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Spaceport: Creating A Manned Space Facility Outside The Earth

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Abstract

These days, space exploration and advancement are progressing. The purpose of this study is to devise a Spaceport as a bridge between the Earth and space. We mainly focus on the structure of the facility. This study explores these: building a flexible architecture, preventing expioners from being exposed to cosmic rays, maintaining bone mass, and orbit calculation. We are going to build a port in the space of a faceted icosahedron by using a 3D printer. To maintain bone mass, we are going to create pseudo-gravity by using centrifugal force. We are going to create a honeycomb structure using polyetheretherketone, and fill it with water and euglena to create a “biomass shield,” which reduces the amount of cosmic rays getting into the room.

1. Introduction

Nowadays, a large number of countries are trying to launch space probes to Mars, the moon, etc. to advance space development and contribute to solving unknown facts. However, the fuel in space probes to reach planets is limited. That is why we need a Spaceport! It becomes a center point to connect the earth and planets which people can hardly reach. However, there are many environmental problems in space which we have to solve. They make it difficult to build a spaceport and for humans to live in space. We started our research focusing on three factors : Construction ,Shielding us from cosmic rays and Medical care.

2. Cosmic Ray

2-1. Cosmic Rays

Cosmic rays are the high-energy radiation which exists in space. It is composed of 90% of protons, 9% of α-particles, and the rest of the composition are the atomic nucleuses of lithium, beryllium, boron, iron and so on. If the sum of the exposure dose exceeds 100 mSv, clinical symptoms such as the increase of probability of cancers are possible. On the surface of the earth, the exposure dose of natural radiation including cosmic rays averages 2.4 mSv per year across the world. Conversely, in the International Space Station (ISS) which is located at an altitude of about 400 km, the exposure dose of cosmic rays averages 200 mSv per year. It means that the exposure dose in the ISS is almost 100 times larger than that of on the earth. Therefore, shielding spaceports residents from dangerous cosmic rays is essential for us to create a Spaceport.

2-2. New And Original Idea for A cosmic Ray Shield

We propose a new and original idea termed ‘’Biomass Shield’’ ’to shield people in space from cosmic rays (fig.1). For the materials, we are going to use euglena, water and polyetheretherketone (PEEK), and we will put euglena and water into the water tank made of PEEK. The reasons for using these three materials are as follows. First, euglena can be used as space food or biofuel, increase the amount of oxygen by photosynthesis and the number is doubled if the condition is suitable when we make recycling-oriented society. Second, water excels at shielding cosmic rays which are mainly composed of protons and is also essential for cultivating euglena. Also, this Shield is based on the premise that the shield will be reusable because we want to make society in space sustainable. And for the last, it has been revealed that the shielding effect of PEEK is higher than aluminum which is used for conventional spaceships and the International Space Station (ISS) by 20 %. Also, PEEK is one of the resin, so it has a high affinity with a method to construct the Spaceport by 3D printers mentioned later.

Moreover, Biomass Shield excels not only at shielding the cosmic rays but also in that it can save the space to store euglena which is useful for space food or the water which is essential to humans.

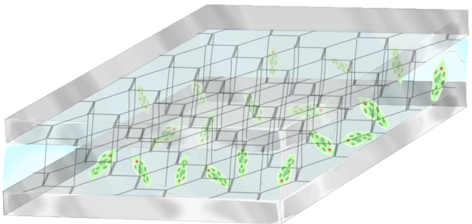


fig.1 an image of Biomass Shield
We will put euglena and water into the water tank made of PEEK.

2-3. How To Verify The Efficiency

2-3-1. The Stopping Power and The Cross Section of The Fragmentation

We verified how effective the biomass shield is by a quantitative approach. To find how effective the materials of the shield are, the things which we have to know are the stopping power and the cross section of the fragmentation. The stopping power is the physical quantity which indicates how much energy the charged particles lose in the material. Fragmentation is the phenomenon where the heavy and dangerous charged particles turn to the light and comparatively safe ones. The larger these numbers are, the more effective the material becomes. We can calculate these numbers by using the following formulas.

$$S_{UM} \propto \frac{Z_T}{A_T} \qquad (1)$$

$$\delta_{UM} \propto c A_T^{-\frac{1}{3}} \qquad (2)$$

S_{UM} : the stopping power

Z_T : the atomic number of target

A_T : the atomic mass of target

δ_{UM} : the cross section of fragmentation

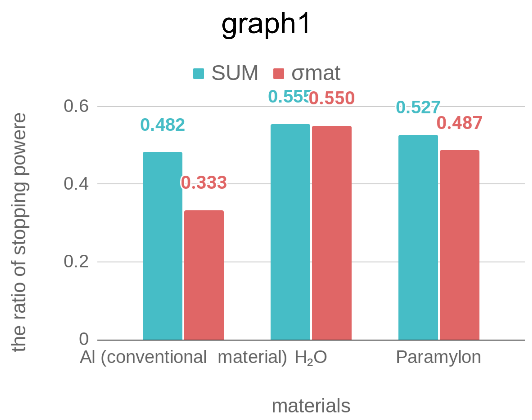
c : parameter

Because we wanted to make aluminum which is used for conventional spaceships and the ISS a standard, we chose aluminum, water which is one of the materials for the shield, and paramylon which is the polysaccharide only made by euglena as the materials to calculate.

