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Author: Dr. Bindhu Oommen
University of Arizona, United States

SPACE ANALOG FOR THE MOON AND MARS (SAM), A HERMETICALLY-SEALED AND PRESSURIZED TERRESTRIAL ANALOG STATION AND RESEARCH FACILITY: FROM INCEPTION TO CREWED ANALOG MISSIONS AND BEYOND

Abstract

We are at an exciting time in the course of human history as we prepare to return to the Moon and endeavor for long-duration travel to Mars. Spaceflight research spans many disciplines, a study in all aspects of what it will take to survive and thrive away from our home planet. Terrestrial analogs play an important role in near-term and future human spaceflight research. Ground-based analogs permit field tests of products and processes before taking them to space–more quickly, affordably, and safely. A number of terrestrial analogs have been recognized and employed by space agencies across the globe, starting with NASA in the 1960s. We introduce and describe the recently developed Space Analog for the Moon and Mars (SAM) at the University of Arizona Biosphere 2 in Oracle, Arizona, USA. SAM is a hi-fidelity, hermetically-sealed and pressurized research facility designed and built around the 1987 Biosphere 2 Test Module greenhouse and its accompanying variable volume pressure regulation chamber ("lung"). SAM's expanded habitat includes 1) an engineering and medical bay, 2) crew quarters complete with bathroom and kitchen, 3) a functional airlock, and 4) a separate, on-site Mission Control Center. Integrated sensor arrays use SIMOC Live to capture and display data, enabling monitoring of air quality and life support systems both in-hab and at Mission Control. A 250 sq-meter, sculpted indoor Mars yard and terrain park includes a 15 meter long reduced-gravity simulator that enables one-third, one-sixth, or any other desired weight off-set, and for use with commercial pressurized spacesuits. Realtime in-suit monitoring of vitals enables hi-fidelity extravehicular activities (EVAs) in the Mars yard terrain park. Additionally, the hydroponics bioregenerative life support and food production system is being upgraded, and a fully-functional medical bay is under development. We expound the facility's experiences and research to date. The first two short-duration analog missions in spring 2023 operated in a pressurized, pass-through mode, demonstrating that SAM is fully operational and safe, with the third analog mission and baseline bioregenerative research scheduled in March and April 2024, respectively. We demonstrate that SAM has the potential to contribute significant research toward human space exploration and habitation of other planetary bodies–including, but not limited to, testing of space suit mobility and functionality, drones, rovers, technologies, equipment, communications, bioregenerative life support systems; observation of behavioral effects of isolation, confinement, team dynamics, food; and more.