ASSC 2025

Orbital autonomous complex in the barycentric orbit of the Pluto-Charon system

Station - CERBERUS

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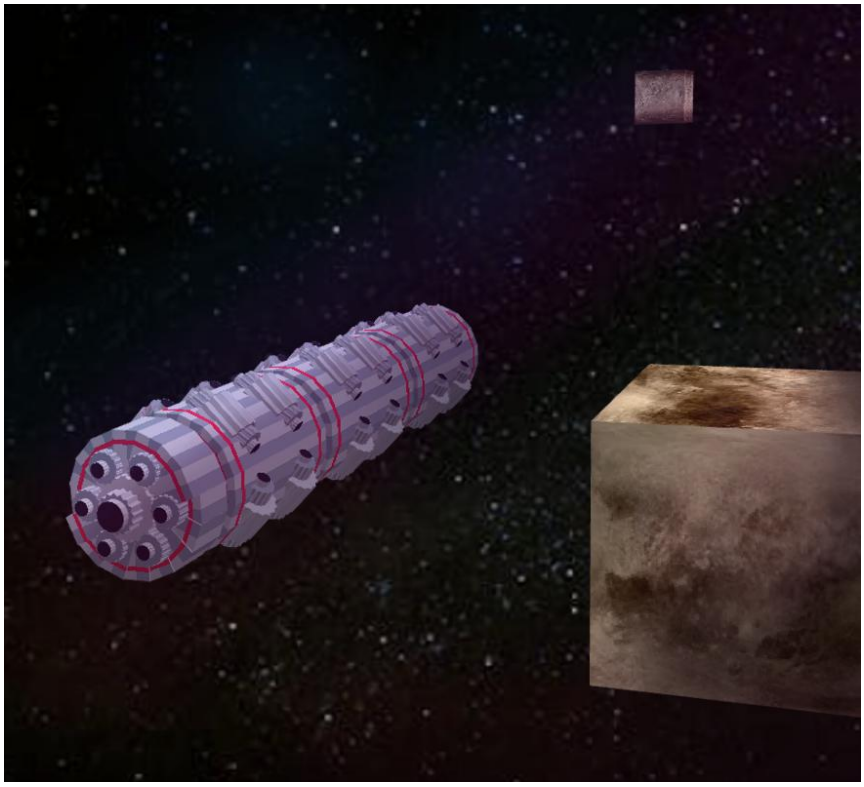
STATION CERBERUS

About the participant

Siranov Arlan - Responsible for text, design, calculations, engineering, modeling and ideas.

The project envisions an autonomous space station orbiting the shared center of mass of Pluto and Charon. The goal is to provide housing and workspace for a large number of people, facilitate scientific research in the extreme conditions of the Kuiper Belt, and create a self-sufficient ecosystem that could be established in the near future.



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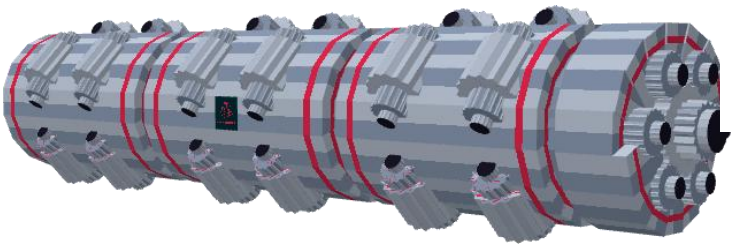
4
Colony specifications

Size & Shape

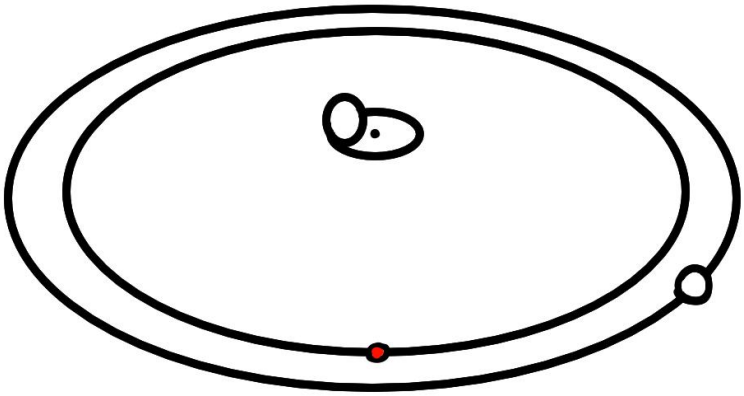
The Cerberus Station is cylindrical in shape, consisting of four large cylinders. The sides of the station have 24 enormous thrusters for rotation control, and the ends have six thrusters for orbital correction. The main airlock, which launches and receives spacecraft, is visible at one end of the station. The station is approximately 10 kilometers long and has a radius of 1 kilometer.



