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Space Colonization for Human Habitation in Space Environment

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ABSTRACT

Space colonization which is also called as space settlement or space humanization or space habitation is the concept of permanent, autonomous that is self-sufficient human habitation of locations outside Earth. To justify the colonization of space, we have variety of reasons, including survival of the human spices, protection of Earth's environment, access to additional natural resources and spreading life in universe. In this paper, we are going to present factors required to colonize in space, including access to space, food, construction materials, energy, transportation, communication, life support, simulated gravity, and radiation protection.

Keywords:Colonization, Environment, Human Settlement, Life, Space

1. INTRODUCTION

Expanding human presence beyond Earth is long-term goal of the manned spaceflight program. Sustaining Human life in Space is a requirement for long-term exploration and extra-terrestrial human settlements. Space is a harsh environment that can have strong consequences on health. Gravity and radiation can impact tissues, brain development, the reproduction function, aging processes etc. As well, sustainable food is also of utmost importance. Basic food sources, both vegetal and animal, have to be adapted from Earth. Space colonization includes space-based operations in earth-based orbit, in transit and on planetary surfaces; robotic, automated and human space explorations and data needs; tourism; development of space colonies and Mars; and other planetary terraforming activities. Space Colonization are the potential of developing low-cost, non-polluting energy, enhanced food-production techniques, pollution/waste and water purification, development of disease-amelioration techniques, and the development of techniques to help protect Earth from potential meteoroid impact hazards. Space colonization, the establishment of permanent human habitats beyond Earth, has been the object of the both practical speculation and specific enquiry for decades.

Space Colonization is tremendously important for the future of humankind in two ways. First, space colonization means that the total future number of humans who will exist and whose lives will be worth living could be orders of magnitude greater than today. By colonizing space, humankind could therefore create a future that is generally morally desirable: There could be vastly more people to enjoy vastly more life-years' worth living if we succeed in colonizing space. Second, engaging in space colonization represents a strategy for mitigating existential risks. Existential risks are risks that could result in the extinction of humankind or in the permanent curtailing of humankind's potential for future development.

S. Bonardiet. al. (2020) describes here a novel robotic concept targeted towards future space colonization missions. Self-Reconfigurable Modular Robots (SRMRs) are robots able to adapt to the task at hand autonomously and have been proposed to provide more versatility to robotic systems. These systems can tackle complex tasks by having the assembly of SRMRs change its shape to adapt and overcome unexpected difficulties. Robotic Exoskeletons proposedto tackle the challenges of the upcoming space missions using a novel concept based on SRMRs and Robotic Exoskeletons (REs). The base unit, design of the Base Units is challenging since they will be the core element of the system [1]. Control framework, the autonomy of robotic framework will be one of the critical elements to developing large scale infrastructures through ever-changing conditions and objectives.

2. OVERVIEW ON SPACE COLONIZATION

The direct translation of space colonization is human habitation in space. It can be anywhere off the Earth. It can be at Mars, other planets or in the orbit. Orbital space station is an example of space colonization that would be located in the orbit. Right now, there is already one fully operational space station which is located in low Earth orbit. This small space station is called International Space Station (ISS). It is solely used to carry out space studies and for space craft testing. It is not used as a permanent space habitat as it can only carry 6 crews. For space colonization, there are some theoretical designs for a big-scale space station. They are known as Stanford Torus and O'Neill Cylinder. The goal for this section is to study these two designs.The design was proposed at Stanford University. Hence, the space station is called Stanford Torus. The idea is to make this space station as a solar power station. This station collects solar energy and beams it back to the Earth for the space power companies. This is a way to fully emphasize solar energy as a new form of energy. The habitat in the station will be used as a home for the solar power workers.

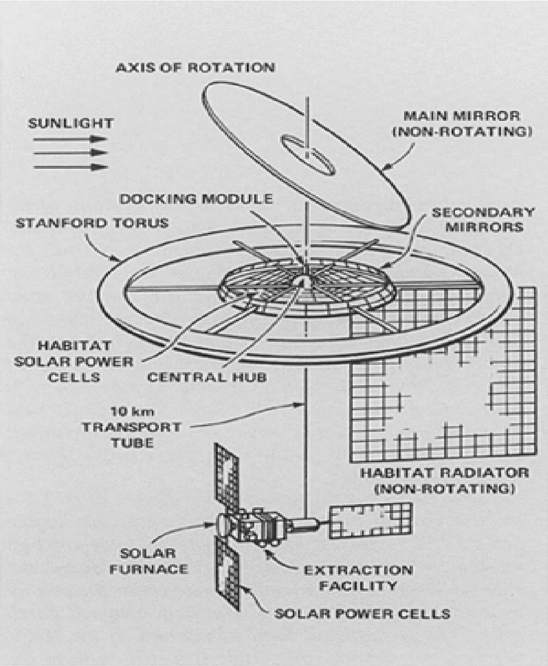

Figure 1: Colony Configuration

It consists of a donut-shaped ring with a diameter of 1,8 km. The ring rotates once per minute to provide artificial gravity inside the habitat. The habitat tube has a diameter of 430 m. The torus rotates at 1 revolution per minute to create artificial gravity. A stationary mirror at 45° is used to redirect sunlight down to the colony. The inner disk of the torus acts as a docking bay and solar generation area. 10 km away from the station is a tethered solar power generation satellite. This satellite provides the remainder of the power required for the colony that is not generated in the inner disk. A large, flat stationary radiator sits below the inner disk and acts to dissipate waste heat from the station.

