra pit for lasers was located directly under the helmet, at the level of the collarbones. Such a system could also display the desired route by superimposing a picture from lasers on reality.

THE BEGINNING

In general, exoplanetary enterprises for the production of stations "Caravan" for the most part did not build more than two stations for the entire time of work. It was due to the lack of need for many such stations and the complete devastation of deposits and the resource of machine tools. Usually, several crawlers and a dozen assembly robots served as the beginning of each workshop. The planetary version of the assemblers was distinguished by legs and doubled dimensions. Crawlers mined some material and prepared for the production of parts from it. Two machines, brought by the landing spheres in advance, were launched using solar panels, and then the entire production was powered by them. The project engineers joked: "It is easier to deliver everything yourself than to produce it in the middle of nowhere." However, there is some truth in every joke. Indeed, it was easier to bring all the materials from Earth than to find them on another planet. Nevertheless, at the same time, the whole philosophy of the project collapsed. After all, it was necessary to achieve complete autonomy from the Earth, and the construction of a station on another planet was part of this idea.
After starting the machines, the first material was loaded into them. It melted and then, through a hermetic passage, passed to the second one, where titanium tubes and adapters for the first parts of the future station and parts for future stations and assemblers were formed from the molten mass. The crawler was razed to up to 120 km to obtain the necessary material. The process could take up to two Earth years. At the end of this time, all adapters and tubes for the station were ready. Also, all machines and solar panels for them were ready. The production of a platform for constructing a station on it began.
It was a network of cranes that kept the axles suspended. After fastening all the axes into a single chain, the cables reached the maximum strength capabilities, and the chain was already supported by titanium tubes. In the process, some of the support tubes were removed. For example, after constructing a full-fledged head sphere, all the support tubes were removed, and the station in this part rested against the belly of the head sphere. After the construction of all geospheres, the assembly of engines began. They say that the construction of these stations completely devastated the district, with a radius of 60 km. In search of suitable materials, crawlers could donate some of their parts. However, since the surface was carefully examined for suitability

before construction, there were always enough resources for at least one station 1800 meters long. Then, in autopilot mode, she took off to reach the nearest large colony, where she was equipped with the necessary tools and devices, plants and crew. All necessary provisions were taken for the first and last time.
In the future, the station had to extract resources on its own. A new adventure began. No one knew what they would find or lose if they would return alive. Despite all the difficulties, they moved forward to meet the new and the unknown. After completing their mission, the crew retired, and the station accepted a new crew. So, one station could carry generations of astronauts eager to build a new world.

P. S.

"-Tell us why you decided to call this project 'Caravan'?
Like a silk road caravan, the stations will cover great distances, fearlessly overcoming any difficulties. As if personifying majestic camels, a chain of spheres will keep brave people safe, who are alien to human fears and prejudices. They open up new horizons of knowledge in the name of the highest goal of the universal scale. They will overcome any sandstorm, sultry heat, or bloodthirsty vultures together, uniting forces and hopes. Over the years, they will visit many neighborhoods, completely different from each other, talking about different worlds and ideas about the unknown. It is the meaning of 'Caravan'…."

Gulyamov Oybek, the general engineer of the Caravan project, said at the interview on November 27, 2099. Unfortunately, he could not complete the project due to health reasons and left his workplace at 93. Claire Hoffman enlisted for further development. By March 2118, the first Caravan-type station 'Patience' was already built and ready for the first flight towards Mars. In the future, her brave crew will visit such planets as Saturn Jupiter, explore their moons and visit the asteroid belt four times in search of supply for 34 years. A total of 13 stations of this type were built, which repeatedly visited all the planets and dwarf celestial bodies of our solar system. They gave rise to more than 20 large colonies throughout the solar system. Thanks to them, many answers were given to the most burning questions about the solar system's origin and life. The flight to Pluto and its satellite Charon took 23 years in one direction and required cardinal modifications of the station. Thanks to this mission, humanity has gained experience in developing distant frontiers, which made it possible to take the next step in studying the universe and the immediate vicinity of our galaxy.
During the second half of the 21st century, humanity was shaken by a series of crises associated with the complete depletion of oil reserves, environmental pollution, and overpopulation. During difficult times, people realized the harmfulness of past decisions and began to take all actions to stabilize the situation and prevent future shocks. From this moment, the rise of the Dark Ages began. The Dark Ages took a period of human development from 1914 to 2202. They are characterized by a series of wars, tragic or happy events, and discoveries, which showed the essence of what was happening and made it possible to build a road to the future. They ended with developing a new type of station that could provide humankind with an interstellar future. This project has been developed since the middle of the 21st