Location & Orbit

The station's orbit will be around the barycenter of Pluto and Charon. It will be at a distance of approximately 11600km.
The turnover period at this radius is approximately 70 hours.

The red dot on the diagram below is the station in its orbit.

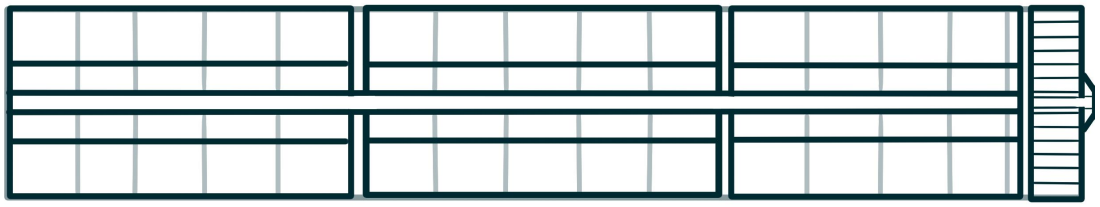


Distance between the system and the sun is approximately 39.5 AU.

Population

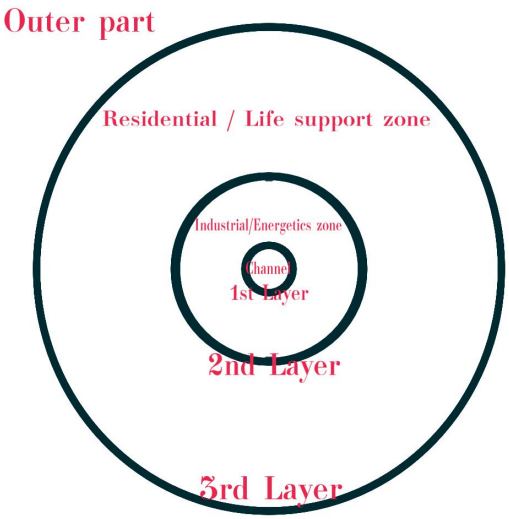
The station's population will be between 200,000 and 300,000. It will start with two hundred thousand people, but can grow to three hundred thousand in 80 years with its demographic policy.

STRUCTURE



Whole system and gravitation

To avoid health problems and muscle atrophy in humans, gravity on the station must be as close to Earth's as possible. [1]
The station's three main sectors each consist of a single structure—three layers/floors with different purposes (as shown at scheme -->).
Gravity on the station is not exactly gravitational force. Force that acts like that is centrifugal force, created by the station's spin.
To ensure approximately the same gravity on each floor, the angular velocity on all layers must be the same. In this case, the linear velocity should be different. According to calculations, here are the linear velocity and radius of each layer for ~1g (table 1).



(table 1)

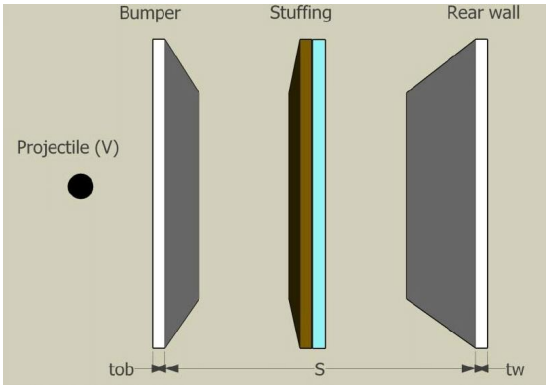
Layer	Linear velocity	Radius
3	99.045 m*s^-2	1000m
2	62.642 m*s^-2	400m
1	31.321 m*s^-2	100m

OUTER PART

Shielding

On Cerberus Station, the protective layer serves as a shield against radiation, solar flares, and physical damage. This layer consists of thousands of shield modules, each with a complex protective structure, and each module is replaceable in the event of damage or accident. [2] [3]

All layers of shielding are shown on table below (table 2).



