NASA TESTBED ENVIRONMENTS FOR ARTEMIS LUNAR SURFACE OPERATIONS. K. E. Young[1], T. G. Graff[2], L. D. Welsh[3], S. Wray[3], A. Naids[4], T. Akker[2], D. Coan[5], H. Bergman[4], M. Miller[2], M. Miller[6], M. Downs[6], T. E. Caswell[3], C. Mavridis[3], J. Kagey[3], S. Korona[4], E. Matula[3], and A. Kanelakos[4]
[1]NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD, 20895 (kelsey.e.young@nasa.gov); [2]Jacobs at NASA Johnson Space Center, 2101 E NASA Pkwy, Houston, TX, 77058; [3]KBR at NASA Johnson Space Center, 2101 E NASA Pkwy, Houston, TX, 77058; [4]NASA Johnson Space Center, 2101 E NASA Pkwy, Houston, TX, 77058; [5]The Aerospace Corporation at NASA Johnson Space Center, 2101 E NASA Pkway, Houston, TX, 77058; [6]NASA Kennedy Space Center, Florida, 32899

Introduction: As NASA prepares to return astronauts to the surface of the Moon in conjunction with international, commercial, and academic partners with the Artemis Program, testing has begun in multiple facilities across the NASA Johnson Space Center (JSC) to test tools for Extravehicular Activity (EVA) and define operations concepts for an exploration-based Mission Control Center (MCC). The latter includes testing video and imagery architecture to link astronauts on lunar EVAs to MCC as well as concepts for documentation to support EVA crews (cuff checklists, procedures, MCC console logs, etc.). This testing has spun up in earnest throughout 2020 in several facilities at JSC, including the rock yard (simulating the surfaces of the Moon and Mars), the Neutral Buoyancy Laboratory (NBL), the Active Response Gravity Offload System (ARGOS), and in a series of Flight Controller Part Task Trainer (FCPTT) exercises. Much more extensive testing is needed, both in these environments and in more robust scientific analog environments, as well as with the inclusion of broader sections of the science community, and in more integrated, full-scale mission simulations. The initial tests described here represent a first step in creating an integrated exploration community through a series of smaller tests and simulations.

Here, we review some of these initial tests in the rock yard and in FCPTT exercises to explore the capabilities of these facilities in preparing for the real-time support of science operations on the lunar surface.

Rock Yard Testing: The JSC rock yard, developed for engineering and local testing onsite, contains several primary components (Figure 1): the Mars Yard is a predominantly flat area with rocks of varying size; the Lunar Yard contains three small craters of varying size and depth; and Mount Kosmo is a small, steep hill with a variety of boulders. The rock yard also contains an area of softer unconsolidated material, as well as facilities support to enable testing (power, trailer facilities, etc.). The rock yard is mostly used for the development testing of assets such as rovers being developed onsite, though it was also used for training and operations during the NASA Desert RATS testing during the Constellation Program. The facility allows operational and logistical aspects of planetary surface operations to be evaluated in an environment physically resembling geologic field sites but, because the geologic context is both simulated and unchanging, those aspects are evaluated independently from the process of geologic discovery.

Following the directive to send humans to the Moon with the Artemis Program, a team of NASA engineers, flight controllers, scientists, and astronauts has been using the JSC rock yard for a series of low-fidelity engineering and operations evaluations (Figure 2). These initial tests were completed in the shirt-sleeve environment (un-suited), with the last several including backpacks providing communications and imagery support. Objectives evaluated during these initial tests included EVA tool concepts, concepts for tool and sample management, coordination between operational and scientific MCC positions (Ground IV and a Lunar Science Officer), initial evaluation of video, imagery, and communications support for MCC operations, teamwork strategies for EVA crews completing EVA science tasks, and evaluations of preliminary operations products (such as procedures) utilized by the MCC team.

Figure 1 (above): Aerial image of the JSC rock yard facility.

Figure 2 (above): Rock yard test from October 2020 showing two EV crew conducting geologic sampling in the Lunar Yard.

To obtain a full evaluation of Artemis surface operations, JSC rock yard testing should be supplemented by both small-scale testing in other JSC facilities (e.g., suited operations in gravity offload simulators) and integrated testing with larger, representative science, MCC, and engineering teams (e.g., operational simulations stressing the full chain of communication between astronauts on the surface and scientists supporting a mission). In addition, information flow and scientific decision-making in a true exploration context can only be evaluated in more representative geologic environments, where true geologic field work takes place. However, this initial testing has been vital in advancing several key tool designs and operations concepts and in unifying the NASA engineering, flight operations, and science team under one broader, integrated team.

Flight Controller Part Task Trainer (FCPTT): FCPTT testing is a form of spaceflight operations training that has been used throughout several human spaceflight programs, including the Space Shuttle and International Space Station programs, to train members of the Flight Control Team (FCT) within NASA's Flight Operations Directorate (FOD). In the FCPTT environment, a subset of MCC personnel participate in focused exercises at realistic control consoles to evaluate (or train) operational skills. The FOD Exploration EVA (xEVA) team has conducted initial FCPTT exercises simulating Artemis lunar surface operations, and begun the evaluation of incorporating science positions into the Flight Control Team (FCT) structure. Two FCPTT exercises were conducted in 2020 to evaluate the structure of the xEVA FCT. Other objectives included initial evaluations of delayed lunar communications, investigations of navigation for lunar surface EVA, and timeline procedure development. More FCPTT exercises will be needed to continue to evaluate these initial concepts, as well as to eventually include a larger science team in these simulations.

Summary: An integrated team of NASA engineers, flight controllers, and scientists have begun a series of small-scale Artemis tests at JSC facilities. These tests, including those at the JSC rock yard and in FCPTTs, have taken the first step toward evaluating concepts for science-driven EVAs under Artemis Program constraints, as well as developing the EVA tools and MCC structure necessary to support these EVAs. Future work will include more small-scale testing, testing in high-fidelity scientific analog environments, and testing in more robust mission simulations, all of which will loop in more of the science community as we move forward towards astronauts on the surface of the Moon with the Artemis Program.