ARTEMIS INTERNAL SCIENCE TEAM UPDATE: ARTEMIS SCIENCE FLIGHT OPERATIONS. K. E. Young[1], T. G. Graff[2,3], C. A. Evans[2], and the Artemis Internal Science Team, [1]NASA Goddard Space Flight Center, Greenbelt, MD, 20771 (kelsey.e.young@nasa.gov); [2]NASA Johnson Space Center, Houston, TX, 77058; [3]Jacobs, Houston, TX, 77058.

Background: The Artemis lunar missions will include astronauts traveling to the Moon to address high priority science objectives, both in lunar orbit and through extravehicular activities (EVAs) designed to explore the lunar surface. Each Artemis mission and operational element must incorporate science planning and expertise to ensure programmatic success. The Artemis Internal Science Team (AIST) is positioned within NASA to provide cross-mission Science leadership across NASA and across Artemis.

The Artemis Science Team: While the AIST provides critical support both in mission and program planning phases and across all Artemis missions, the larger Artemis Science Team (AST) structure has been designed to provide detailed support to each Artemis surface mission. Each mission's AST will include the AIST, competitively selected Geology Teams, Participating Scientists, and instrument payload teams.

AIST work crosses NASA mission directorates and key program elements and focuses on programmatic areas where science expertise is particularly relevant and high priority. This submission delivers an AIST update on Artemis Science Flight Operations, including organizational structure, simulation-based testing, and training.

Artemis Science Flight Operations: There have been no surface science EVAs conducted since the Apollo lunar surface missions, conducted from 1969-1972. However, we draw heavily from the Apollo experience, from the decades of SkyLab, Space Shuttle, and International Space Station (ISS) EVAs, and from a variety of analog testing programs, to design the structure by which science will be integrated into flight operations for Artemis missions. Members of the AIST have been working for several years to integrate science into the Artemis flight operations structure, most notably through elements of the NASA JSC Flight Operations Directorate. First and foremost, AIST members are members of the Exploration EVA Surface Operations Team, where they provide science leadership and guidance on critical science topics, training curriculum development support (for astronauts, flight controllers, and the Artemis Science Team), testing leadership and support, and participation in Artemis simulations (see examples below). Additionally, AIST members engage with the Crew Office, the Flight Director Office, the EVA and Surface Mobility Office, and many other stakeholder groups across the Agency (i.e., EVA Tools, Imagery) to ensure science priorities are integrated across key Artemis elements.

Here we describe work in these key areas, including how the AST Team will be integrated into the broader Flight Control Team, recent testing experience, and the development of training to onboard the Artemis Science Team.

Structure of Real-Time Science Team Integration: A current focus of the AIST Science Operations Team is designing the mission operations structure by which science will integrate into the Flight Control Team (FCT) in the Mission Control Center (MCC) during Artemis EVAs and other mission science activities (Figure 1). EVA support in MCC is led by the EVA Officer, located in the Flight Control Room (FCR), or the MCC Front Room. This structure enables direct communications between the EVA Officer and the mission Flight Director (FD, who has ultimate authority over the entire mission, including the EVAs) and the Ground IV (G-IV, or prime communicator between MCC and the EVA crew). These positions also coordinate closely with the EVA Multi-Purpose Support Room (MPSR). The Shuttle and ISS EVA MPSR contain two critical roles: EVA Task and EVA Systems. Systems is responsible for the health and performance of the space suit while Task is responsible for the timeline, tools, and tasks of the EVA crew. Artemis EVAs will add a third MPSR position, the *EVA Science Officer* (ESO). The ESO will be the senior science officer within the FCT and will provide connectivity between the FCT and the Science Evaluation Room (SER).

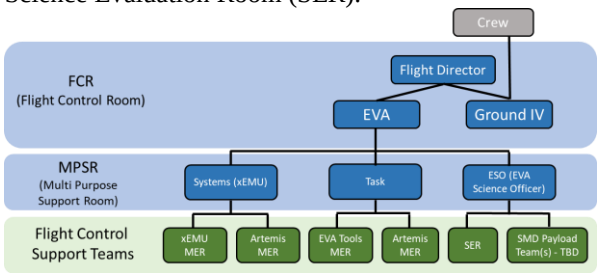

Figure 1: The Artemis EVA FCT Structure. The SER nomenclature is consistent with the Task and Systems MERs (Mission Evaluation Room).