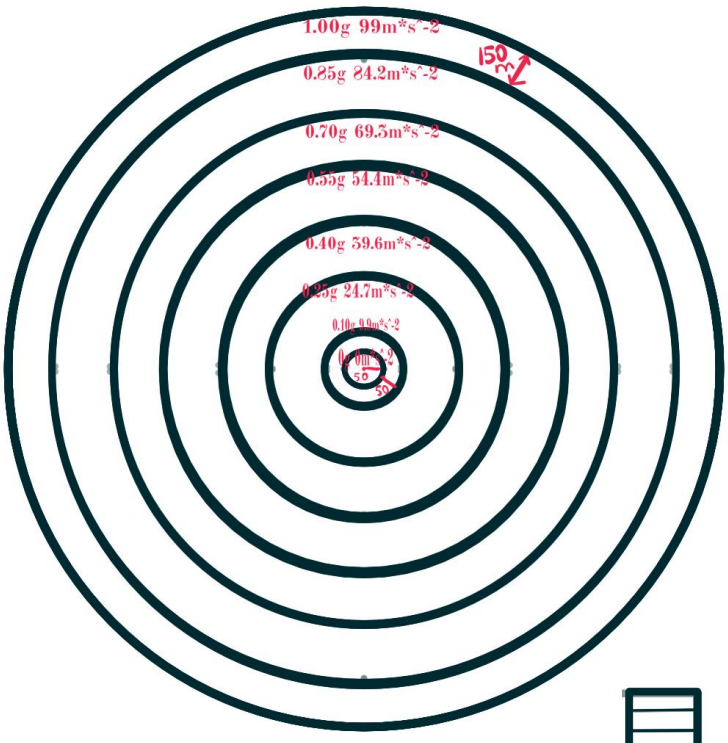
Whipple shield configuration NASA (figure 7)

Number	Layer and its purpose
1	Outer Layer (Whipple) — Thin metal shell/mesh + Nextel [3] + Kevlar [3] layer. — Purpose: Takes physical damage and reduces the kinetic energy of fragments.
2	Primary Moderator — Water/Ice/HDPE [4] — The main working layer against protons/neutrons/GCR fragments. — Implementation: Modular water cartridge tanks and HDPE/borated polyethylene blocks. [5] — Advantages: water/ice is easy to obtain/refill, serves as radiation suppression.
3	Neutron Absorber Layer — Ceramic tiles with boron carbide. Absorbs moderated neutrons.[6]
4	Gamma Shield — Thin sheets of tungsten [7] — Protection from gamma rays
5	Inner Layer — Internal protective material (Aluminium composite panels), durable panels that can be replaced quickly

(table 2)

Space Port

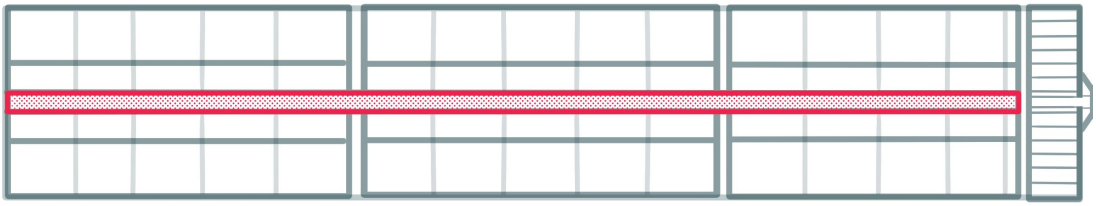
A spaceport is needed to launch ships into space (for repairs, resource extraction, and so on), and it will be Cerberus' fourth major sector.
To ensure ships can depart the station without rotation or difficulty, a system for gradually reducing rotation and gravity in eight stages has been designed (see Figure 7).
The system involves reducing rotation through gears and wheels similar to the three-stage system in the other three sectors, as well as a complete absence of gravity and rotation in the center.



The port itself includes gas exhaust channels for ships, unloading by mechanical arms and conveyors, fuel depots, and loading facilities. Also, for transport between layers, a precisely calibrated elevator will be installed. The elevator's speed and precise movement will allow the elevator to pass through rotating openings in the layers.

INNER PART

Central Channel

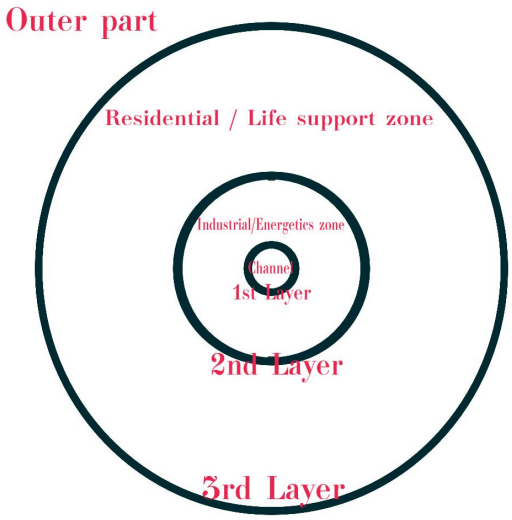


The central channel is the deepest interior section of the station, separated by a layer 1 wall. It connects all major sectors of Cerberus. In the central channel, the centrifugal force varies greatly with altitude (approximately 0.01g per meter), which can severely affect human organs, so it is separated from all other zones. The station's main logistics network runs through the central channel via ventilation, pipes, wires, and conveyors.

