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SPELEOLOGY ANALOG MISSION CRITICAL SYSTEMS VALIDATION THROUGH RELEVANT ENVIRONMENT TESTS: ADVANCEMENTS FROM THE GEA PROJECT

Abstract

Innovative systems and technologies implemented for future human Lunar exploration missions find in analog missions a crucial step for achieving preliminary on-field validation and to obtain lessons learned and design drivers. In this perspective, speleology analog missions can allow relevant environment validation of Lunar lava tube missions systems and technologies. GEA (Analog Exploration Group) is a project created by the Sapienza S5Lab research group at Sapienza University of Rome and by Rome's Chapter of the Italian Alpine Club (CAI) in 2022 for establishing a permanent research infrastructure for speleology analog missions, allowing to support human missions simulations through the implementation of mission support and control systems, and to test innovative technologies that might be exploited in the future in the framework of real space and planetary exploration missions. The primary project aim is to develop a short duration mission of 72 hours with a crew of six astronauts and by developing all the support systems and tools to perform the mission simulation. In July 2023, the GEA research group has successfully completed a first 24-hour mission test in the caves near Rome, Italy, by verifying the majority of critical systems well-functioning and applicability, including electrical power, data and voice connection with the Mission Control Center (MCC) and by obtaining a variety of lessons learned. The 24-hour test was completed with a crew of six astronauts that took part in the first 12 hours, and 3 astronauts enduring the entire 24-hour demonstration, while around 20 people were taking care of the critical systems, MCC operations, support logistics and safety procedures. During the test, a set of experiments were completed, including the preliminary verification of autonomous edible vegetables cultivation systems in relevant environment, and the development and preliminary testing of microbial fuel cells for energy harvesting within the exploration activity. These last topics will be further investigated in the next three years with an Italian Space Agency-funded experimentation. A 72-hour mission test is foreseen for Q3-2024 and it will benefit from all lessons learned from the 2023 testing campaign. Such campaign will be held by improving the MCC operations and by remotizing part of the support centers. This paper

will present the GEA mission and the outcomes of the speleology analog environment tests of 2023 and 2024. After an introduction on the project and the performed activities, a detailed report over the analog tests will provided before leading to future perspectives.