SamrukStation

Team members

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Abstract

SamrukStation is the space settlement in the Earth's Moon polar orbit. Mission of the SamrukStation is an experimental platform of building large fully autonomous orbital settlements, being a transhipment point for spacecrafts that have long-distance missions and being an industrial complex. It will have a population of 120000 people after 80 years of operation, having 25200 people at the start. The settlement can be fully autonomous and doesn't need constant support from the Earth. Living conditions of the settlement are close to the Earth's conditions, having imitation of Earth's gravity, biodiversity and social/cultural life. In our project, we try to maintain balance between realism and innovations.

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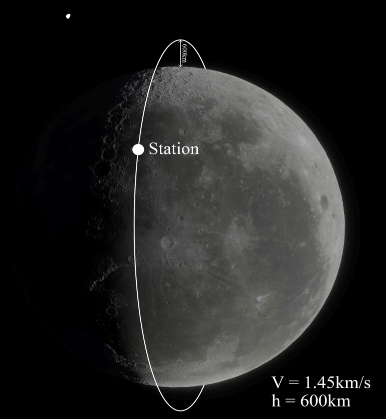
Location and mission

Our team chose the polar orbit of the Moon as the location of our space settlement.

"...But why, some say the moon? Why choose this as our goal?..."

We are not limited in the scale of the project, but we want it to be as realistic and achievable as possible. Moon — is the closest and most thoroughly explored celestial body, but still not settled. In our opinion, we need to overcome this frontier, before we will move beyond. A station in the orbit of the Moon can be a transhipment point or spaceport in long-distance missions, such as missions to Mars, Venus, Mercury and the outer solar system, where spacecraft can refuel and have repair. Thus, settlement in the orbit of the Moon would be a very important step toward the colonizing of the solar system.

Station will be located in circular 600km polar orbit [Picture A]



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- Polar orbit allows near-continuous exposure to sunlight. The moon's axial tilt is only 5.145° [1], which means the poles are constantly illuminated by the Sun.
- Polar orbit and rotation of the moon around its axis allows it to land on any point on the surface.
- 600km altitude is more stable and requires less amount of corrections, but still close enough to the surface.

Space settlement can be fully autonomous.

- The moon surface consists not very much, but enough water [2] to provide for the needs of the biosphere and infrastructure in the settlement.
- The surface of the moon has a lot of Helium-3 [3] — which can cover the fuel and energetics needs of the station.
- Lunar regolith is very similar to the Earth rock by the chemical compound (and consists of silicon, iron, aluminum, calcium etc.) [4] which can be used as building material for the new modules of the station.
- Space near the Moon has dozens of times less radiation than, for example, near gas giants. About 1.37 мSv/day at the Moon's orbit [5].

Structure of the station

The orbital station consists of a central not-rotating cylinder — a central hub, two artificial gravity rings rotating in different directions and engines. The central hub is used for experiments with weightlessness, industry and docking. Living modules rotate by magnetic forces and the whole biosphere lives there. Engines are placed on the end face of the central hub and used for maneuvers and orbital corrections.

Central hub

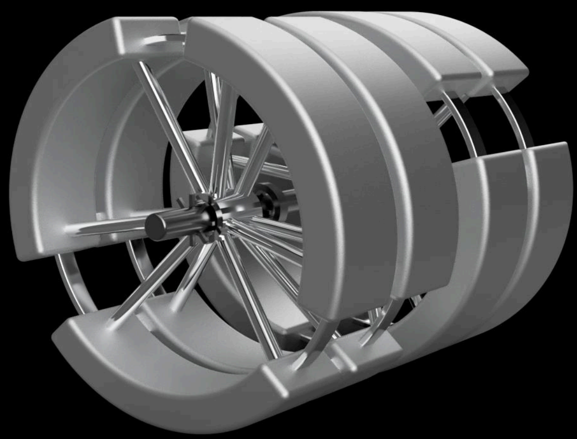
The central hub is a cylinder with 30m diameter that doesn't rotate and has no artificial gravity. It has docking ports, engines, magnetic elements and flywheels. The central hub is used as an adapter between two rings, for docking, for industrial complexes and for experiments with weightlessness. It is connected with living modules (through magnetism, without contact) and gives them a rotation.

Living modules

Each "ring" has 3 pairs of living modules, that is, in total the station has 12 living modules. Living modules are separated to increase safety and fault tolerance (in case of an accident in one or several living modules, the others will be safe), but they are also connected with each other through tunnels with gateways. Each living module is connected with a rotor through two cylinder tunnels.
Each living module is a segment of ring and has a height of 60m and width of 120m. Living modules have an angle of 12° between them.
Therefore,

$$(108:360)\times(2\times3.142)\times120\times(12R-330) = 731700.$$

$$R = 297m, \ r = 237m$$



[Picture B]

2

Artificial gravity

In order for the biosphere to be able to inhabit the station for a long time, it is necessary to recreate conditions on Earth as closely as possible, including imitating the Earth's gravity. Artificial gravity will be made by centrifugal force by rotation of the living modules. Acceleration in living modules will be equal to about 1 Earth's g.

$$a = \omega^2 * R_{av} = g$$

$$\omega = \sqrt{g / Rav}$$

$$\omega = 0.1917 rad/s = 10.96°/s$$

$$T = 360° / 10.96°/s = 32.84s$$

$$RPM = 60s / 34.29s = 1.83 \text{ — rotation frequency to maintain } g$$

Rotation method

The inner rim of the rotor has 64 permanent magnets that alternate poles. The outer rim of the central hub has 64 electromagnets (that create a field when current is passed through them and polarity is dependent on direction of the current). Each electromagnet is turned on at a certain moment, which is controlled by a speed controller (ESC). The ESC receives angular position data from Hall sensors along the rim. By sequentially energizing electromagnets with a phase shift of 120°, continuous rotation of the ring is achieved, similar to a 3-phase BLDC system. Thus, the rotation of the living modules is made by the same construction as rotation in brushless motors.

Torque compensation

To avoid the rotation of the central hub, the torque must be fully compensated, that is, the sum of torque must be equal to zero. To compensate for the most of the torque, two rings with 6 living modules each will rotate in different directions.

$$L = m * r^2 * \omega$$

According to this formula, the torque depends not only on speed of rotation, but on mass too. The mass of each ring can be different, but we can't change the speed of rotation of the rings (to keep centrifugal force) to compensate for the torque. There will be residual uncompensated torque and that's why the central hub will have flywheels. Flywheels will be rotated by motor. Their mass and radius are constant, therefore, it is enough to rotate them with certain speed (which will be calculated by PID or more developed controllers) to compensate for residual torque.

Flywheels' saturation

However, the station will have a lot of microdisturbances: micrometeorites, solar pressure, gravity gradients, orbital corrections, reaction during docking of ships — they all give an extra torque. Thus, overtime, flywheels will accumulate too much, not safe speed — which is called flywheel's saturation. To solve this problem, the station will make desaturation — removal of the torque, when flywheels accumulate too dangerous speed. The station will use RCS to shed excess torque and desaturate flywheels.

