SPACE NOA+

Colony orbiting around Ross 128 b
Terraforming Space Station

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1-Introduction

“God said to Noah

Make yourself an ark of cypress wood;

Make room in it and coat it with pitch inside and out.”[1]

With increasing space development technology, it is possible to explore planets farther than Jupiter. However, the farther we get from the sun, the weaker the sunlight becomes and solar-powered energy can not be obtainable. The desire to go to more distant stars is a human dream. However, these explorations may last for decades, and many problems have to be solved.

We made a scenario where Earth is unlivable and people have to look for a new planet to live on. In this way, we can more easily identify problems with space travel.

We had three obstacles when designing Space NoΛ+;

1-Design a concept of a new engine called an “Accelerated Plasma Propulsion Engine” and Methods of interstellar travel.

2-Proposal for an artificial hibernation program.

3-An environmental design for long-term living in the space station.

Figure(1) 1994,Pale Blue Dot: A Vision of the Human Future in Space, By Carl Edward Sagan [2]

2-Method

It was difficult to get together and have meetings because members went on summer vacation. So, we had Zoom meetings for consecutive days. We searched the internet for related topics and brainstormed by watching videos. The Zoom meeting was recorded, and the members' opinions were added to the Google classroom. In addition, each member selected their theme and held their Zoom seminar. Then, each member wrote down one chapter. Each member put together their chapter and made a proposal. For the design, to have an identity on the proposal, one of the members designed the whole image using Blender. To propose artificial hibernation, we received direct advice from Dr. Genshiro Sunagawa, a world top-class scientist on artificial human hibernation. We visited the SLAC National Accelerator Laboratory of Stanford University and received advice from a researcher to design the accelerated plasma propulsion engine. We also studied electromagnetism to understand the Lorentz force. In addition, we learned mechanics and mathematics to calculate interstellar travel.

Figure(2) Zoom Meeting

3- Background

Earth was made 4.6 billion years ago. (3) Microorganisms started living on Earth 3.5 billion years ago. (3-1) During 3.5 billion years, five great extinction occurred. (4) 65 million years ago, dinosaurs were extinct in a single meteorite impact. (5) Three hundred thousand years ago, mankind appeared in Africa. (6) We evolved and developed science and technology, and now we travel to space. In the 21st century, mankind will build colonies on the Moon and Mars. (7) The Space NoΛ project, that was our previous proposal to NSS Space Settlement Contest 2022, was built to conserve life on Earth. We are now living in a new era of space exploration.

We assumed the following situation to clarify the problems in proposing the contest. Earth is facing the 6th mass extinction. Humanity has already built colonies on the Moon and Mars and completed the space station named Space NoΛ on Lagrange point 1. People were temporarily evacuation to these facilities. However, the damage to Earth was worse than expected, and people have to give up returning to Earth. Colonists building their civilization on the Moon or Mars have frequent health problems due to the lack of gravity. When babies are born in the colonies, their bone structure is abnormal from the lack of enough gravity,(8) soon will wipe out all colonies. The passengers of Space NoΛ concluded that it became impossible for them to return to Earth and that we could not survive in the solar system anymore. We dismantled Space NoΛ and built the flying space station, called Space NoΛ+. However, there are no planets or satellites that are Earth-like nearby. So, we selected Ross 128 b(12), which is close to the solar system and it is an Earth-like planet. The reason for the selection is that it is located in the habitable zone, the gravity is almost the same as Earth, and there is liquid water, having an atmosphere. The sun of Ross 128 b, Ross 128(12-1) is 7 billion years old, so the radiation is not strong. To get to Ross 128 b, it was necessary to develop a new engine that would enable interstellar travel, and the power could not be solar energy but is a small nuclear reactor (SNR) because we will be leaving the solar system. We also have to make artificial hibernation technology. In addition, it is not possible to land immediately on Ross 128 b. It is thought that a very long period is required to create an environment where humans and other life can survive. Space NoΛ+ will remain as a colony in orbit of Ross 128 b permanently as a terraforming development base.

Figure(3) Earth

4- Setting condition of Space NoΛ+

Figure(4) Maximum capacity of passengers

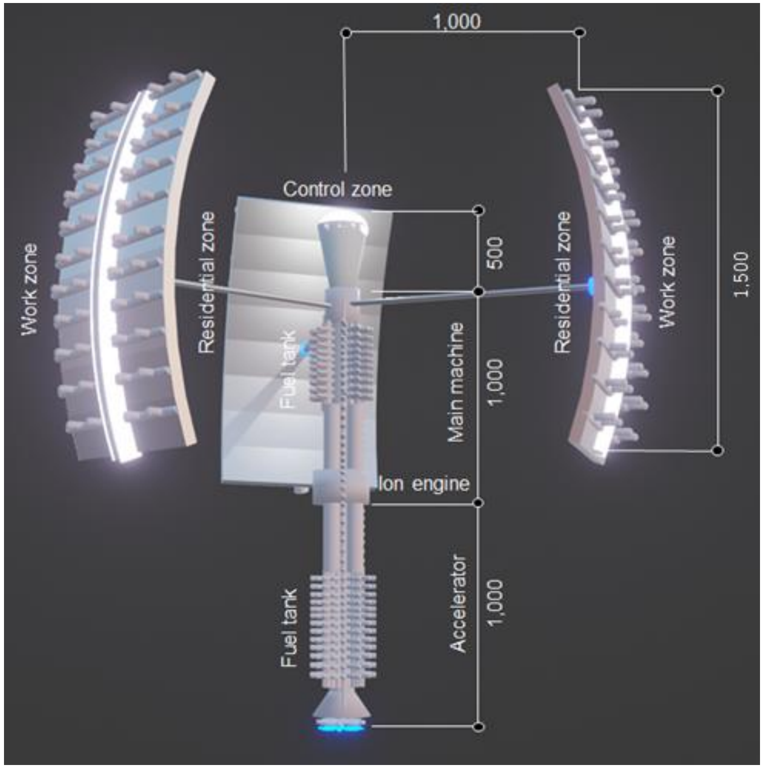
	person	Calculation
Passengers	27,000	2,200 (family/wing)×{ 2 (parents)+2.1(person/ family)[9] } ×3 (wings) =27,060 (person)

Figure(5) Maximum capacity of passengers

*Tower	Size	Person	Calculation
A-Tower	L=500m, H=30m, D=20m	2,250	125(families/Floor)×6(floors)=750(families) 750(families)×3(person/family)=2,250(person)
B-Tower C-Tower	L=785m, H=30m, D=20m	6,840	190(families/Floor)×6(floors)=1,140(families) 1,140(families)×3(person/family)×2(towers)=6,840(person)
	Total	27,000	9,090(sub total of one wing)×3(wings)=27,270(person)
Average one housing unit size, A:W=4.0m, D=20m, H=3.5m, S=80m^2 ,B:W=4.0m, D=15m, H=3.5m, S=60m^2			

* See Figure(13)

Figure(8) Structure of Space NoΛ+



Figure(6) Population composition by age

15 years old or younger	9,000(person)
15 years old and more	18,000(person)
Total	27,000(person)

Figure(7) Occupational population

(1)Control	500(person)
(2)Engineer	3,000(person)
(3)Factory	2,700(person) 10%
(4)Food	2,700(person) 10%
(5)Handling (three wings)	2,700(person) 10% each wing
(6)Medical care, Hibernation	2,700(person) 10% each wing
(7)Scientists/Education	1,000(person)
(8)Child	9,000(person)
(9)Other	2,700(person)
Total	27,000(person)

Figure(9) Artificial gravity

a- Acceleration	$g=9.8m/s^2$	
b- Rotation	T=63.44 (s)	$g=r\omega^2$, $\omega=(g/r)^{1/2}$, $T=2\pi/\omega=2\pi(r/g)^{1/2}$, r=1,000 (m/s),

Figure(10) Weight of Space NoΛ+

677,000(t)	ISS (w×d)=(108m×73m), weight=450(t) One tank of Space NoΛ+ (120m×30m) ≒1/2 ISS Volume of Space NoΛ+ ={1/2×500(tank)+500(wings) +500(main machine)}×450(t)= 676,750 (t)

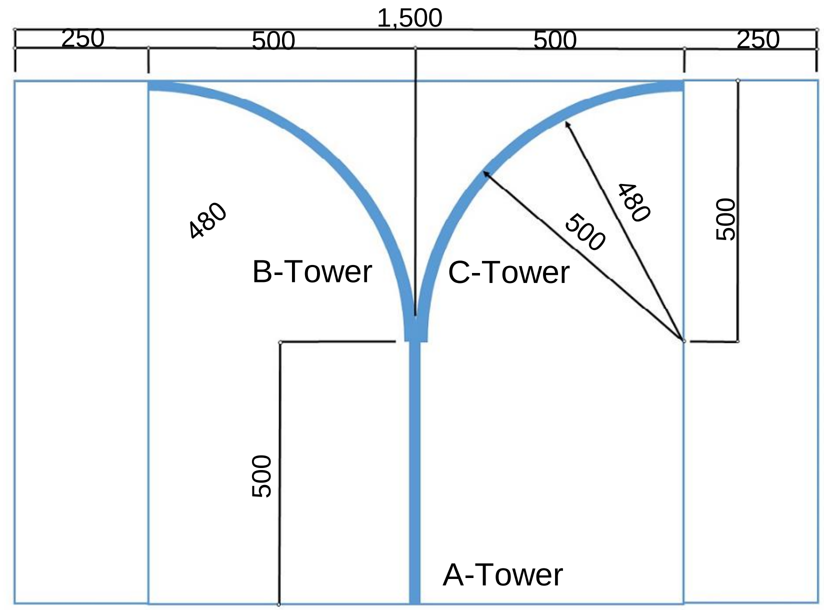
Figure(11) Weight of water

21,195(t)	Volume of one water tank $=3.14\times15^2\times60=42,390(m^3)$ =42.39(t) Total weight of water ={(240(tanks)+260(tanks)}×42.39 =21,195(t)

Figure(12) Weight of liquid hydrogen

1,500,606(t)	Total weight of Hydrogen Mass of liquid hydrogen 70.8 (kg/m^3) (10) 500 (tanks)×42,390(m^3)×0.0708(t/m^3) =1,500,606(t)

Figure(13) Apartment house layout plan of the wings



5- Investigation
5-(1) Second Earth

List the most suitable terrestrial planets for human migration.

Planetary state

a. Rocky planet
b. Habitable zone
c. Rich in liquid water
d. Not too close to the main star.
e. Belonging constellation
f. Distance from the earth
g. Main star
h. Orbital period
i. Size compare to Earth
j. Atmosphere
k. Water
l. Distance from the main star (comparison between Earth and the sun)

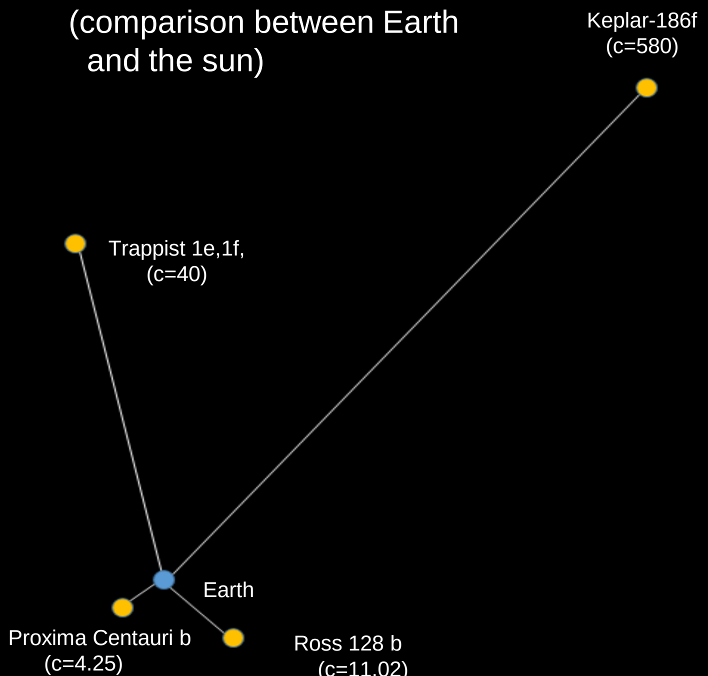


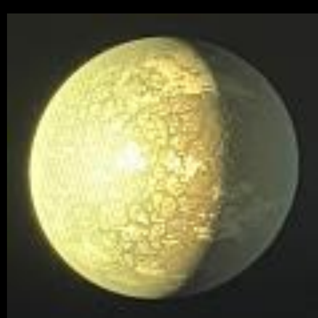
Figure (14) List of the second Earth

1-Proxima Centauri b[11]	2-Ross128 b[12]
a. yes	a. likely
b. yes	b. yes
c. possibly	c. possibly
d. yes	d. yes
e. Centaurus	e. Virgo
f. 4.25 light years	f. 11.02 light years
g. Proxima Centauri	g. Ross128
h. 11.2 earth days	h. 9.9 earth days
i. <~130%	i. >30%
j. unknown	j. possibly
k. possibly	k. If there is an atmosphere
l. 1/20 (0.05au)	l. 1/20 (0.05au)
Possibility of life underground because of x-rays and radiation	There is a high possibility of life. We chose Ross 128 b to the second Earth.
	

Figure (15) List of the second Earth

3-Trappist 1f[13]

a. unlikely fully rocky
b. yes
c. unknown
d. yes
e. Aquarius
f. 40 light years
g. Trappist-1
h. 9.2 6 earth days
i. <~1.045 radius
j. likely (not confirmed)
k. possibly
l. 0.037 2u



4-Trappist-1e[14]

a. yes
b. yes
c. unknown
d. yes
e. Aquarius
f. 40 light years
g. Trappist-1
h. 6.099 earth days
i. 91% earth radius
j. unknown
k. possibly
l. 0.02928285 au

5-Keplar-186f[15]

A .possibly
b. yes
c. unknown
d. yes
e. Cygnus
f. 580 light years
g. Keplar - 186
h. 129.9 earth day
i. <11%
j. unknown/possibly
k. If it is rocky
l. 0.04 au

Seasonal changes like Mars

5-(2)-a. Flight Plan

As this is a continuation of Space NoΛ, the last year's project, we started at Lagrange Point One, an area where neither the Earth's nor the Moon's gravity pulls Space NoΛ to either body. And our goal is Ross 128 b which is a relatively close exoplanet from Earth and its distance is 11.02 light years. The flight plan is divided into two parts, which are outer planet and interstellar.

This flight method of Space NoΛ+ is similar to the ancient navigation method. For example, according to Herodotus Book 4, 2,600 years ago, the Phoenicians set sail from the Red Sea to explore Africa. In the spring, they landed and sowed wheat, waited for the harvest, and then went out again. [16] They returned to the Mediterranean from the Straits of Gibraltar in the third year. The flight plan of Space NoΛ+ was made regarding such ancient navigational methods.

Solar energy cannot be used outside the solar system, so we installed a small nuclear reactor (SNR) for electrical energy. Also, there is no place to refill water or liquid hydrogen out of the solar system until we get to Ross 128 b. Therefore, we have to prepare enough water and liquid hydrogen before we leave the last port of call, Charon (Pluto).

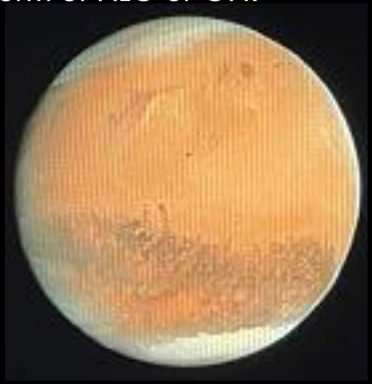
The fastest human-made vehicles are Helios-2. Its speed is 70 km per second. [17] If we travel at the speed of Helios-2, It would take 47,229 years to get to Ross 128 b. But with a Space NoΛ+ engine, just by accelerating 1G ($9.8 m/s^2$) for 60 days, the ship can go 17% of light speed. After that, the ship flies in a linear motion for 65 years, and then deaccelerates for 60 days again. The technology for this is already built, as humans can travel faster than 1G.

Figure(16) Outer Planets (Solar system)

1-Mars [18]

a. Orbital period =1.88085yr.
b. Surface gravity =$3.720 m/s^2$
c. Escape velocity =5.027km/s<11.2km/s [19] (Earth)
d. Rocky planet
e. Rich in liquid water
f. Rich Hydrogen
g. Rich in gas Xenon

Liquid water on the surface of Nars does not exist because the atmosphere is thin.
Hydrogen exists in the form of H_2O or OH. [20]



2-Europa (Jupiter) [21]

a. Orbital period =0.009729yr.
a. Surface gravity =$1.314 m/s^2$
c. Escape velocity =2.025km/s<11.2km/s [19]
d. Rocky planet
e. Rich in liquid water
f. Rich Hydrogen

Figure(17) Outer Planets (Solar system)

3- Enceladus (Saturn) [22]

a. Orbital period
=0.00375402yr.
a. Surface gravity
b. =0.113m/s^2
c. Escape velocity
=0.241km/s<11.2km/s [19]
d. Rocky planet
e. Rich in ice water
f. Rich Hydrogen

Enceladus has the organic matter, heat sources, and water needed for life, so life may exist.

4- Miranda (Uranus) [23]

a. Orbital period
=0.003872545yr.
a. Surface gravity
=0.077m/s^2
c. Escape velocity
=0.193km/s<11.2km/s [19]
d. Rocky planet
e. Rich in ice water
f. Rich Hydrogen

The reason for choosing Miranda is that there is water on the surface and the escape velocity is low.