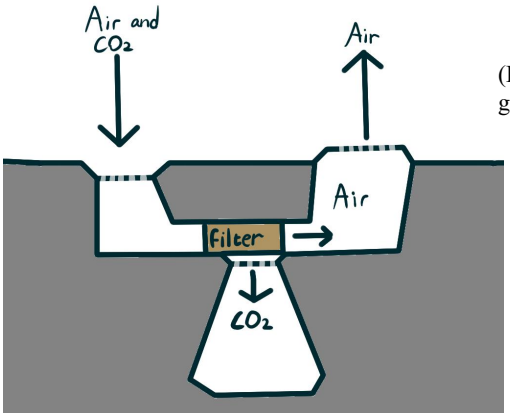
Inner Walls

Walls 1 and 2, and the inner part of Wall 3, are constructed primarily of aluminum and ceramic composites.

They have a durable structure capable of supporting the heaviest structures and centrifugal forces, although they are less well protected than the outer portion of Wall 3.

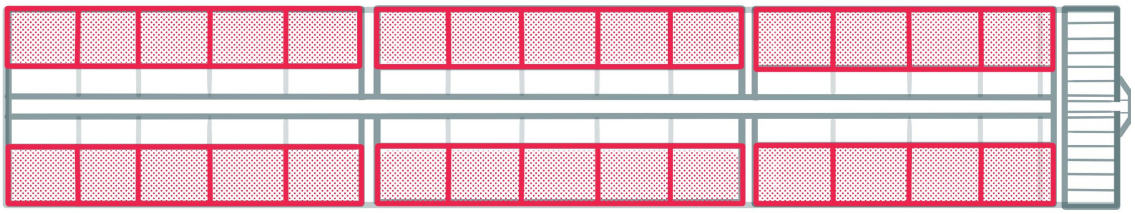


Volatile gases in the station's atmosphere on their floors are transported upward to the dividing walls. The dividing walls (or layer 1 & 2 walls) contain ventilation systems that collect these gases, sort them, and send them back into the system or to special storage facilities where they can be used or recycled. Heavier-than-air gases are collected at the bottom and processed through the same system. The walls also supply the necessary atmospheric gases from special units.



(Figure 11) Visual representation of gas collection system in the walls

Residential modules



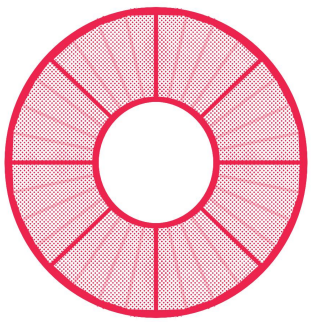
The station contains 112 residential modules. Each module is virtually identical and designed to accommodate a maximum of 2,800 people. Considering the floor area of the entire third layer, where the residential modules are located (56 million square meters, including losses due to walls and transitions between sectors), each module requires 499,200 square meters (780 square meters by 640 square meters).

Each module will contain four-story buildings, occupying 500 square meters, which can accommodate up to 40 people, for a total of 70 residential buildings in each module. The area occupied by residential buildings will be 35,000 square meters.

About 65,000 square meters will be devoted to infrastructure, roads, commerce schools, kindergartens, and so on.

About 40,000 square meters will be devoted to culture and entertainment - a cinema, amusement parks, and playgrounds. An internal culture—a culture of workers, space, and duty to the station—will also be developed, occupying approximately 20,000 square meters.

