

2020 Annual Meeting of the Lunar Exploration Analysis Group Findings

Overview: This document contains the findings of the 2020 Annual Meeting of the Lunar Exploration Analysis Group, which was held virtually due to the global health crisis resulting from the COVID-19 pandemic. The attendees of the 2020 virtual meeting endorse the findings contained within. These findings are divided into the following overarching themes and are expanded in the following pages:

1. Artemis Program;
2. Sustainable Exploration on the Moon and Beyond;
3. Diversity, Equity, Inclusion, and Accessibility;
4. Commercial Advisory Board.

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THEME 1: ARTEMIS PROGRAM

Finding 1.1: LEAG advocates for ensuring a sample return mass capability for Artemis that equals or exceeds that of Apollo in order to adequately collect a diverse set of samples to assess the complexity of the south polar region. The return of lunar samples to Earth is a vital goal of the Artemis program. These samples will be invaluable for a wide range of lunar, terrestrial, planetary, heliophysical, geotechnical, and biological investigations and can be analyzed on Earth in ways not possible on the lunar surface. To maximize scientific return, adequate sample mass (>150 kg) must be returned to support the numerous needed analytical measurements on individual samples; this mass is recommended in the 2007 CAPTEM Analysis document, “Analysis of Lunar Sample Mass Capability for the Lunar Exploration Architecture.” Additionally, having a carefully curated catalog of samples on Earth enables future scientific discoveries as technological advances are made that enable new and improved analytical tools and techniques. To maximize scientific return, numerous analytical measurements are typically required on individual samples.

Finding 1.2: LEAG encourages the Artemis program to ensure that increasing time on the lunar surface is prioritized as part of the Artemis program. LEAG encourages NASA to ensure that missions to the Artemis Base Camp can be maintained at a rate of >2 expeditions per year for at least 60-day surface increments each by the end of the 2020s. In order to progressively work towards sustained human presence on the Moon as well as answering outstanding big picture lunar science questions (as explained in community documents such as the Lunar Exploration Roadmap, the Decadal Survey, etc.), astronauts must be on the surface for longer durations of time to allow for comprehensive exploration, collecting samples, performing experiments, and deploying long-lived instruments.

Finding 1.3: LEAG recommends having a lunar roving vehicle (or mobile platform with comparable capabilities) for the Artemis III mission as mobility uniquely provides enhanced benefits and capabilities to surface missions. Enhanced mobility is critical for a variety of scientific, commercial, and exploration purposes. LEAG recognizes that science will benefit significantly if astronauts have mobility on the lunar surface in the form of a lunar roving vehicle or the like. Mobility will afford human missions both enhanced operational efficiency and extended exploration range, which will both increase and help to define the develop capabilities necessary for future, permanent settlements.

Finding 1.4: LEAG strongly encourages the development of a communication relay capability through a continuum of means to facilitate access to and navigation on the lunar surface and enhance the science productivity of missions to the Moon. This includes leveraging planned robotic missions as short-duration communications relays (e.g., Lunar Trailblazer) as well as deploying dedicated communications satellites and stationary surface transmitters. LEAG appreciated hearing the briefing from Andy Petro of NASA Space Communications and Navigations (SCaN) about lunar communications relay capabilities in the context of the Artemis program. The LEAG United States Lunar Exploration Roadmap clearly outlines the enabling impact of robust communications and navigation capabilities for lunar surface exploration and utilization (<https://www.lpi.usra.edu/leag/LER-2016.pdf>).

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Finding 1.5: LEAG supports the formation of a Science Definition Team (SDT) for the Artemis III mission. We look forward to, and stand ready to help with, an SDT for the subsequent Artemis missions and the Artemis Base Camp buildup sequence. The Artemis III mission SDT has been announced and will work towards developing a report with recommendations of science priorities for the mission. A community Town Hall was held during the LEAG meeting to introduce the SDT and provide a timeline for the process. Community input was solicited through a second Town Hall and via direct input through an online submission system after the draft report was released on October 16, 2020.