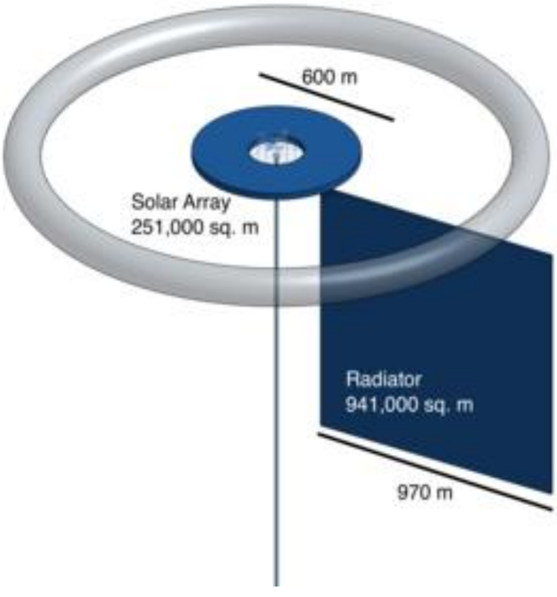

Figure 2: Stanford Torus solar array and radiator sized to scale

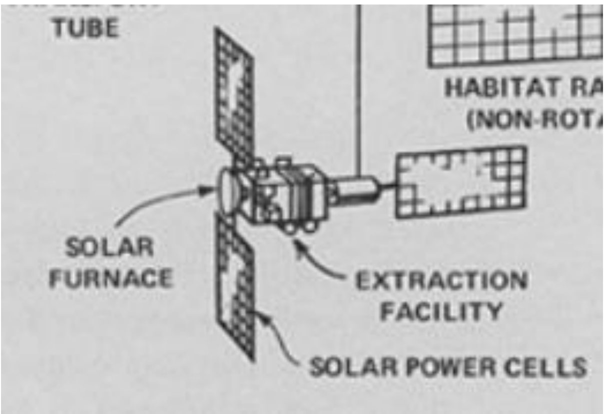

Figure 3: The Solar Power Generation Satellite

It also consists of a big stationary mirror at 45° at the top of the ring. Small mirrors which are also at 45° are located in the inner part of the ring. The reason of mirrors is to redirect the sunlight towards the outer ring by using light reflection method. Behind the small mirrors, there are main solar power cells shaped like a disc which is used for powering up the station and electricity in the habitat inside the outer ring via photovoltaics. A flat stationary radiator is located below the inner disc. It is used to dissipate heat waste released by the station. In the center of the solar power cells, there is a docking module for the space craft to land and dock with the station. At the bottom of the transport tube, there is a tethered solar power generation satellite. It collects solar energy and use it to generate the remainder of power required that is not generated by the main solar power cells.

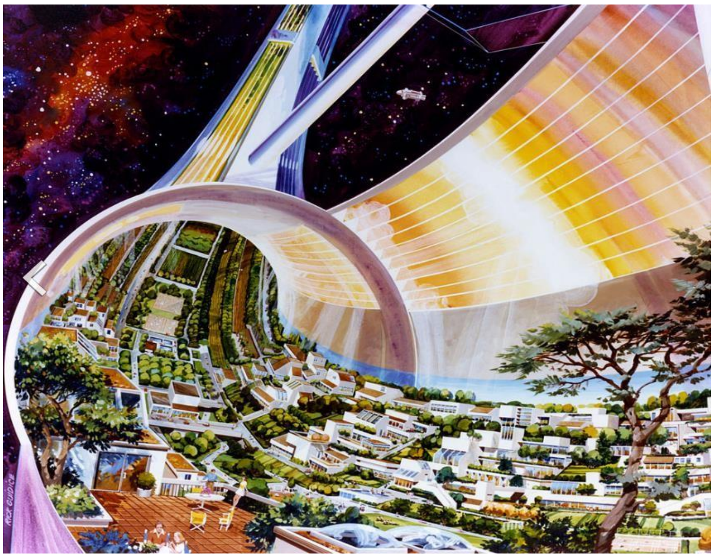

Figure 4: Halfway section view of Stanford Tours

Energy Requirements: This Stanford Torus is fully powered by using solar energy. Solar power generation via photovoltaics would be used to generate all the electricity in the torus. In that case, a sufficient amount of solar panel area is needed to be installed has to be calculated. Stanford Torus design estimated that there is 1390 W per square meter of solar energy available in space. The average electrical power needed for each person in the habitat is 3 kW. It is actually a double amount per capita electricity consumption of American in 1975. As the habitat can house 10.000 people, this means that the electrical power needed is 30 MW. With the solar panel efficiency of 10%, Stanford Torus will require a minimum solar panel area of 215.827 m^2.