2-3-2. The Results of The Calculations

table1

material	the atomic number	the atomic mass	the stopping power	the cross section of fragmentation
Al	13. 000	26. 982	0. 482	0. 333
H_2O	3. 333	6. 005	0. 555	0. 550
Paramylon	4. 553	8. 643	0. 527	0. 487



2-3-3. Discussion

The number of the stopping power and the cross section of the fragmentation of the water and paramylon were larger than those of aluminum which is used as conventional spaceships. Therefore we conclude that the Biomass Shield is better than aluminum as a shield of cosmic rays.

2-4. Future Outlook

We verified that Biomass Shield is effective in blocking the cosmic rays in this research, but we do not know that it excels at strength or cost. Thus, we want to consider them.

3. Architecture

3-1. Space Architecture

Space architecture refers to theories of structures outside the Earth's atmosphere. The structures are designed for humans to live comfortably in space. We will consider the shape of the building and its construction method, starting with the construction of a spaceport. In the scope of this experiment, we will consider the construction of a spaceport in geostationary orbit among the entirety of the spaceport.

3-2. Proposed Form of Spaceport

3-2-1. In A Geostationary Orbit

First, we consider the construction of a spaceport in the geostationary orbit within the overall spaceport (fig.2). A geostationary orbit is an Earth orbit with an orbital period that coincides with the Earth's rotation period. The gravity inside of the spaceport in geostationary orbit is perceived as weightless because the earth's gravity and the centrifugal force caused by the port's orbit, cancels out the gravity inside of the spaceport. On the earth, which is affected by gravity, humans must walk on the floor when in a building and the building itself needs to be supported by columns and beams.

On the other hand, in geostationary orbit, due to gravity, there is no need to consider the above, so buildings can be constructed freely. For example, humans can walk on the ceiling and the shape of the building can be more creative.

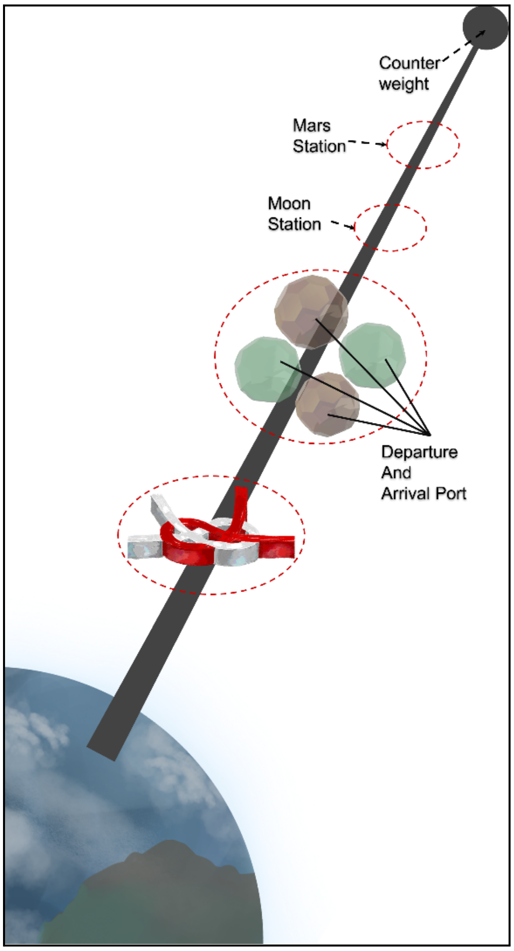


fig.2 Overall view of Spaceport

3-2-2. Cut-apex Icosahedral Spaceport

We propose a spaceport in the form of an icosahedron. A truncated dodecahedron is a regular icosahedron with each vertex truncated (fig.3). A typical soccer ball is made by filling this solid with air to make it more like a sphere. It has 32 faces (12 regular pentagons and 20 regular hexagons), 90 edges, and 60 vertices.

We propose this shape for four main reasons: first, the naturally occurring fullerene C60 is a soccer ball-shaped molecule, which is one of the most durable structures. Second, we will need to increase the number of facilities as the number of users increase, so the icosahedron shape allows for us to make new ports and connect them easily because of the flat surfaces on the shape. Third, the facilities should be easy to replace when they break down. Since aging may create hazards, a certain period of time should be set aside to inspect and replace this spaceport and its equipment. Since the icosahedron is composed of planes, replacement can be done efficiently and quickly. The fourth is that it is easy to produce with a machine.

fig.3 Cut-topped icosahedral spaceport (Created by fusion360)

3-3. How To Construct A Spaceport

3-3-1. Method of Construction

Instead of launching the completed spaceport from the ground into space, the company will, as much as possible, launch portions of the spaceport and perform the rest of the assemblies in space. We are considering the use of a 3D printer for the assembly in space.

3-3-2. Method of International Space Station (ISS) Construction

The ISS was completed in July 2011 after the first module was launched in 1998 and parts launched 46 times were assembled in orbit around the Earth in space. This precedent was taken into consideration and utilized in the construction of our spaceport.

