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Simulating Space Habitation: Habitats, Design and Simulation Missions (6)

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ECHO V2: CONCEPTUAL DESIGN OF A MODULAR INFLATABLE HABITAT MODULE FOR SUB-SURFACE ANALOG SPACE MISSIONS

Abstract

Space exploration is inherently dangerous and requires extensive preparation and precautions to mitigate risks. Analog space missions, like CHILL-ICE by ICEE Space, provide a cost-effective way to develop and test space technologies and operations on Earth, reducing the risks involved. These missions require temporary habitats set up in space-like environments where the analog astronauts reside for the duration of the mission. Existing space analog habitats are primarily built for survival but do not focus on the comfort of their inhabitants. The current work by ICEE Space aims to develop a habitat that ensures not only survival but also comfort and privacy.

Building on the successful ECHO V1 habitat by Wilson School of Design, ICEE Space analyzed feedback and observations from past missions during pre-phase A studies to develop goals for the new habitat that include introducing ergonomic features, reducing habitat assembly time, and improving multi-functionality.

During CHILL-ICE II, double bubble was used for thermal insulation, but they required strenuous assembly during habitat setup. To solve this, ICEE Space proposes to sew the insulation to the habitat skin, creating a foldable, geometric origami-like structure that maintains structural integrity while deployed. Parametric studies were conducted to create a preliminary CAD model for the proposed structure, and FEM analyses were done to test structural stability. Materials chosen for ECHO V1 and during pre-phase A studies—PVC inflatable tubes, double bubble pads, Tyvek and Nylon habitat skin—are used in the simulations. Based on these studies, recommendations were made for prototyping and development in consequent phases. The habitat is also designed to be modular, allowing for the addition of more ECHO modules for longer missions accommodating more astronauts.

Another important consideration for the habitat design is the multifunctionality of its interior. According to astronaut feedback, space reconfiguration suggested in previous missions took time and effort, which outweighed the physical and psychological benefits of having discrete setups for different periods of the day. With ECHO V2, ICEE Space aims to alleviate this issue by creating a space that is reconfigurable with minimal time and physical effort, and the processes will be scheduled so that they do not interfere with critical activities.

With the proposed redesign of the ECHO habitat, ICEE Space takes a major step forward in providing a safe, comfortable, and functional environment to conduct analog research in fields including but not limited to geology, human factors, space suits, and other space technologies.