Finding 1.6: LEAG strongly supports, in no uncertain terms, the goal of establishing a thriving and successful Artemis Base Camp on the surface of the Moon through the Artemis program as quickly as possible. The LEAG community stands ready to ensure that it is as successful and capable as possible. The Moon is an important location for international cooperation and collaboration in science, exploration, and commerce. The Artemis Base Camp will provide enormous capability and advances for the benefit of all stakeholders in each of these endeavors through its infrastructure, including the stationary surface habitat, power systems, ISRU capability, and mobility assets, as well as the knowledge and experience gained in operating human and robotic missions from there. The Artemis Base Camp will serve as the cornerstone upon which to build future human exploration capability throughout the solar system, much as McMurdo Station has served as a foundation for Antarctic studies.

Finding 1.7: LEAG applauds the work that has been highlighted in the series of Lunar Surface Science Workshops, and the high rate of participation indicates the excitement and support of the Artemis program within the broad lunar community. LEAG encourages that these workshops or similar forums continue at a regular cadence to support the human return to the Moon. The Lunar Surface Science Workshops were originally intended as a single, in-person workshop held over the course of several days. However, due to the global health crisis, this original workshop was divided into separate, smaller, virtual workshops and then expanded to include additional topics. These workshops provide an important venue for community input, and regularly had at least 200 participants, which is proof of greater and more frequent engagement from the community than would normally be practical (i.e., no travel required, etc.).

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SUB-THEME INFORMATION REQUESTS FOR ARTEMIS PROGRAM (THEME 1)

LEAG respectfully requests more information about the following aspects of Artemis III and subsequent missions within the Artemis Program as well as the Artemis Base Camp.

Information Request Finding 1a: LEAG requests more information regarding the cadence of flights for Artemis after the Artemis III mission nominally scheduled for 2024; e.g., how many missions per year, the timing between missions (if less than one per year), and how many missions are to be included in the Artemis program.

Information Request Finding 1b: LEAG requests more information regarding plans for the Artemis Base Camp including, but not limited to, budget, time-phasing of construction, involvement of commercial partners, surface mobility, and use of ISRU allow the sustained human presence on the lunar surface, which would feed forward to Mars and other locations in the solar system. Considering the immense value of the Artemis Base Camp, there is community concern about the lack of transparent and specific detail for time phasing and manifests designed to lead to an operational habitat and associated infrastructure by 2028.

Information Request Finding 1c: LEAG requests more information on the timing of delivery of planned lunar surface assets and ISRU capability, particularly that of power systems and large-scale ISRU in support of Artemis III and subsequent missions.

THEME 2: SUSTAINABLE EXPLORATION ON THE MOON AND BEYOND

Finding 2.1: We thank our colleagues at NASA HQ for their time, support, and for providing updates on the mission directorates as well as plans for moving forward to the Moon. A sustainable and continued human presence on the lunar surface will cultivate economic growth, scientific discoveries, and expeditions to other targets in the Solar System.

Finding 2.2: Studies should be conducted on the lunar surface to advance capabilities and technologies that will enable sustainable human missions to Mars and beyond; these studies should include the use of humans on the surface and should not be limited to robotic tests of technology. The Moon is a unique planetary surface destination conveniently located near Earth and its resources. Technologies needed for sustainable exploration include, but are not limited to, life support systems; communications; ISRU; power systems; operations in extreme environments; and construction and manufacturing. Human missions to the lunar surface of increasing duration will similarly advance knowledge of crew health issues for long-term surface stays, astronaut training needs, and operational paradigms for human exploration with varying amounts of autonomy.

Finding 2.3: LEAG recognizes the value of innovative approaches to getting payloads to the lunar surface and applauds the continuing work from the Lunar Discovery and Exploration Program (LDEP) and Commercial Lunar Payload Services (CLPS) programs to foster science and exploration of the Moon using partnerships with commercial, academic, and federal stakeholders.