Poster showing labor centered and duty to station culture

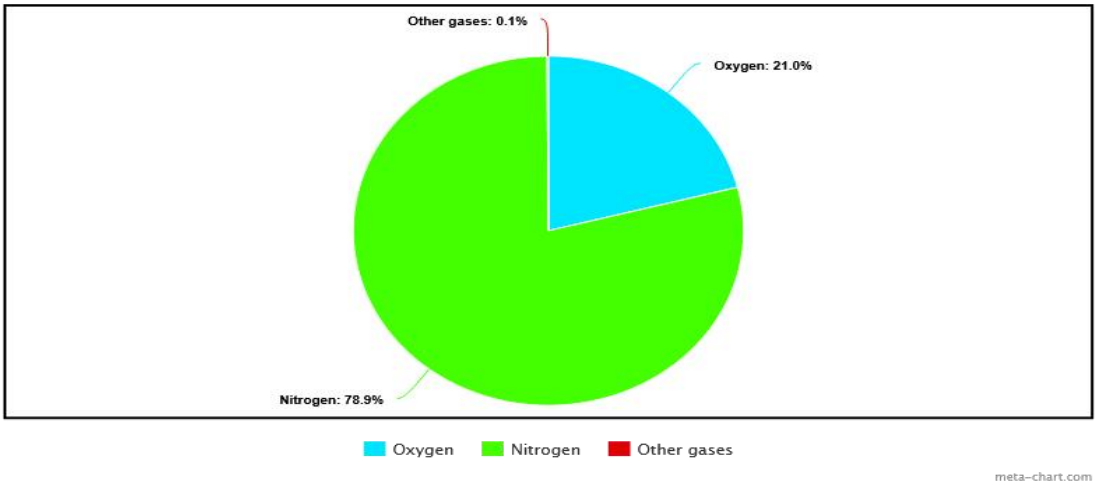


60,000 square meters will be needed for non-industrial areas, such as offices, banks, laboratories, servers, and so on. 120,000 square meters are allocated for station operations—interlayer elevators, life support stations, and rotation by mechanical components of the second layer.

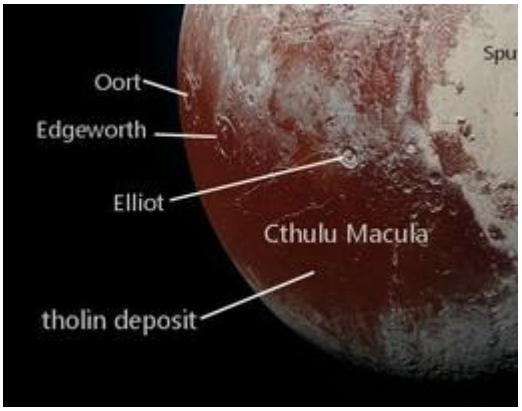
The remaining ~160,000 square meters of free space are designated for parks, bio-environments, multi-story agriculture, and free passage between residential modules.

Life support

Ventilation and atmosphere



The station's atmosphere should be similar to Earth's—1 atmosphere—and should consist of approximately 21% oxygen and 78.9% ballast gas, such as nitrogen.
Oxygen reserves, which are constantly being used for ship propellant and air, can be replenished by electrolysis of easily replenished water. Using the hydrogen and carbon dioxide obtained from the respiration of humans and plants (not all of the carbon dioxide should be used; some must be left for plant life), water and methane can be additionally produced using the Sabatier reaction [8].

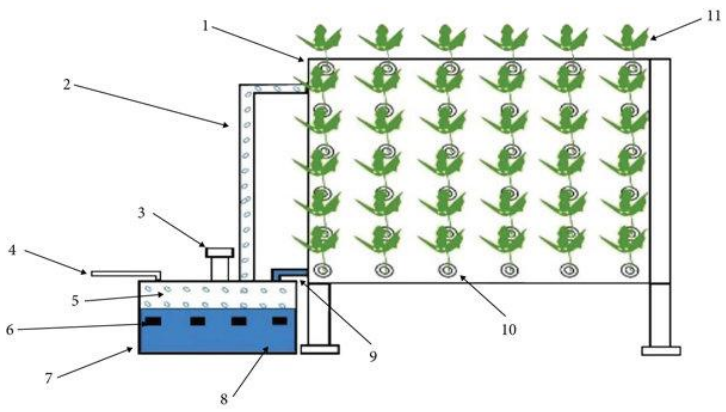


Food and agriculture

For growing plants in the Cerberus space station, the main tasks are soil synthesis and the creation of artificial sunlight.

Some space objects are rich in tholins—complex organic compounds—Pluto being the most prominent example. [11]
Soil for agriculture can be synthesized using Pluto's tholin. However, tholin is unsuitable without processing—it is insoluble in water and can be toxic to plants. Processing occurs in three stages:
1: Collection and processing of tholins by thermolysis or catalytic oxidation to convert them into simpler organic molecules.
2: Mixing processed tholins with mineral dust, water, salts, and microbiota produces a bioreactive pseudosoil.
3: Gradually colonize the soil with bacteria and mosses, which will begin to transform it into a fully functional "viable" environment.[10]

Growing in soil is suitable for plants that require it (trees and other plants).
To provide light for plant growth, specially tuned LED lamps can be used. [9]