Magnetic suspensions

To avoid mechanical contact and increase the service life of the station, the rotor will be stabilized by active magnetic bearing (AMB). Supports with electromagnets will be placed on the central hub. The controller takes data about the location of the ring and applies certain current to the matching electromagnets to stabilize it. In case of failure of AMB, spare mechanical bearing will be used.

Transport system

The central hub doesn't rotate, while living modules and rotor do. That's why the station needs a special system to transfer humans and cargo between them — transport rings.

Transport rings work like an "elevator". Transport rings rotate the same way as the rotors and living modules.

At first, the transport ring synchronizes with rotation of point A.

Then, it docks to point A through a tunnel, humans and cargo move to the ring.

Then, it undocks and changes its rotation speed to synchronize with rotation of point B.

Then, it docks to point B in the same way.

Finally, it undocks and synchronizes with rotation of point A and the process repeats.

Communication and power transmission

The central hub and rotor don't contact, that's why living modules will be powered by inductive wireless transmission, through magnetic coils.

$$\eta = \eta_0 \times (r_0 / r)^3, \text{ where}$$

η — current efficiency, r — current distance, r_0 — minimal distance, η_0 — r_0 efficiency

Efficiency of this power transmission method is approximately proportional to the cube of the distance between coils, which means that efficiency drops sharply with increasing distance.

To increase efficiency of power transmission, resonant inductive transmission and HTS superconductors will be used.

$$\eta = (k^2 \times Q1 \times Q2) / (1 + k^2 \times Q1 \times Q2) \text{ — efficiency with resonant inductive transmission, where}$$

η — efficiency, k — connection coefficient (>0, <1), $Q1$, $Q2$ — quality coefficient of coils.

$$k = (R / r)^3, \text{ where}$$

R — coil radius, r — distance between coils.

if R = 5m, Q1 = Q2 = 10^3 (for HTS superconductors), η = 0.99 (for maximum efficiency)

$$k^2 \times Q1 \times Q2 = 99$$

$$k = \sqrt{(99 / (Q1 \times Q2} = 0.00994$$

$$r = R \times (1/k)^{1/3} = 5m \times (1 / 0.00994)^{1/3} = 20m$$

According to this calculation, the distance between rotor and central hub could be 20m, keeping 99% efficiency. To support the work of HTS superconductors, their temperature must be about 80K. A backup laser-based power transmission system provides emergency power if inductive coupling fails.

Each ring consumes about 200MW of energy, therefore,

$$Ploss = 200MW \times 0.01 = 2MW \text{ — of extra energy.}$$

To transmit data radio communication will be used.

Energy production

To calculate the station's approximate energy consumption, we'll assume 2.5 kW per person[1]. Powering the entire station will require the use of several energy sources.

Solar energy

Since the Moon is close to the Sun, solar energy is suitable for solar panels on the station. Also, since the station is in polar orbit, the time in the shadows is limited, improving efficiency. At lunar orbit, the solar flux is approximately 1360W per square meter. To increase solar cell efficiency, we propose using IMMs, which provide 33% [2] of the total energy. If the station has a total of 120,000 people, then 2.5 kW * 120,000 = 300 MW. +30% for other processes and, as a reserve, let's assign this task to thermonuclear fusion.

$A = P/(E \times \eta \times k)$, where

A — the required panel area, P — the required electrical power, E — the solar constant, η — the solar panel efficiency, k — the system loss coefficient (taking into account inverters, temperature, pollution, etc.).

Substituting the values: $\eta = 0.33$, $k = 0.95$ (approximate value taking into account the station's technology and the insignificant shadow in polar orbit), the effective power per square meter is then: P_(1"m"^2) = 1361 × 0.33 × 0.95 ≈ 427" W/m²". Therefore, the formula for the area becomes: A = P/427. If the station requires 300 MW, the panel area will be: A = (300000000)/427 ≈ 702576m². Thus, with an efficiency of 33% and system losses of 5%, approximately 702576m² will be required to generate 300 MW.

Thermonuclear fusion

Thermonuclear fusion — a technology not yet in use today, but one that will be highly effective in the future and is being actively studied. Thermonuclear fusion is very promising due to its incredible power (one reactor produces the equivalent of thousands of solar panels), its non-polluting properties, and its ability to operate continuously for decades. In our case, D-He3 can be used for thermonuclear fusion. Both of these components can be extracted from the Moon, but since this technology is not yet fully developed, we will not consider it as a basis for this study. Its efficiency is 40% [3], which means the reactions should release not 90, but 225 MW: Reaction energy E_D3≈18.3" MeV"=2.93×10^(-12) " J". Required number of reactions: R_D3=(225×10^6)/(2.93×10^(-12))≈7.68×10^19 " reactions/s". Mass per reaction: D+³He ≈5.03 u ≈ 8.35×10^(-27)kg → m ≈7.68×10^19×8.35×10^(-27)≈6.41×10^(-7) kg/s. → ~0.055 kg/day ≈ 20 kg/year (sum of D+³He). For a mixture of deuterium and helium-3 (reaction D + He-3 → He-4 + p) with a total fuel of 20.2 kg and a molar ratio of 2:1 (deuterium: helium-3), the calculation is as follows: total mass m=2.014×2x+3.016×x=7.044x, where 2.014 g/mol is the molar mass of the deuterium isotope (²H, one proton and one neutron), and 3.016 g/mol is the molar mass of the helium-3 isotope (³He, two protons and one neutron). From the equation x=20200/7.044≈2869mol. Then the mass of deuterium = 2 x 2.014 x 2869 ≈ 11.55 kg, the mass of helium-3 = 3.016 x 2869 ≈ 8.66 kg per year.

Energy storage

To store energy and distribute it during necessary and emergency situations, lithium-ion battery modules will be used. Let's say we want a 7-day energy reserve, then we need to calculate how much energy this is. E = P * N * t * 130% where E is energy, P is Power for 1 human, N is the number of humans, t is time (7 days) 2.5 * 1000 * N * 24 * 3600 * 1.3 * 7 = 181 440 000 000 000 Joules Various mirrors and other components will also redirect light into special "ovens," where the temperature will be approximately 1500 degrees Celsius. To store all this energy, the batteries have a capacity, which is subtracted by the product of voltage and capacity in ampere-hours. In other words, if the station has 10,000 A*h batteries with a voltage of 400 volts, their number will be equal to the energy divided by the capacity of one battery module. 181,440,000,000,000 Joules = 50,400 MWh; 50,400 MWh: (10,000 * 400) = 12,600 such modules, which will be distributed evenly across all units. FES (flywheel energy storage system) and SMES (superconducting energy storage system) systems will also be used as backup options. Food processing will also produce methane, which can be burned to generate energy or stored as fuel for the engines. Combustion energy is calculated by multiplying the efficiency by the specific heat of combustion of the fuel and by the mass of the fuel. However, this energy will be considered reserve and additional in certain cases, as it accounts for less than 1 percent of the total. (For more details on the operating principle, see the waste section)

Shielding

Radiation

Since the Moon has neither a magnetic field nor an atmosphere similar to Earth's, nearly 100% of cosmic rays reach its surface. Therefore, the station itself requires reliable protection from radiation, which is extremely harmful to humans. According to studies, radiation levels in lunar orbit reach approximately 1.37 mSv [1] per day, equivalent to 500 mSv per year. For humans, this exceeds the natural background radiation on Earth, which is approximately 3 mSv per year. [2] For long-term habitation and life extension, the dose should be reduced to 20 mSv per year, and for pregnant women, to 6.6 mSv per year. In other words, the crew should receive only about 4% of external radiation. [3]

