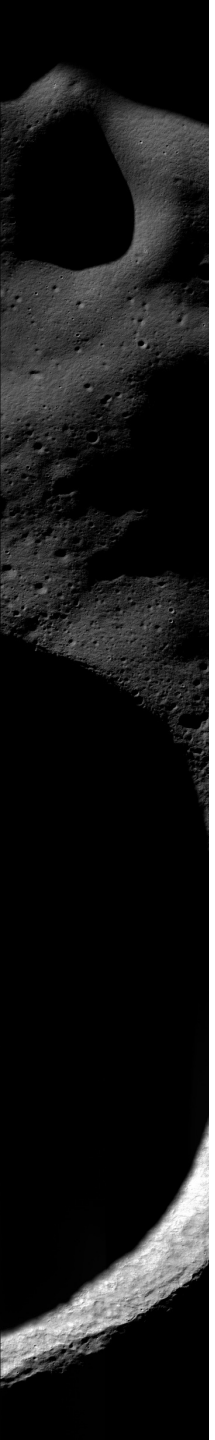
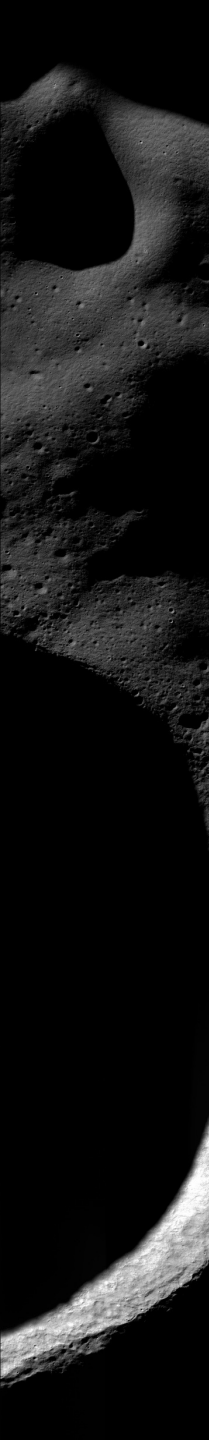


# Update from the Lunar Exploration Analysis Group

Dr. Amy L. Fagan, LEAG Chair

Presented to National Academies Committee on Planetary Science

28 September 2022



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    - **Catalog and prioritize** objectives for science and science operations that can be achieved through analog activities
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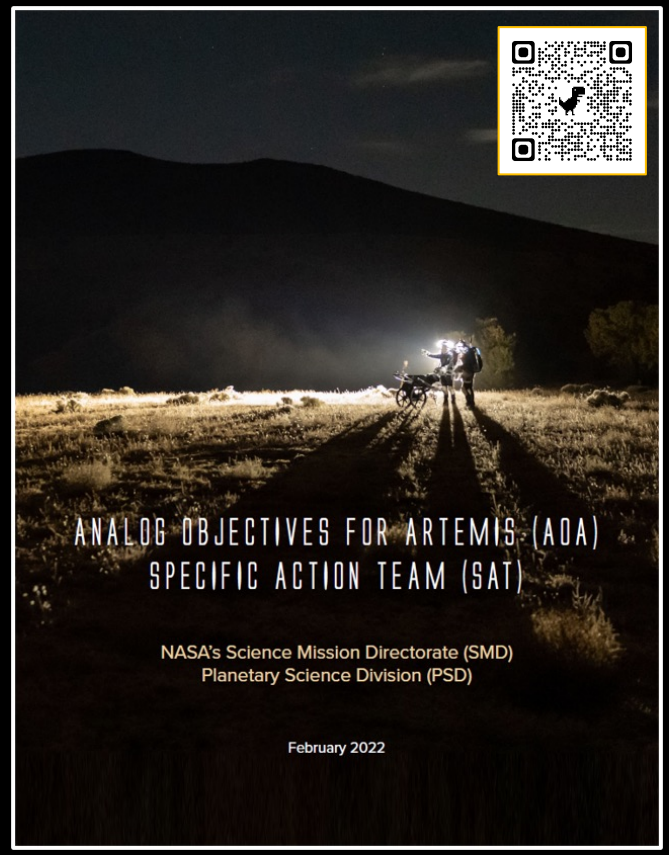