3-3-3. Building Methods Using 3D Printers

3D printers are a technology that will revolutionize manufacturing, especially in the aerospace industry, which is characterized by low-volume, high-mix production. This technology is likely to make it possible in the field of space exploration to manufacture in space and construct bases using materials from exploration destinations. Furthermore, NASA and private space companies are already developing 3D printing technology, and the space industry and 3D printing technology are becoming closely related. We believe that the use of such 3D printers is essential because the increased human workload is expected to increase the level of danger to humans and the management of food, oxygen, energy, etc. necessary to sustain life. However, we believe that it is necessary to consider the limitations of the material to be used as a material, its strength, durability, and the removal of heat generated during operation.

3-3-4. Examples of 3D Printer Applications

One example of the use of 3D printers is the "SpiderFab "8) project for use in space by the aerospace company Tethers Unlimited Inc. This is part of a project to develop a manufacturing device that utilizes a proprietary carbon composite additive. This 3D printing robot builds wire-frame structures in space after being launched from the ground. Unlike conventional construction methods, which require multiple component supplies from the ground, the robot will be able to continue generating structures without being limited by size or mass, as long as it continues to be supplied with the print material.

3-4. Challenge for The Future

It is necessary to examine in detail how to join spaceports together, how to fix spaceports, and where to connect spaceports to the space elevator. Furthermore, it is necessary to actually consider other medical field ideas and space radiation design in a concrete and comprehensive manner.

4. Medical

It is known that osteoclasts are overactive in the space environment. Osteoclasts are cells that metabolize the calcium in the bone and stimulate metabolism. However, in space, where there is an abundance of osteoclasts,they accelerate bone loss and cause osteoporosis. Therefore, astronauts must strive to maintain bone mass in the space environment. The main method to maintain bone mass is to exercise for about two hours daily using aerobic exercise equipment. In some cases, drugs (bisphosphonates) are administered to induce the natural death of osteoclasts. Often, after returning to earth, humans experience bone density loss and their bones are weakened. loss observed after returning to Earth and maintaining bone strength under microgravity remains a problem. In addition, the current drug and exercise-only approach is far from optimal when considering that the general public will travel to and from the spaceport. Thus, the need for a new method to increase bone mass adequately and efficiently will arise. In addition, the space hotel station being designed by Orbital Assembly is of the Von Braun type (fig.4). (a type in which the pseudo-gravity caused by centrifugal force can reduce the effects of bone density loss in space)

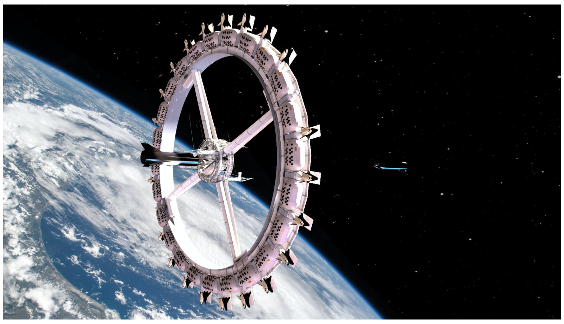


fig. 4 Von Braun type

Based on this, we worked to develop a new facility as a way to further the research of space port creation. This is described in Method 2.

Method 1: The focus of method 1 was on physical stimulation, which has been shown to be effective in reducing bone loss. As specific examples, electrotherapy (a treatment method for osteoporosis) and ultrasound therapy (a treatment method for bone fractures) are believed to provide physical stimulation. Currently, the ISS does not use these two methods to maintain bone mass. Therefore, we decided to use these methods to reduce the amount of exercise required for bone mass maintenance and thus extend the amount of time people can reside in space.
The study was conducted. However, a comparison of the two treatments showed that, unlike ultrasound treatment, electrotherapy involves pain and discomfort due to the treatment. Therefore, we decided to focus only on the ultrasound treatment method.
The proposal we came up with is as follows. Consider using a fitness bike equipped with an ultrasound therapy machine. Using the electricity generated by pedaling it, the ultrasound therapy machine would be activated and channeled to the body during exercise. In other words, it is a mechanism that simultaneously applies two types of stimulation: the load from normal exercise and the physical stimulation from ultrasound. (The stimulation from the ultrasound is not felt as physically demanding as that from

exercise). By doing so, the load on the bones per unit of time is increased, which is expected to improve the efficiency of bone mass maintenance.

Method 2: In method two, we adapted the Von Braun disk-shaped facility created by Orbital Assembly so that it could create pseudo-gravity for different lengths of times. First, the operation of the facility should be limited to the sleeping hours of the guests. By utilizing the residents' sleeping time to apply pseudo-gravity, it decreases the possibility of residents developing osteoporosis when they return to earth, and thus we can extend the amount of time they can spend in space. In addition, the system will eliminate the generation of pseudo-gravity beyond what is necessary, thereby reducing excess energy consumption. Furthermore, multiple disk-shaped facilities will be installed and modified so that each can operate independently. This allows the system to be applied to residents of various sleeping patterns.

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