Mechanical Damage

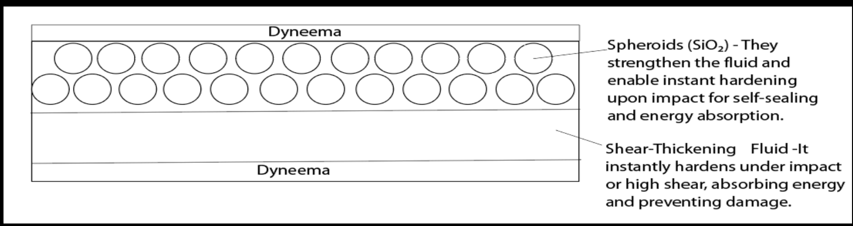
Since small space objects, such as micrometeorites, could collide with the station, structural protection is necessary. Space is filled with debris, and avoiding every collision is impossible, so even minor collisions will occur.

Temperature

To prevent the station from overheating due to solar radiation and internal heat generation, thermal protection and heat dissipation systems (such as radiators and ammonia-based heat pipes) are required. About half of solar energy is infrared, about 40% is visible light, and the rest is ultraviolet radiation. Additionally, the station is exposed to charged particles from the solar wind. Without reflective coatings (such as aluminized Kapton, white paint, or photonic crystals), the station's hull would quickly heat up—like a sheet of metal exposed to the sun.

Protective layers

1. The outer layer is the white "Beta" fabric used on the ISS. It provides thermal resistance, reflects light, and protects the surface from degradation. [4]
2. Multilayer insulation (MLI) made of aluminized Kapton, approximately 0.05 cm thick and with a surface density of 0.007 g/cm². It reflects solar radiation and minimizes thermal fluctuations. This material reflects more than 90% of light and prevents overheating. It is widely used on the ISS, the James Webb Space Telescope, and other space missions. [5]
3. Self-healing composite panel made of Dyneema fibers filled with polyethylene glycol and silicon particles, 6.5 cm thick and with a density of 11.8 g/cm². When punctured by micrometeoroids, the layer seals almost instantly. Capillary and shear forces drive solid microspheres toward the impact site, where the thickening of the liquid filler leads to hardening and sealing. The Dyneema mesh redistributes stress, allowing the layer to withstand multiple impacts without failure. This innovative material enables long-term missions by reducing the need for external repairs. [12] [Picture C]



4. Boron nitride nanotube (BNNT) composite with a thickness of 10 cm and a density of 14 g/cm². BNNTs have exceptional mechanical strength, thermal stability, and radiation attenuation properties, making them ideal for lightweight yet strong space structures. [6]
5. Water shield with a thickness of 40 cm and a density of 40 g/cm². Due to its hydrogen content, water effectively absorbs protons and neutrons; NASA recognizes it as an excellent material for radiation shielding. [7]
6. Kevlar with a thickness of 0.5 cm and a density of 0.72 g/cm². Kevlar is five times stronger than steel by weight, intercepts micrometeorite fragments, and is resistant to tearing. Often used in Whipple shields for impact protection. [9]
7. 30 cm thick, 28.5 g/cm² high-density polyethylene (HDPE) layer, providing hydrogen-containing shielding to attenuate protons and neutrons. [7]
8. The final layer is a 0.35 cm thick, 0.945 g/cm² anodized aluminum housing, providing a hermetic seal and mechanical strength. [8]

Windows

For space observation without compromising radiation shielding, multilayer transparent windows are offered: borosilicate glass (17.5 mm) [9], transparent polycarbonate (10 mm), transparent ceramic (25 mm) [12], a thin layer of barium or lead glass (4 mm) [10], and external louvers made of aluminum alloy and Kapton (2 cm thick). This combination provides transparency while blocking most harmful radiation.**Radiation Attenuation Calculation**: Attenuation follows an exponential law: $D = D_0 e^{(-x/\lambda)}$, where $\lambda \approx 30$ g/cm² for hydrogen-rich materials such as HDPE or water, $D_0 = 500$ mSv/year, and the total thickness of the protective mass $x \approx 95$ g/cm². [6] Therefore, $D \approx 20$ mSv/year, which corresponds to the recommended safe level for long-term use. This multilayer system provides impact resistance, excellent heat dissipation, and reliable radiation protection. Innovative materials such as BNNT composites and self-healing polymers enable durable, lightweight, and self-sustaining station designs suitable for long-term lunar orbit missions.

Thermal control systems

To distribute heat evenly on the station itself and get rid of its surplus, there will be a system of water and ammonia pipes and radiator systems. The internal circuit of the heat dissipation systems of residential complexes will be equipped with water pipes. The water pipes run through the modules and cool the following: electronics, servers, and pumps; and the air through heat exchangers (to keep people cool). Next, there is the external circuit, where water is less effective, so ammonia is used instead. Ammonia is highly resistant to temperature changes, does not become solid or gaseous, and is much lighter than water. It is also very lightweight, fluid, and highly conductive, which is crucial for the functioning of space systems. If we compare the properties of water and ammonia, we get the following values.

Parameter	Water (H_2O)	Ammonia (NH_3)	Comment / Which one is better

Density at 20°C, kg/m³	1000	682	Water is denser, which means that the system is heavier
Heat capacity, J/(kg·K)	4184	4700	Ammonia transfers more heat for the same weight
Thermal conductivity, W/(m·K)	0.6	0.5	Almost the same, the difference is insignificant
Freezing point, °C	0	−77.7	Ammonia does not freeze even in space
Boiling point at 1 atm, °C	+100	−33	Ammonia evaporates at low temperatures — convenient for radiators
Working pressure in the system	Higher (at high T)	Lower (under the same conditions)	Ammonia is easier to keep in a liquid state
Toxicity	Safe	Very toxic	Water is safer for the crew
Operation at low temperatures	Freezes	Works stably	Ammonia is effective in orbit
Safety requirements	Minimal	Very strict	Ammonia requires leak detectors and protection when handling
Final application on the ISS	Internal circuit (water)	External circuit (ammonia)	The combined system provides maximum efficiency and safety

In this case, the question arises as to why not immediately give the heat to ammonia, but it is very toxic and will be very harmful to residential complexes in case of leaks. Even a small amount of toxic ammonia (a fraction of a percent in the air) is very harmful to the crew itself.
The main components of the water and ammonia circuit will also include:
Pump modules (create force for the movement of fluid), Heat exchangers (receive and transmit heat), Valves that regulate the flow of fluid, and reserve tanks with the liquid itself. In this case, the entire system can be considered functioning, but there is still an unresolved issue: in the event of excess heat, which will be caused by the sun's heat, human activity (100 W), and the operation of all equipment, the heat must be disposed of from the station. For this purpose, radiator modules are used, which work by transferring heat in the form of infrared rays into space.
A radiator is a technology that removes excess heat from equipment or liquid into the environment. Hot liquid or gas flows through the tubes of the radiator, and the heat is transferred through the walls of these tubes to the outside, such as air, water, or space. In space, the radiator cannot use air, so it releases heat in the form of infrared radiation. The larger the surface area of the radiator and the higher the temperature of the liquid, the faster the heat is removed. Radiators are used everywhere, including on the International Space Station.
To calculate the formula and surface area of radiators, a special formula called the Stefan-Boltzmann Law is used:

$$Q=\varepsilon\sigma AT^4,$$ *where*

Q — the power of the radiated heat, ε — the coefficient of the surface emissivity (0-1), σ — the Stefan–Boltzmann constant = 5.67×10^{-8}, A — the radiator area (m²), T — the temperature difference