5- Triton (Neptune) [24]

a. Orbital period
=0.01610096yr.
a. Surface gravity
=0.779m/s^2
c. Escape velocity
=1.455km/s<11.2km/s [19]
d. Rocky planet
e. Rich in ice water
f. Rich Hydrogen

6- Charon (Pluto) [25]

a. Orbital period
=0.01749863yr.
a. Surface gravity
=0.59m/s^2
c. Escape velocity
=0.59km/s<11.2km/s [19]
d. Rocky planet
e. Rich in ice water
f. Rich Hydrogen

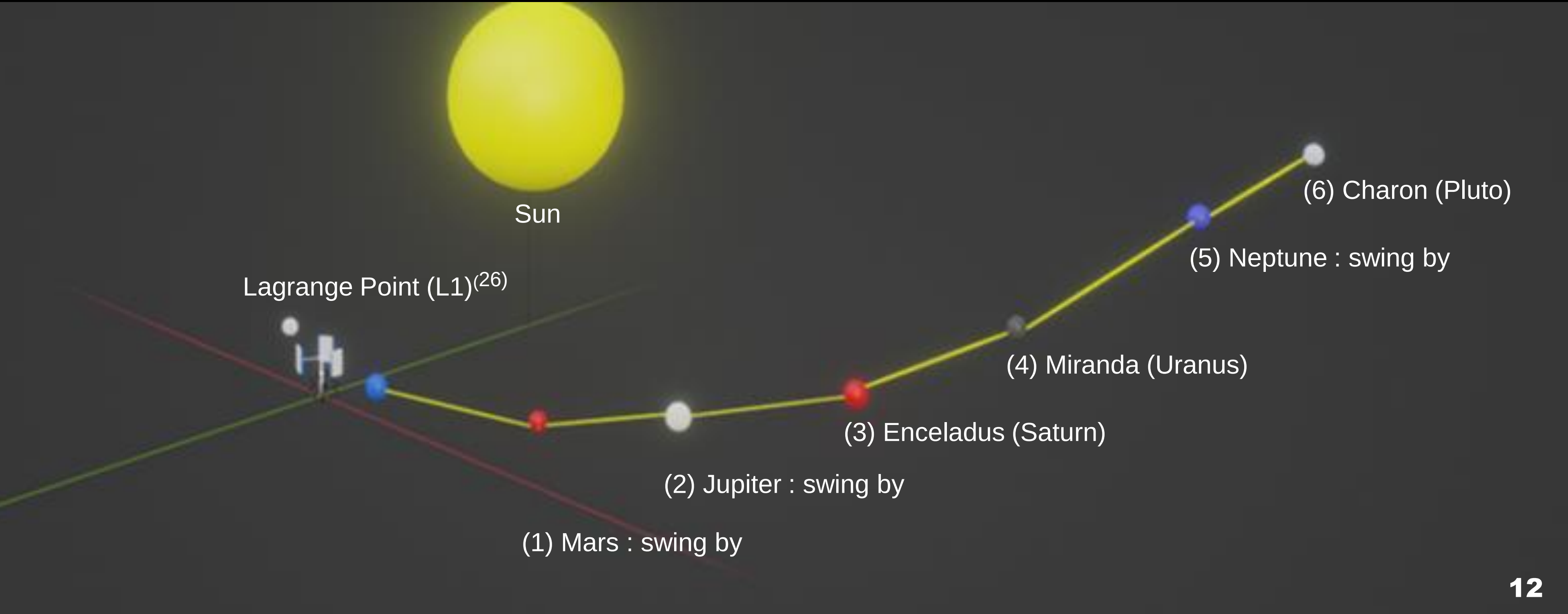
5-(2)-b. Flight Plan A (Outer planet)

The flight plan is divided into two parts, which are outer planets and extrasolar planets. During outer space flight, we have to prepare for interstellar flight such as water, liquid hydrogen, mineral, and so on. Space No⋀+ has no landing function. Instead, there are small spacecraft with chemical fuel rocket engines to collect water and other materials. Space No⋀+ has four fixed small nuclear reactors (SNRs) and one portable SNR. Two SNRs for the Plasma Propulsion engines, one SNR for energy for living, and one SNR for backup. The portable SNR is installed on a small spacecraft inside Space No⋀+. It is used to power other ships and collect frozen water together with the work spacecraft. The necessary water will be secured on the Moon before departure. The water, that is used during the flight, will be replenisged at other stops along the way.

Space No⋀+ stops on three satellites along the voyage to load water and necessary materials from the trip and swings by three planets. Travel time to each port of call will be two years on average. We will pass the Moons of Mars, Jupiter, and Neptune because their escape velocity is over 1.0km/s. It means to need a lot of energy to take out water. Instead, Space No⋀+ will swing by and accelerate.

Continuing to Saturn's Moon, Enceladus, they collect water and liquid hydrogen on Miranda of Uranus and Charon of Pluto. Space No⋀+ has to fill all tanks with water and liquid hydrogen before leaving each stop

Figure(18) Flight Plan A (Outer planets)



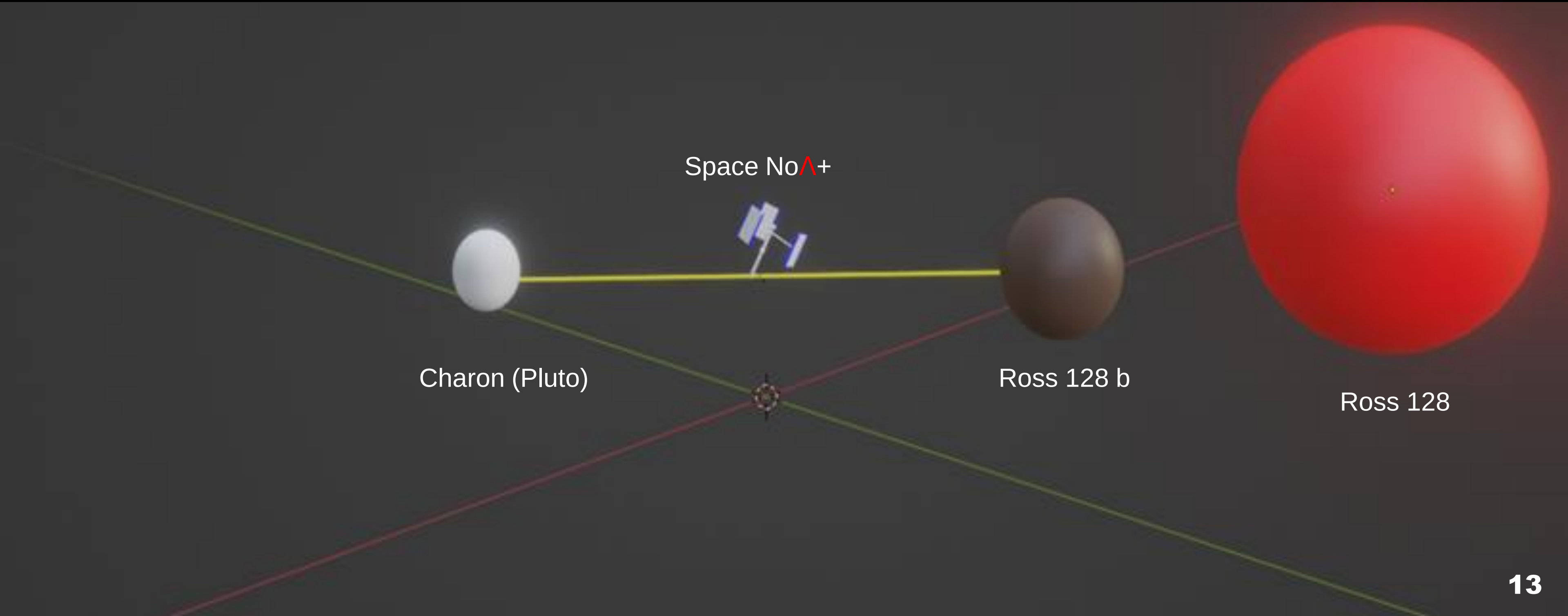
5-(2)-c. Flight Plan B (Extrasolar planet)

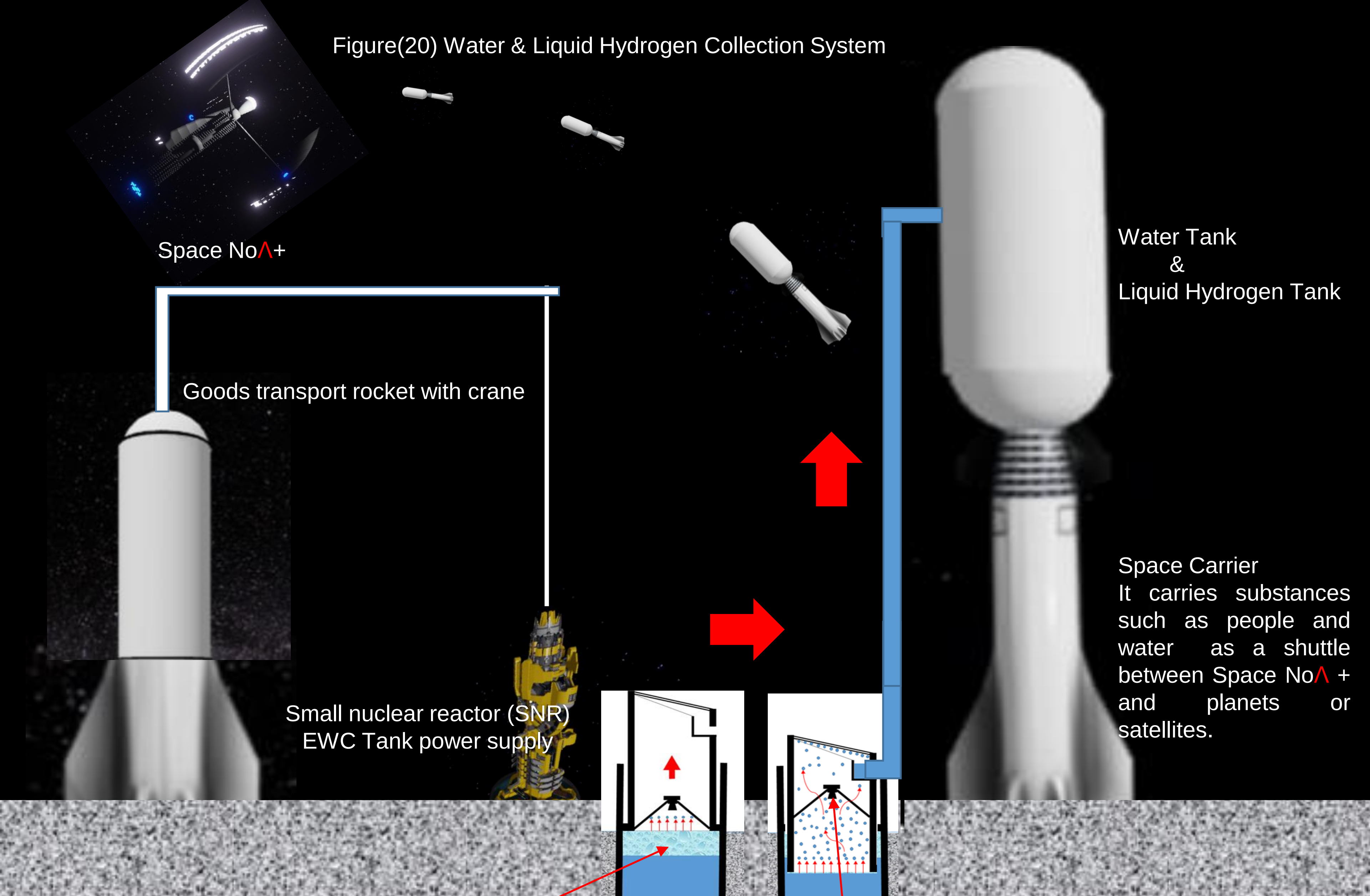
From Pluto's Moon, Charon, we travel straight to Ross 128 b. The voyage will be divided into three stages. *Phase 1 is to accelerate Space NoΛ+. The ship will take 60 days to accelerate at 1G ($9.8m/s^2$) with the plasma propulsion engine and the top speed will be 50,800km/s, which is 17% of the speed of light. Phase 2 is a period of constant velocity flight. It lasts 65 years and all passengers are in intermittent artificial hibernation. During the flight, Space NoΛ+ will be fully automated and the AI computer uses radar to check for obstacles ahead and calculates the safest and shortest course to fly. Phase 3 is the period to deaccelerate. And it is 60 more days. Passengers are programmed to wake up sequentially based on an artificial hibernation schedule, starting one year before the end of Phase 2. Our extrasolar travel from Charon to Ross 128 b will take a total of 65 years and 120 days.

When Space NoΛ+ enters orbit around Ross 128 b it will be the colony of terraforming development for several generations. Space NoΛ+ has a lot of animals and plants brought from Earth. When the animals migrate to Ross 128 b, we need to carefully observe whether Earth life forms can live together with Ross life forms. We must never be invaders.

*See Figure(22)

Figure(19) Flight Plan B (Outer planets)





Figure(20) Water & Liquid Hydrogen Collection System

Turn ice into steam with a magnetron. Cool the steam and collect distilled water. Collecting as water does not require drilling hard ice and 50% or more efficient than carrying ice.

Figure(21) Flight plan B: from Charon to Ross 128 b (11.02 light year away[12])

Plan-A

The fastest spacecraft developed by mankind
(Helios-2: 70km/sec)

(1) How far light speed can travel in a year

Seconds in a year
=365×24×60×60
=31,536,000 (sec/year)
Distance that one light year
= 31,536,000×300,000
=9.4608e12 (km/year)

(2) The fastest spacecraft developed

Velocity=70 (km/sec)*
Distance that one year
=70×365×24×60×60
=2.20752e9 (km/year)
Time required to fly one light year
=9.4608e12/2.20752e9
=4,285.714 (year)

(3) The required time to go to Ross 128 b

the required time
=11.02×4,285.714
=47,229 (years)

***How is speed measured in interstellar flight?**

Accurate speed cannot be obtained as the flight speed becomes faster than the time on the ground. In Space NoΛ+, the speed measured by the redshift of the target sun's light (Ross 128). Due to the Doppler effect, the spectrum shifts to the blue direction when accelerating, and to the red direction when decelerating.

Plan-B

Accelerated plasma propulsion engin rocket
(Acceleration time: ±60 days)

(1) Speed after acceleration (km/sec)

g: Gravity (9.8m/s$_2$)
c: Speed of light (300,000km/sec)
t_{60}: 60days' time (sec)
v_{60}: After 60days accelerated velocity
t_{60} = 60×24×60×60
= 5,184,000 (s/60days)
v_{60} = g×t_{60} (m/sec)
= 9.8×5,184,000
= 50,803,200 (m/sec)
= 50,803.2 (km/sec)*<300,000 (km/sec): 16.93%

(2) Distance to Ross 128 b (km)

$L_{c.year}$: Distance traveled for one year of light speed
$L_{60.year}$: Distance traveled for one year by v_{60}
$L_{c11.02}$: Distance traveled for 11.02 light year
t_{year} = 365×24×60×60
= 31,536,000 (sec/year)
$L_{c.year}$= 300,000×31,536,000
= 9.4608e12 (km/year)
$L_{c11.02}$ = 11.02×9.4608e12
= 1.04258e14 (km)
$L_{60.year}$= 50,803.2×31,536,000
= 1.60213e12 (km)

(3) The required time to go to Ross 128 b

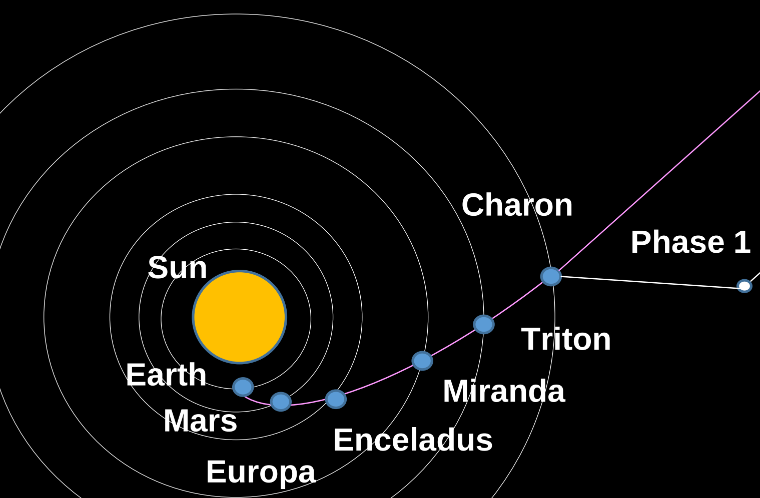
t = $L_{c11.02}$/$L_{60.year}$
= 1.04258e14/1.60213e12
= 65.071
= 65(years)

Figure(22) Flight plan from Lagrange Point One to Ross 128 b

Flight Plan A

1-Fligft rout
Start: Earth (Lagrange point one)
(1)Mars …swing by
(2)Europa (Jupiter) …swing by
(3)Enceladus (Saturn) …port of call
(4)Miranda (Uranus) …port of call
(5)Triton (Neptune) …swing by
(6)Charon (Pluto) …port of call
*Go to flight Plan B
2-Total Period 10years
As for the departure time from one port of call to the next port of call, consider the time of water and fuel collection and closest approach each other.
The average travel period from one port of call to the next port of call is two years.

