

MATTHEW MAWHINNEY & JOEL T. DUGAN, Dept of Architecture Art + Design, Fairmont State University, Fairmont, WV 26554. Regolith-Integrated Geodesic Kinetic Habitat with Adaptive Membrane for Radiation-Resilient Permanent Settlement in Lunar Lava Tubes.

This study introduces a dual-component kinetic habitat concept intended for sustainable and permanent human habitation within lunar lava tunnels. The objective is to design a radiation-resilient, structurally robust alternative to currently deployed inflatable habitat systems, which remain vulnerable to micrometeoroid puncture and high-velocity regolith particulates. This project proposes utilizing naturally occurring lunar lava tubes as a protective subsurface environment capable of supporting long-duration settlement and mitigating radiation exposure. This proposed system consists of a geodesic dome cap fabricated from regolith-based composite materials on-site to provide geometric load distribution, structural redundancy, and radiation attenuation. Beneath this dome cap, a compliant elastomeric membrane conforms to irregular lava tube geometries, forming a sealed and adaptable environmental interface. Current methodology includes a robust literature review of aerospace research, analysis of lunar geological data, and synthesis of architecture and engineering structural principles. Computational modeling frameworks, focused on finite element analysis, geometric optimization, and radiation attenuation estimation, are under development, and quantitative performance metrics remain under investigation. Preliminary findings suggest that integrating a regolith-derived geodesic dome with a conformal adaptive base may provide a more permanent and resilient alternative to inflatable systems in subsurface lunar environments. Definitive structural and shielding performance values are forthcoming as simulation and validation efforts progress. This research was made possible by WV Higher Education Policy Commission, STaR Division.