From the formula, it can be seen that as epsilon increases, the emissivity increases, and the range of epsilon is between 0 and 1. However, it is also worth considering that the radiator should not absorb excessive heat, so we suggest using anodized aluminum panels [1], because their epsilon reaches 0.9 [4], which is very high, the panels themselves will have white ceramic paint, which reduces the ability to absorb energy. In order to prevent paint degradation, we offer a special type of it – Z-93 (an inorganic white coating based on zinc dioxide (ZnO), UV-resistant), the same as that used by the ISS) [2]. If we start calculating, we will use the fact that each person emits an average of 100 watts [3] to calculate the heat that needs to be radiated. The station heats up when it is exposed to sunlight, and there is also equipment
In other words, 120,000 people will produce 12 MW of heat, and the solar panels will cover the entire station, but they will need to be cooled because 67 percent (100-33) of the energy will be converted into heat. Therefore, the energy from the sun will be calculated by multiplying the efficiency factor by the solar constant and the area of the panels:
1361*0.67*702 576 = 640657977 Watts. In total, the energy is 652657977 Watts, and if we add another 20 percent as heat from the equipment, we get approximately 784 Mega Watts.
Given that ε is approximately equal to 0.9, and the temperature difference is reasonable to take as 130 degrees Celsius, which is 403 degrees Kelvin, the area is equal to:
$784000000:0.9:(5.67\times10^{-8}):(403^4)$ = 582 thousand square meters of radiators, which will be placed on the rim of the rings.

Waste management

To minimize the return of resources from the Moon, the system will be completely closed. Let's divide the waste into several sections:

Water:

Moisture will be condensed from the air, as on the ISS, using a cold condensing heat exchanger (CHX) [1].
Principle: Air passes through a cooler (cold surface), the air temperature drops below the dew point → moisture condenses and drains.
Components: Fan → Pre-filter (dust) → Cold-side heat exchanger → Condensate tray → Pump for the purification system.
Efficiency: Simple, reliable; large mass flows are easy to maintain.
Requirement: Cold source (cooling capacity), heat removal/utilization. For 300 m³/day, approximately 7.8 MW of cooling capacity will be required to remove latent heat (see explanation in the numbers section below). Therefore, large-scale production is expensive—it's better to combine it with other sources.
The dirty water itself will also be purified through reverse osmosis, UV rays, activated carbon, and so on. In other words, the entire sewage system will be filtered to minimize losses. In case of water shortages, water will be brought from the Moon.

Food:

For waste processing, automated AI systems will separate plastic and other inorganic compounds from other waste. There will also be other bio-sections. There, black soldier fly larvae quickly convert organic matter into protein mass and fertilizer. The protein mass is used as feed or as a protein source, and the fertilizer is used in hydroponic farms. Residues that the insects cannot break down are processed by fungi and bacteria, turning them into nutrient substrate and water. Then, everything is fed to an anaerobic bioreactor, where microbes, in the absence of oxygen, produce methane, water, and carbon dioxide. The reaction occurs at 35–55°C (due to the station's waste heat). Methane is used as fuel, water is purified and returned to the system, and CO_2 is used for plants. Solid residues are burned in a plasma reactor, turning into syngas and carbon. As a result, waste becomes energy, fertilizer, and new food—the system is completely closed, unlike the ISS, where garbage is simply incinerated in the atmosphere.

Example calculation for 36 tons/day of food waste (realistic for 120k): [5]

Biogas ~ 0.5 m³/kg → ~18,000 m³/day. [2]

Energy content ~ 108 MWh/day (Methane/biogas heating value ≈ 6 kW h/m³). [4]

With a typical CHP (electrical efficiency ≈ 35%) [3] — electricity ≈ 37.8 MWh/day; Less than 1 percent of what is needed

Inorganic materials:

Metals are remelted in mini-smelting modules, purified, and returned to production.

Plastics are sorted by type (PET, ABS, etc.), crushed, melted, filtered, and fed back into 3D printers or molds.

Glass is crushed and remelted at 1000°C; it can be used for building panels and transparent domes.

Composites are disassembled into their component parts layer by layer using lasers and mechanical separation, then recycled.

Hazardous waste:

Medical waste is sterilized in plasma autoclaves;

Chemical waste is neutralized in reactors with catalysts;

Electronics are disassembled, and rare metals (Au, Ag, Cu, Li, Ni) are extracted electrochemically.

Radioactive elements:

Isotopes will be regenerated using neutron reactors for some elements. Residues that cannot be reprocessed will be sent to special storage facilities where they will be used as thermal energy sources. (After all, these elements will constantly generate heat.) They will not be used directly for electricity, but they can contribute to heating, etc.

What is not reprocessed will be sent to a plasma reactor: the material is completely converted into plasma → decomposed into atoms → the gases condense into pure elements.

Nutrition

To sustain a lunar orbital colony with an expanding population over 80 years, food production must be entirely self-sufficient, reliable, and regenerative. The system should operate in a closed ecological cycle, combining biological, technological, and automated processes. Early years (0–10) will rely on starting reserves and system activation, while later decades will be maintained through autonomous, modular farms capable of adapting to demographic and environmental changes. [1][2][3]

Diet composition

The astronauts' and colonists' diet must be carefully balanced to sustain muscle mass, bone strength, immune stability, and cognitive performance in reduced gravity. According to NASA's Human Research Program and ESA nutrition protocols, the daily intake per person should include approximately: Proteins: 100–120 g/day [4]: Proteins maintain muscle tissue, repair cells, and regulate enzymatic activity. In low gravity, muscle atrophy occurs faster; therefore, protein consumption is vital. Sources include freeze-dried poultry, soy protein isolates, lentils, and microalgae such as Spirulina and Chlorella. Insect-based protein powders derived from crickets (Acheta domesticus), mealworms (Tenebrio molitor), and black soldier fly larvae (Hermetia illucens) provide a renewable, high-density source of essential amino acids. [5] Fats: 110–130 g/day [4]: Fats serve as compact energy sources and enable absorption of vitamins A, D, E, and K. Omega-3-rich algae oils will be the primary source, along with nuts, powdered dairy, and vegetable oils (olive, flaxseed). These fats play a key role in keeping the cardiovascular system healthy and maintaining immune balance during space missions. Carbohydrates: 350–400 g/day [4]: Carbohydrates provide the primary source of energy and stabilize blood glucose levels critical which are essential for concentration and mental performance. Main sources include dehydrated fruits, potatoes, whole-grain pasta, and long-storage bread mixes that can be rehydrated with purified water. Vitamins and Micronutrients: Because sunlight exposure is limited in space, vitamin D must be supplied through synthetic sources. Calcium, phosphorus, and magnesium maintain bone mineral density; iron and vitamin B12 sustain oxygen transport and cognitive health. These micronutrients will be included in fortified foods, microalgae supplements, and compact multivitamin tablets to ensure a balanced diet. [6] These macronutrients are complemented by essential vitamins and minerals to prevent bone loss, anemia, and neurocognitive decline. [Table D]