Flight Course A



Ross 128 b

Phase 3

Flight Plan B

Phase 3

1- Engine	restart
2-Period	60days
3-Acceleration	$a=-9.8m/s^2$
4-Velocity	Orbital speed

Phase 2

1- Engine	stop
2-Period	65 years
3-Acceleration	a= 0
4-Velocity	v_{max}=50,800km/s (Ratio to the Light speed r=17%)

Phase 1

1- Engine	start
2-Period	60days
3-Acceleration	$a=9.8m/s^2$
4-Velocity	from v=0km/s to v_{max}=50,800km/s (Ratio to the Light speed r=17%)

5-(3) Space NoΛ+ Design

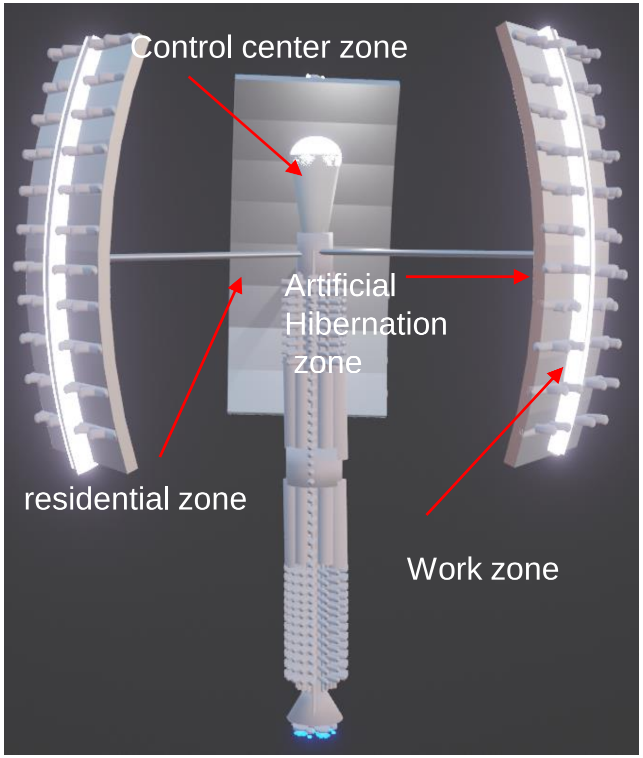
5-(3)-a. Zoning

Space NoΛ+ diameter is 2km. The height is 3km. There are three wings. Each wing is 1km wide and 1.5km long. The main rocket is located in the center and the residential zone and work zones are located on the three wings. The wings are rotating around the rocket producing artificial gravity. The wings will complete a full rotation in one minute, and give the artificial gravity $g=9.8m/s^2$. The center rocket is an accelerated plasma propulsion engine those are mainly used for interstellar flights. The wing has a chemical engine rocket that is used inside the solar system. The chemical rocket is docked on the ship meaning it can undock and fly independently. The three wings are connected by a passageway. Inside the passageway are elevators and different types of cables and pipes supplying the wings with electricity and water etc.

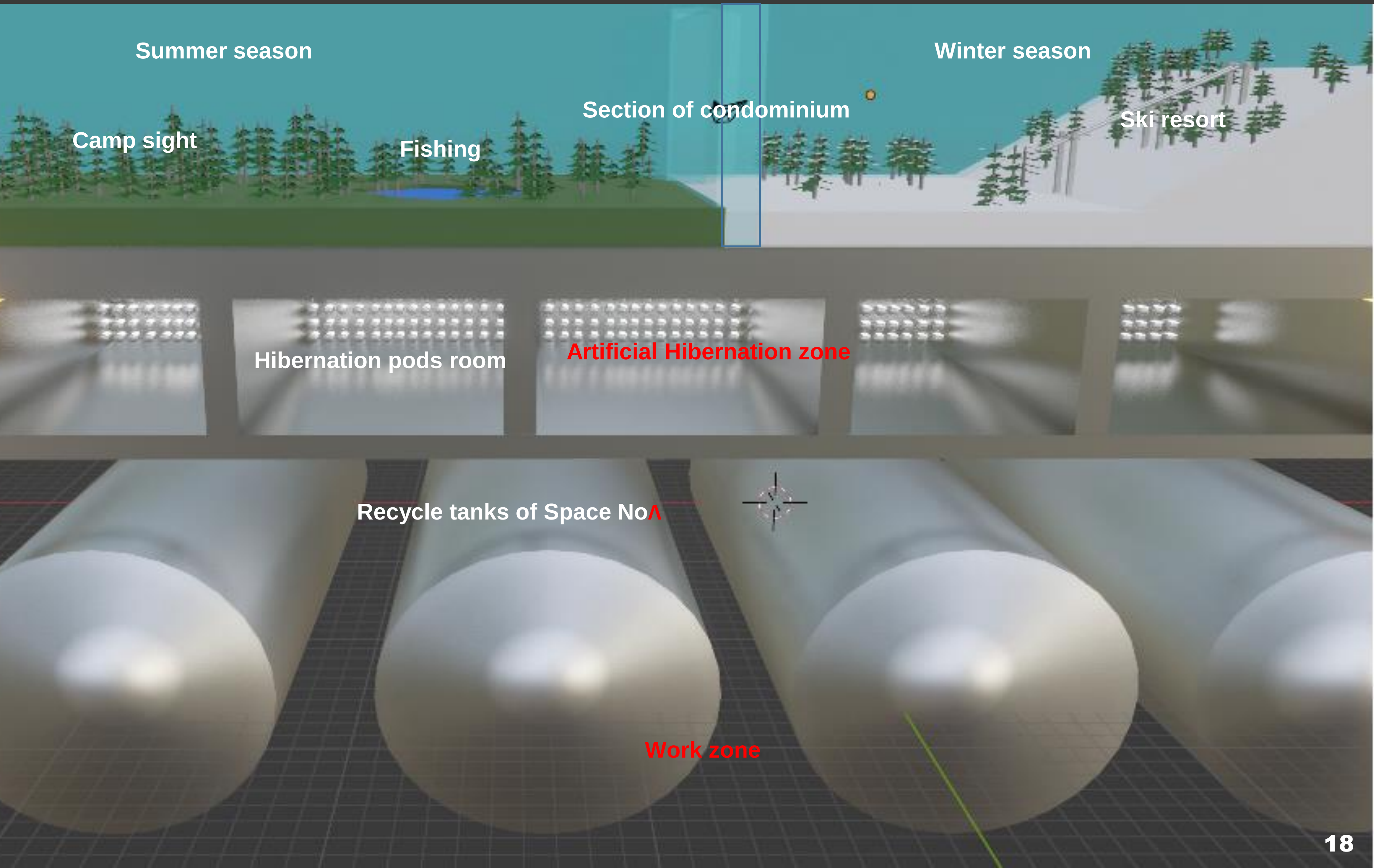
Figure(23) Zoning list

1-Control center zone	Located in the center to control the spacecraft. Control center, computer room, flight deck, observation room, engine room, power room, machine room, battery room, fuel tanks (500 tanks), Small nuclear reactors (4 SNR), accelerated plasma propulsion engines (49 engines), space-based laser station on small scale space debris.
2-Residential Zone	To spend daily life divided into three wings. Housing, park, tennis court, soccer court, baseball ground, trekking course, wall climbing, ski resort, skate, ice hockey field, sports gym, hospital, school, Assembly hall, training center, virtual library, music halls, shopping mall, recreation center, restaurant, virtual museum, virtual art museum, health promotion center.
3-Artificial Hibernation Zone	Artificial Hibernation is necessary for future space development. There is a hospital in the artificial hibernation laboratory. To go to Ross 128 b, we will hibernate 65 years.
4-Work Zone	Places for food production and space station maintenance activities. Water tanks(500tanks), power room, machine room, water supply, air conditioning, battery room docking port, chemical fuel rockets, solar panel, space factory (3D printers), maintenance repair, recovery room, field, fish tanks, food stockpile, orchard, pharmaceutical factory, chemical factory, clothing factory, construction. (All of the work is done by robots and will be monitored by a computer.)

Figure(24) Zoning of Space NoΛ+

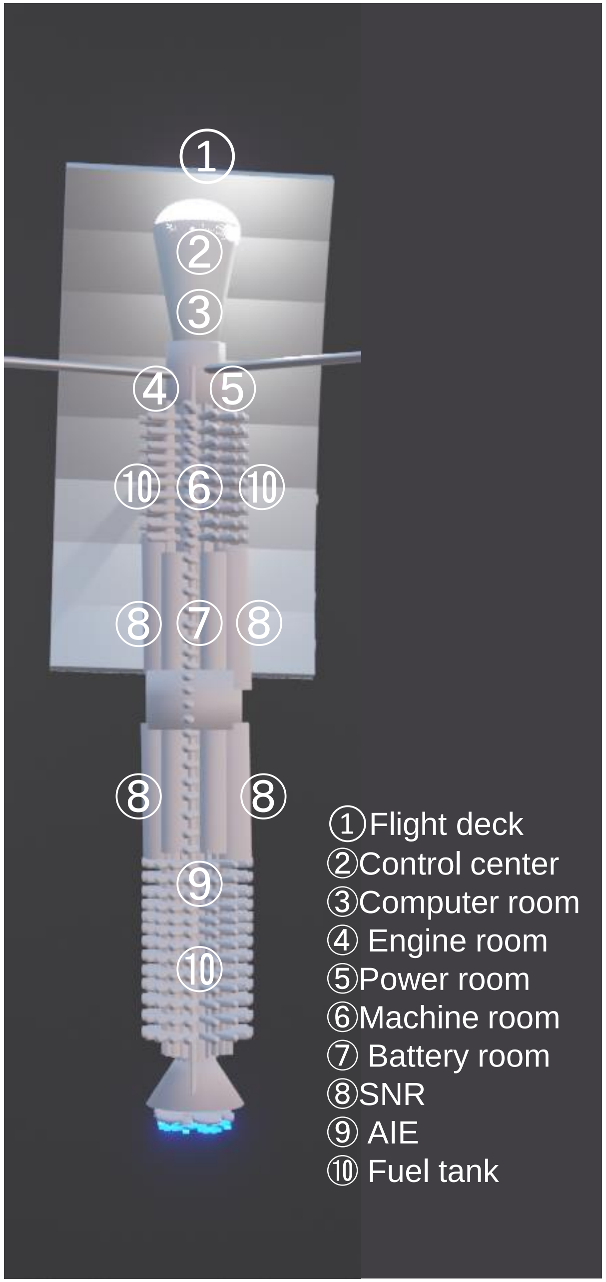


Figure(25) Three Zones of the wing



5-(3)-a-1. Control center Zone

Figure(26) Control Zone



Control center zone is in the middle of Space No∧+. The people on board the control center is listed on the chart bellow.

Figure(27) The population of the Control center

Position	Person	Criteria: Each position member is divided into 2 teams. Each teams is also divided into 4 other groups.
Officer	50	Commanders.
Crew	450	Pilots mission Specialists etc.
Engineer	3,000	Mechanical engineer, Air conditioning engineer, Electrician Rocket engine engineer, Nuclear power plant engineer, etc.
Total	3,500	

During interstellar flight the passengers will be in artificial hibernation. Space No∧+ will use intermitted hibernation, so 1/7 of the passengers will always be awake. For the three wings, there will be at least 2 commanders, 20 crewmember, and 140 engineers. They control space No∧+ for 24 hours in two shifts. The chart for the crew is below.

Figure(27-1)

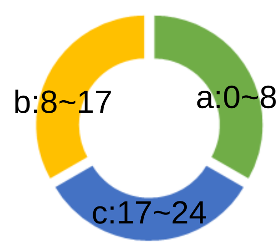
	In artificial hibernation		Normal time		Capacity
	one wing	three wings	one wing	three wings	
Officer	2	6	14	42	50
Crew	20	60	140	420	450
Engineer	140	420	980	2,940	3,000
Total	162	486	1,134	3,402	3,500

Figure(28) Work 2-months rotation

Team-A	Team-B

team-A	○	-	Group 1~4
team-B	-	○	Group 1~4

Figure(29) Working one day hours



Work 4-days rotation

Group-1	a	b	c	-
Group-2	b	c	-	a
Group-3	c	-	a	b
Group-4	-	a	b	c

5-(3)-a-2. Residential Zone

Various open space

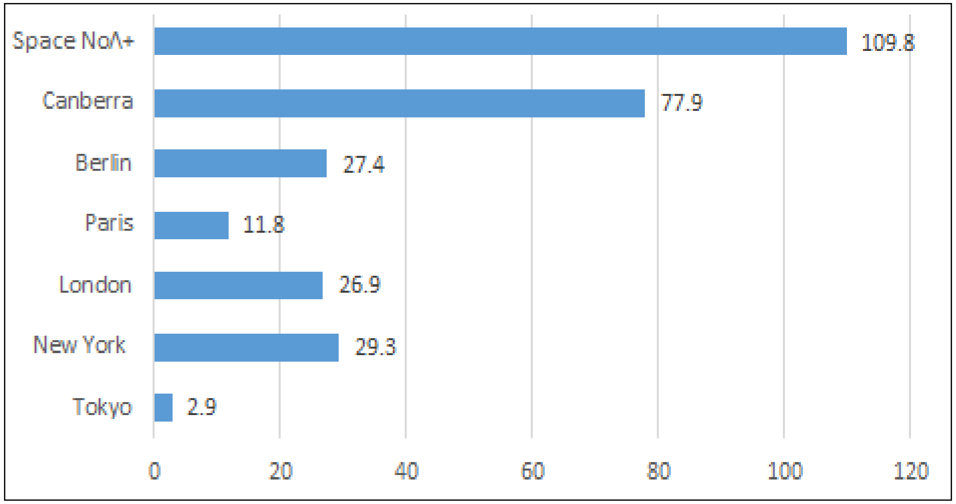
Being in a space station for a long time is stressful so we proposed diverse weather conditions. This picture is from the climate DF’s open space. It is snowing by an artificial snow-making machine. The ski resort has a 30-degree angle and is 1km. It can be used for ski competitions as well. The ski course surrounded by trees will feel like it is on Earth. We can fully enjoy life in the space station.

Figure(30) Ski resort

The Largest city park in the world

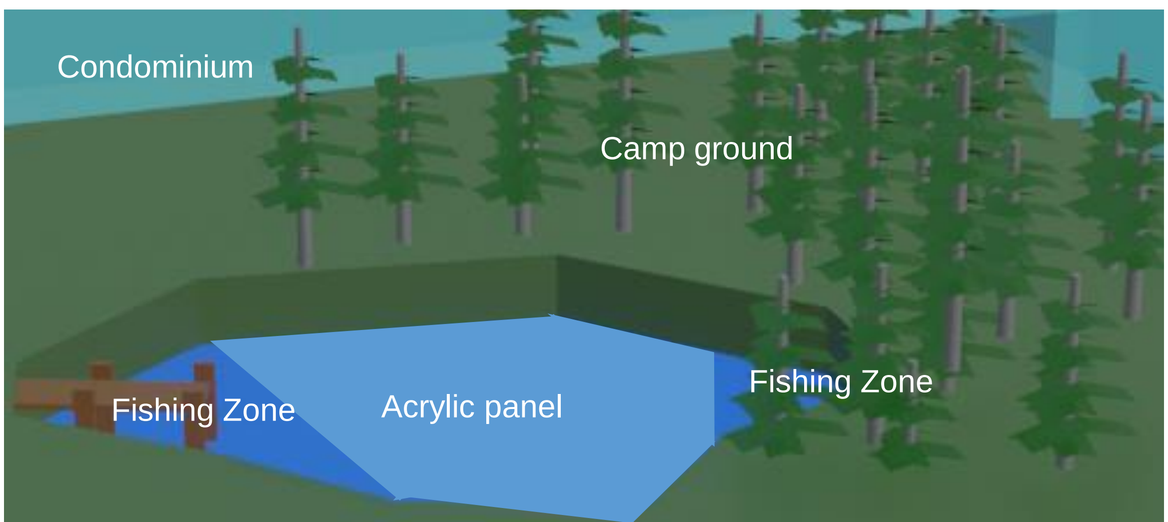
Each wing can hold up to 9,000 people so in total there are 27,000 people on Space No∧ + The living space is 1.5km by 1km. The residential unit is a high-rise apartment building to secure open space. All of the open spaces are parks so that passengers can continue to live in space for a long time. As a result, the area of the city park per resident became the largest in the world. (27)

Figure(31) The area of the city park per resident (m^2/person)

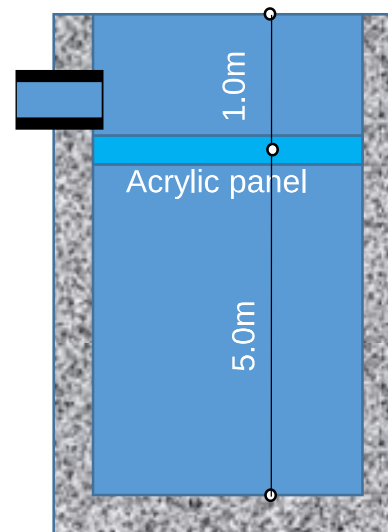


People on board can enjoy skiing, swimming, hiking, and camping, and fun activities that can make the passengers forget about being trapped in space. To make the passengers feel like they are on Earth there will not be a torus-shaped design, but rather a horizontal design similar to Earth. The large lake is dangerous if the artificial gravity stops, so there is an acrylic wall separating the lake in two. The top part will be 1 meter and the bottom part will be 5 meters. On the top part of the lakes, there is a high-speed drainage system so that if the gravity stops only 1 meter of the lake will be drained and the bottom 5 meters will not because there is an acrylic wall that prevents the water from escaping.

Figure(32) Residential zone lake



Figure(33) a high speed drainage system



Campout

Three of our members are Boy Scouts. I am one of them. The first time I went camping I was astonished by all the stars in the sky. Especially since I live in the downtown area, the light pollution makes it hard to see stars. Looking at the stars I felt how small we were compared to the universe and that there is so much more to explore. When ancient people looked at the sky they made up all kinds of stories to try to understand it. But now and in the near future, we can go to space and watch and even go to the stars that our ancestors gazed upon long ago.

