JASMAC Conference of the Japan Society of Microgravity Application

OS1-4

一般民間人滞在のための快適 ECLSS

An Inclusive ECLSS for Comfortability

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The Basic Plan on Space Policy, approved by the Cabinet on June 13, 2023, was established to define the fundamental direction of space policy for the next decade, with an outlook extending 20 years into the future. This plan aims to promote new economic and social activities in space, reflecting the expanding sphere of human activity beyond Earth and low Earth orbit to the Moon's surface and deep space.

Traditionally, space has been perceived by the general public as an arena exclusively for astronauts and other specially trained individuals to accomplish their missions, making it seem distant and inaccessible to ordinary people. However, it is projected that by 2030, around 100 people will travel and stay in low Earth orbit, with that number increasing to 200–300 people for short to medium-term stays in the 2040s[1)]. According to another roadmap, by 2050, the number of annual travelers by orbital flight could rise to several thousand, with suborbital flight numbers reaching approximately 100,000[2)]. Until now, space station usage has been restricted to specialized personnel and professional astronauts carrying out their missions. However, post-2030, access to space stations is expected to open up to the private sector. In response, many companies, including those outside the traditional space industry, are accelerating space-oriented research and development.

The environmental conditions at a space base—such as gravity, temperature, humidity, and air/water circulation—differ significantly from those on Earth. Research on Environmental Control and Life Support Systems (ECLSS)[3)] for human space activities has focused on enabling humans to operate in space over the mid- to long-term. Additionally, CELSS (Closed Ecology Experiment Facilities) research[4)] has been conducted for deep space manned exploration activities on Mars and beyond the Moon. These technological developments have enabled environmental control and life support at space bases, allowing astronauts to perform their missions.

Given the drastically different environment and behavioral constraints in space compared to Earth, it is anticipated that human perception and experience will be affected in space. We propose that the key to achieving quality of life (QOL) and well-being in space may lie in the “everydayness” that we experience in our lives on Earth. The purpose of this study is to present an overview and concept of the “Inclusive ECLSS for Comfortability,” a novel approach to ECLSS that aims to ensure ordinary civilians feel as comfortable as possible while operating in a space base, despite the limited resources and unique environment of space.

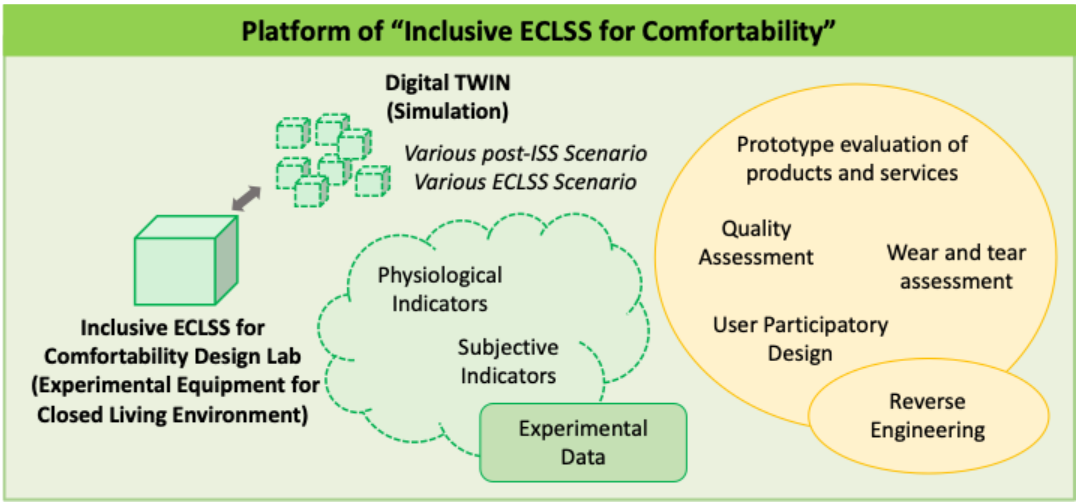

Figure 1. A Conceptual diagram of Plat form of "Inclusive ECLSS for Comfortability".

The "Inclusive ECLSS for Comfortability" integrates approaches from various technologies and disciplines through system design management techniques. Systems engineering is employed to establish objectives, functional design, and physical design, taking into account the uniqueness of the space station and the diversity of individuals.

Figure 1 presents a conceptual diagram of the "Inclusive ECLSS for Comfortability." This study focuses on low Earth orbit. The Inclusive ECLSS for Comfortability Design Lab (Experimental Equipment for simulating a closed living environment) will be implemented on Earth. This experimental device simulates material circulation, excluding gravity, within a space base to the extent necessary for design, evaluation, and verification. The device will be capable of controlling all environmental parameters except gravity. Within this controlled environment, conditions necessary for verification will be simulated. In this experimental space, people and objects will interact, and the effects of these interactions will be evaluated and analyzed. Experiments and analyses will include prototype evaluation, quality assessment, and wear-and-tear evaluation of products and services. Additionally, user-participatory design will be realized. In the future, we aim to bring back products used at the space station for reverse engineering evaluations and analyses.

Acknowledgement: The authors are grateful to Prof. Takashi Kawai, Prof. Motohiko Miyachi, Dr. Yoshihiro Banchi, Prof. Tatsuya Shimizu, Dr. Michihiro Koyanagi, Ms. Kaori Itagaki, Prof. Kan Imai, Prof. Toru Asahi and Prof. Seiko Shirasaka, and other project members for discussing the topic treated in this paper. Also I would like to thank Dr. Masato Sakurai and Prof. Naoko Yamazaki for useful advices.

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