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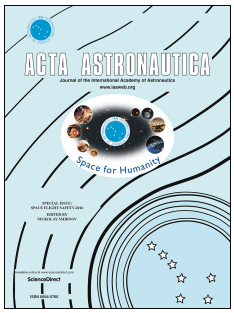

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Abstract

The Moon is now being considered as the starting point for human exploration of the Solar System beyond low-Earth orbit. Many national space agencies are actively advocating to build up a lunar surface habitat capability starting from 2030 or earlier: according to ESA Technology Roadmaps for Exploration this should be the result of a broad international cooperation. Taking into account an incremental approach to reduce risks and costs of space missions, a lunar outpost can be considered as a test bed towards Mars, allowing to validate enabling technologies, such as water processing, waste management, power generation and storage, automation, robotics and human factors. Our natural satellite is rich in resources that could be used to pursue such a goal through a necessary assessment of ISRU techniques.

The aim of this research is the analysis of a Moon outpost dedicated to the validation of enabling technologies for human space exploration.

The main building blocks of the outpost are identified and feasible evolutionary scenarios are depicted, to highlight the incremental steps to build up the outpost. Main aspects that are dealt with include outpost location and architecture, as well as ISRU facilities, which in a far term future can help reduce the mass at launch, by producing hydrogen and oxygen for consumables, ECLSS and propellant for Earth-Moon sorties and Mars journeys. A test outpost is implemented in a Virtual Reality (VR) environment as a first proof-of-concepts, where the elements are computer-based mock-ups. The VR facility has a first-person interactive perspective, allowing for specific in-depth analyses of ergonomics and operations. The feedbacks of these analyses are crucial to highlight requirements that might otherwise be overlooked, while their general outputs are fundamental to write down procedures. Moreover, the mimic of astronauts' EVAs is useful for pre-flight training, but can also represent an additional tool for failures troubleshooting during the flight controllers' nominal operations. Additionally, illumination maps have been obtained to study the light conditions, which are essential parameters to assess the base elements location. This unique simulation environment may offer the largest suite of benefits during the design and development phase, as it allows to design future systems to optimize operations, thus maximizing the mission's scientific return, and to enhance the astronauts training, by saving time and cost.

The paper describes how a virtual environment could help to design a Moon outpost for an incremental architecture strategy towards Mars missions.

Keywords: Virtual Reality, Moon outpost, Illumination analysis, Incremental exploration architecture

Acronyms/Abbreviations

Two-Dimensional (2D)
Three-Dimensional (3D)
Four-Dimensional (4D)
Assembly Integration and Test (AIT)
Augmented Reality (AR)
Ames Research Centre (ARC)
Computer-Aided Design (CAD)