Crop	Share (%)	$Area_{80}$ (m²)	$Daily_{80}$ (L/day)	$Annual_{80}$ (L/year)
Potato	40%	328,513.6	2,628,108.8	959,259,712
Tomato	20%	164,256.8	1,642,568.0	599,473,320
Lettuce	12%	98,554.08	394,216.32	143,673,960
Spinach	10%	82,128.4	369,577.8	134,962,647
Kale	7%	57,489.88	287,449.4	104,919,031
Chard	7%	57,489.88	287,449.4	104,919,031
Basil	4%	32,851.36	98,554.08	35,972,239
Итого (hydroponics)	100%	821,284	5,707,923.8 L/day	2,083,392,187 L/year

Final area and water use (at A(80_hydro) = 821,284 m²)

Farm type	Initial area A(0,i) (m²)	Final area A(80,i) = A(0,i) * scale (m²)
Hydroponics	201600	821284
Algae	25200	102660
Insect farms	12600	51330
Microbial modules	1260	5133
Total	240660	980407

Table meaning: required farm areas after 80 years when scaled by the exponent α=0.9

[Table E]

N(0)=25200;N(80)=120000;α=0.9;scale = (N(80)/N(0))^α = (120000/25200)^0.9 ≈ 4.0738

Atmosphere and climate

Oxygen production

The Samruk station will employ Chlorella microalgae as a primary oxygen source. Chlorella is a powerful tool for generating oxygen in space, as it exhibits a high rate of photosynthesis and is compact and efficient. It has been used in space missions and has shown its potential. The photosynthetic process in Chlorella requires only fundamental inputs: water, carbon dioxide, light energy, and trace minerals (including potassium, phosphorus, and sodium) to sustain cellular reproduction. In the experimental facilities of the Institute of Biophysics in Krasnoyarsk, specifically BIOS-1, BIOS-2, and BIOS-3, a two-component closed-loop life support system has been implemented, consisting of humans and chlorella. Carbon dioxide is placed in a specialized container that contains water with specific minerals and chlorella. Under the influence of fluorescent light, the carbon dioxide undergoes a photosynthesis reaction, converting it into oxygen.[1][2]

Stoichiometry and Key Constants (per person)

Daily oxygen requirement (24 h): 1.5 m^3 O_2 = 66.96 mol O_2. 1 mol = 10^15 fmol => 66.96 mol = 6.696 * 10^16 fmol. Stoichiometrically, 1 mol of O_2 requires 1 mol of H_2O(for photosynthesis). Thus, the reaction water mass ≈ 1.206 L/person/day (66.96 mol * 18.015 g/mol ≈ 1205.5 g). This is a stoichiometric value; the actual circulating water volume in the reactor will be significantly larger. Chlorella cell parameters: Average cell diameter: ≈5 µm => cell volume ≈ 65.45 µm^3 = 6.545 * 10^(-14) L. Oxygen production rate: 25–400 fmol O_2/cell/hour[3]. Daily oxygen production per cell: 600–9,600 fmol/cell/day High productivity (400 fmol/h => 9,600 fmol/day): N(min) = (6.696 * 10^16 fmol) / (9.6 * 10^3 fmol/day) ≈ 6.98 * 10^12 cells Low productivity (25 fmol/h => 600 fmol/day): N(max) = (6.696 * 10^16 fmol) / (600 fmol/day) ≈ 1.12 * 10^14 cells (Thus, 6.98 * 10^12 – 1.12 * 10^14 cells/day are required per person depending on productivity.) Chlorella biomass volume per person (range). High productivity: V(min) = 6.98 * 10^12 cells * 6.545 * 10^(-14) L/cell = 0.4566 L. Low productivity: V(max) = 1.12 * 10^14 cells * 6.545 * 10^(-14) L/cell = 7.309 L (Thus, 0.457–7.31 L of biomass is required per person.) Stoichiometric water mass/volume for photosynthesis (per person). n(O_2) = 66.96 mol ⇒ requires ~66.96 mol H_2O⇒ water mass = 1,205.5 g ≈ 1.206 L. (This is a stoichiometric value – the reactor will utilize and circulate significantly more water.).

Scaling for 120,000 people (final values):

O_2 and H_2O totals: O_2: 1.5 m^3 * 120,000 = 180,000 m^3/day Stoichiometric water: 1.206 L * 120,000 = 144,720 L/day = 144.72 m^3/day Chlorella cells (total): High productivity (400 fmol/h): N(total,min) = 6.98 * 10^12 * 120,000 ≈ 8.37 * 10^17 cells Low productivity (25 fmol/h): N(total,max) = 1.12 * 10^14 * 120,000 ≈ 1.34 * 10^19 cells Biomass volume (total): High productivity: V(total,min) = 0.4566 L * 120,000 ≈ 54,792 L ≈ 54.79 m^3 Low productivity: V(total,max) = 7.309 L * 120,000 ≈ 877,080 L ≈ 877.08 m^3 (Summary: For 120,000 people, 8.37 * 10^17 – 1.34 * 10^19 cells are required, equivalent to ~54.8 m^3 of biomass under optimal conditions or ~877.1 m^3 under low productivity.)

Reserve Oxygen Production Method

In emergency scenarios (e.g., bioreactor failure or sudden crew expansion), the Samruk station employs water electrolysis (Electrolysis is the process of decomposing water (H_2O) into oxygen (O_2) and hydrogen (H_2) through the application of direct electric current) as a reliable backup method for oxygen generation [4]. $2H_2O \rightarrow 2H_2 + O_2$. Oxygen — directed into the life support system. Hydrogen — stored as fuel for propulsion, power generation, or synthetic chemical processes. This method ensures 150% of daily oxygen demand and serves as a critical contingency capability under all non-nominal conditions.[5][6]

Atmosphere composition

The atmospheric composition aboard the Samruk station will be identical to that of Earth[7] to ensure crew safety and comfort:

- Nitrogen (N_2) — 78%
- Oxygen (O_2) — 21%
- Carbon dioxide (CO_2) — 0,03% Rationale for this composition:
- Pure oxygen increases fire hazards and can be toxic to humans at high concentrations.
- A nitrogen-dominated atmosphere would accelerate corrosion of the station's metal components.
- The inclusion of water vapor is necessary to maintain comfortable air humidity levels This atmospheric composition provides optimal conditions for both human habitation and equipment operation aboard the station.