Figure(34) Campout

Conservation of animals and plants

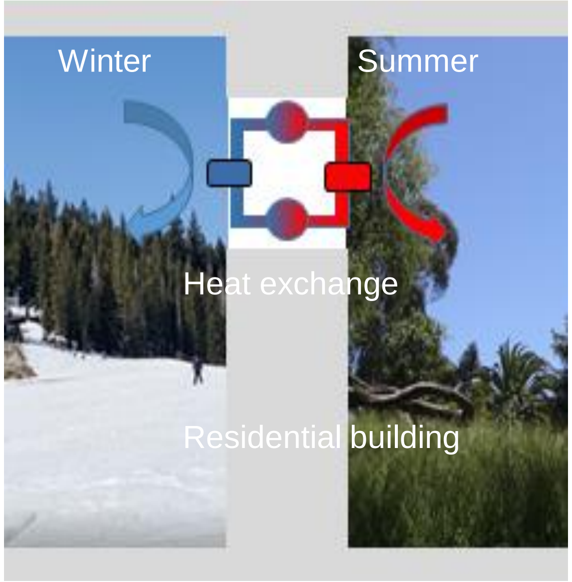
The purpose of Space No∧+ is to preserve a variety of life on Earth. It is the natural environment that divides life into various species. Humans are a part of these diverse life chains. And it is the climate that has a great influence on the natural environment. [28] One wing has three separate parks. The parks have different weather and seasons. Every park has four seasons. Using these changes in weather we can conserve animals by letting them live not by hibernation. These diverse weathers will make the passengers feel elated.

The Residential zone animal and plant conservation criteria are listed on the chart below.

Figure(35) Animal and plant selection criteria

1. Animals that can make humans happy (dogs, cats, etc.)
2. Small wildlife animals (Birds, Fish, etc.)
3. Organisms that are beneficial to the natural environment (Bees, Moles, etc.)
4. Animals that represent the specific climate (Butterfly, Dragonflies, Rabbits, Deer (for Santa), etc.)
5. Different Food for different climates (Mushrooms, Strawberries, Blue Berries, etc.)

Figure(36) Weather in the wing



Figure(37) Köppen climate classification of the open space [29] [30]

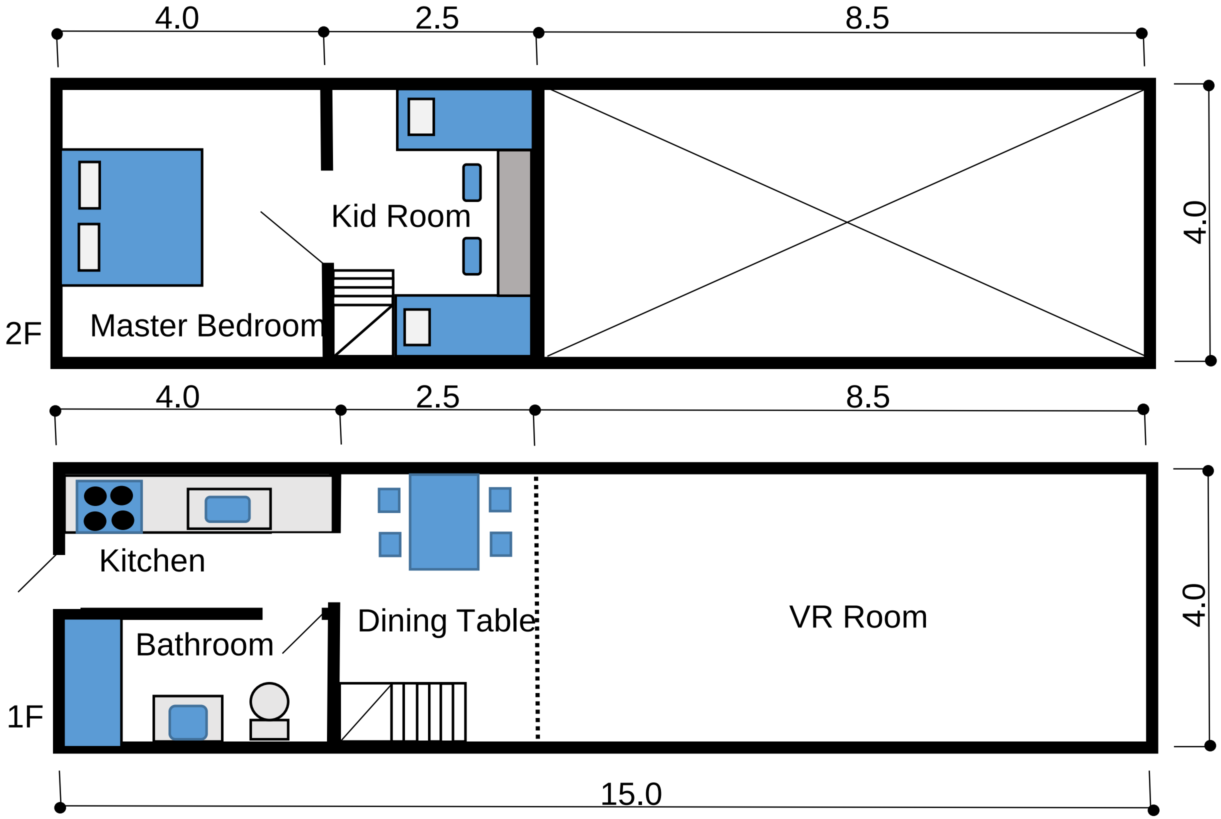
Wig-1 Df: Continental climate[31]
Continental climate. Hot Summers Cold Winters, Some precipitation, Animals include squirrels, prairie dogs, Plants include everlasting pea, big leaf maple, English holly

Wig-2 Cfa: Humid subtropical climate[32]
Humid subtropical climate. Hot and humid summers and cool to mild winters, Animals include turtles, frogs, snakes, capybaras, plants including shrubs, bushes, broadleaf, evergreen

Wig-3 Cfb: Temperate oceanic climate[33]
Temperate oceanic climate. Temperate, no dry season, warm summer, Animals include salmon, tuna, anglerfish, Plants include seaweed

Housing Plan

Figure (38) Housing Plan



I am one of the few kids that live in San Francisco downtown. Downtown houses are very small. When my friends come, we have to assemble chairs that we don't use for dinner in the living room, and the living room turns into the bedroom. And when I get projects from school my living room becomes a laboratory, and of course, during online learning, the living room became a classroom. The living room in my house is usually never used as its actual intention.

The Downtown plaza is always used for many things as well due to the lack of space. At some times it is a consort, and sometimes it is an ice skating ring. Downtown is always changing its figure. When I designed Space NoΛ+ with limited space, downtown's idea of changing for events was useful. Space NoΛ+ housing design has only one room. If there is only one room a lot of things can be changed around. We turned the living room into a VR room so that there is no feeling of isolation.

Figure(39) View the VR room from the kid's room

Virtual-Room

Most images of spacecraft living areas do not have windows. The reason is that there is no outside meaning so windows are not required. But windows are a very important component. It has an important function of connecting the internal and external spaces as well as the function of the barrier. Without windows, we would feel trapped.
It is said that the isolation chamber used for astronaut training is very uncomfortable. General people will not be able to live in these conditions for long. [34][35] So Space No∧+, we proposed Virtual-Room. The glass is an LCD screen and it can be projected many landscape images on the window. The ceiling screen shows the sky so the house could be set as if you were outside. The wall-mounted windows can stop the feeling of isolation.

For example, in the case of a high-rise house in downtown San Francisco, the price of the house is very high, so my house is very small and narrow. Residents put a big mirror on the wall and try to release the feeling of being trapped, but it is not very effective. Furthermore, the position of the windows is also limited to the minimum, so it is a closed space just like the isolation chamber. I think that if residents use the Virtual Room, they can immediately solve the problem of space and make their downtown life more comfortable.

Figure(40) my house

Figure(41) Before the image

Figure(42) After the image

5-(3)-a-3. Artificial Hibernation Zone

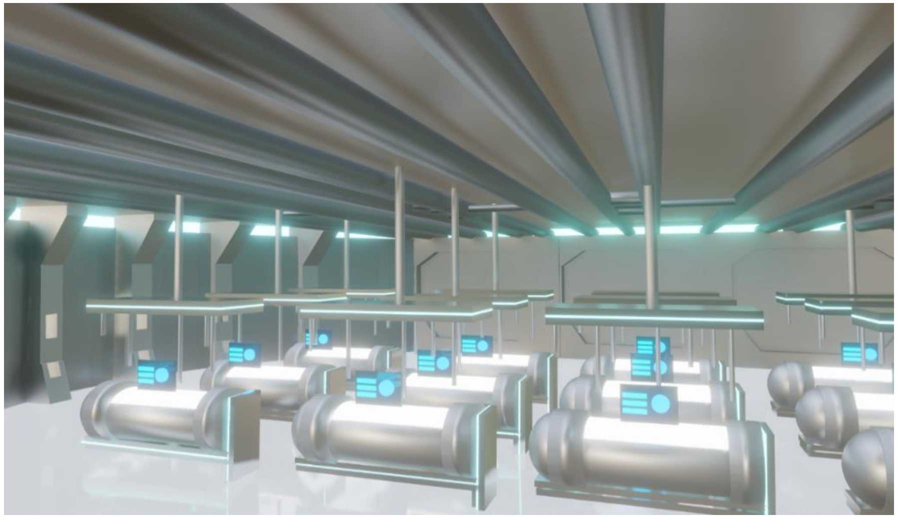
Artificial hibernation is an important technology to support the Space No∧+ project. When we are going to Ross 128 b, after we leave the solar system, we will hibernate for 65 years. There are 28,350 hibernation pods (including spare pods 5%). There will be one expert in charge of 10~15 people to hibernate. The experts will make sure everyone is accounted for and is safely hibernating. During artificial hibernation, family members from small groups of 10~15 people with relatives or friends.

The hibernation pods are located between the water tanks and the Residential zone. Both the top and the bottom layers have water protecting the artificial hibernation pods from dangerous cosmic rays. The hibernation pods are separated into small isolated rooms so that if something punctured the outer wall, those rooms will shut down until the repairs are made. People can safely survive in the hibernation pods even if the room is temporarily out of the air during this time. In other words, the Artificial hibernation zone is also a shelter for serious accidents, such as a small meteorite hitting a space station and causing an air leak. The Artificial hibernation zone is located on the lower floor of the Residential Zone, so people can evacuate within 3 minutes. Evacuation drills are held regularly, and each of the three wings competes for evacuation time and then has a big party, making it a fun event.

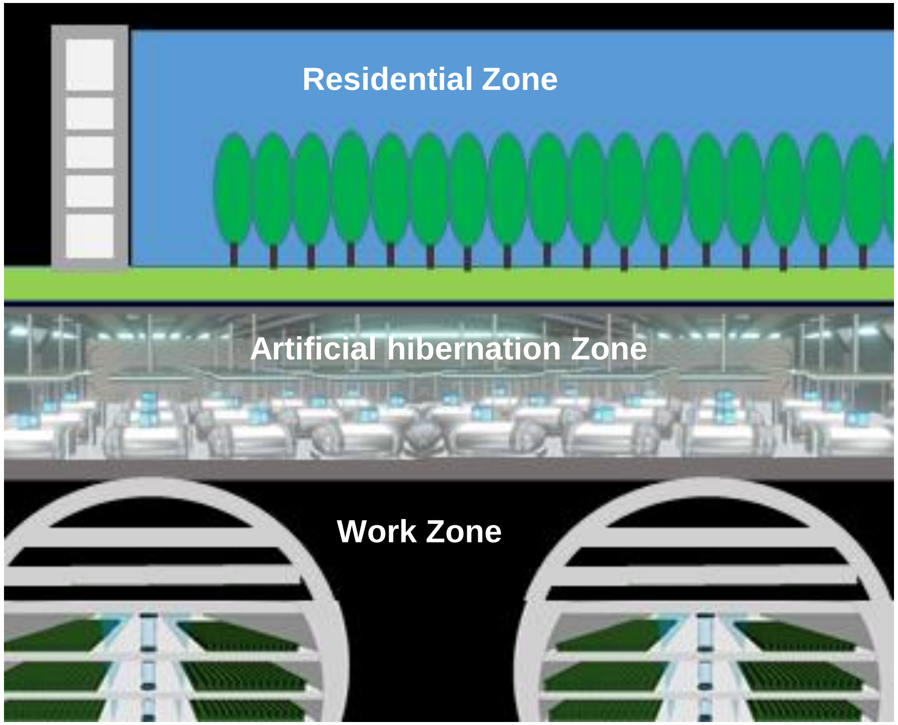
In Space No∧+, people must obtain a license to operate an artificial hibernation pod until the age of 18. People can learn how to operate artificial hibernation pods at school or hospital seminars and obtain the hibernation's operating licenses. This system is similar to a car driver's license on Earth. The hibernation's operating license is divided into three ranks. The beginners start with operating pods, middle-level operations related to medical equipment, and advanced-level mastering of maintenance and management of artificial hibernation systems.

The artificial hibernation takes in the outer planet stage (Flight plan B), but for over fifty years old, it can be done in the extrasolar planet stage (Flight plan A) if desired and with the approval of a doctor.

Figure(43) Artificial hibernation



Figure(44) Wing's section

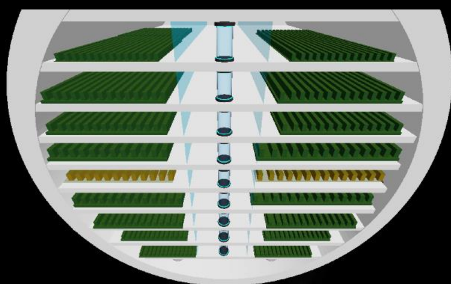


5-(3)-a-4. Work Zone

The equipment of the work zone will be a reuse of Space NoΛ's facilities. The visitor zone of Space NoΛ was closed so, we recycled them to the work zone. For example in the space station, viruses are a big threat. So the training dormitories of the visitor zone will be turned into an infectious disease ward (IDW) of Space NoΛ's Work Zone. The artificial hibernation hospital and the IDW will be connected by an elevator directly for easy access. The virus can be completely isolated by the elevator from IDW and other compartments of the space station.

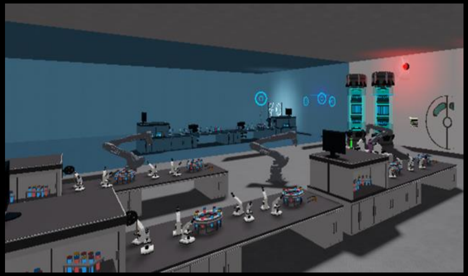
Figure(46) Facility to reuse from Space NoΛ

Agriculture field

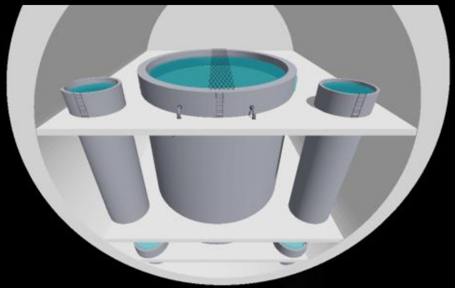


Seed Storage

Isolated Laboratory

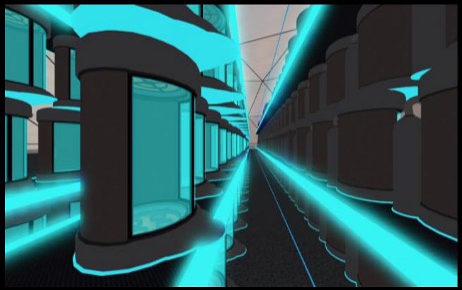


Fish tanks



Artificial hibernation laboratory

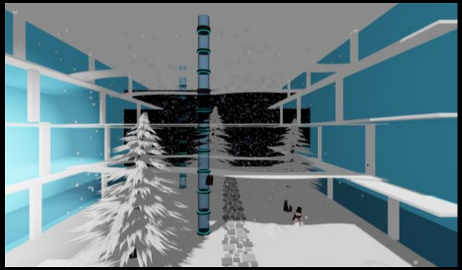
Artificial hibernation tanks



Meeting room

Restaurant

(Isolation hospital Reform)



5-(3)-b-1. Accelerated plasma propulsion engine

There are two types of rockets. Chemical fuel rockets and Electric propulsion rockets. Furthermore, Chemical fuel rockets can be classified into two types as well, solid fuel rockets and Liquid fuel rockets. (36)(37) As typical electric propulsion rockets are mainly ion rocket engines. (38) Chemical fuel rockets are good for propulsion, but it requires a large amount of fuel to travel long distances. (39) Electric propulsion rocket has small propulsion, but they can travel long distances with little fuel. (40) In recent years, xenon ion thrusters are used to power satellites such as *Akebono* and *Hayabusa*. (41)(42) Compare to previously used chemical thrusters, xenon-ion propulsion thruster has 10 times higher velocity. Also, xenon propellant is 1/10 lighter than chemical fuel. (43) (Ashley, 1995, as cited in Beattie's)

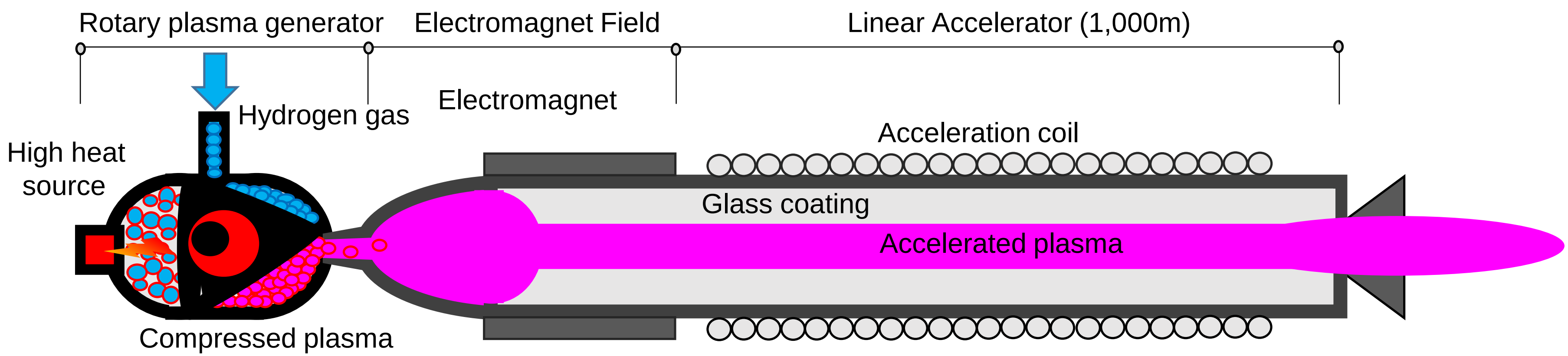
We will be using an accelerated plasma propulsion Engine (44) that will be powering Space NoΛ+ to Ross 128 b. Xenon, which has a large atomic weight and is highly efficient in acceleration, is used in the ion engine. (45)(46) But we will be using hydrogen because of the following reasons.

