ARTEMIS III EXTRAVEHICULAR ACTIVITY SCIENCE IMAGING USE CASES AND NEEDS.

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Introduction: Astronaut-acquired photography will provide a critical context for maximizing the scientific return from the extravehicular activities (EVAs) planned for Artemis III. Images will be used to understand the context of crew observations and samples spatially in the exploration area, temporally within the mission timeline, and thematically within the Artemis III science traceability matrix (STM). Both in during the mission in the science evaluation room (SER) and after the mission during curation (preliminary examination and beyond), image data will enable scientific observations and interpretations of the Artemis III landing site. Image data will also be useful for navigation and for monitoring EVA progress and astronaut safety should image data be available in near real time, as well as precise localization during and after the mission. The cameras for Artemis III should be considered an extension of surface science possibilities for the mission. Building on other documents [1–2], here we report on our identified use cases and needs concerning the capabilities of these instruments for Artemis III.

Artemis III Cameras: Each Artemis astronaut will be equipped with the Handheld Universal Lunar Camera (HULC) for EVAs. The baseline HULC hardware for Artemis III is the Nikon Z9, a full-frame mirrorless digital camera. HULC images will be made available to the science team during the mission, but not necessarily in (near) real-time during EVAs. Each astronaut will also have a video camera mounted on their EVA spacesuit. Where communication allows during EVAs, suit camera video will stream to mission control, will be available the science team, and will also be recorded.

Science Imaging Operations: HULC images and suit video will support a variety of science tasks across various phases of the mission: science analysis during EVAs (RT); inter-EVA scientific and operational assessment and traverse (re)planning (PL); and post-mission analysis and curation (PM). For each of these phases, we identify image types required to achieve science objectives [3]. We note that the RT use cases would require downlink of HULC images and suit video during EVAs.

Reconnaissance From Human Landing System (HLS): HULC images acquired by the astronauts from inside HLS during descent or after landing could provide synoptic, high-resolution images to support traverse (re)planning and additional context to augment pre-mission data (RT, PL). The images would also be necessary for documenting the surface after landing, but prior to surface operations, as a point of comparison for change detection throughout the surface stay (PM).

Reconnaissance Between Science Stations: While walking, the astronauts will obtain single HULC images or panoramas as time allows. These images will document traverses at higher resolution than possible from orbital images or the suit video cameras. Astronauts can also capture images of features of interest for future investigation, i.e. at a station to be visited later during the mission or at a potential new/alternate station if replanning is necessary (RT, PL). The HULC images and video captured during traverses will be useful for reconstructing traverse paths and for detailed geologic analysis (PM).

Imaging at Science Stations: The astronauts will be trained to acquire still and video photography of all EVA station activities at several scales, i.e., station (10's of m), worksite (<10 m), and sample (<m).

At the station scale, astronauts will employ the HULC to obtain panoramic sequences (Fig. 1). These images will be used to (a) ensure SER situational awareness to inform at-station decision making (RT); (b) provide a basis for making station-scale geologic interpretations and understanding sample and observation context (RT, PL); (c) inform post-EVA crew debriefs (PL); (d) enable updates to traverse plans (PL); and (e) document stations in support of long-term curation of EVA science observations and samples (PM).

At worksites (specific locations within a ~100-m radius station; Fig. 1), astronauts will document sampling activities with images to capture contextual details of a sample and its surroundings, particularly those that might be lost or not otherwise represented in the sample (i.e., orientation on the surface), as well as to capture the process of sample selection, acquisition, and containment (PM).

Depending on the sample type and the EVA timeline, sample documentation images can include narrower angle panoramas; pre-sampling images from a standoff distance (~3–10 m); before and after close-up (~1–3 m) images; and post-sampling images (Fig. 1). These image sets can be used to: (a) provide advice on sample selection if time permits (RT); (b) evaluate sample characteristics in relation to science objectives (RT, PL); (c) estimate sample mass/volume (RT, PL); (d) make interpretations/assessments that could influence future sampling plans (PL); and (e) support sample curation, including assessing container integrity and sample contamination (PM).