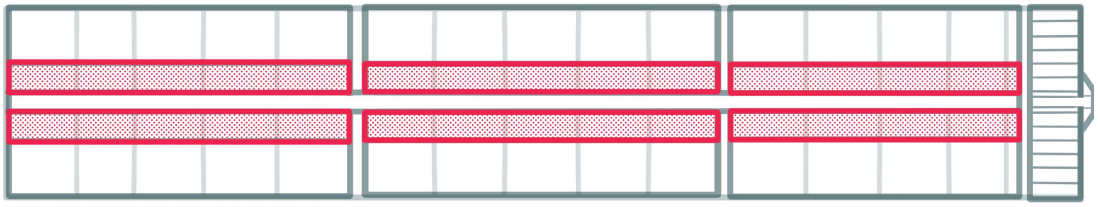


In addition to standard plant growing methods, most edible crops can be grown aeroponics [12]. Aeroponics, while energy-intensive, uses less water than other options. Hydroponics will not be used at the station, as it would require much more water than the station can afford. The table below shows the plants grown at the station, as well as the rationale for their selection.

Plants	Rationale for their selection
Lettuce, Arugula	Grow quickly, tested in space conditions
Spinach, Basil, Cilantro	Medical and nutritional properties
Radish, Carrot	Nutritional properties
Tomato, Pepper	Also nutritional properties, promising prolificness, yet are longer to grow
Aloe vera, Chamomile, Mint, Garlic, Lemon balm	Medical properties
Eucalyptus, Citrus, Olive	Oils, wood, psychological effect

Using laboratory-grown animal stem cells, it's possible to create artificial meat that contains all the necessary nutrients. [13] The meat can be created using specialized 3D printers that replicate the structure of muscle and fat fibers.
The stem cells, which are essential for all food products, can be stored in special banks and multiplied using the necessary substances synthesized by autotrophic bacteria.

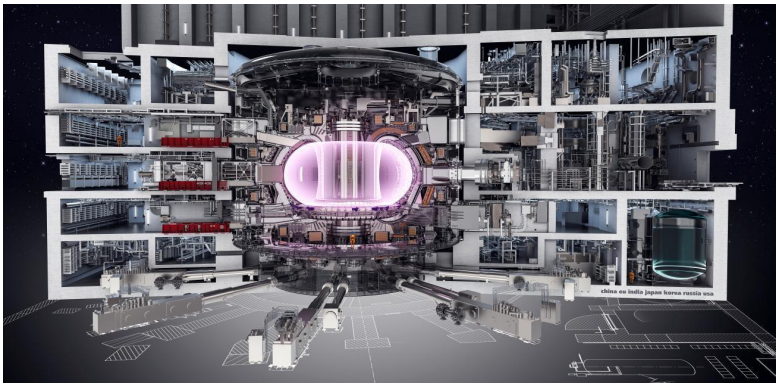
Industrial modules



Cerberus Station will house an industrial and energy zone in the second-layer networks. Access to the industrial zone from the residential zone will be via special elevators, and it will house the majority of jobs for the station's residents. The industrial zone will focus on the following primary activities: production of materials for construction or replacement of station parts, equipment manufacturing, fuel production for fusion reactors, fuel production for ships, resource logistics throughout the station, material and resource warehouses, and everything else intended for heavy work or part thereof, as well as products for civilian use. Since metal is quite limited, most metal and ceramic products will be created on 3D printers. [14][15]

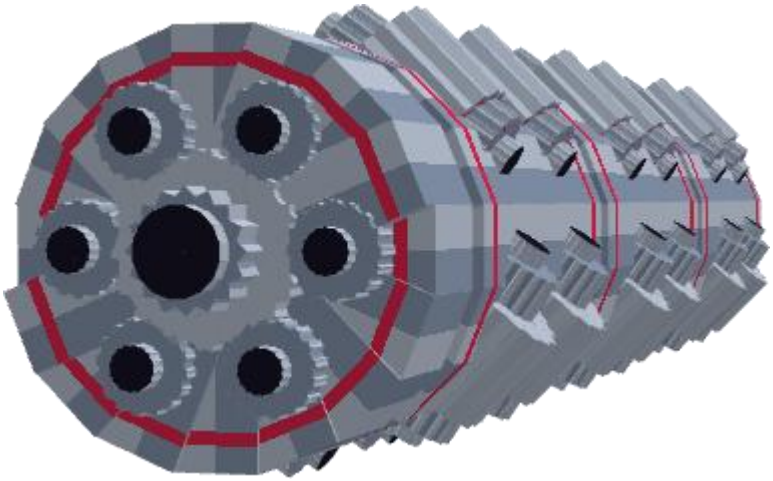
Electricity generation

The station's electricity will be generated by fusion power plants. Fusion reactors and their components will be located in the center of the industrial zone of all large sectors except the spaceport. Fusion power plants are efficient because they require little fuel relative to other options, have a high power output, produce no hazardous waste, and an accident there cannot destroy the entire space station (unlike nuclear power plants). Each fusion power plant will produce approximately 1.5 gigawatts of energy at maximum output—a total of 4.5 GW. The station's energy consumption is estimated to be around 2-3 GW, with peak power consumption reaching 4.5 GW (a third plant will act as a backup and will be activated when the others are unable to cope).



