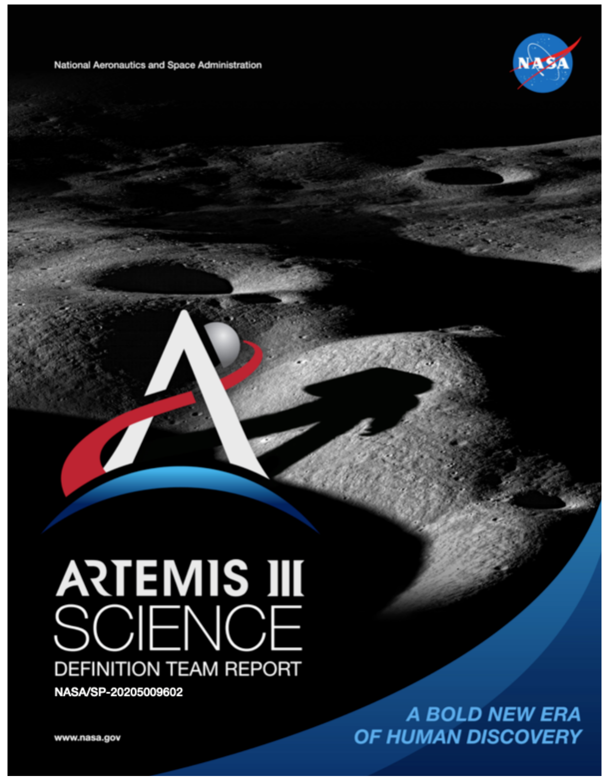
THE ARTEMIS III SCIENCE DEFINITION TEAM REPORT. R. C. Weber[1], S. J. Lawrence[2], B. A. Cohen[3], J. E. Bleacher[4], J. W. Boyce[2], M. R. Collier[3], D. Draper[4], A. L. Fagan[5], C. I. Fassett[1], L. Gaddis[6], J. Gross[7], J. E. Gruener[2], J. L. Heldmann[8], F. M. McCubbin[2], J. L. Mitchell[2], A. L. Nahm[9], D. H. Needham[4], S. Noble[4], C. M. Pieters[10], N. Petro[3], K. Y. Sato[4], J. Spann[4], K. E. Young[3] [1]NASA MSFC (renee.c.weber@nasa.gov), [2]NASA JSC, [3]NASA GSFC, [4]NASA HQ, [5]Western Carolina U., [6]USGS (now at LPI), [7]Rutgers U., [8]NASA Ames, [9]ASRC Federal, [10]Brown U.

Introduction: The Artemis III mission will be the first crewed mission to the surface of the Moon in the 21st Century, building on the legacy of Apollo and ushering in a modern era of human exploration and development in deep space. The lunar surface is an ideal location to answer fundamental planetary science questions. In the nearly 50 years since humans last visited the Moon, new scientific advances arising from robotic lunar missions, reanalysis of Apollo-era data, improved modeling, and modern sample analysis have produced dramatic results and new questions about planetary volcanism, volatiles, impact processes, tectonics, and the lunar environment. Driven by these questions, the Artemis III Science Definition Team (SDT) created a robust science plan for the Artemis III crew on the lunar surface. This abstract outlines the major findings of the SDT report and points to recommendations for science considerations in future Artemis programmatic decision-making.

Artemis III Science Objectives: Seven overarching Science Objectives were defined by NASA's Science Mission Directorate in the Artemis Plan, forming the foundation of the SDT's consideration. The SDT expanded the Objectives to encompass the full range of science goals identified by the community over the last decade in guiding documents [1-4] and in the white papers solicited specifically for this report. The Artemis Science Objectives are:

- 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

The SDT substantiated these Objectives with Goals (areas of research) and Investigations (specific activities undertaken to address Goals). The team's intent was to be as inclusive as possible in this effort, so that the scope of science that is of interest to the community is clear, and so that future human missions beyond Artemis III can build on the completed Investigations. The SDT prioritized specific Investigations for the Artemis III mission based on the community-authored guiding documents as well as the team's assessment of compelling science questions that could be realistically addressed during the Artemis III surface mission, taking into account the down- and up-mass capabilities of the Human Landing System (HLS), duration of the surface mission, and expected number of EVAs [5].