Some at-station imaging tasks will be unrelated to sampling, but will be equally important for confirming that science objectives are being met (RT, PL) and for providing primary data for scientific study (PM). Examples include documentation of undisturbed and disturbed regolith characteristics and documentation of boulders and other geomorphic features. Because the scientific return from these tasks will come solely from astronaut observations and the images, these tasks place the most demands on the performance of the HULC and the choice of lens, particularly with regard to spatial resolution. Some of these tasks involve specialized image acquisition techniques that require crew training, e.g., astronauts may need to obtain stereo pairs (or sets of overlapping images) for photogrammetry or photometric sequences over a range of phase angles.

Availability and Utility of EVA Images: Analog tests [4–6] have included EVAs during which astronauts acquired images with both the HULC and mockup EVA suit video cameras (Fig. 1). These tests revealed the impact on EVA science of suit video dropouts, including diminished awareness of crew location and lack of context for observations and sample collection. As a result, we recognize that the scientific return from Artemis III will be enhanced with a prioritized real-time downlink of the suit video [6]. Similarly, analog tests have [4–6] demonstrated that (near) real-time access to HULC images enhances situational awareness, informs tactical decisions, and enhances scientific interpretation (aided by processing to create high dynamic range composites, panoramas, and 3D models). While we will rely on all available data to support EVAs, access to HULC images in (near) real-time will significantly increase the scientific return of the Artemis EVAs.

Third-Person Point-of-View (3POV) Capability: Analog tests have demonstrated the difficulties for real-time science when video only comes from crew suit cameras [4–6] and have documented the benefits of a 3POV video camera [7]. Suit video provides a valuable first-person perspective, but it comes with a limited field-of-view and can be disorienting due to frequent changes in pointing. This makes it difficult to localize the astronauts and place them in context with their surroundings. A 3POV video camera would add a stable, synoptic perspective from which to spatially contextualize crew position and to better document astronaut activities [7]. Mounting the 3POV camera on a ~2-m mast would provide an unobstructed, overhead view, enabling photogrammetric reconstruction of the surrounding terrain and traverse paths [7]. With panoramic capability, this camera could capture all EVA activity around it without the need for manual pointing or active tracking capability. The utility of the 3POV video camera could be expanded with quick

deployment on a tripod at a standoff distance from the astronauts. Analog tests [7] show that the time needed to deploy and retrieve such a camera system is estimated to be under a minute. While a 3POV camera is not part of the current Artemis III architecture, we advocate for considering one for Artemis III.

Future Work: We will continue to work with the teams responsible for engineering and testing the HULC, including aiding in radiometric and geometric calibration. Radiometric calibration is required for some science objectives (e.g., photometry for regolith characterization), and geometric calibration is necessary for deriving precise morphometric measurements and for photogrammetric processing. Building on the results of [4–7], additional testing is needed to determine optimal procedures (e.g., astronaut and camera position, framing and overlap, number of angles, etc.) and camera settings (e.g., exposure and focus) for the various imaging scenarios we envision, including the potential inclusion of a 3POV capability. Testing will be done iteratively to include image acquisition and derivation and analysis of image products.

Finally, to maximize the science derived from HULC imaging, Artemis III astronauts must understand the scientific intent of the images and have sufficient experience using the HULC in the field. We recommend that astronauts use the HULC every time they are in the field and work with the Artemis III science team on example analyses of acquired images to develop an intuitive understanding of what makes for the most scientifically robust images.

References: [1] https://www.lpi.usra.edu/Artemis; [2] https://ntrs.nasa.gov/citations/20230003021; [3] Denevi et al. (2025), this meeting; [4] Hurtado et al. (2023), *LPSC 54*, 2739; [5] Henderson et al. (2025), this meeting; [6] Edgar et al. (2025), this meeting; [7] Sweeney (2024), UTEP Ph.D. dissertation.

Fig. 1. *HULC images from the JETT5 analog test [6], including a station-level panorama (top), a workspace-level context photograph (bottom, left), and an after-sampling image with scale markers (bottom, right).*