The only available fusion fuels are deuterium and tritium (helium-3 is unavailable). Deuterium can be synthesized using protium and nanocrystalline silicon—deuterium is efficiently produced on the surface of the latter.[16] Tritium can be produced in reactors themselves using two methods: through a lithium-6 blanket [17] and through the collision of deuterium and deuterium, which produces one protium and one tritium. Although the fuel is expensive to produce, small reserves last a long time (maximum one ton per 10 years).

Operational module



The Operations Module is the control "brain" of the entire station. It consists of multiple control buildings within Cerberus, from which the following aspects are controlled:

The rotation speed of the entire station (via external thrusters)

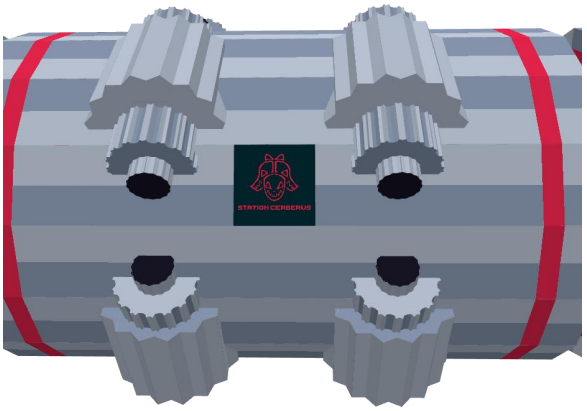
The rotation speed of the internal floors (via mechanical components in the walls)

Orbital position (for adjusting the station's position, also via external thrusters)

Logistics for the central channel and industrial sector

Energy and resource management

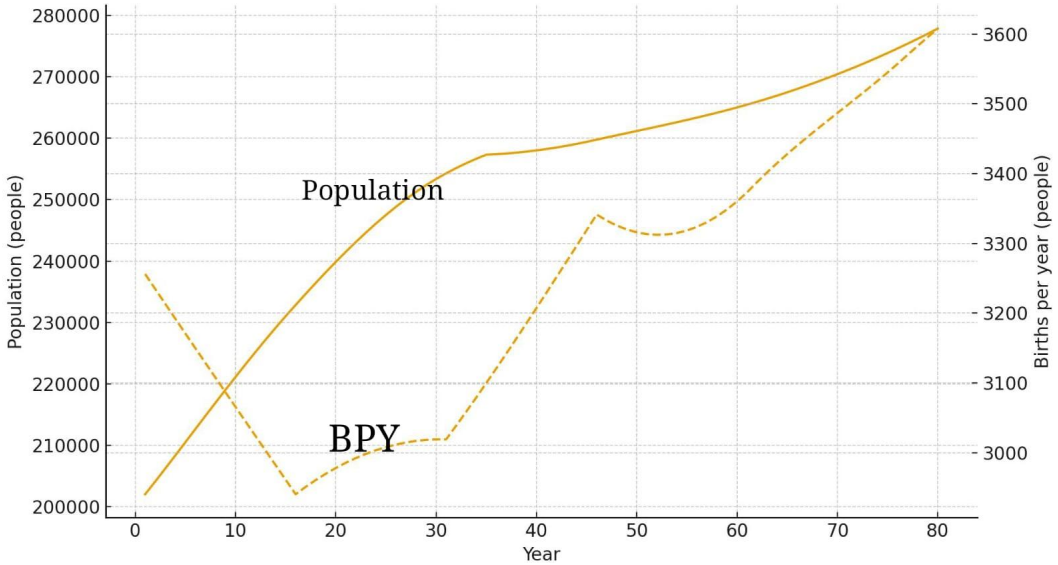
Resource excavation mission assignments

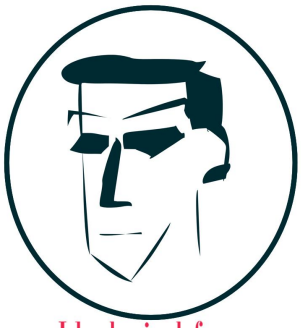


LIFE

Demography

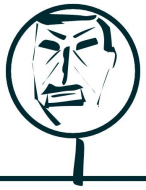
The station's initial population will be 200,000, but can support up to 300,000.
Population growth in the station is regulated by a special demographic law: families are prohibited from having more than three children. As the population approaches 300,000, a stricter law is applied, prohibiting families from having more than two children. Below is a population forecast chart that takes into account station conditions and the demographic regulations set forth in the law.





