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

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BUILDING INDIA'S FIRST SPACE ANALOGUES : LESSONS FOR SPACE HABITATION DESIGN

Abstract

India's Gaganyaan program marks the nation's commitment to sending astronauts to Low Earth Orbit (LEO) in 2025, laying the foundation for future crewed Moon missions. This milestone will make India only the fourth country to achieve human spaceflight, following Russia, the USA, and China. As a signatory of the Artemis Accords, India benefits from international collaboration in achieving this goal. In November 2024, Australia strengthened this partnership by signing an Implementation Agreement with the Indian Space Research Organisation (ISRO), fostering a dynamic exchange of knowledge between the two nations.

Despite its ambitions, India currently lacks space analogue facilities—critical for gathering data essential to mission planning. To address this gap, ISRO partnered with AAKA Space Studio to conduct two pioneering analogue habitat experiments in 2024: one in the extreme heat of the Dholavira White Desert and another in the frigid Himalayan environment of Ladakh. These experiments provided crucial physiological and psychological data while testing habitat materials and configurations under extreme thermal cycling, fine dust exposure, and reduced atmospheric pressure.

The data is now being jointly analysed by the Indian Institute of Science (Bangalore, India) and the Andy Thomas Centre for Space Resources (Adelaide, Australia). In the initial research phase, thermal regulation data was assessed using computational fluid mechanics simulations and correlated with human physiological monitoring—including blood oxygen levels and body temperature—to evaluate the impact of different design parameters. Additionally, heart rate variability and blood pressure data were analysed to assess psychological well-being, validated using questionnaires and the Psychomotor Vigilance Task (PVT). The findings were then used to identify key architectural design parameters as well as material configurations that needed to be adjusted to create more effective space habitation analogues.

This paper presents preliminary results from this India-Australia collaboration, using India's first space analogue data to enhance our understanding of the challenges and solutions in space habitat design. This initiative plays a key role in democratizing space exploration knowledge, enabling emerging spacefaring nations to develop indigenous capabilities through strategic partnerships. Ultimately, it contributes to the global effort toward a sustainable human presence beyond Earth, reinforcing the international space exploration ecosystem.