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Finding 2.4: LEAG continues to recommend an integrated, lunar-focused program office that ties together multiple directorates. While we recognize that the directorates are collaborating to move forward to the Moon, a centralized office whose primary focus is on lunar programs will promote efficiency. LEAG encourages and supports coordination between SMD, STMD, and HEOMD for investigations that can collect both engineering and scientific data. Cross-directorate collaboration will enhance the technological development and scientific return of upcoming and future missions, and this cross-divisional coordination is essential for creating a sustainable lunar program.

Finding 2.5: LEAG encourages and supports international collaboration as we work towards a sustained human presence on the Moon. LEAG appreciates the efforts of the International Space Exploration Coordination Group, and particularly appreciates the updated Global Exploration Roadmap that provides a guide for international space exploration.

Finding 2.6: LEAG applauds STMD on its efforts to engage the community through the Lunar Surface Innovation Consortium (LSIC). LEAG looks forward to collaborating with LSIC in fostering the necessary linkages between academic, industry, government, and other stakeholders. LEAG will work with LSIC to communicate the technology needs of our community and to drive technology and expertise development for lunar exploration.

Finding 2.7: LEAG applauds the Volatiles Investigating Polar Exploration Rover (VIPER) mission as a key first step to characterizing lunar resources and strongly urges a resource prospecting campaign to truly understand the science, exploration, and commercial potential of lunar volatile deposits. The LEAG community stands ready to help to build on its existing strategic planning efforts to refine such a campaign. Extracting and utilizing lunar resources would significantly reduce the cost of exploration to other targets in the solar system as well as enable more extensive surface activities, including science return.

Finding 2.8: LEAG supports the definition of a long-term strategy to meet orbital remote sensing and other needs beyond the life of the 2009 Lunar Reconnaissance Orbiter. Specifically, LEAG encourages NASA to engage the community in this activity, provide details on trade studies to date, and evaluate a broad range of science and exploration use cases. Orbital lunar assets provide critical capabilities in support of ongoing science and exploration and will continue to do so for the foreseeable future.

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THEME 3: DIVERSITY, EQUITY, INCLUSION, AND ACCESSIBILITY

Finding 3.1: LEAG recognizes the need to include diversity, equity, and inclusion in all aspects of our work and our community. This mindset is critical as we work together towards beyond Earth exploration during a global pandemic that impacts individuals in different ways. Beyond Earth exploration is an endeavor that impacts all of humanity, and therefore needs to be done thoughtfully and inclusively. The current community of implementers does not reflect all aspects of society, so we must be aware of this fact while we strive to be more inclusive on our mission teams, specific action teams, and more.

Finding 3.2: LEAG requests more information on NASA's plans to maintain sustainable and robust R&A funding, particularly one that can foster the growth of a diverse workforce. The LEAG community is concerned about the recent low funding rates in NASA's Research and analysis program (e.g., Solar System Workings selection rate was 11%, whereas historically it has been closer to 20%) and its potential long-term effect on the community's ability to contribute to Artemis and beyond. Moreover, some programs such as PSTAR calls have been modified to be every other year. Low funding rates and less-frequent calls impact the early career members of our community the hardest and we risk losing them from the profession altogether.

Finding 3.3: Virtual meetings cannot replace some of the informal discussions that occur during an in-person meeting, but the streaming nature of the 2020 annual meeting (as well as the widely popular Lunar Surface Science Workshops) allowed more accessibility and therefore broader participation. LEAG will continue to endeavor to find avenues for increasing accessibility for the community. The 2019 in-person LEAG meeting had approximately 250 participants. The 2020 virtual meeting reported 433 unique Zoom log-ins on Day 1, with 314 and 242 on the subsequent meeting days. The large number of participants resulted in extensive and thorough discussions as well as many findings.

THEME 4: COMMERCIAL ADVISORY BOARD

Finding 4.1: The LEAG Commercial Advisory Board is supportive of the increasing number of NASA opportunities for commercial involvement in lunar exploration and encourages the creation of further avenues of involvement.