Ideological face
- speaks to people

Chief Executive



Parliament
- managing everything

Government

The station's government will consist of a 250-seat parliament, a chief executive who will govern the station de facto, and an ideological "face" and orator who will govern Cerberus de jure. Access to parliament will be restricted to specialists in their respective fields, and the parliament will be divided into multiple sections, each representing a specific area and governing each section of Cerberus. Large meetings of the entire parliament will be held to address the most important issues, requiring little specificity.

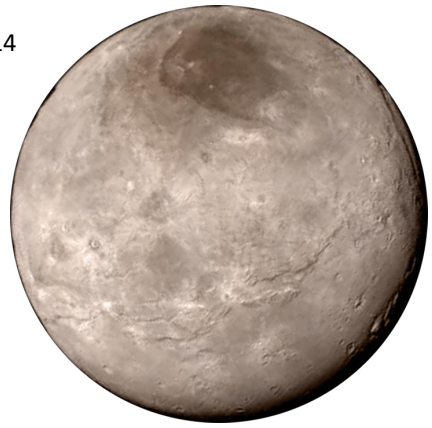
Law

The station's laws will be standard, based on the American Constitution, but with additions such as changes to the government, a one-party system, space laws, including laws governing spaceships, a demographic law, laws related to modules and sectors, and so on. Punishments include hard labor in the industrial sector, criminal imprisonment, or both.

RESOURCES

PLUTO [18]

Ices:
N2, CH4, CO, H2O, C2H6
Tholins:
complex organic materials from exogenic
and endogenic sources
Best source of tholins. Main problem - It is relatively expensive in terms of fuel to fly from Pluto (Pluto has the highest gravity of all objects in the system)

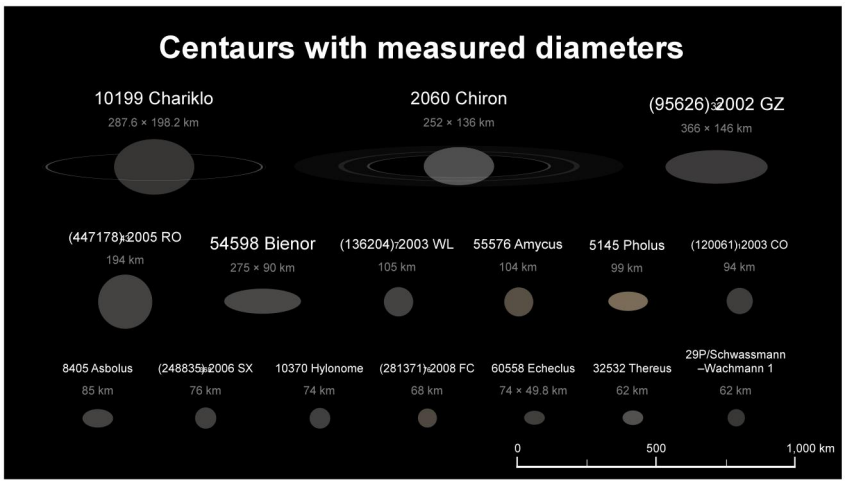


CHARON [18]

Ices:
H2O, NH3
Tholins- part of tholins from Pluto got to Charon
Has large quantities of H2O, and it is the closest to station.

SMALLER MOONS OF PLUTO

They consist mainly of ices and they are the cheapest for return flights because of their low gravity



CENTAURS

They are the farthest from the station relative to other objects, but at the same time they are the only ones that can contain solid metal or silicates on their surfaces. [19]

Resource extraction

Various methods can be used to collect various ices from Pluto and its moons on different mining ships and stations. Methane and water are among the most important elements. Methane is the primary propellant on the station, and water is essential for a wide range of processes. However, collecting other ices is also important. Method 1 involves scraping and collecting the cold material, while Method 2 involves heating and collecting the gas/liquid, then packaging and storing it back into a solid state.[20] Method 1 is also applicable to collecting tholin from Pluto.

To mine metals and silicates on the Centaurs, satellites must first scan the surface of nearby moons for metal, and then deploy large spacecraft for surface mining using drills, augers, and controlled robots. Mining on the Centaurs is the most difficult and fuel-intensive, but it is the only way to replenish metal and silicate reserves without drilling 160 kilometers into Charon.

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AI USE - population forecast chart