Climate

Below is the set of operational parameters and baseline requirements for the station's life support subsystems.[8]. Pressure: Nominal cabin pressure: approximately 101.3 kPa (1 atm), or slightly reduced (~90–101 kPa) depending on the station's architectural design. A near-Earth pressure level is preferred to prevent crew adaptation difficulties. Temperature: Comfortable temperature range: 18–26 °C in inhabited modules. Auxiliary modules (e.g., agricultural or technical compartments) maintain specific temperature ranges depending on equipment requirements. Relative humidity: 1)40–60 % in living areas (for human comfort and respiratory health), 2)lower in technical zones to reduce corrosion risk and prevent condensation. Ventilation: Continuous mechanical ventilation with balanced supply and exhaust airflow circulation. Air treatment includes: 1)HEPA filtration for particulates[9], 2)adsorption of volatile organic compounds (VOC)[10],3) catalytic purification for trace contaminants.

Resource industry

To maintain its existence, the settlement needs to have a constant flow of resources, such as water, building materials, rocket and energy fuel. The closest place to extract these resources — Surface of the Earth's Moon.

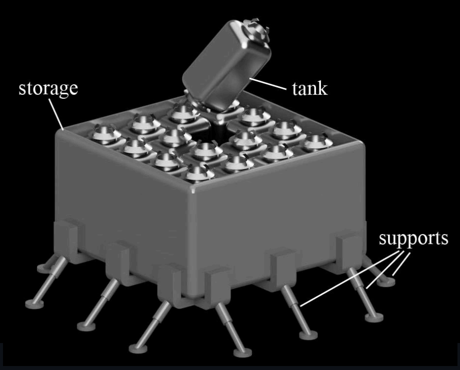
Extraction

The three types of raw materials that will be extracted from the surface: building materials, water ice and helium-3. All of them are found in lunar regolith. Several resources-extracting complexes will be placed across the surface of the Moon. Each complex will be specialized for a particular resource (water, metals or helium-3).

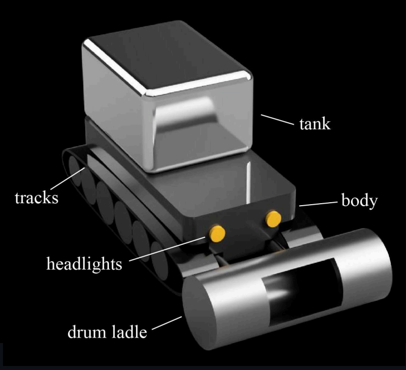
Structure of the resources-extracting stations

- Resource storage (base). Each station has a large building with tanks that store lunar regolith. Lunar regolith will be pressurized in tanks to store it as effectively as possible. Each tank has docking ports for delivering rockets.
- Mining rovers. Each station has a large amount of autonomous rovers that mine lunar regolith and deliver it to storage. They use tracks to move and regolith digging devices.
- Delivering rockets. Rockets that are docked to the storage and lift full tanks to the orbital settlement. They have 4 free-rotating rocket engines and RCS to perform maneuvers and for docking.
- Power supply. All described earlier structures have solar panels to power themselves. The complexes also will be supplied by solar batteries and energy from the orbital station that will be transferred through laser rays, microwaves and delivering rockets.

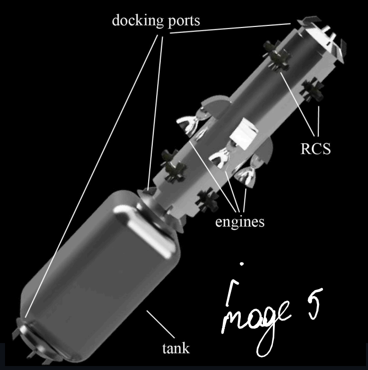
[Picture F]



[Picture G]



[Picture H]



Resources

- Water. Water ice is concentrated at the south pole of the moon, in eternally darkened craters, such as Shackleton crater in which one of the regolith-extracting stations will be placed. According to LRO data, regolith in Shackleton consists about 5-10% of water by mass [1].
- Heluim-3. Unlike water, helium-3 is concentrated in illuminated regions, such as the lunar maria (Mare Tranquillitatis, Oceanus Procellarum or Mare Fecunditatis), in which regolith-extracting stations also will be placed. Regolith in these regions consist of about 50ppb of Helium-3 [2].
- Building materials. Metals will be extracted from the rest of the regolith that is mined by water and helium-3 extracting stations.

Transportation

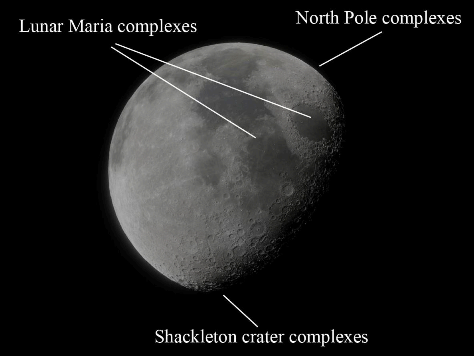
As stated above, lunar regolith will be transported to the orbital settlement by large amounts of delivering rockets. Rockets are docked to the tank in the base and fly to orbit when the tank is full and orbital settlement's trajectory is above. Delivering rockets have 4 thrust-vectoring engines and RCS to perform maneuvers. After approaching the orbital station, rockets attach the tank to the station and refuel to deorbit and ereturn empty tanks back and lift other tanks.

Processing

On the orbital settlement regolith will be heated and melted in vacuum furnaces to separate volatile components of it.

- Water. Most of the water will be used by the biosphere of the settlement and thermoregulation systems. Another part will be electrolyzed to gain hydrogen and oxygen that can be used as fuel pair for rocket engines and for production of "heavy water" that is used in thermonuclear energetics.
- Building materials. Metals are then refined from the rest of metals-consisting regolith by electromagnetic separation and used in building of new modules, repairing, manufacturing etc.
- Heluim-3. Helium-3 will be extracted from regolith and used in thermonuclear energetics in pair with heavy hydrogen.

[Picture I]



Financial aspect

Finance in the colony exists with the purpose of helping society and global development. There are no debts, external investors and private enterprises whose goal is maximum revenue. Everything is done transparently, honestly, simply and clearly for all citizens of the colony. Centralized currency: The Monetary Council is responsible for the issuance and control of the domestic currency. The goal of this council is to ensure that the amount of currency issued always corresponds to the actual amount of production, resources, and services. In other words, when production increases, the amount of currency issued also increases. Conversely, when production decreases, the amount of currency issued decreases. In other words, these two parameters are directly proportional to each other. A debt-free economy: In the colony, there are no debts, loans, installments, or similar payment methods. No one is in debt to anyone else. Instead, there is a system of public investment. If someone comes up with an idea that could benefit the entire community, they can receive funding from the public innovation fund. This fund is regularly contributed to by all members of the colony. In case of success, innovators will receive modest monetary rewards, public recognition, and additional privileges. The primary source of income will be shared among all citizens.

Public Startups: As mentioned earlier, anyone can start a project for the benefit of the public. Funding from the fund is provided in stages:

1. A small grant for testing the idea, which is evaluated by specialized experts in the relevant fields.

2. Full funding for the remaining part of the project if it demonstrates the desired results.

3. A reward after the project is successfully completed.

If the project fails, the government will not lose significant funds, and all losses due to unsuccessful attempts will be covered by successful ideas in the future. Reward and Equality: Since there are no billionaires and no poor people in our society, instead of huge incomes, a person will receive minor bonuses, status in society and its recognition. The amount of the reward depends directly on the degree of globality and usefulness for society of the project performed. Reserve Fund: In addition to the state innovation fund, there is also a reserve fund for emergency situations, such as breakdowns within the station, poor harvest seasons, the spread of a dangerous virus, etc. Funds for this fund are also regularly allocated from the public's salaries. All residents pay an equal amount of money. Maintaining economic activity: The Monetary Council monitors the speed of money circulation in society, and if money is not circulating and is stuck in one place, certain measures are taken. For example, tax incentives, additional funding for projects, and other innovations that encourage the population to be more proactive and engaged.

