ARTEMIS INTERNAL SCIENCE TEAM UPDATE: CREW TRAINING. C. A. Evans[1,4], K. E. Young[2,4], T. G. Graff[3,4], Artemis Science Training Team*, and Artemis Internal Science Team[4], [1]NASA JSC, Houston TX, 77058 (*cindy.evans-1@nasa.gov),* [2]NASA/GSFC, [3]Jacobs, NASA/JSC, [4] OneNASA

Introduction: Astronauts will soon return to the Moon as part of Artemis — a campaign of crewed missions to explore the lunar surface [1]. The first crewed Artemis missions include Artemis II, which will send four astronauts to lunar orbit to test the Orion spacecraft and observe the lunar surface; and Artemis III, the first human mission to land on the Moon in the vicinity of the South Pole. Artemis III surface objectives include lunar exploration through scientific traverses and observations, collection of lunar samples for Earth return, and deployment of scientific instruments. From this point, human missions to the lunar surface will continue under Artemis, with increasing exploration capability [2].

A fundamental element of mission success for Artemis missions is a well-trained astronaut crew and ground support team. Building from Apollo lessons, a cross-disciplinary group of scientists, flight operations trainers, exploration Extravehicular Activity (xEVA) hardware engineers and trainers, and astronauts are collaborating on developing the training flow, the scientific training content, and an integrated training program. The training will include not only the Artemis crew members, but also mission operators, managers, and scientists. Importantly, the Artemis training will include general knowledge about the Moon, specific mission science training, and increasingly mission-like integrated training with exploration hardware and mission teams in planetary-relevant locations. It also draws from related work being performed by the Artemis Internal Science Team (AIST), especially the Hardware Testing [3] and Science Operations [4] teams. These teams are developing methods, facilities, and field locations to test hardware and evaluate concepts of operations for training both crew and mission support personnel. For more discussion of NASA's Science Team structure supporting the Artemis Program, see [3-5]. This abstract is an update about the science training developments that occurred in 2022 and describes plans for future training efforts.

Artemis Geology Training Flow: Our team has worked with the Astronaut Office, Astronaut Candidate Working Group, and the EVA Training Office to develop and refine a training flow for astronauts in three phases (Fig.1) [6-8]. Starting with incoming astronaut classes (Phase 1) we introduce geology, planetary science concepts, and field methods. Phase 2 builds on the skills acquired during Phase 1 and includes focused content about the Moon in a curriculum called Lunar Fundamentals. Phase 3 provides mission-specific training for the Artemis crew, starting 24 months prior to launch. We describe each phase in more detail below.

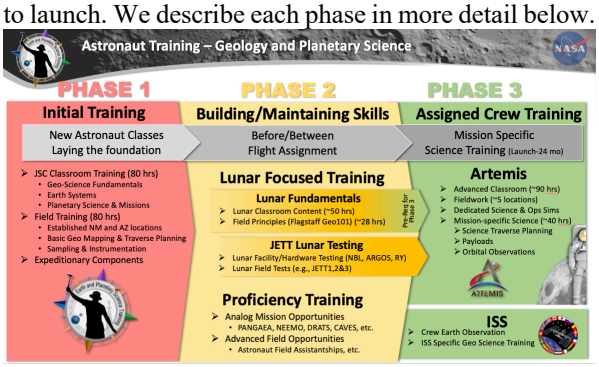

Fig. 1. Updated schematic describing Astronaut Training Flow

Phase 1: Astronaut Candidacy – Basic geological training: Incoming astronauts enter a 2-year training flow as a class, leaning basic concepts for spaceflight, Russian language skills, EVA training, and foundational Earth and planetary science. During those two years our training team conducts training for the astronauts in basic geology and field methods (Fig. 2). Over the past 14 years and four new astronaut classes, we have refined the content to include one week of classroom content and one week of field mapping in *each* of the two years of astronaut candidate training (for a total of 80 hours of classroom content and 2 weeks in the field), building upon the geoscience and field content from one year to the next, introducing basic planetary science concepts, and developing expeditionary skills. Details of this flow have been described in earlier publications [6-12].

Fig. 2. Astronauts from Class 23 (The Flies) making a geologic map during their Phase 1 geology training.

