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DESIGNING FOR REPAIR AND REPAIRABILITY IN LUNAR HABITATS: PRELIMINARY INVESTIGATIONS IN REGOLITH BLOCK BASED CONSTRUCTION

Abstract

In the development of Lunar Habitats, the extreme environmental conditions, including hypervelocity micro-meteorites or extreme thermal cycling, can pose significant challenges for the choice of external materials. Many existing proposals, which have received substantial coverage in the media, rely on the abundantly available in-situ resource of lunar regolith, and deep layering of loose or sintered regolith is proposed as a way to mitigate these environmental risks. Fortunately, the current research shows that the fine texture of regolith is effective in managing hyper-velocity projectiles, and a certain thickness also works as an effective radiation shield. None of this, however, mitigates the ongoing damage to the structure, and while some aspects of maintainability have been discussed before, there is no current framework to account for repairs after significant damage has occurred. This paper presents the results of some preliminary investigations in developing a "Design for Repair" approach to the design of Lunar Habitats. The experimental design primarily focuses on Regolith Block Based Construction. The design process incorporates aspects of 'assessment based iterative design', including Life-Cycle Assessment (LCA), Performance or Value assessment, and Optimisation Algorithm based approaches. It also learns from the recent literature on 'Circular Economy' including Closed-Loop Cycles and focus on the 6Rs (Reduce, Reuse, Recycle, Recover, Remanufacture, Redesign). The subsequent performance testing at our laboratory facilities looked at System Properties particularly focusing on ease of Disassembly and Reassembly, as well as the extent of Modularity and Adaptability in the design. In terms of the Designed Components the testing evaluated the level of Standardisation including Connection Selection, Fault Isolation, and incorporation of Sacrificial Elements in the design. Finally, the process tested for Manufacturing Process Selection in terms of Human-Robot Interaction and the challenges of Documentation or Knowledge Transfer in this context. Here we employed new techniques in computer vision to incorporate construction information into the building elements themselves. These initial results outline the set of challenges for repairability in the design of lunar habitats and present solutions for both design and testing in order to develop a more resilient lunar architecture. This is not only relevant for the discipline of Space Architecture but also charts a path to "Design for Repair," which will help us achieve our Sustainable Development Goals (SDGs) here on Earth.