22nd IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Interactive Presentations - 22nd IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (IP)

Author: Mr. Daniele Florenzano
University of Southern Denmark, Denmark

Dr. Valentina Sumini
Politecnico di Milano, Italy
Prof.Dr. Roberto Naboni
Denmark

AUTOMATED DESIGN AND ADDITIVE CONSTRUCTION OF REGOLITH-SHIELDED LUNAR HABITATS

Abstract

The goal of establishing sustained human settlements on the lunar surface poses unprecedented challenges and necessitates a sustainable approach to space exploration that minimises dependence on Earth's resources.

This necessitates the automation and gapless integration of design and construction processes to provide habitats that respond to mission-specific requirements. Design criteria include maximising In Situ Resource Utilization while considering human factors, such as the psychological and physical well-being of the crew.

Computational design of lunar habitats and construction robotics play a crucial role in conceiving flexible lunar settlements responsive to site-specific conditions. This research delves into adaptive robotic 3D printing, space-driven site planning, and habitat design. The primary contributions of this study encompass the development of a Class II-III habitat design workflow that incorporates radiation shielding through regolith-based shells and a mission-oriented site definition.

The proposed design workflow seamlessly integrates mission objectives, duration, crew size, and activities with landing site conditions, thereby defining the settlement's functional and spatial layout. The habitat design explores innovative material and energy-efficient radiation shielding possibilities. In this context, an experimental investigation was conducted to simulate the automated robotic fabrication of on-site 3D printing of structural elements using lunar regolith as scaffolding and construction material, effectively serving as inert radiation mass. This experiment is a terrestrial proof of concept for regolith-based 3D printed radiation shielding on the lunar surface.

The reduction in resources transferred from Earth, coupled with the automation of environment-aware construction, showcases the potential for digitally fabricated structures in extreme lunar environments without extensive support infrastructure. By leveraging computational design and robotics, this approach ensures the adaptability and resilience of lunar architectures, addressing the multifaceted challenges of the lunar environment. The goal of reducing Earth-dependency through ISRU-based construction technologies, and the increased human capability for permanent settlement on the Moon and Mars based on site and planetary-informed design strategies, highlights a new paradigm for the development of innovative solutions to enable the extended permanence of humanity in space.