Artemis III Candidate Science Program: From the prioritized Investigations, the Science Definition Team built a candidate reference program that would capture the highest-priority science for Artemis III and provide the greatest feed-forward to follow-on missions and the ultimate build-up to the Artemis Base Camp. The reference program would include complementary elements of field science, sample collection and return, deployed, long-lived experiments, and *in situ* characterization. However, many of the specifics are dependent on Artemis program details, so the SDT recommended that a more detailed mission operations plan be developed by NASA when HLS system capabilities, a landing site, and other architectural details come into sharper focus.

Findings: The 15 major findings from the SDT report are summarized here and numbered according to the sections of the report whence they originated. The full report also contains recommendations to NASA for actions to address each finding, encompassing crew training, coordinated sampling strategies, enabling capabilities (*e.g.*, needed technology development), Artemis program architecture and science implementation strategy considerations, cartographic considerations, and landing site selection criteria.

Finding 6.1.4-1: The optimal sample return program is built upon geologic-context observations made by well-trained astronauts, aided by modern tools and real-time communication with scientists on Earth.

Finding 6.1.4-2: The high-priority Investigations described in this report require the collection of a diverse set of sample types, collected from geographically diverse locations broadly representative of the complex geology of the south polar region, and a total return sample mass from the Artemis III south polar site exceeding the average return mass for the Apollo missions.

Finding 6.1.4-3: Sample collection and *in situ* measurement campaigns are complementary and increase science return.

Finding 6.1.4-4: The return of hermetically sealed volatile bearing samples from the lunar south polar region can preserve lunar volatile signatures within the sample containment system and prevent gas-exposure hazards in the crew cabin.

Finding 6.2.4-1: Geophysical and environmental monitoring are needed to address multiple Artemis III Objectives.

Finding 6.3.7-1: *In situ* instrumentation will be greatly beneficial in addressing a number of Artemis III science investigations, including instrumentation to support sampling, volatile monitoring, geophysics objectives, down hole monitoring, and geotechnical characterization.

Finding 6.4-1: Existing mass allocations expected to be available on the HLS system for delivery of tools and payloads to the lunar surface are insufficient to achieve the full spectrum of science objectives outlined by the stakeholder community.

Finding 6.5-1: In light of the importance of the Artemis III scientific results towards implementation of commercial resource extraction strategies and the construction of the Artemis Base Camp, efforts should be maintained to promote cross-directorate integration between the diverse stake- holders within NASA in the Human Exploration and Operations Mission Directorate (HEOMD), Science Mission Directorate (SMD), and the Space Technology Mission Directorate (STMD), and in the external scientific, engineering, and commercial communities.

Finding 7.1-1: Several of the Investigations prioritized in this report would be maximally enabled by a long-lived power source and communications capability for deployed experiments.

Finding 7.3-1: Crew mobility on the lunar surface is a key factor for enhancing the scientific Investigations outlined in this report.

Finding 7.4-1: The ability to conduct cryogenic sample return from the Moon increases the scientific yield of samples containing icy and/or volatile components.

Finding 8.2-1: Accurate geodetic control of data has a direct impact on the accuracy of spatial data analysis and intercomparison of data products, which is vital both to mission planning and scientific analysis.

Finding 8.2-2: Standardization of cartographic and timing parameters is vital for interrelating the timing of crew activities and the timing of measurements from instruments.

Finding 8.3-1: During preparations for Artemis III, existing lunar data should be readily and easily available to scientists and mission planners. Accurate landing and localization during surface operations are dependent on the accurate and robust use of existing data.

Finding 9.1-1: The scientific return of the Artemis III mission will be intrinsically linked to the Artemis III landing site.

Looking forward: The scientific knowledge resulting from the Artemis III mission will enable fundamental advances in our understanding of the Solar System and Universe. The Moon is a spectacular world full of wonder and opportunity that is only a few days away. With its bounty of accessible resources, stunningly beautiful vistas, and compelling scientific questions, the Moon continues to beckon us towards the next horizon as the gateway to our Solar System.

References: [1] National Research Council (2007) The Scientific Context for Exploration of the Moon. Washington, DC: The National Academies Press. [2] Lunar Exploration Analysis Group (2016) The Lunar Exploration Roadmap: Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities. [3] Lunar Exploration Analysis Group (2018) Advancing Science of the Moon: Report of the LEAG Specific Action Team. [4] National Research Council (2011). Vision and Voyages for Planetary Science in the Decade 2013– 2022, Natl. Acad. Press, Washington, DC. [5] NASA (2019) NextSTEP H: Human Landing System Solicitation, Requirement HLS-R-0356.