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LUNAR SUB-TERRA: AN INNOVATIVE SELF-INTEGRATING HABITATION UNIT

Abstract

As humans venture deeper into space, the need for a lunar settlement, housing the first group of settlers, grows steadily. By means of modern technologies such as in situ resource utilization (ISRU) as well as computational design, this goal can be implemented in present years. Providing the first arrivals with a fast underground habitat safe from radiation and other environmental constraints is of crucial importance to initialize a prolonged mission on the Moon. The proposal revolves around the idea of establishing a base which provides an immediately habitable space with the possibility for future expansion. Advanced construction methods and sustainable practices lay the groundwork for a permanent human presence, predominantly based on ISRU.

The narrative outlines a two-phase initiative aimed at the foundation of the Lunar Subterra, followed by an extension of the habitat above ground. The mission initiates upon the arrival of the Lander on the lunar surface, which delivers the initial circular modules designed to respect a common spaceship payload diameter. Subsequently these units are ejected onto the ground where they integrate themselves autonomously into the lunar soil using their core's integrated drilling mechanism, immediately forming a temporary safe habitat. In the following phase, the unit inflates a Kevlar membrane on its top to create an additional habitable space above the subterranean modules, which creates a habitable space on the surface for up to 6 settlers. Utilizing the local regolith soil, a protective shield is 3D-printed above the inflatable membrane. This shield is individually adapted to each module, following the use of a structural analyzer software, ensuring efficient material use by outlining stresses and displacement, guaranteeing

an optimized printed structure. The interior inflatable membrane dimensions are obtained using an algorithm-based computational design, which optimizes the membrane's size and interior habitable area, following parameters such as tensile strength and internal pressure. In later stages of the settlement, the core showcases its multifunctionality by acting as a vertical connector between under- and aboveground areas. In this manner the proposed design stands out through its rapid implementation and infinite expansion possibilities through sustainable approaches. Following our collaboration with the PoliSpace Sparc Student Association group, a Virtual Reality (VR) reproduction enabled quick iterative testing of the habitable space with the use of a Meta Quest 2 headset. This Allowed, the evaluation of the environment's impact on residents and eliminated the need for physical models, facilitating rapid user-centered design for future space exploration.