Figure(47) The reason why Space NoΛ+ uses liquid Hydrogen instead of Xenon

1- When we collect oxygen from ionizing onboard water, we can get hydrogen at the same time(47)(48), and that can be used as fuel.
2- Since the melting point of liquid hydrogen is -259.2°C(49) and the temperature in outer space is -270.45°C(50), hydrogen can be stored in its liquid state without temperature modifications.
3- The density of xenon is 5.89g/L at 0°C(46), while hydrogen is 0.08988 g/L at 0°C(49). To make up for the shortfall, the amount and speed of release are increased using a linear accelerator.
4- Xenon(46) is a very rare gas and during the flight Space NoΛ+ will not be able to resupply.

One accelerated plasma propulsion (APP) engine's diameter is 9m and the width is 1,100m. There are seven APP engines in one bundle. The seven bundles make the whole engine have 49 APP engines. The APP engine is made of three parts. The top 10m of the APP engine are the rotary and the electromagnetic field. The bottom 1,000m is the linear accelerator. The rotary plasma generator works by liquid hydrogen turning into gas then with a high heat source the gas will turn into plasma. After that, the plasma will be compressed by the electromagnetic field and shot out into the accelerator at high speeds. The linear accelerator is 1km increasing the speed of the plasma. There are four small nuclear reactors (SNR) on the bottom of the linear accelerators. The SNR is mostly used to power the accelerator. Constantly electricity is produced and some of the energy goes to a storage battery. The maximums storage battery voltage is 4,882MW/day. The APP engines are used for the first 60 days and the last 60 days of travel so the APP is only used for 120 days. The fuel is liquid hydrogen and they are stored in 500 outer liquid hydrogen tanks. Like the water tanks it docks to the ship and it can independently fly to satellites to find hydrogen. The electrolysis of water can be used to make hydrogen as well.

Figure(48) Accelerated plasma propulsion engine section



Accelerated plasma propulsion engine

Accelerated plasma propulsion (APP) engines are made by 3D printers in Space No∧+'s factory.

Figure(49) APP engines features[51][52]

1.Merit
- It can go far with little energy.
- Specific impulse is 10X more than a regular rocket.

2.Demerit
- It takes time to accelerate, but the linear accelerator makes up for those.
- It can only use in vacuum space.

Figure (51) Rocket engine nozzle

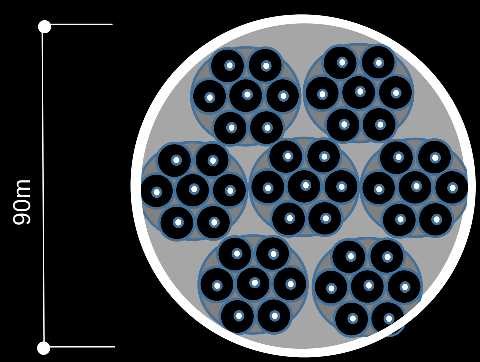


Figure (50) System of APP engine

1. System
- The APP engine accelerates plasma with Linear Accelerator in order to make the ship go faster.
- Use hydrogen for fuel, the space station needs oxygen and to do electrolysis of water hydrogen is needed.
- When hydrogen becomes plasma, small nuclear reactors (SNR) will supply a lot of energy.

2. Steps
- Turn liquid hydrogen into gas.
- The small nuclear reactors (SNR) heat and exchange hydrogen gas for plasma.
- When the hydrogen becomes plasma with momentary ultra-high temperature will expand rotating the rotary.
- The plasmas are compressed and bringing them to the center with the electromagnet and launched from the linear accelerator.
- Using a coil the plasma gets accelerated, and the inner wall of the accelerator has a glass coating so that the plasma can accelerate easier.
- The exterior has magnetic shielding so that all of the accelerators don't get affected by the ones next to it.

Calculation of liquid hydrogen fuel of Space NoΛ+

Mass of Space NoΛ+

(1) Size of ISS [52]

-Mass 444,615kg
-Length 73m
-Width 109m
-high 20m
-Volume 73×109×20=159,140m³

(2) Size of Space NoΛ+ (one tank=main parts)

-Length 60m
-Diameter 30m
-Volume of one tank 15²×3.14×60=42,390m³

(3) Number of tanks (Space NoΛ+)

(a)Main tanks
3(wings) ×12 (tanks)×16 (row) = 576(tanks)
(b)Water tanks
3(wings) ×5 (tanks) ×16 (row) = 500(tanks)
(c)Habitant Zone (≒Main tanks) = 576(tanks)
(d)Sola panel (=1/2aria of Habitant Zone)
1/2×576 (tanks) = 288(tanks)
(e)Control Center Zone + Machine room
3×1,000/60≒50 (times of one tanks) = 50(tanks)
(f)Accelerated ion engine
7×1,500/60=175 (times of one tanks) = 175(tanks)
(g)Liquid hydrogen tanks = 500(tanks)
Total =2,665(tanks)

(4) Volume comparison of (1) and (2)

(1)/(2)=159,140 (m³)/42,390(m³) ≒3.75
ISS=3.75×one tank

(5) Mass of Space NoΛ+

(a)444.615(t)×1/3.75×2,665(tanks) =315,973(t)
(b)Water 500(tanks)×42,390(m³) = 21,195(t)
Total =**337,168(t)**

Required of liquid hydrogen fuel

(1) Calculate the required fuel using *Hayabusa* data.[54]

-Wet mass 510(kg)
-Dry mass 380(kg)
-Fuel ratio to wet mass
510(kg)/380(kg)=1.34

(2) Liquid hydrogen

-Mass 70.8(kg/m³)
-Melting point -259.20℃
-Vacuum universe temperature -270.45℃
-Temperature difference
(-259.20℃)-(-270.45℃)= **11.25℃**

(3) Required of liquid hydrogen fuel

-Fuel ratio to wet mass of Space NoΛ+
Wet mass(without acceleration)
=(Dry mass)×(1.34)=337,168(t)×1.34=451,805(t)
(Required of liquid hydrogen fuel)
=(Wet mass)-(Dry mass)
=451,805(t)-337,168(t)
=114,637(t)
-Assume 300% up to accelerate fuel
(Required of liquid hydrogen fuel with acceleration)
=(Required of liquid hydrogen fuel without acceleration) ×4
=114,637(t) ×4 **=458,548(t)**

(4) Maximum mounting weight of liquid hydrogen

-Mass of liquid hydrogen 70.8 (kg/m³)
300 (cylinders)×42,390(m³)×0.0708(t/m³) **=900,363(t)**

(5) Capability margin

(4)/(3)=900,363(t)/ 458,548(t)= **1.96 >1.0**

Total load capacity of liquid hydrogen is about 2 times the required amount.

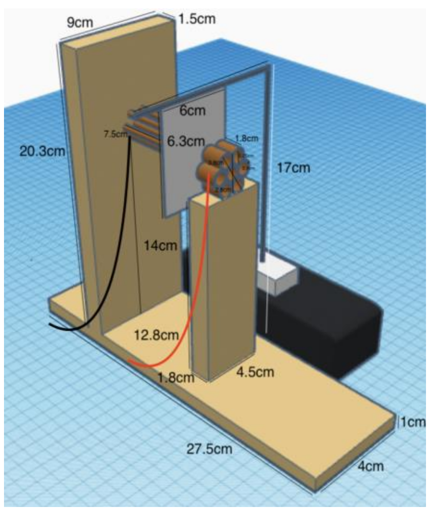
5-(3)-b-2. Ion engine experiment

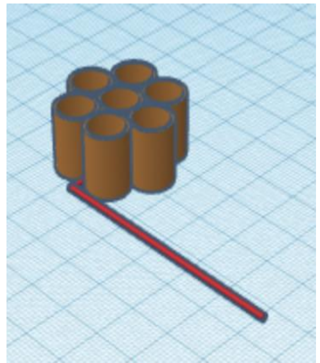
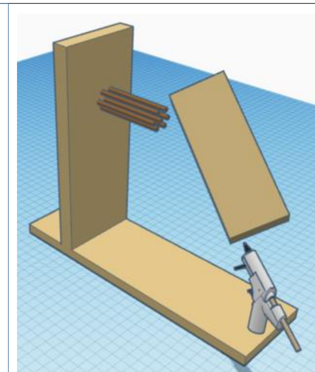
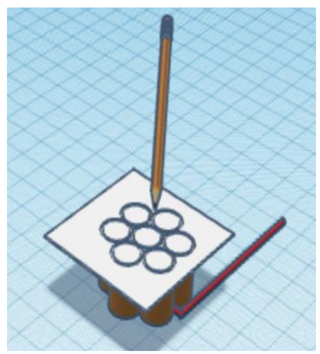
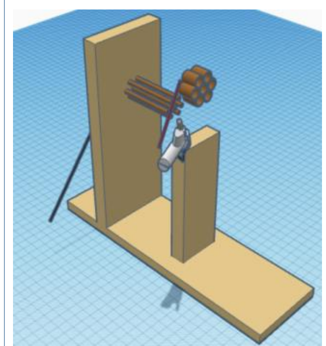
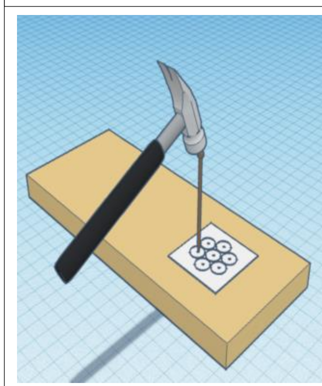
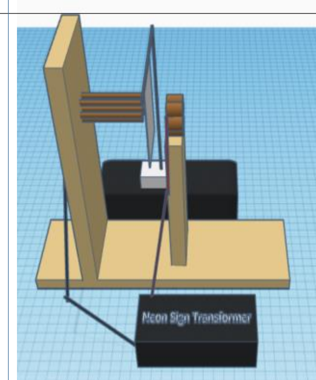
Hypothesis: Investigate whether ions have the power to move material.

Method:

Figure(52) Material method and assembly

- -cpper pipe(7x)
- -copper nails(7x)
- -30,000 volt at 30 mAH NST (neon sign transformer)
- -wood planks
- -thick wire
- -solder stuff
- -solder flux
- -sandpaper
- -hot glue gun
- -thin wire
- -eraser
- -push rod
- -foil and paper



	The flux was spread on each copper pipe fitting. The copper pipes were bounded in a honeycomb pattern. A positive wire was soldered onto the honeycomb copper pipe.		The copper-plated nails were hammered 3cm deep into a wood piece. A thick wire was wrapped on the back of the nails and the piece of wood was placed under the copper pipe in a way that the copper pipe will be horizontal and aligned with the nails. Using a hot glue gun, carefully hot glued the nail board and copper pipe together.
	The honeycomb copper pipe was placed on a piece of paper and flipped over and shaded over with a pencil. With a ruler, the center of the copper pipe was marked.		
	The honeycomb shape was cut out. Using a hammer and a nail, the nail was hammered over the center of each circle.		Lastly, the piece of paper (6.3cmx6cm) was folded in half and placed on a custom rack. The rack was placed between the nails and the copper pipes.

Results

Figure (53) Data of Ion engine experiment

Position	(A)		(B)	
Material	foil	paper	foil	paper
Moving Distance(mm)	×	±1mm	×	±1mm

×: The foil was moved by magnetic field.

1. Washi paper in position A&B

The washi paper in position A&B moved ±1mm because of the ionized oxygen molecule that pushed the paper.

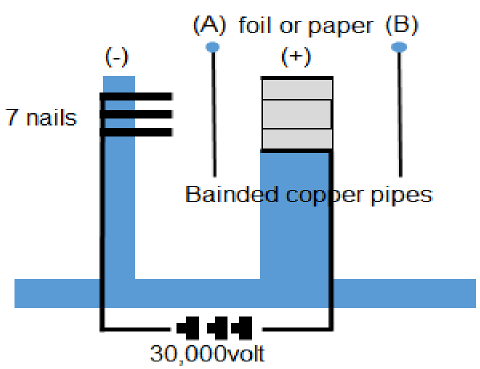
2. Aluminum foil in position A&B

The aluminum foil was pulled toward the honeycomb pattern because the honeycomb pattern was emitting a magnetic field and the foil was not moved by ions.

Two things can be concluded from the above.

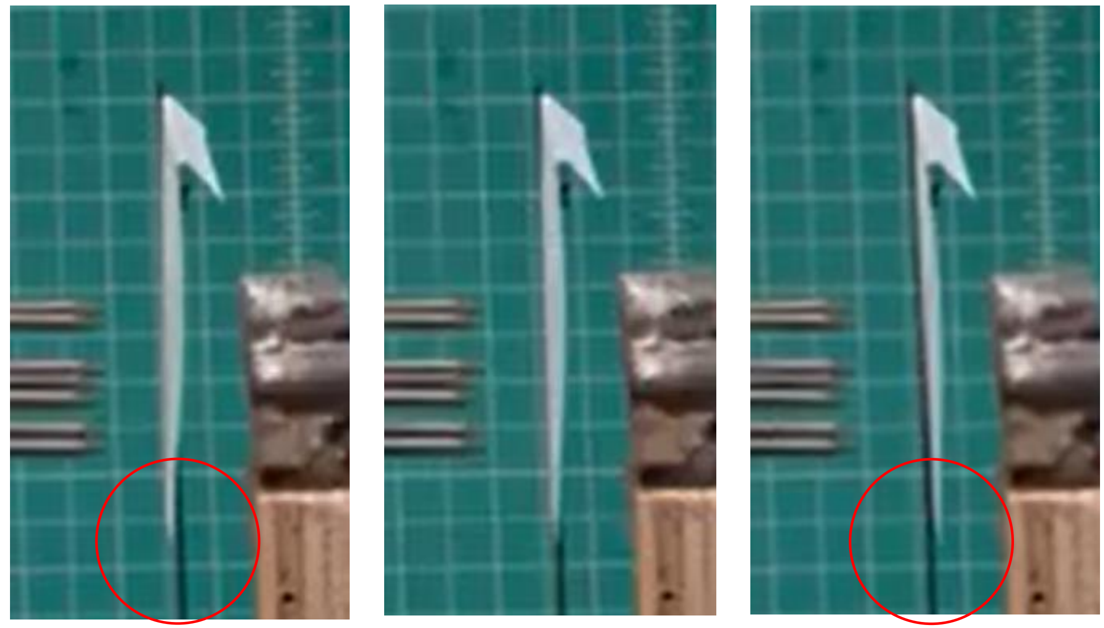
1. The ionized oxygen molecules do have the potential to push light objects.

2. The paper in position B moved about the same distance as the washi paper in position A. So, it can be concluded that the ions gain enough speed to pass through the honeycomb pattern without getting pulled by the honeycomb pattern.



Figure(54) Swing width of sheet caused by ions

(A) Left Center (B) Right

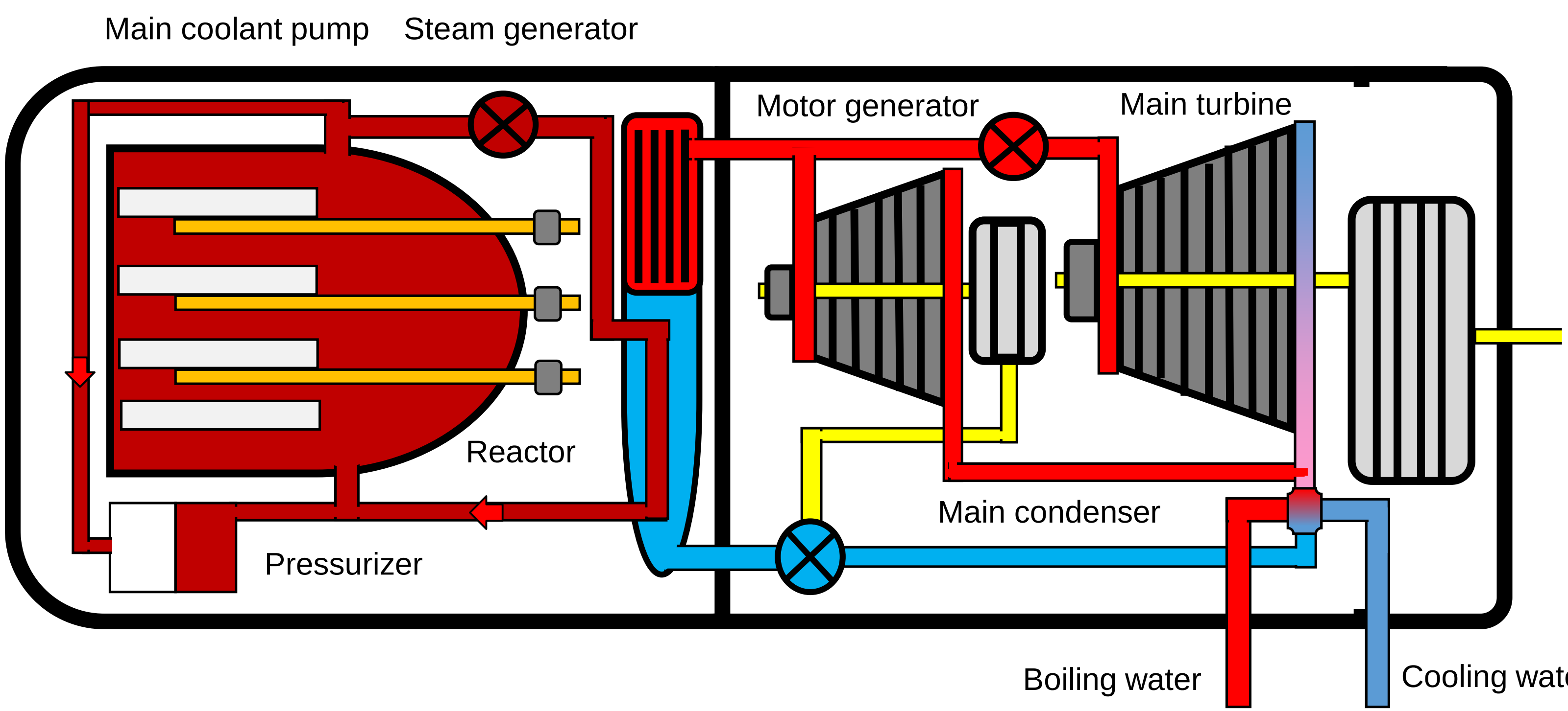


Discussion

In this experiment, it was found that ionized oxygen molecules have the power to move objects, but the power is very small. The spaceship Hayabusa [54] has xenon gas, which has a large molecular weight. It is turned into plasma using microwaves, which are then accelerated by a strong electric field and ejected at high speed. However, Space No∧+ is 579,058 times heavier than Hayabusa and uses hydrogen to refuel during flight, so I don’t think the same engine as Hayabusa can provide enough propulsion for flight. To increase propulsion, it is necessary to inject plasma hydrogen from the engine at high temperature, high pressure, and high speed. Therefore, we proposed an accelerated plasma propulsion engine in which a linear accelerator is attached to the ion engine to compensate for the small molecular weight.