The SER will be the primary Artemis science backroom, and SER personnel will be responsible for funneling science guidance through the ESO to the rest of the FCT and therefore to the crew members on the Moon. Key members of the Artemis Science Team

(AST) will sit in the SER, which will be structured to support real-time science operations (both EVAs and any science activities performed within the crew cabin). The design of the SER is underway, including the size, layout, hardware and software requirements, IT infrastructure, etc. Recent testing has focused on refining these requirements as well as developing recommendations for the roles and responsibilities of AST members within the SER.

Developing the ESO Role: The definition of the ESO role has been developed through EVA simulations over the last several years. As described above, critical experience was gained through Apollo, Shuttle, and ISS missions, but as Artemis missions will represent a new generation of exploration, the traditional MCC structure must be adapted to fit this new paradigm. The integration of a new operations role requires significant planning, training, and testing.

Testing the SER Structure: A clear lesson of the Apollo exploration of the Moon was the value of simulation-based training [1], a philosophy adopted for Artemis training.

The JETT3 Mission Simulation: The flight operations integration philosophy discussed above was implemented in the Joint EVA & Human Surface Mobility Test Team (JETT) 3 Artemis mission simulation in October 2022 [2]. Details of JETT3 can be found in [2], but the test was designed to simulate an Artemis 3 mission profile as closely as possible and represents the highest fidelity Artemis EVA mission simulation thus far.

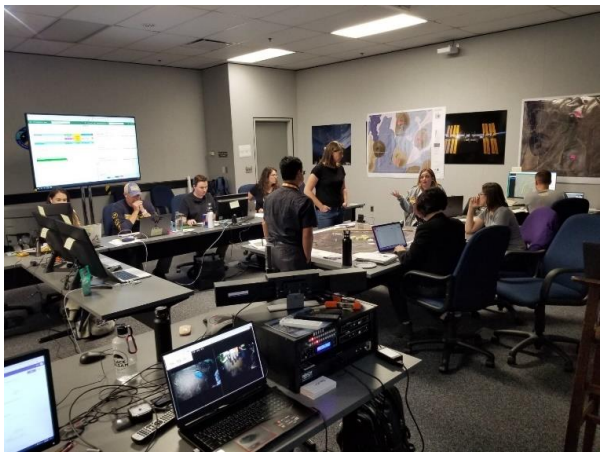

Figure 2: The JETT3 SER during a JETT3 EVA, October 2022.

JETT3 Flight Control Team (FCT) Structure: The JETT3 FCT was structured to test the Artemis FCT structure described above in an operational setting. Front Room positions included the FD, G-IV, and EVA Officer. The MPSR included the ESO, Task, and Systems positions. And, critically, there was a full Science Team embedded both into real-time operations in the SER (Figure 2) and in the mission preparation phase [3]. JETT3 represents the highest fidelity Artemis EVA simulation ever conducted, and we were able to gather insights in several key areas (i.e., SER layout and requirements; Science Team structure [4], roles and responsibilities; mission/traverse planning and science team integration; ESO role refinement; and much more).

Science Team Training: Science training is critical for all operational roles supporting Artemis EVAs (including not only the crew but FCT members as well). This science training is detailed in [5], but providing operational training to science personnel is also important in achieving mission goals.

The AST will support mission and traverse planning as well as real-time operations. AST training to understand the human spaceflight environment, necessary aspects of the EVA environment (suit capabilities and parameters, tools, etc.), communications protocols, required hardware and software, etc. will be critical to the success of both the AST in pre-mission and real-time mission execution as well as the science return of each Artemis mission. The development of the training flow for the AST is underway to ensure that when the AST is assembled, their path to certification is ready.

The JETT3 Science Team completed a component of this larger training complement to support the test, and lessons learned about sustains and improves for this Science Team onboarding process were captured. It is expected that the ESO position as well as SER roles that will communicate to other members of the FCT (SER Lead, SER Communicator, etc. [4]) will require additional training beyond the training given to the bulk of the AST.

Conclusions: Artemis missions will unlock new scientific discoveries that will feed the next generation of scientists and explorers. It is critical that science is tightly woven into the fabric of pre-mission planning and real-time operations. Work is ongoing to ensure the tight and collaborative relationship between science and operations, and the Artemis FCT structure will ensure that science objectives will be accomplished effectively and efficiently.

Acknowledgments: We would like to thank the entire AIST, the Exploration EVA Surface Operations Team and the JSC Flight Operations Directorate, the EVA and Human Surface Mobility Program, and the JETT3 team for their work on these topics.

References: [1] Schmitt and Hodges, 2011. GSA Spec. Paper 483. [2] Caswell et al. (2023) LPSC 2023. [3] Young et al. (2023) LPSC 2023. [4] Bell et al. (2023) LPSC 2023. [5] Evans et al. (2023) LPSC 2023.