Phase 2: Lunar Fundamental and Proficiency Training: Once an astronaut class completes the initial Astronaut Candidate Training Flow, astronauts will be

assigned jobs within the Crew Office, such as flight assignments to the International Space Station (ISS). To complement the planetary science training provided to ISS crew for their Earth observations, our team is developing a Lunar Fundamentals training module for the Crew Office. This module is designed to provide basic training about the Moon—lunar science and high-level Artemis science objectives, an overview of knowledge gained from lunar samples, data collected from instruments on spacecraft such as LRO, and basic content about the lunar environment, lunar processes such as impact cratering and volcanism, and lunar volatiles. Beyond formalized training classes, additional training and testing opportunities are available to members of the astronaut office to refresh and reinforce basic geology and field training. Examples include exploration hardware tests in NASA facilities [3], field-based analog tests [3,4], and field opportunities with NASA's international partners.

Phase 3. Mission-Specific Training for Artemis Astronauts: Mission-specific training starts 24 months prior to launch for crew assigned to Artemis missions to the Moon. Our team is working closely with and integrating into the Artemis II planning team, Artemis III surface operations team, the xEVA hardware teams and testing forums [3,7], and the EVA Training and Crew Training Office to ensure that lunar science and field training is included and logically scheduled into the Artemis III training flow. The planned content includes additional in-depth lunar science, advanced field science and methods in planetary-relevant locations, and traverse simulations integrated with hardware and operations teams.

Cross-NASA Coordination: Because a significant amount of training time is dedicated to lunar science and field training, we work closely across several organizations to ensure training is integrated with surface operations planning and crew training flows.

Geology Training for Hardware and Operations Engineers and Managers - Geology 101: Apollo lessons highlighted the need to include science and field training for the engineers and managers responsible for mission hardware (*e.g.,* xEVA suits and tools) and mission operations (e.g., Flight Directors) for mission success. Understanding basic geology concepts and learning the language of geology takes time, and to meet this need within the NASA operations community, we have developed a field training class for NASA engineers and managers. Using concepts developed during the Constellation Program [12], we conduct a 2-day field class near Flagstaff, AZ and have trained nearly 100 engineers and managers since 2019 [13]. This class has provided great benefits in collaborations with hardware and operations teams developing critical systems and operational concepts for Artemis missions.

Next Steps for Artemis Training:. Our primary collaboration is with the EVA Training Office in NASA's Flight Operations Directorate. In addition to developing specific science training objectives, we are identifying common science and operational objectives for integrated training. We continue to build the logistics and collaborations needed to support both targeted science and integrated science-operations training in remote field locations (e.g., Flagstaff AZ, Iceland, Potrillo NM, Nevada National Security Site, Canadian impact craters) [14]. Our AIST training team also coordinates with the Hardware and Testing Team [3], Science Operations Team [4], and Data and Software Team [15] to enable the full integration of the future Artemis Geology Team, to infuse the relevant detailed science and payload objectives into the final science training flow, and to ensure that the entire science and operations team is cross-trained with the necessary knowledge and data regarding mission science, mission operations and operational concepts for mission success.

Acknowledgments: The Artemis Science Training Team* also includes Juliane Gross, Jen Heldmann, Noah Petro, Jacob Richardson, Tim Stubbs, Sarah Noble, Jake Bleacher, Chelsea Trainor, Angela Garcia, and Scott Wray from JSC's Flight Operations EVA Training Team. Artemis Geology Training builds from the training philosophy and extensive work provided for Phase 1 training by the Astronaut Candidate Geology Training Team (Barb Tewksbury, Mark Helper, Jose Hurtado, Jake Bleacher, Matt Zimmerer, Mike Timmons and NMIT staff, Lauren Edgar, Jim Skinner, Marissa Palucis, and Will Stefanov).

References: [1] NASA (2020), https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf; [2] NASA (2022), https://www.nasa.gov/sites/default/files/atoms/files/m2m-objectives-exec-summary.pdf ; [3] Graff T. G., et al. LPSC (2023); [4] Young K. E., et al. LPSC (2023); [5] LPSC 52 (2021) Artemis Town Hall; [6] Graff, T.G., et al. (2020), LPSC 51, 1787; [7] Young, K.E., et al. (2022), LPSC 52, 2043; [8] Evans, C.A, et al. (2020) AGU Fall Meeting P063-01; [9] Graff T. G. et al. (2019) 50th LPSC, 2139. [10] Evans C. A. et al. (2018), AGU, P31H-3798; [11] Evans, C. A., et al. (2022), GSA Abst, V. 50, no. 5, (https://doi.org/10.1130/abs/2022AM-378331); [12] Eppler D. et al. (2016) GSA Today v.26 no.8, 34-35.; [13] Evans, C., et al. (2022) LPSC 52, 1605; [14] Graff, T. G. et al. (2023) IAVCEI, #521. [15] Miller, M.J., et al. LPSC (2023).