Cooling Requirements: Assuming that the power needed to generate electricity is 30 MW, for agriculture is 66 MW, for illumination and heating is 35 MW, the estimated waste heat that needs to be radiate would be 131 MW. The characteristics of the radiator are 280 K in temperature, can emit 348.5 W/m^2, and has an efficiency of 60%. This means that the radiator area needed is 628.000 m2 [16]. But the radiator area of Stanford Torus is 941.000 m^2 (refer Figure 3) which is almost 1.5 times bigger. Therefore, the radiator used by Stanford Torus is more than enough to expel all the waste heat out into the space.

Size: Providing a numerical understanding of the size of social cell and radiator arrays required for the Stanford Torus, it can be challenging to visualize what these would look like at scale, especially as areas increase by a power of 2 given the length of a panel side.

Material Requirements: A spacecraft would be placed at this point and would be used to process and produce materials from the elements obtained from the Moon. Aluminium, Titanium, Silicon and Oxygen are the elements required to build this design. Aluminium and glass would be produced at L5 from lunar material. Becausedesign requires huge amount of aluminium and glass, and transporting things from the Moon would take 5% lesser energy than transporting things from Earth. Aluminium would be used to build the structure and the glass would be used to build the transparent windows (Solar 1, 2 and 3) and the main mirrors. Lunar soil would also be needed. It would be used for agriculture.

O'Neill Cylinder: American physicist named Gerard K. O'Neill proposed a concept of space colonization in his book The High Frontier: Human Colonies in Space which was published in 1976 and in his article The Colonization of Space in a book, Physics Today. He later proposed three designs, which he called Island 1, Island 2 and Island 3. Island 1 and 2 are spherical in shape while Island 3 is a cylinder which later named as O'Neill Cylinder.

3. CHALLENGES AND THREATS IN SPACE COLONIZATION

Building colonies in space would require access to water, food, space, people, construction materials, energy, transportation, communication, life support, simulated gravity, radiation protection and capital investment. It is likely the colonies would be located near the necessary physical resources.

Life Support: In space settlements, a life support system must recycle or import all the nutrients without "crashing." The closest terrestrial analogue to space life support is possibly that of a nuclear marine. Nuclear submarines use mechanical life support systems to support humans for months without surfacing, and this same basic technology could presumably be employed for space use.

Health Risks: Although there are many physical, mental, and emotional health risks for future colonizers and pioneers, solutions have been proposed to correct these problems. Mars500, Hi-Seas, and SMART-OP represent efforts to help reduce the effects of loneliness and confinement for long periods of time. Keeping contact with family members, celebrating holidays, and maintaining cultural identities all had an impact on minimizing the deterioration of mental health. There are also health tools in development to help astronauts reduce anxiety, as well as helpful tips to reduce the spread of germs and bacteria in a closed environment. Radiation risk may be reduced for astronauts by frequent monitoring and focusing work away from the shielding on the shuttle. Future space agencies can also ensure that every colonizer would have a mandatory amount of daily exercise to prevent degradation of muscle.

Radiation Protection: Cosmic rays and solar flares create a lethal radiation environment in space. In Earth orbit, the Van Allen Belts make living above the Earth's atmosphere difficult. To protect life, settlements must be surrounded by sufficient mass to absorb most incoming radiation, unless magnetic or plasma radiation shields were developed. Passive mass shielding of four metric tons per square meter of surface area will reduce radiation dosage to several or less annually, well below the rate of some populated high natural background areas on Earth. This can be leftover material (slag) from processing lunar soil and asteroids into oxygen, metals, and other useful materials. However, it represents a significant obstacle to manoeuvring vessels with such massive bulk (mobile spacecraft being particularly likely to use less massive active shielding). Inertia would necessitate powerful thrusters to start or stop rotation, or electric motors to spin two massive portions of a vessel in opposite senses. Shielding material can be stationary around a rotating interior.

Psychological Adjustment: The monotony and loneliness that comes from a prolonged space mission can leave astronauts susceptible to cabin fever or having a psychotic break. Moreover, lack of sleep, fatigue, and work overload can affect an astronaut's ability to perform well in an environment such as space where every action is critical.

CONCLUSION

Space colonization, the establishment of permanent human habitats beyond Earth, has an enormous potential moral value because successful space colonization is the necessary condition for trillions of future people to come into existence. At the same time, however, space colonization is not risk-free. The risks of space colonization are so grave that, in a bad-case scenario, successful space colonization could create more moral disvalue than value; possibly even orders of magnitude more. It is not impossible to colonize in space when we are ready with all necessities, risk awareness and solutions on it.

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