5-(3)-c. Small nuclear reactor (SNR)

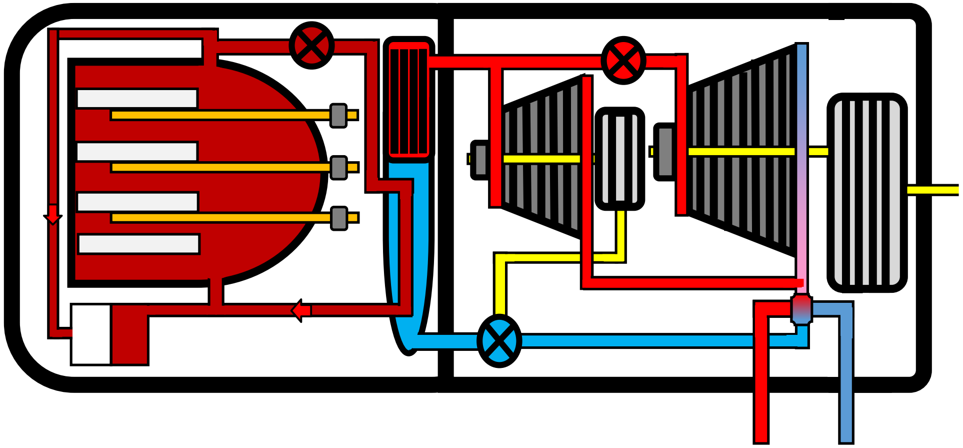
Figure(55) Small nuclear reactor[55][56]



The main power for spacecraft is solar energy. But as the distance gets farther the illumination gets weaker. The solar system snow line[57] is near the asteroid belt.[58] Inside the snow line water evaporates but outside of the line water freezes. Outside the snow belt there will not be enough sunlight for the solar panels to produce enough electricity for a whole settlement. So that is why we used an SNR. Space is a vacuumed area so the heat cannot escape.[59] We used the heat generated by the SNR to regulate the temperature by keeping the water tanks of Space NoΛ+ at 4 degrees Celsius (the state of highest water density). [60] We also used heat conduction metals to bring the heat to the thermoelectric generator, which can be used to generate energy again, and will be used to cool down the SNR. The biggest use of the SNR will be phase 1 and phase 3. The acceleration is ±9.8 m/s^2 and will be used for 60 days. 2 SNR operate at 100 MW to power 49 plasma propulsion engines which need 196 MW. Another SNR is operated at 7 MW to support passengers lives. There are 4 SNRs including 1 backup on Space NoΛ+.

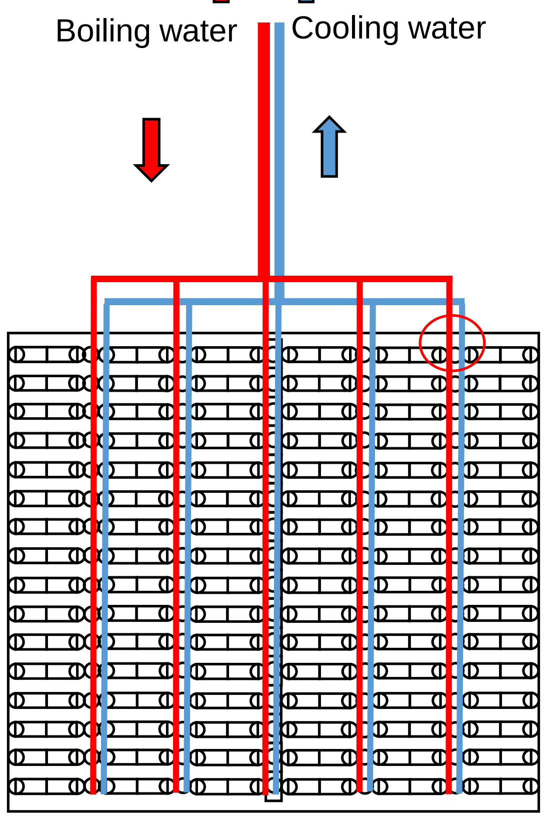
Figure(56) SNR cooling system

No1- Small nuclear reactor (SNR)

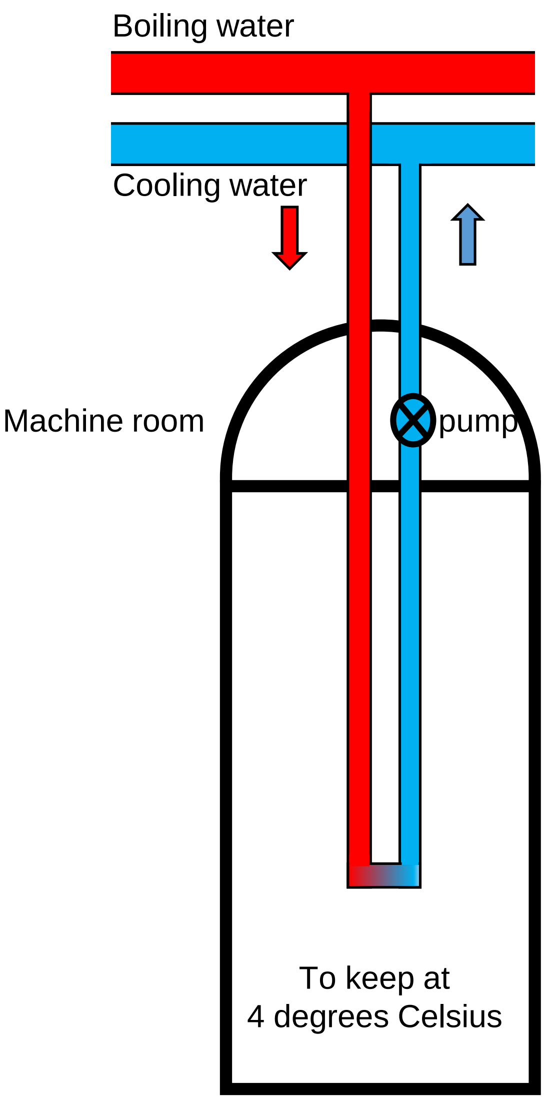


SNR generates high heat during operation, so it needs to be cooled down with cooling water. (61) In 2011, the three reactors of the Fukushima Daiichi Nuclear Power Plant exploded one another the other in a massive earthquake off the coast of Miyagi Prefecture, Japan. The cause was that the cooling water pump did not work due to the loss of all power. (62) Since outer space is a vacuum, it is difficult for heat to be released.

Space NoΛ+ uses water tanks to exchange heat and cool the SNR. In addition to the SNR cooling system, the heat which was generated by SNR is used in various places such as the air conditioning heat source, the sewage water purification system using evaporation, etc. in Space NoΛ+.



No2- Boiling/ Cooling water piping route of Wing



No3-Water tank

Figure(57) Evaporation sewage purification system

Evaporation sewage purification plant boils water to make steam and cools it to make distilled water. So, it can be drunk. 2/3 of the used water is recycled.

How does it work[63]

(1) Collect sewage in the Evaporation sewage purification plant

(2) Submerge small debris, mud, etc. in the sewage

(3) Clean sewage with microorganisms

(4) Sink the mud

(5) Remove small dust

(6) Send some of the cleaned water to agricultural water and urban infrastructure water

(7) Collect skim water

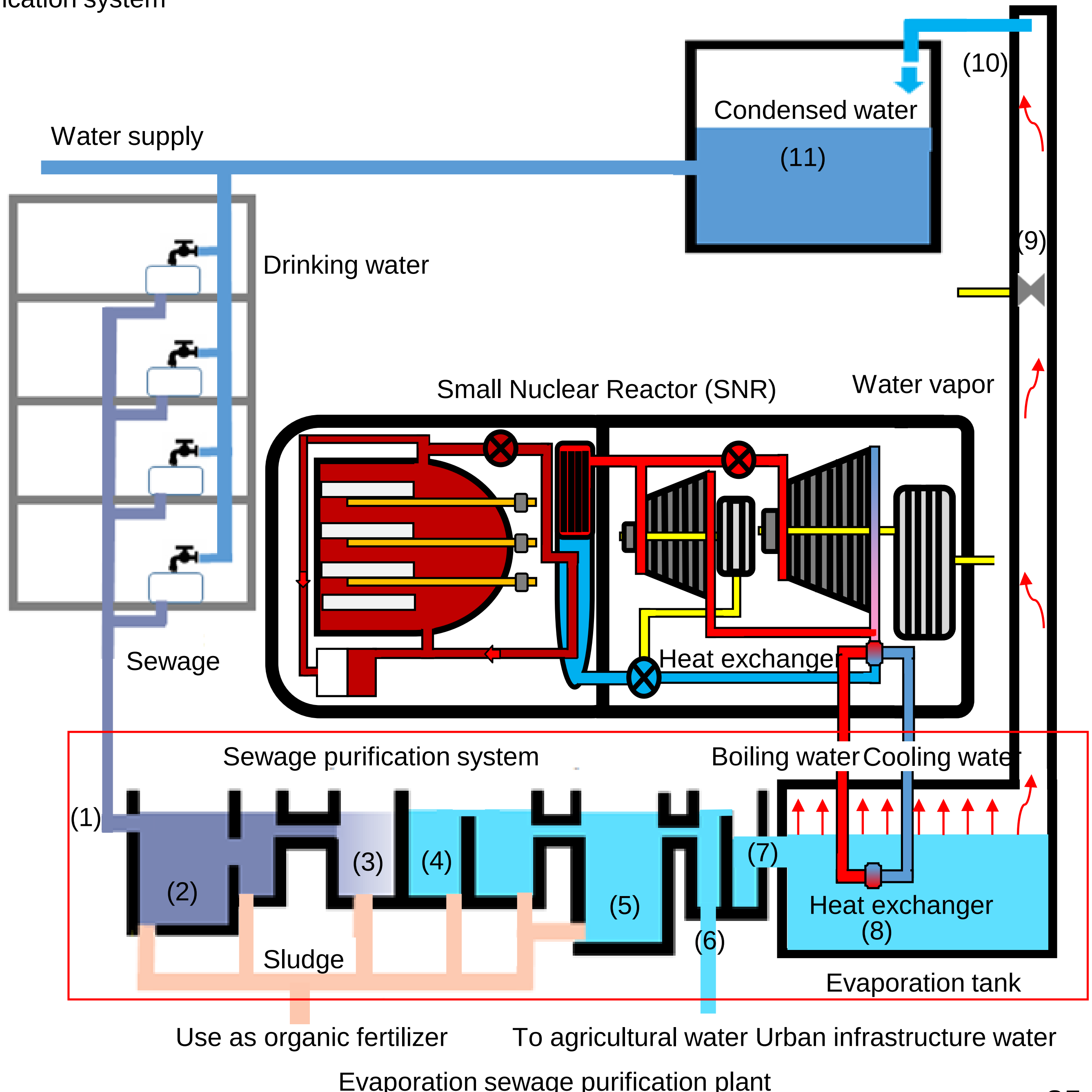
(8) Use SNR's waste heat to make steam in the Evaporation sewage purification tank

(9) Steam turns turbine to generate electricity.

(10) Send vapor water to the cooling tower

(11) Collect the condensed water into a tank

(12) Produces drinking water by mixing an appropriate amount of minerals and sending it by pump



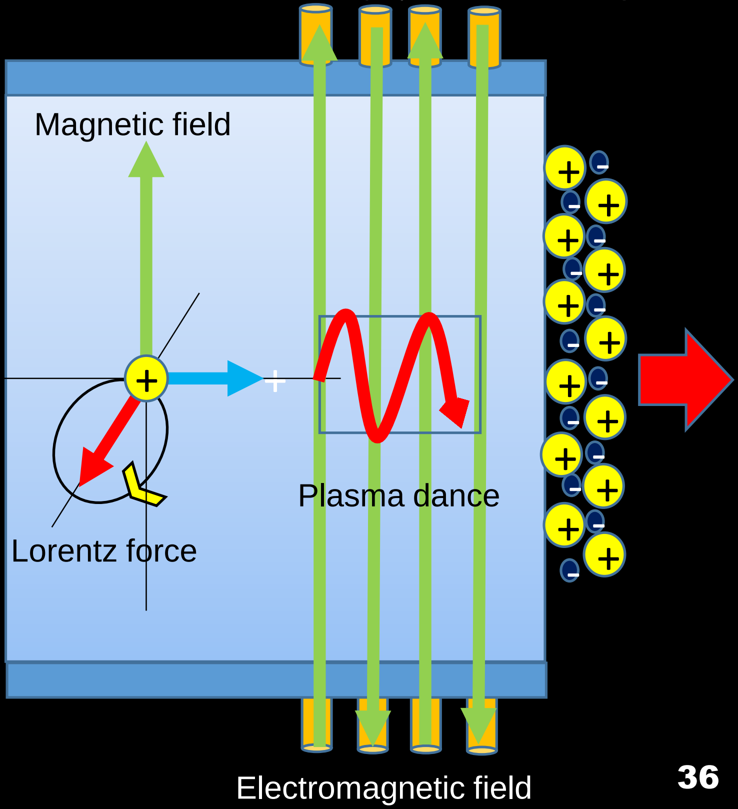
Figure(58) Comparison of Space NoΛ+ and SLAC[64]

	Space NoΛ+	SLAC
Classification	Accelerated plasma propulsion engine	Research center for physics, chemistry, and biology using X-ray generated from accelerated electrons
Acceleration principle	Electromagnetic thruster	Electrostatic charge accelerator
Acceleration force	Lorentz force	Coulomb force
Acceleration capacity	One engine has the capacity to accelerate 45,000 tons of mass at an acceleration of $9.8 m/s^2$ for 60 days	Does not move anything
Acceleration substance	Plasma gasification	Ionization
Source of energy	Liquid Hydrogen	Electrons
Structure	Full length: 1.3km Length of acceleration part: 1km Diameter: 90m	Full length: 3.2km Length of acceleration part: 3.2km Diameter: 1.5m
System	1-Rotary plasma generation 2-Electromagnet Field 3-Linear Accelerator	1-Injector 2-Linac 3-Undulator 4-Experimental Hall
Power	1 ion engine needs 4 MW/h	(Information was not found)
Target	50,800km/s (Light speed 17%)	50 GeV (Light speed 99.999%)

Figure(59) SLAK facility tour photo 10/14/2022

How does a linear accelerator accelerate plasma？ (our question)

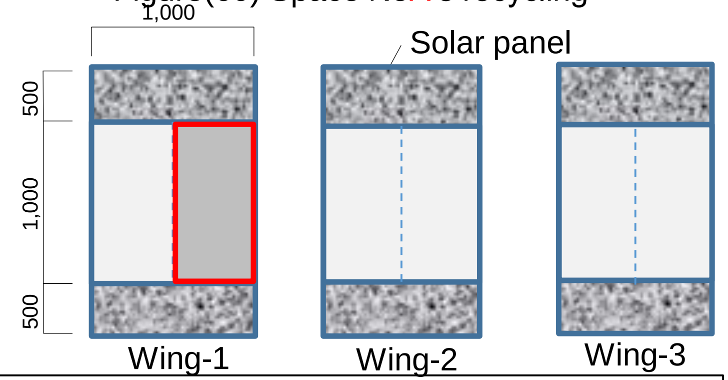
Plasma is attracted by magnetic force and accelerates while dancing. (SLAC's answer)



