Development of lunar surface analog environment testing capabilities at the nasa johnson space center. O.S. Bekdash[1], L.D. Welsh[2], B.H. Scheib[2], S.J. Wray[2], T.G. Graff[3], K.E. Young[4], A.J. Naids[4], H.R. Bergman[4], P.S. Valle[4], K.J. Kim[2], J.T. Dunn[2], A. FJ. Abercromby[4].

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Introduction: NASA is preparing to land the first woman and first person of color on the Moon within the next decade and ensuring the success of these missions will depend on our preparation on the ground in multiple ground based lunar environment analogs. To achieve this NASA has been working to develop multiple analog environment facilities at the Johnson Space Center in Houston, Texas in order to acceptably simulate partial gravity operations for use in ground-based research, crew training, and engineering design evaluations. These environmental analog facilities include the Neutral Buoyancy Lab (NBL), Active Response Gravity Offload System (ARGOS), and JSC Rockyard. No single analog can simulate all the different aspects of the lunar environment, which is why a complement of analogs for specific testing of operations and hardware are being developed.

Discussion: In 2020, testing focused on evaluating best practices for performing geologic science on the lunar surface, including which tools, sampling methods, distribution of tasks between crewmembers, and communication with ground science teams enable safe and effective EVA operations. This work also investigated human performance metrics to better understand the physical and cognitive workload of astronauts during exploration class missions. It is expected that operating in a partial gravity environment will result in higher workloads than astronauts typically experience in microgravity EVA operations on the International Space Station. Therefore, characterizing these human performance parameters is necessary to ensure that both the crewmembers and the suit hardware can support all required tasks. Results from this testing will inform multiple spaceflight domains including tool design, flight operations, suit design, task design, thermal models, and life support system capacity verification plans, among others.

Testing was performed at several of the analog sites at JSC. At the NBL, the Z2.5 planetary prototype suit was used to understand how to simulate lunar gravity in the pool environment using a pressurized suit and test the geology station simulation area. Overall, subjects reported that the environment is a great space for performing these initial tests, evaluating suited operations, and assessing ergonomics when using different tools. At the rockyard, operations related to distribution of crew tasks, tool utilization, communication with science backrooms and MCC, and early evaluations of EVA informatics systems were performed. Lastly at the ARGOS facility, evaluations of partial gravity suited operations including long distance walk back (via treadmill), ergonomics for tool usage when performing sampling, and measurements of human performance metrics such as metabolic rate, and cognitive loading were performed. Figure 1 shows subjects working these various environments.

Conclusion: Each of these analog facilities provide a unique capability to simulate a different aspect of lunar surface operations at different levels of fidelity, and the combination of these will best enable safe and effective EVAs in future exploration missions.

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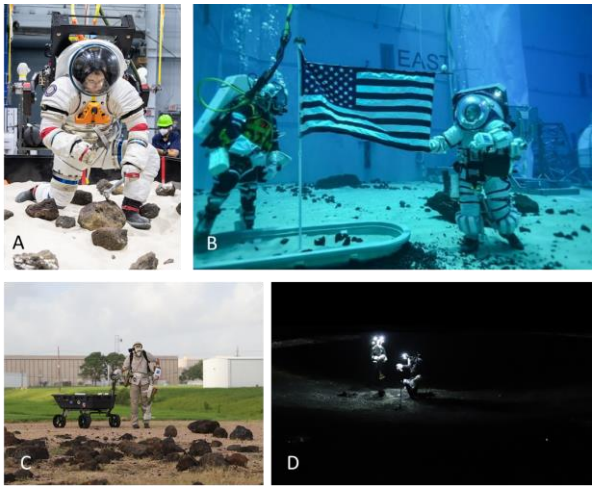

Figure 1. A test subject performing simulated lunar surface EVA geologic science operations in various JSC environmental analogs. (A) ARGOS; (B) NBL; (C) Rockyard; (D) Rockyard night operations