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SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

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ANALYSIS OF A MOON OUTPOST FOR MARS ENABLING TECHNOLOGIES THROUGH A VIRTUAL REALITY ENVIRONMENT

Abstract

The Moon has again been considered as the starting point for human exploration of the Solar System since few years. National space agencies rise the attention to build up a lunar base station by 2030: 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 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. Starting from the mission statement, 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 crew size, tasks analysis, 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. The complete architecture is implemented in a Virtual Reality (VR) environment, where every building block of the outpost is a computer-based mock-up of the future system to reproduce both physical and functional behaviours. 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 an astronaut in EVA is useful for pre-flight training, but can also represent an additional tool for failures troubleshooting during the flight controllers nominal operations. 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 the incremental architecture of the Moon outpost in the VR environment and highlights considerations and requirements on ergonomics and operations to design systems able to maximize scientific return.