5-(3)-d. Space NoΛ's recycling

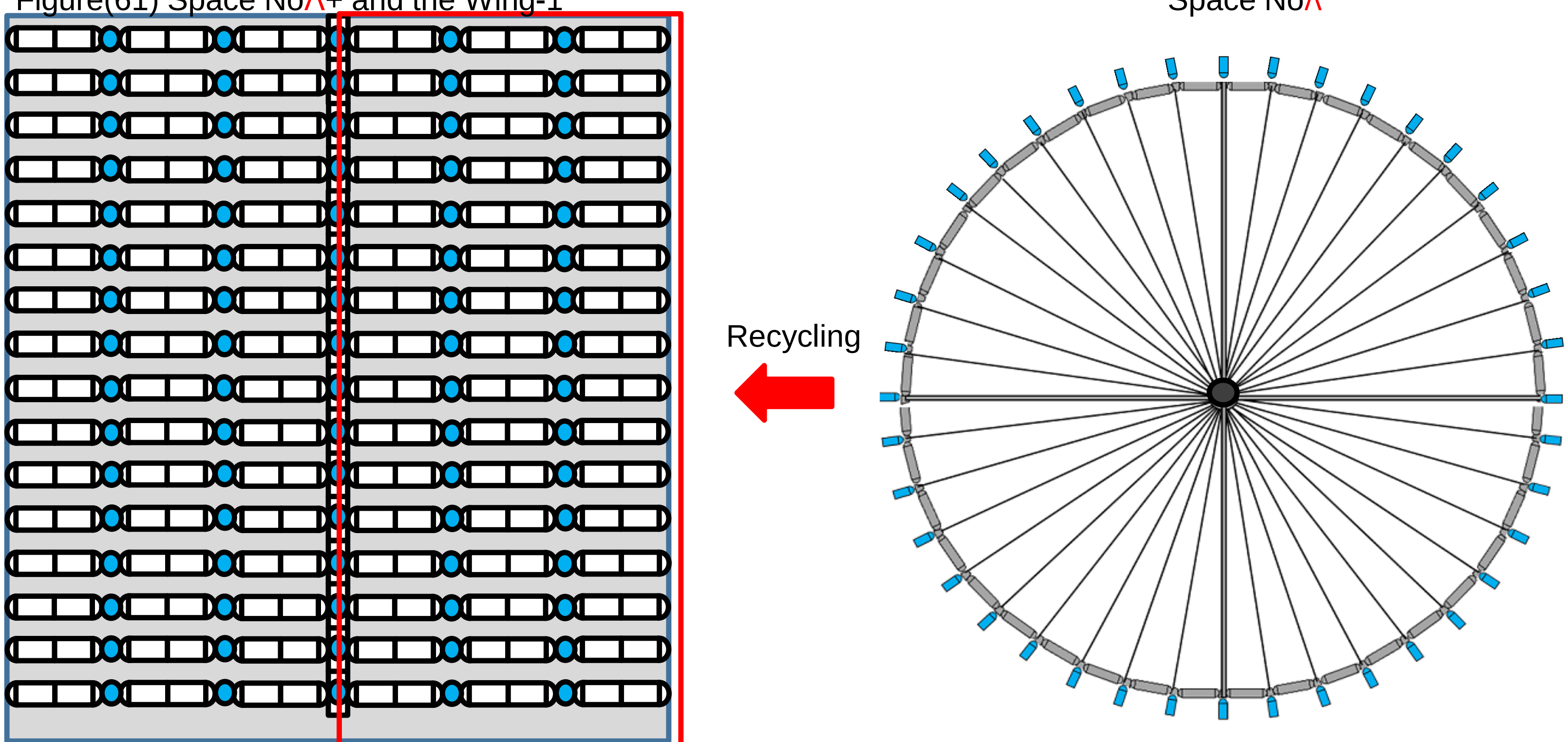
Space NoΛ, the first space station was built in only five parts. Space NoΛ+ can reuse 100% of Space NoΛ's parts. All of Space NoΛ's parts can get recycled to half a wing. Space NoΛ+ will be made in outer space. The space factories have giant 3D printers which make parts of Space NoΛ+, and its module is the same as Space NoΛ. The materials are iron and other minerals from asteroids. In this way, space debris can be reduced by recycling old space stations and rocket wreckage.

Figure(60) Space NoΛ's recycling



Space NoΛ+	Space NoΛ
Tanks of half brock	Tanks of one station
6 (tanks)×16 (row)=96 (tanks)	20 (tanks) ×4 (Blocks)=80 (tanks)
Water tanks	Water tanks
2(tanks) × 16 (row)+16/2 (tanks)=40 (tanks)	10 (tanks)×4 (blocks)=40 (tanks)

Figure(61) Space NoΛ+ and the Wing-1



Figure(62) Calculation of SNRs and pellets required

Demand

(1) **The Plasma Propulsion engine (first and last 60 days)**

(1a) Hourly electric power

Each Plasma Propulsion engine needs 4 MW(65)of electricity every hour

4 MW x 49 Engines = 196 MW

(1b) Total electric energy

196 MW x 24 hours x (60 days + 60 days) = 564 GWh

We will use 564 GWh for the Plasma Propulsion engines

(2) **Passengers + hibernation**

(2a) Hourly electric power

Average family of four uses 27 kWh per day(66)

Less electricity consumption is estimated when the passengers are hibernated

27 kWh x 6,600 families ÷ 24 hours = 7 MW

(2b) Total electric energy

(1a) x 24 hours x 365 days x 65 years = 3,986 GWh

(3) **Whole Flight**

(3a) Hourly electric power (1a) + (2a) = 203 MW

(3b) Total electric energy (1b) + (2b) = 4,550 GWh

Supply

SNR can produce 100 MW of electricity without fuel bundle replacement for 2 years(67)

(1) **2 SNRs for the Plasma Propulsion engines**

196 MW ÷ 100 MW per SNR = 2 SNR

No fuel bundle replacement is necessary because the plasma Propulsion engine only runs for 120 days

(2) **1 SNR for the passengers and hibernation**

100 MW x 2 years = 7 MW x 28.5 years

By reducing power generation down to 7 MW, the fuel bundle will last for 28.5 years. Fuel replacement is required 2 times for our 65 year journey.

(3) **1 SNR for backup**

We will have 1 extra SNR as a backup for emergency use.

(4) **Potableb 1 SNR for water collection missions**

The necessary water will be secured on the moon before departure. The water will be replenished at each stop.

(5) **Total SNRs** (1) + (2) + (3) = 4 fuel bundles for 4 SNRs

(6) **Pellets**

Each fuel bundle contains 289 fuel rods (17 x 17)(68)

each rods contains 200 pellets(68)

200 pellets x 289 fuel rods x 6 bundle = 346,800 pellets for the whole flight

5-(4) Life support activity

Figure(64) Water supply and demand

Flight condition
Flight Plan A (Outer planet) 10-year travel Replenish water and liquid hydrogen at three ports of call When Space NoΛ+leaves ports of call, water liquid hydrogen tanks are always 100% full Flight Plan B (Extrasolar planet) 65-year travel There can not be water replenishment until Ross 128 b This period is artificial hibernation 6/7 of the population goes into hibernation A water supply and demand check was done on Flight Plan B, which does not have a supply base
Domestic Water 192(tanks)>240(tanks)
*Water Demand(65 years) (149,650+2,463,750+18,250)(m^3/year)×1/7×65(years)= 24,436,750(m^3) 2/3 of the used water is recycled. Fresh water is 1/3 24,436,750(m^3) 24,436,750(m^3) ×1/3= 8,145,583(m^3) Amount of water in one water tank; 15(m)×15(m)×3.14×60(m)= 42,390(m^3) Amount of water tank required 8,145,583(m^3)/ 42,390(m^3)= 192(tanks) Maximum loading capacity 240(tanks)×42,390(m^3)= 10,173,600(m^3) Rate of surplus 240(tanks)/ 192(tanks)= 125(%) *Figure(64) Annual water supply and demand)
Oxygenated Water 238(tanks)>260(tanks)
*Air Demand(per year) 137,970,000(m^3/year) *Amount of O_2 produced water in one water tank; 42,390(m^3/tank)×888.88(m^3)= 37,679,623(m^3/tank) Amount of water tanks required 65 years 137,970,000(m^3) ×65(years)/ 37,679,623(m^3)= 238(tanks) Maximum loading capacity 260(tanks)×42,390(m^3)= 11,021,400(m^3) Rate of surplus 260(tanks)/ 238(tanks)= 109.2(%) *Figure(65) Annual air supply and demand In Space NoΛ+, in addition to the electrolysis of the water system, oxygen is generated by photosynthesis in plants and artificial photosynthesis devices.

5-(4)-a. Annual water supply and demand

Figure(64) Annual water supply and demand (A):Normal flight (B):During artificial hibernation flight

1. Control center Zone (A)	(A-1)+(A-2)+(A-3)= 49,650(m^3)
(1)Officer	(A-1) 50(person)×100(ℓ/day)[69]×365= 1,825,000(ℓ)
(2)Crew	(A-2) 450(person)×100(ℓ/day)[69]×365= 16,425,000(ℓ)
(3)Engineer	(A-3) 3,000(person)×120(ℓ/day)[69]×365= 31,400,000(ℓ)
2. Residential Zone (A),(B)	(A-4)= 2,463,750(m^3) (B-5)= 821,250(m^3)
(4)Residence	(A-4) 27,000(person)×250(ℓ/day)[70]×365= 2,463,750,000(ℓ) (B-5) 27,000(person)×1/7×250(ℓ/day)[71]×365=35,196,429(ℓ)
3. Artificial Hibernation Zone	(A-6)= 18,250(m^3)
(6)Medical doctor	(A-6) 500(person)×100(ℓ/day) [69]×365= 18,250,000(ℓ)
4. Work Zone (A)	Σ(A-7)~(A-20)= 1,124,959(m^3)
a. Worker	
(7) Wings' Maintenance	(A- 7) 2,700(person)×120(ℓ/day)[69]×365= 118,260,000(ℓ)
(8) Factory	(A- 8) 2,700(person)×120(ℓ/day) [69]×365= 118,260,000(ℓ)
(9) Food	(A- 9) 2,700(person)×120(ℓ/day) [69]×365= 118,260,000(ℓ)
(10) Scientist / Education	(A-10) 1,000(person)×120(ℓ/day) [69]×365= 43,800,000(ℓ)
b. Agricultural Block	
Plant Block : 20m×70m×7(floors: one tanks)=8,400m^2 (8.4ares)	
(11) Wheat (2times/ year, 12tanks)	(A-11) 2(times/ year)×8.4(ares)×12(tanks)×280(t/ are)[72]= 56,448(t)
(12) Rice (2times/ year, 6tanks)	(A-12) 2(times/ year) ×8.4(ares)× 6(tanks)×400(t/ are) [72]= 40,320(t)
(13) Corn (3times/ year, 18tanks)	(A-13) 3(times/ year)×8.4(ares)×18(tanks)×210(t/ are) [72]= 95,256(t)
(14) Potato / Bean (4times/ year, 12tanks)	(A-14) 4(times/ year)×8.4(ares)×12(tanks)×250(t/ are) [72]=100,800(t)
(15) Vegetable (Yield per unit area 648 lettuce/ m^2 , 0.11ℓ/one lettuce[73],12times/ year,16floors,6tanks)	(A-15) 12(times/ year)×19,200(m^2)×648(lettuce)×0.00011(ℓ/one lettuce)×6(tanks)=98,537,472(ℓ)
(16) Fruit (1 times/ year, Annual rainfall suitable for grapes 800mm~900mm/ spring~ autumn[74]	(A-16) 1(times/ year)×19,200(m^2)×1(t/m2)×6(tanks)= 115,200(t)
c. Fish Block	
(17) Large tank	(A-17) 12(m)×12(m)×3.14×18(m)×24(tanks)= 195,333(m^3)
(18) Medium tank	(A-18) 6(m)× 6(m)×3.14× 6(m)×24(tanks)= 16,278(m^3)
(19) Small tank	(A-19) 2.5(m)×2.5(m)×3.14×2(m)×36(tanks)= 707(m^3)
(20) pond(Residential Zone, 4-ponds)	(A-20) 25(m)×15(m)×5(m)×4(ponds)= 7,500(m^3)
Total	**A= 3,656,609 (m^3/ year)**

5-(4)-b. Annual air supply and demand

Figure(65) Annual air supply and demand

1- Annual air usage 137,970,000(m^3/year)

The daily respiration rate of a person weighting 50kg is 14m^3

0.5(ℓ)×28,800*(times/day)[75]=14,400(ℓ)=14(m^3)

*Breathing rate per minute: 20 times

Average ventilation per volume: 0.5(ℓ)

The number of crew is 27,000(people). Total daily respiration in Space No∧+ is 63,000(m^3/day).

14 (m^3)×27,000(people)=378,000(m^3/day)

378,000(m^3)×365=137,970,000(m^3/year)

2- Air volume inside Space No∧+ 101,816,720(m^3)

(1)-Control center zone

30(m) ×30(m) ×3.14×1,500(m)=4,239,000(m^3)

(2)-Residential zone

1,000(m) ×1,000(m)×40(m)×3(wings)= 120,000,000(m^3)

(3)-Work zone

96(cylinders) ×2(blocks)×3(wings)×15(m) ×15(m)×3.14×60(m)=24,416,640(m^3)

4/3×3.14×{15(m^3)}×96(cylinders) ×3(wings)= 4,069,440(m^3)

(4)-Subtotal

{(1)+(2)+(3)} ×2/3= 101,816,720(m^3)

3- Air stock 269(days)

(1)- Day air usage 378,000(m^3/day)

(2)- Air volume inside Space No∧+ 101,816,720(m^3)

(3)- (2)/(1)=101,816,7209(m^3)/378,000 (m^3/day)= 269(days)

When all supply of new oxygen is stopped, the residual oxygen period is 269 days. Then emergency power supply kicks in and activates an emergency oxygen supply system connected to 40 water tanks.

4- Amount of water tanks required 65 years 237.9(tanks)

(1)- Amount of water in one water tank; 15(m)×15(m)×3.14×60(m)=42,390(m^3)

(2)- Amount of oxygen gas produced in 1m^3 of water[76]

a. Molecular weight of water (H_2O=18[77]),density of water (1g/cm^3,1ℓ=1,000mℓ=1,000g);1Molar mass of water=18g/mol

b. Number of H_2O molecules in 1ℓ of water at 0℃ (1mℓ=1g); 1,000g/18(g/mol)=55.555(mol)

c. Number of O_2 molecules in 1ℓ of water ; 55.555(mol)/2=27.8(mol)

d. Amount of O_2 produced in 1ℓ of water (atomic number of oxygen atom = 16); 32(ℓ/mol) ×55.555/2(mol)=888.88(ℓ)

e. Amount of O_2 produced water in one water tank; 42,390(m^3/tank)×888.88(m^3)=37,679,623(m^3/tank)

(3)- Amount of water tanks required per year; 137,970,000(m^3/year)/ 37,679,623(m^3/tank)=3.66(tanks/year)

5-(4)-c. Food supply and demand

Figure(66) Yield and Consumption of the three major grains (9,000person/one wing)

	Wheat (n=10)	Corm (n=8)	Rice (n=4)
(1)Planted area 20(m)×60(m) ×9(floors) ×n(cylinders)	108,000 (m^2) =1,080 (a)	86,400 (m^2) =864 (a)	43,200 (m^2) =432 (a)
(2)Unit yield (kg/10a) [78][79][80]	810 (kg/10a)	1,490 (kg/10a)	535 (kg/10a)
(3)Number of harvest (times/year)	2 (times/year)	3 (times/year)	2 (times/year)
(5)Annual yield (kg/year), (1) ×(2) ×(3)	1,749,600(kg/year)	3,862,080(kg/year)	462,240(kg/year)

Figure(67) Amount of consumption (Wheat type ; France)[81]

	Wheat	Corm	Rice
(6)Per person (kg)	318.2 (kg/person)	124.0 (kg/person)	4.3 (kg/person)
(7)person, 3,000×(6)	954,600kg)	372,000(kg)	12,000(kg)

Figure(68) Amount of consumption (Corn type ; USA)[81]

	Wheat	Corm	Rice
(8)Per person (kg)	138.8 (kg/person)	683.3 (kg/person)	14.4 (kg/person)
(9)person, 3,000×(8)	416,400(kg)	2,049,900(kg)	43,200(kg)

Figure(69) Amount of consumption (Rice type ; Japan)[81]

	Wheat	Corm	Rice
(10)Per person (kg)	49.6 (kg/person)	131.8 (kg/person)	72.6 (kg/person)
(11)person, 3,000×(10)	148,800(kg)	395,400(kg)	217,800(kg)

Figure(70) Rate of surplus

	Wheat	Corm	Rice
(12)Yield, (5)	1,749,600(kg)	3,862,080(kg)	462,240(kg)
(13)Consumption, (7)+(9)+(11)	1,519,800(kg)	2,817,300(kg)	273,000(kg)
(14)Rate of surplus, (13)/(12)	115(%)	137(%)	169(%)

5-(4)-d-1. Artificial Hibernation mechanism

Scientists say that the amount of energy and oxygen is reduced during hibernation. (82) Archaeologists also believe that early humans 430,000 years ago, may have hibernated during the ice age when food was scarce. (83) This can be easily imagined from the fact that humans are a kind of mammal. The reason modern humans are unable to hibernate is not that they have lost their ability to hibernate, but because they haven't needed to hibernate for a long time. We believe that the function that commands hibernation is sleeping somewhere in our brains.

In an experiment conducted by a research group at the RIKEN and the University of Tsukuba, the brains of mice were stimulated and they started to hibernate. (84)(85) Also, we think animals go into hibernation mode when the temperature drops due to seasonal change and wake up from hibernation when the temperature rises. Dr. Sunagawa said that mouse hibernation may be controlled by Quiescence-inducing neurons (Q-neurons). (86) If these Q-neurons control the hibernation function, artificial hibernation in humans will become possible in near future. However, since our brain has not used the information pathway related to hibernation for a long time, it is necessary to activate the information transmission pathway. (87)

The mechanism that we think about artificial hibernation of humans.