Economy aspect

The main difference between the economy on the station and the economy of the real world is that the colony exists autonomously, and there are no supplies from Earth, which means that resources will be limited, and they will need to be distributed among the citizens as accurately as possible. All of the following points are based on limited resources, fairness, democracy, and public considerations.

The internal currency and its stability
The colony uses its own currency, which is not related to or tied to the Earth's currency. This is done because there is no connection between the amount of resources on the station and the Earth. Having its own currency enhances the colony's autonomy and independence.
Payment based on contributions
In order to avoid conflicts, the difference in citizens' salaries should not be excessive, so that society does not begin to stratify into different social levels. However, at the same time, it is necessary to maintain the motivation and desire of residents to strive upward. As a result, more complex jobs, such as those of scientists, will be more financially rewarded than simpler jobs, such as those of maintenance personnel, but the difference in salaries will not be too noticeable, with a maximum of 30-40 percent. People are not chasing after money, but rather strive to be more useful to society.
Control of savings
Since the amount of resources on the station is not static, but constantly changes, the same amount of money can be used to purchase different amounts of goods and services at different times. This makes the internal economy less stable and increases the risk of inflation. To address this, accumulated money will lose its value over time. This encourages people to invest and spend their money immediately, keeping the economy vibrant rather than stagnant.
Balance of professions and rotation
Every citizen has the opportunity to change their profession after at least 5 years of working in their previous position. In this case, the citizen is responsible for the training for their new position, which means that they will need to allocate their own money and time for this purpose. This approach allows for diversity in people's lives and gives them a second chance to find themselves, but it is a time-consuming decision for the citizen, and they will need to approach it with awareness.
Closed production cycles
Almost all industries are trying to reduce waste to zero. What is unnecessary in one area is highly sought after in another. For example: Food scraps are processed into biofuels, metals from old equipment are used to create new tools, carbon dioxide from human respiration is used in greenhouses, etc. In this way, everything is used efficiently and potential losses are kept to a minimum.

Political aspect

The colony's political system is based on democratic technocracy, a form of government where all residents are aware of the events and policies taking place, while also having the right to make choices. In a closed system like a space station, this is crucial to prevent any serious conflicts between the government and the citizens, whether they are ideological or armed.
The colony's council
The main governing body is the Colony Council, which consists of 18 representatives divided into three key areas: life support (farms, recycling systems), technology and security (energy, radiation protection), and social organization (education, distribution of responsibilities). Members of the Council are elected for a specific limited term, such as 1 year. This system allows more people to experience leadership and prevents power from being held by a single individual for an extended period, thereby reducing the risk of corruption.
The double approval system
Any global decision goes through 2 stages. At the beginning, the request for innovation is checked by experts, who determine whether it is feasible in principle. Next, the entire society votes for or against this decision. That is, if the decision passed the expert review and later more than 50 percent of the population approved it, then it is applied in practice.
Transparency and participation
All council meetings and all votes are held in real time on an online forum that is open to all citizens. Anyone can vote for someone else's idea or propose their own. If at least 10 percent of the population votes in favor of an idea (and less than 10 percent votes against), the council is required to publicly consider the proposal. This allows everyone to contribute to improving public welfare.
Conflict resolution
Disagreements are not resolved through punishments or prison sentences, but rather through compensation and community service. To fairly determine which party is in the right in a conflict, there will be a court based on the opinions of judges (experts in the field) and the opinions of ordinary citizens.

Social aspects

Education and childcare:
Education on the station plays an equally important role as on Earth, but it differs from the usual format of education. Children's education and life in space: children grow up in different gravitational and spatial conditions, which requires adaptation of educational programs and pedagogy.
The educational environment is more closely integrated with the station's life: children participate in the station's life, have "service" projects, and participate in agro/engineering projects.

• Elementary school, middle school, and career guidance will all be available on board the station. Children will have live teachers, mentors, AI teachers, and online courses. [1].
• The educational program includes a general academic foundation (mathematics, language, science, and art).-online, with AI teachers and mentors, space adaptation (astronautics, life in orbit, ecology, engineering)online and offline, creativity and social skills-offline with live teachers.
• Education: special programs in psychology, team life, responsibility, station care, participation in station projects.
Adult education:
• Regular advanced training courses, retraining, research programs.
• Station University system: lectures, seminars, laboratories, interdisciplinary projects

Work and Leisure

Work and leisure in the lunar orbital colony will be closely intertwined and built around the principle of balance between productivity, psychological health, and a sense of community. Thanks to artificial intelligence and automation, most routine tasks, such as maintaining life support systems, monitoring crops, and performing technical diagnostics, are performed by intelligent machines, allowing humans to focus on creative, managerial, and research functions. The working day is shorter than on Earth, about 5-6 hours, to reduce stress and accommodate adaptation to confined spaces. Work is divided into scientific and engineering (station management, research, medicine, and biotechnology), educational (teaching and training), service (housing support, logistics, and culture), and creative (art, media, architecture, and environmental design).
Leisure is an integral part of the colony's life. To maintain mental health, there are park domes with green spaces, weightlessness halls, sports centers with artificial gravity, and recreation areas with simulated Earth landscapes. Cultural life revolves around collaborative events, such as concerts, theater performances, art labs, and science and art festivals. The use of VR/AR technologies for "virtual trips" to Earth or lunar surfaces helps to reduce feelings of isolation. [2] A recent study suggests that VR environments can significantly alleviate the stress associated with isolation in a confined space. Unlike on Earth, leisure and work on the station are not only focused on personal goals, but also on maintaining the harmony of a closed ecosystem. Every profession and activity is seen as a contribution to the overall survival and development of humanity beyond Earth.

Demographic aspect

The initial population is 25,200 people. According to our calculations (see below), the population will reach approximately 120,000 people in 80 years.
Calculations:
x — initial population (people); N — final population in 80 years (people); r — reproduction rate per generation; s — survival rate for generations 2–4 at the time of calculation
Used model:
(generations change every 23 years; generation 0 is completely eliminated by the age of 80 due to natural mortality)
Formula: $r\cdot x / 2 + s\cdot(r^2x + r^3x + r^4x) = N$
From here: $x = N / (r/2 + s\cdot(r^2 + r^3 + r^4))$
Parameters taken in the calculation:
N = 120000; r = 1.144 [1]; s = 0.98 [2]; r / 2 = 0.572; r2 = 1.308736; r3 = 1.497193984; r^4 = 1.712789917696; r2 + r3 + r^4 = 4.518719901696
s·(r2 + r3 + r^4) = 0.98 × 4.518719901696 = 4.42834550366208
Denominator = 0.572 + 4.42834550366208 = 5.00034550366208
Therefore:
x = 120000 / 5.00034550366208 ≈ 23998.34 ≈ 24000 (rounding)
Accounting for older specialists:
Specialists make up 5% of the general population.
0.05 × 24000 = 1200
Final initial population (including specialists):
24000 + 1200 = 25200 people
The r and s parameters are approximate and may be slightly adjusted depending on the station's conditions [3].
Of the total population of the colony, 4.8% will be adult mentors who supervise and educate the rest of the colony's residents (people aged 30-50). Therefore, 95.2% of the population consists of young residents (people aged 18-30), with a 1:1 ratio of men and women.
These 95.2% are divided into five equal groups;
18, 21 , 24 , 27 ,30 years old
Residents are divided by age categories in order to evenly distribute their future children in educational institutions, such as children. kindergartens and schools. Thus, there will be no overcrowding in school classrooms, which effectively affects the efficiency of teachers and the quality of children's education.