century and has existed for more than 110 years. They are characterized by a series of wars, tragic or happy events, and discoveries, which showed the essence of what was happening and made it possible to build a road to the future. They ended with developing a new type of station that could provide humankind with an interstellar future. The subsequent project was developed from the shoreline of the 21st century and lasted more than 110 years. He helped to feel the extraterrestrial beauty and deadly horror of the cosmos explore the phenomenon of life and conscious existence. Only thanks to the previous projects "Sphere" and "Caravan."

However, after the Dark Ages, there was a rise. People, or rather, their more perfect descendants, having lost the fetters of the animal past, flew to know the eternal. New mathematics sections were created, the problem of combining quantum effects with the theory of gravity was practically solved, art and creativity were brought to a new level. Society has completely changed its structure, becoming organic, fair, indifferent, and cognizant. Fortunately or unfortunately, this period lasted only 230 years. During this time, humanity has rethought life and science. It settled in the nearest star systems and found unintelligent advanced carbon life.

However, this was not enough. Karandi Gwantanma, a member of the Supreme Council of the Nearest Star Systems (NSS), decided to break away from the bulk of humanity and create his ideology. By colluding, he and his fellows could discreetly prepare a small army to establish their dominance in the 3BG Star System by the new coding. As a result, on March 1, 2434, an assault began on the main building of the Keller Council on the Planet Mert. This day was called The Oblivion, and in the future, on this date, major inspections of the entire council were carried out to prevent such cases. After a successful capture with minimal resistance, many were taken, prisoner. The culture of the peoples living there, scientific progress, and religious heritage were destroyed. They landed on the rest of the planets of this system and appropriated all the colonies. As soon as the NSS found out about this, they immediately organized an army of pacifier droids to neutralize all the rebels safely. There was a hard war of attrition from the Day of The Oblivion to July 7, 2442. Although only three people died in the war due to accidents, both sides spent enormous resources on defense or advancement. On the day of the victory of the NSS, the entire Karandian army was disorganized and disbanded as fugitives.

Many hid under false names and helped restore cultural and technological heritage out of guilt. Ultimately, this period was called the Great Collapse, which stopped the development of humankind for several hundred years. Therefore, programs for the restoration of cultural heritage were organized, of which this report by middle school student Prey Collins is a part. As a project assignment, she sent a reconnaissance station to the abandoned planet Earth, which became uninhabitable after the sabotage of the Karandyan guerrillas, as a result of which a massive amount of waste was released into the atmosphere. Her scout infiltrated the former facility to produce parts of the early experimental stations of the "Caravan" type. Although much of the data was lost, she did her research and, by deductive reasoning, followed the path of developing the station of her general engineers. She did some calculations, explained the details, and found excerpts from interviews with some crew members. For this project, she was awarded the Carl Sagan Prize, which is given for a significant contribution to the restoration of humankind's cultural and technological heritage.

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THANK YOU!

Sehriyo School Technical Department- for providing the necessary conditions for productive work.

Nezametdinov Mirzogayrat- for organization and all technical support.

Afsarov Furkat- for 3-d models and funny sleepless nights at work.

Gulyamov Anvar- for inspiring and motivating me. Without you, this work would not exist!

KSP (Kerbal Space Program), Blender, and Planner 5D were used in this paper as additional visualization tools.