(1)-Stimulates Q- neurons in the hypothalamus. (88)

(2)-Stimulated Q- neurons will produce Dopamine. (88)

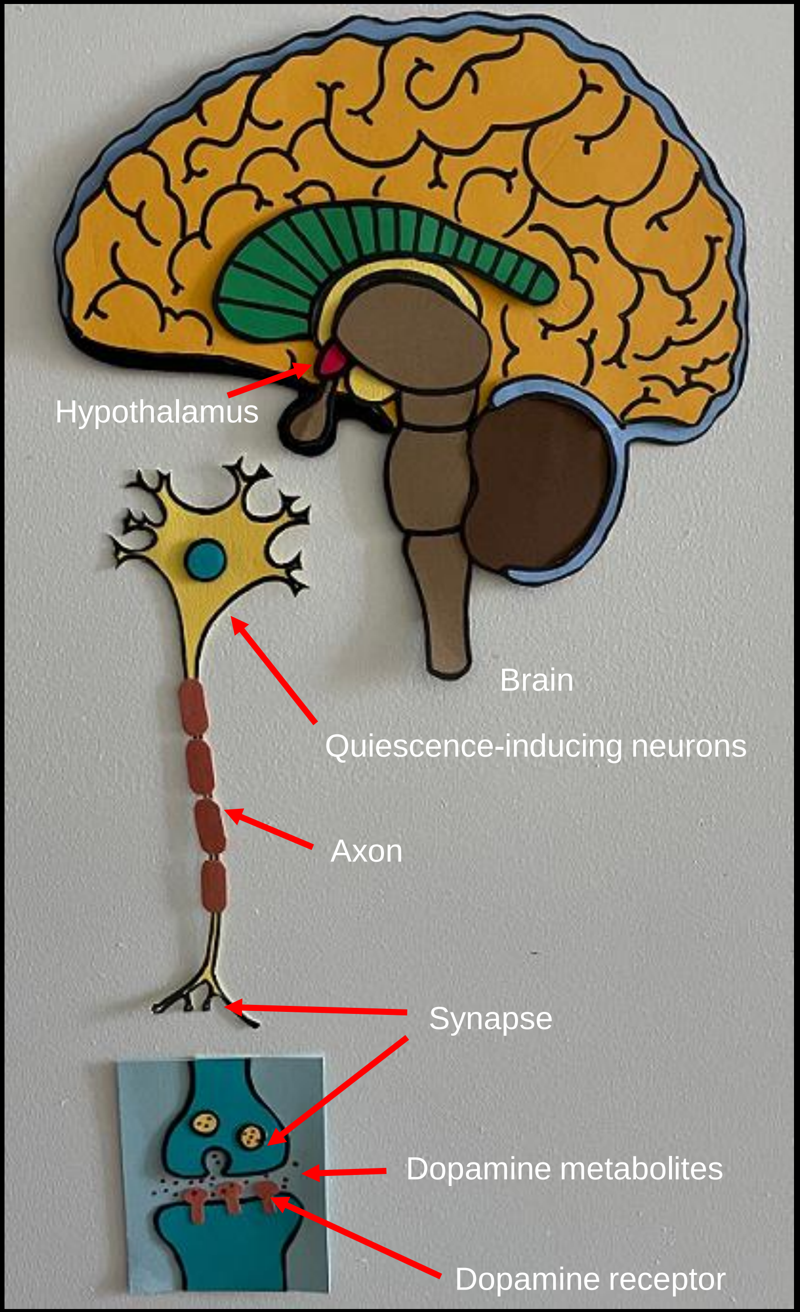
(3)-The Dopamine is sprayed out from the synapse which is grabbed by the Dopamine receptor of the next neurons. (88)

(4)-The synapse receives information about body temperature, breathing, heart rate, etc. Regular humans have a body temperature of 37 degrees Celsius. With the hibernation pod, the temperature will slowly decrease bringing the body temperature to 30 degrees. (89) When the metabolism lowers, the human will enter a state of hibernation.

(5)-To ensure that everyone in hibernation is alive and healthy, a computer will monitor them 24 hours 7 days a week.

(6)-When humans wake us from hibernation, the hibernation peptide will stop and slowly increase metabolism. This work can be done on demand.

Figure(71) . Artificial Hibernation mechanism



5-(4)-d-2. Artificial Hibernation equipment

We designed the hibernation pod and suit. The passenger of Space NoΛ+ will be assigned to their hibernation pod. The hibernation pod is used not only for artificial hibernation but also for health management in daily life, as it is linked with medical equipment. The hibernation suit has a measuring terminal that records their heart rate, breathing, and more. In case of a medical emergency, an automatic treatment device linked to the hibernation pod will activate. The hibernation pod has a shield that protects the human body from harmful cosmic rays.

Hibernation suit

(1)-The hibernation suit has a double-layer structure.

(2)-A mesh of thin water tubes is placed inside the suit to regulate body temperature just like the astronaut space suit used for spacewalk missions.

(3)-On the suits, some sensors monitor the vital organs, and the information is sent to a life support computer 24 hours every day.

(4)-The fabric is made from the best cotton grown in Space NoΛ+, and the size, color, and design can be made according to one's taste from the patterns provided.

(5)-Suits are made new for each hibernation, and discarded suits are 100% recycled.

Hibernation pod

(1)-After wearing a hibernation suit and lying in a hibernation pod, the monitoring device starts up and data is automatically sent to the life support system.

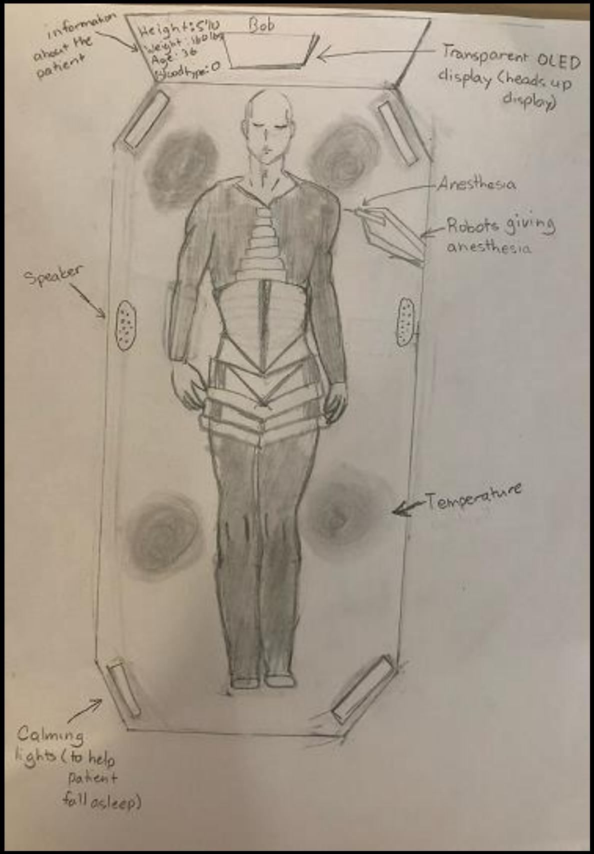
(2)-One group is 10~15 people, there is one hibernation expert that connects life support pipes and checks final safety. During this time, the people who are inside the pod can freely enjoy conversations with family and friends through a heads-up display on the hibernation pod window.

(3)-Once everything is ready, the artificial hibernation mode system will activate, and everyone inside the pod can choose music, the temperature is warm as they gradually sleep for the longest time they ever slept.

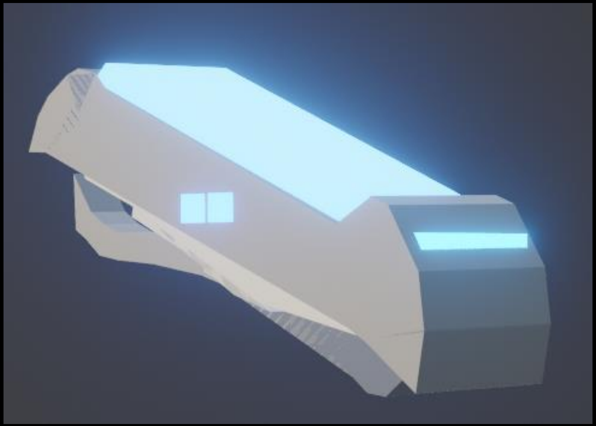
(4)- The limit of hypothermia is 30 degrees Celsius. [89] We think that the limit of hypothermia differs from person to person, but Space NoΛ+ has set the limit of hypothermia at 30 degrees Celsius.

(5)-Robots giving anesthesia, Q-neuron stimulant, etc. with needleless jet injection system, which no pain and no infections waste, and suitable for robotic medicine.

Figure(72) Hibernation suit



Figure(73) Hibernation pod



5-(4)-d-3. Hibernation health maintenance management program

65-year artificial hibernation schedule

On Space No∧+ one artificial hibernation period is 6 months. When people wake up from hibernation, they take a month-long break. During this time, they prepare themselves for the next hibernation. There will be 130 breaks over 65 years, for a total of 11 years of high metabolism. We think this method is a realistic solution. This system is based on how bears and early humans hibernate.

Figure(74) Intermittent hibernation (6 months hibernate, 1 month rest)

If metabolite problems occur during artificial hibernation.

(1)-Dialysis

Blood is circulated through the body and then it is brought to dialysis using a blood vessel. The dialysis cleans all of the waste and it is sent to artificial photosynthesis. All the body waste will go to the agricultural plant and will be used as fertilizer.

(2)-Artificial Photosynthesis

Artificial photosynthesis separated the O_2 and carbon from the blood. The carbon will be sent to the agricultural plants. The O_2 will be brought to the Nutrition Generator

(3)-Nutrition Generator

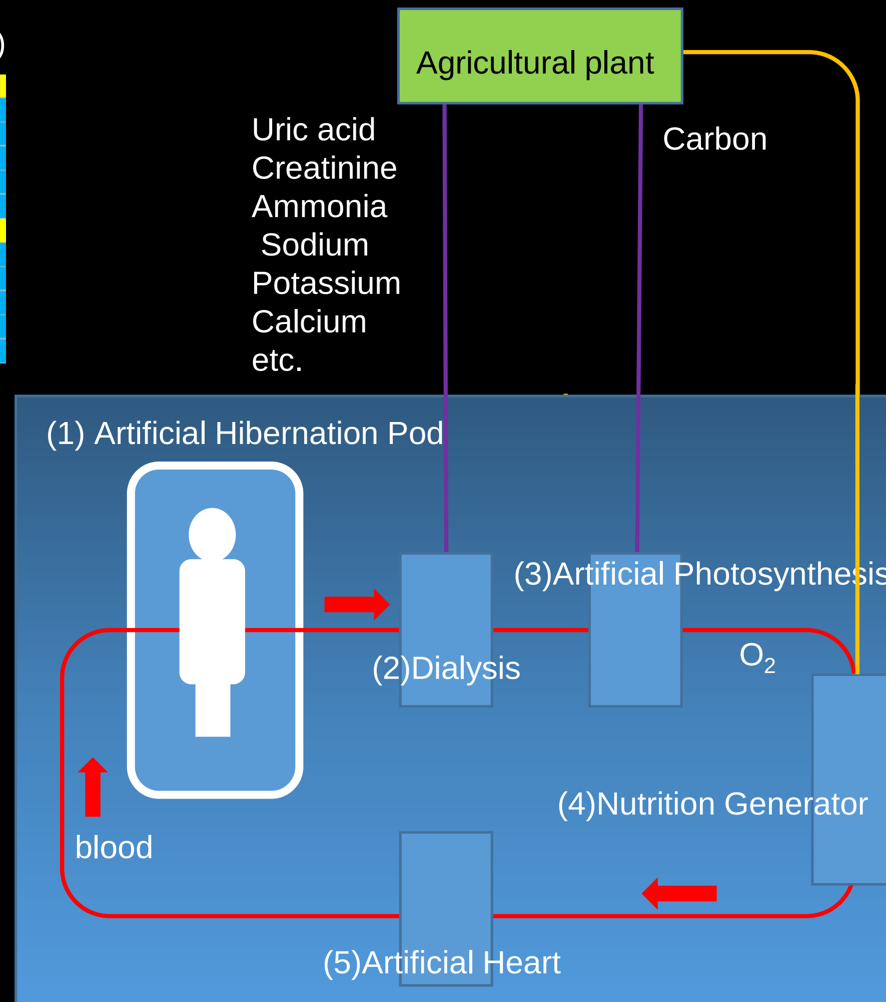
The nutrition generator will be used to monitor the nutrition of the body for 24 hours and will supply the body with nutrition, and it can be used to give medicine. All of this will be done by a computer.

(4)-Medical Artificial Heart

The artificial heart will pump blood so the heart does not have to work. But to not weaken the heart muscles, there will be a small amount of heart pulse.

Figure(75) Hibernation health maintenance management

Agricultural Plant
The agriculture plant will use the fertilizer and will grow. Plants will be harvested and stockpiled and some plants' nutrition will be taken away and used for the nutrition generator.



Life Support System

5-(4)-d-4. Overview of the artificial hibernation meeting with Dr. Genshiro Sunagawa

(1)-Place; Pier 1, the Embarcadero, San Francisco, CA U.S.A. (2)Date & Time; Nov.7th 2022, 13:00~15:30 (3) Attendees; Dr. Genshiro Sunagawa, Leo Shiina, Darby Powell, Kara da Liz, Misato Sobue, Jinwon Le

Our presentation

When a bear wakes up from hibernation, its bones and muscles return to normal. [90][91] However, when examining the bones of early humans from the Ice Age, it is reported that there are traces of various diseased that are thought to have been caused by hibernation. In particular, symptoms such as osteoporosis, which we think is because early humans did not store enough nutrients and hibernated, resulting in the excretion of calcium from the body and the weakening of the bones. [83]

Humans are mammals, just like bears so we think humans can hibernate as well. When bears hibernate they slow down their metabolism. Early humans however could not slow down metabolism so when the scientist was researching their bones they found out that early humans had chronic kidney disease. [83]

Figure(76) The Members and Dr.Sunagawa

Q & A with Dr.Sunagawa

Q; We are proposing Intermittent hibernation, but what is your opinion?

A; That was a good idea, but if we use dialysis the passengers will not have to do intermittent hibernation. However, with current technology, it is not possible to keep dialysis needles in the skin for 25 years.

Q; What is the switch for artificial hibernation on demand?

A; A peptide or a drug of some sort.

Q; Does human metabolism slow down during hibernation, and will they age?

A; No the human will age slowly while hibernating.

Q; If two people hibernate and wake up at the same time, do they age the same?

A; This is a very interesting question, I hadn’t thought of it.

Q; What is the set point temperature of the human body during artificial hibernation?

A; The set point of the experimental mice was 22 degrees Celsius. [85] Bears are 30 degrees Celsius. The humans’ set point should be around 30 degrees Celsius.

Q; Do you think humans have Quiescence-inducing neurons (Q-neurons) about hibernation? If so where is it?

A; Since humans are a kind of mammal, I think that Q-neurons are located in the hypothalamus of the brain.

Q; When we wake up from a long hibernation, would we have amnesia? If that is so, we need to make our record before hibernating.

A; It is not known at this stage whether amnesia occurs when waking up from a long hibernation. There is a possibility.

Figure(77) The meeting with Dr.Sunagawa

6-Conclusion

We investigated the feasibility of Space NoΛ+. We found out that Space NoΛ+ can be built with technologies we have now or will be invented in the near future. We were able to make two meaningful proposals through this project. One is the possibility of manned interstellar flight. In Sci-Fi, some ways to travel long distances are, wormholes, warp, and hyperspace, which are all impossible ways to travel now and in the near future. Space NoΛ+ uses an accelerated plasma propulsion engine that accelerates the ship for 60 days bringing the flight time to Ross 128 b only 65 years. When we learned that we can travel long distances in a short time with the accelerated plasma propulsion engine, we became more fascinated with space than ever! The other proposal is the hibernation system. Our hibernation system can be a realistic solution for long-time space travel. In this project, we could travel from the farthest reaches of space to the invisible world of atoms.

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Incho Lee
Ayaka Lee

7-Members

Leo Shiina
G-7
St. Cecilia School

I am the leader of our group, Space NoΛ+. Last year, I did a project called Space NoΛ. That project was to make a temporary space station for Earth if it becomes unlivable. This year, we proposed the idea that Earth will never become livable again due to a great disaster and we must search the enormous universe to find our new home. Staying in space for a long time can be very stressful so we built different weather conditions to make the residents feel joyful by skiing, swimming, kayaking, and more! Space NoΛ+ has taught me everything in space is limited but we can still be creative and use everything to our advantage.

Darby Powell
G-7
St. Cecilia School

I am the flight plan researcher and creator, making sure we have enough fuel and an efficient course to safely land on our new home planet. I joined this group to learn more about space and its technologies, and how I work as a team member. Creating the flight plan will teach me many things about planets and space I do not know. Space NoΛ+ really gives a good learning opportunity for many things needed in life like good teamwork, pulling your own weight in a group project, managing a schedule between everything you have to do, and finishing work on time. This is a great group, and I enjoy working with everyone in it!

Kara da Luz
G-7
St. Cecilia School

I joined Space NoΛ+ because this is an opportunity to make new friends and learn new things. I feel so excited to work with others and help each other out. I find it interesting to think about what life would be like in space. Some people believe that the Earth may not be livable in the future, so I want to help people prepare to go to space safely. I believe that the Space NoΛ+ project will both help us learn and teach others.

Misato Sobue
G-6
San Francisco Japanese School

It's my second time participating in the Space Settlement Contest. Our last project called Space NoΛ had an idea I had never thought of and I learned a lot about new things, which motivated me to join Space NoΛ+. In Space NoΛ+, we will fly out of the earth and explore a new planet we would live in. I think this project could be utilized for future space development. In the future, I want to be an astronaut and explore our galaxy.

Jinwon Lee
G-6
San Francisco Japanese School

I am a thruster researcher. Being a part of Space NoΛ+ has been an amazing adventure. I proposed the idea of using ion engines to power Space NoΛ because I saw that *Akebono* used ion thrusters and was inspired. I think that without the ion thrusters it would be impossible to get to Ross 128 b. I hope that my contribution to Space NoΛ+ will save many lives and in the future, my dream is to see spaceships using the ion thrusters I designed.

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