Selection of citizens:

primary criteria:
absence of chronic diseases, addictions, and mental disorders
Lack of criminal record:To reduce the safety hazard risks as much as possible.

Filling out a psychological and medical profile (passing medical and psychological examinations and tests, described later)
Primary assessment of the profession: availability of in-demand skills/educational background (the station requires specific specialists, described in the social aspects)
Psychological diagnosis:
Long-term isolation can lead to psychological trauma, stress, and burnout. For example, the third-quarter phenomenon[4]: A group of symptoms has been described as overwintering syndrome, which includes sleep disturbances, cognitive impairments, negative affect, and interpersonal tension and conflicts faced by individuals participating in polar expeditions in Antarctica.This phenomenon is also applicable to long-term stays in space, and it is most likely related to the realization that the mission is only half complete and that there is still a long period of isolation ahead. Therefore, psychological resilience, adaptability, and motivation are key criteria that are often more important than age or profession. During the selection process, individuals must complete a "motivational profile" (explaining why they want to live in the colony and what role they are willing to play). To reduce the risk of psychological issues, it is essential to complete psychological tests.[5] Also, after selection, candidates must undergo a test cycle: Participants live in an earthly analogue of the station, in a closed environment, for 3-6 months (similar to the Mars-500[6] or Biosphere 2 project).• Adaptation, stress level, social stability, and emotional stability are monitored.
Based on the analysis results, ratings and recommendations are formed for inclusion in the first wave of colonists
Mandatory medical examination: cardiology, neurology, ophthalmology, genetic screening, radiation resistance, and absence of allergies to basic environmental elements.
Testing for resistance to motion sickness and spatial disorientation (in rotating modules)Assessment of sleep and circadian rhythms

Distribution of specialists [Table J]

Category	% of the population	number of people	Commentary
Engineering	25%	30 000	Support and monitoring of the station's operation and rotating modules. Energy
Medicine	8%	9 600	Doctors, surgeons, midwives, and nurses
Biology/agriculture	10%	12 000	Management of farms, "green modules", and microbiome
IT / AI	8%	9 600	Management of AI, cybersecurity at the station, database management, and automation
Psychology	2%	2 400	Adaptation programs, relaxation, emotional support, counseling
Education	7%	8 400	Schools, mentoring, retraining
Culture/sport/entertainment	3%	3 600	Leisure activities, art, sports programs, cultural events.
Administration / Finance / Law	5%	6 000	Management of the colony and finances. Logistics
Scientific research	15%	18	Physics, biology, applied sciences. Research on life on the station
Technical maintenance	12%	14 400	production of spare parts, repair teams.
Security / Emergency services	3%	3 600	Firefighters, emergency teams, station security
Architects / Infrastructure	2%	2 400	Design and development of the environment and infrastructure.

Healthcare

Healthcare represents one of the fundamental pillars of any developed society. Our station will include a comprehensive healthcare system consisting of emergency services, hospitals, and specialized clinics. Medical professionals will be trained in dedicated institutions designed to prepare surgeons, pediatricians, and other specialists. The quality of healthcare reflects the overall level of social progress and plays a crucial role in preventing large-scale epidemics and maintaining public health.
Radiation Risks in Space
In lunar orbit (600 km above the surface), the crew is exposed to galactic cosmic rays (GCR) and solar particles. Without shielding, the annual dose exceeds 500 mSv, which is 500 times higher than Earth's average dramatically increasing risks of cancer, cataracts, and genetic mutations.
How Samruk Minimizes Radiation
We use multi-layer shielding with a total areal density of 95 g/cm², absorbing 96% of external radiation.
Results:
● General crew: ≤20 mSv/year (comparable to high-altitude Earth regions).
● Pregnant individuals: ≤6.6 mGy/year (safe for fetal development).
Shielding includes: 40 cm water layer, polyethylene, boron nitride nanotubes, self-healing composites, and outer reflective screens all integrated into the station's hull. [1]
Emergency Measures & Treatment
1. Storm shelters during solar flares central modules with extra 50 g/cm² shielding; full crew relocation in 15 minutes.
2. Dedicated oncology module:
○ Robotic surgery (da Vinci–type).[2]

○ Proton therapy (compact cyclotron).
○ Onboard CAR-T cell and CRISPR therapy production.
3. Medical team:
○ 2 radiation oncologists, 1 geneticist, 3 space-medicine nurses.
○ Annual screening: biomarkers + AI-enhanced MRI.
○ Early-stage treatment >90% survival rate.[3]
Bottom line: Radiation on Samruk is reduced to safe Earth-like levels, and if issues arise full diagnostics and treatment are available directly onboard.Mental Health
Mental health is an equally vital component of the healthcare system. The station will host psychological support centers and psychiatric clinics, supported by qualified teams of psychologists and psychiatrists. Their mission will be to achieve emotional well-being and psychological stability among the inhabitants, essential factors for maintaining productivity and harmonious social interaction on the station.[4]

Risks

1. The underdevelopment of thermonuclear energy.
2. Dependence of energy on the amount of light.
3. Lack of a detailed plan in case of an emergency.
4. Catastrophic consequences in the event of failure of life support.

Methods and Instruments

1. ChatGPT. Used for advice, but not to write text.
2. Adobe Illustrator. To make and edit images.
3. Fusion360. To create, design and render 3D-models.
4. SpaceEngine. To render images of celestial bodies and space.
5. GitHub/Git. To store files and work in groups.

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[A] (/location-01.jpg) Orbit of the station. Made in Adobe Illustrator and SpaceEngine.
[B] (SamrukStation3DModelInScale.step) Stations structure. Made and rendered in Fusion360.
[C] Self-healing dynema layer structure. Made in Adobe Illustrator.
[D] Hydroponic Crop Distribution, Area,Water Consumption daily(80) and Annual(80) (at A(80_hydro) = 821,284 m²)
[E] Table meaning: required farm areas after 80 years when scaled by the exponent α=0.9
[F] (/Storage.jpg) Resource storage 3D-model. Made and rendered in Fusion360.
[G] (/Rover.jpg) Mining rover 3D-model. Made and rendered in Fusion360.
[H] (/Delivering rocket.jpg) Delivering rocket 3D-model. Made and rendered in Fusion360.
[I] (/Complexes location.jpg) Location of resource-exracting complexes. Made in Adobe Illustrator and SpaceEngine.
[J] Distribution of specialists.