ARTEMIS INTERNAL SCIENCE TEAM UPDATE: DEPLOYED PAYLOADS. R. C. Weber,[1] A. Nahm[2,3], R. N. Watkins[2,3], and the Artemis Internal Science Team. [1]NASA Marshall Space Flight Center (renee.c.weber@nasa.gov), [2]NASA Headquarters Science Mission Directorate (SMD), [3]Arctic Slope Regional Corporation Federal.

Introduction: Artemis will reestablish human presence on the Moon and lead to a new era of scientific discovery and exploration. Led by the National Aeronautics and Space Administration (NASA), the Artemis effort includes a collaboration of space agencies and companies from around the world [1]. In support of Artemis, a cross-disciplinary effort of science, engineering, operations, and human factors personnel is currently developing the best methods, facilities, and field locations to test hardware, train astronauts, and evaluate concepts of operations. This abstract, as part of the Artemis Internal Science Team (AIST) [2], provides an update to NASA's plans for the solicitation, development, and operations of deployed surface payloads.

In calendar year 2023, NASA's Science Mission Directorate will solicit proposals for instruments to be deployed by crew on the surface of the Moon (Fig. 1), beginning with Artemis III [3]. The Artemis III mission will land in the south polar region of the Moon, within 6º of latitude from the south pole, in the vicinity of both persistently illuminated and permanently shadowed areas of the Moon, with potential access to surface-accessible volatile deposits [4]. Several of the proposed landing regions are located among some of the oldest parts of the Moon, and together with the permanently shadowed regions, provide the opportunity to learn about the history of the Moon through previously unexplored lunar regions [5]. Deployed payloads will be a critical part of a notional program that captures the highest-priority science for Artemis III and provides the greatest feed-forward to follow-on missions and the build-up to the Artemis Base Camp.

Payload Objectives: Deployed payloads are experiment packages installed on the lunar surface by astronauts during extravehicular activities (EVAs). These science packages will enable a variety of investigations. Some measurements from deployed instruments may also reduce risks to astronauts in addition to their intrinsic scientific value. Proposed deployed instruments must address scientific objectives outlined in the Artemis Plan, as well as those identified in the Artemis III Science Definition Team (SDT) Report [5]. These objectives are:

Figure 1: Artist's interpretation of an astronaut deploying geophones on the lunar surface.

- Understanding planetary processes
- Understanding the character and origin of lunar polar volatiles
- Interpreting the impact history of the Earth-Moon system
- Revealing the record of the ancient sun and our astronomical environment
- Observing the universe and the local space environment from a unique location
- Conducting experimental science in the lunar environment
- Investigating and mitigating exploration risks

In addition to these objectives, the SDT report also described a candidate science program that includes measurements by deployed instruments. Specific measurements identified include geophysical monitoring, environmental monitoring (including, but not limited to, magnetic and electric fields, radiation, and plasma), and understanding the human impact on the Moon. For Artemis III, preference will be given to instruments that address one or more these measurements. Other investigations that are in scope for Artemis III include studies of plant biology, concrete microstructure using lunar regolith, flammability of solid materials, soft media flow, quantum physics, and the theory of relativity and the equivalence principle.

NASA's Human Landing System (HLS): HLS will serve as a habitat on the lunar surface for the early Artemis missions and a research platform both on the surface and in lunar orbit, enabling critical scientific investigations, such as delivering instruments for deployment on the lunar surface. For the Artemis III mission, the HLS Program is working with SpaceX throughout the development process to design and build an innovative and technically advanced lunar lander, the Starship.

The Starship HLS and mission equipment (including payloads) will launch from Earth to a near-rectilinear halo orbit (NRHO) around the Moon, where it will await the arrival of crew, who launch separately in the Orion spacecraft onboard the Space Launch System (SLS). HLS launch is tied to Orion launch readiness, occurring between 60 and 90 days prior. After Orion inserts into NRHO, it will dock with the loitering Starship in preparation for the surface mission.

Once the crew are ready for the surface mission phase, Starship (with 2 crew onboard) will undock from Orion and descend to the lunar surface. While on the surface, the crew will perform multiple EVAs, during which they will collect lunar samples, perform field science, and deploy payloads. Once the ~6.5 day surface mission has been completed, Starship will ascend from the surface to return the crew (and samples) to Orion in NRHO. Following crew transfer to Orion, Starship will be disposed of in a location that neither poses harm to nor interferes with NASA lunar orbit missions, vehicles, or assets of historical value and will comply with applicable planetary protection regulations to ensure a safe disposal of the vehicle.

Payload Development: Payloads must be accommodatable by Starship subject to mass, volume, power (if needed), interface, and other technical requirements that will be described in detail in the solicitation. The total available volume for payload stowage may be split between the pressurized and unpressurized volumes of Starship. Payloads must be designed to "do no harm" to the HLS spacecraft or flight crew and will be subject to safety reviews as part of the development lifecycle.

NASA encourages the development of instruments that can address more than one measurement need and/or science investigation. Factors that will be evaluated as part of the selection process include:

- Expected science results from the investigation;
- Instrument concept of operations, including why crew are needed for deployment, how and when during surface operations the instrument is to be deployed, any special requirements for deployment (i.e., positioning, surface slope, etc.), and an estimate of the crew time needed for deployment; and
- Resource requirements for the proposed investigation including cost, mass, volume, telemetry, data transfer need, astronaut interaction, etc.

Payload Operations: The science team members of the deployed instrument teams will be members of the larger Artemis Science Team, which is comprised of the Artemis Internal Science Team, the competed Artemis III Geology Team, and the competed Participating Scientists. Payload operations will occur as part of the larger overall plan for mission science operations [6]. Deployment operations during EVA should be planned such that the required astronaut interaction is minimized, with limited expectations for recurrent monitoring or troubleshooting.

Payload operations that rely on the presence of HLS (e.g. for power or communication relay) will be limited to the duration of the surface mission (~6.5 days). Independently powered payloads with self-contained data relay capability will be operated via the Lunar Utilization Control Area (LUCA) at the Marshall Space Flight Center, part of the larger Huntsville Operations Support Center (HOSC), leveraging over 20 years of successful payload mission operations services for the International Space Station.

References: [1] The Artemis Plan: NASA's Lunar Exploration Program Overview (2020). [2] LPSC Artemis Town Hall (2022). [3] NASA draft solicitation F.12: Artemis Deployed Instruments Program (2022). [4] NASA Press Release 22-089 (2022). [5] NASA's Artemis III Science Definition Team Report (2020). [6] Young et al., this meeting (2023).