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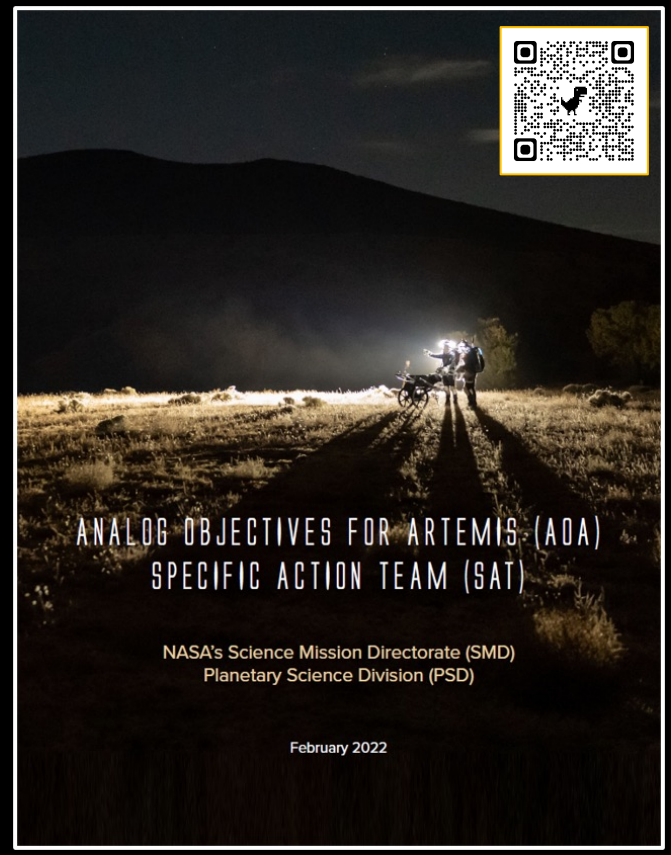

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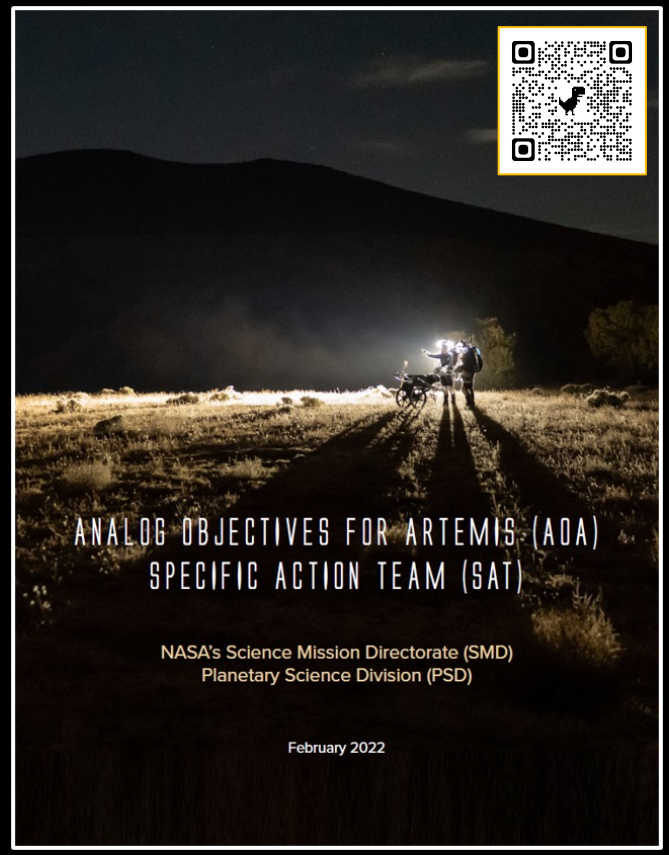
**Analog Objectives:**

- Science Support Room
- Software and Instrumentation
- Human/Robotic Partnerships
- Complex Lighting Conditions
- Data collection: Imaging, Sampling, Tools, Documentation
- Advancing Technologies
- Communication
- Crew Autonomy
- Analog Science Training
- Location/Navigation
- Test Design



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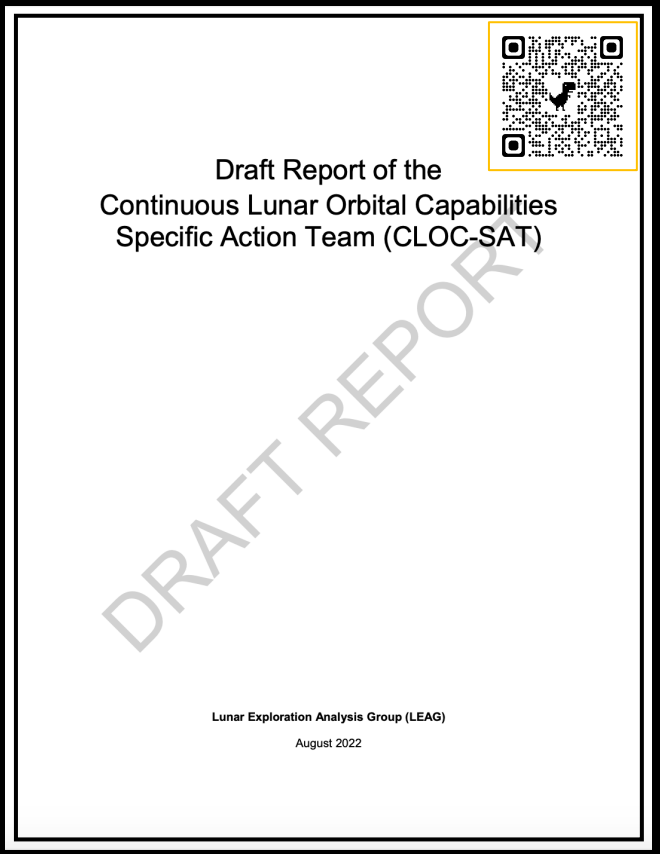

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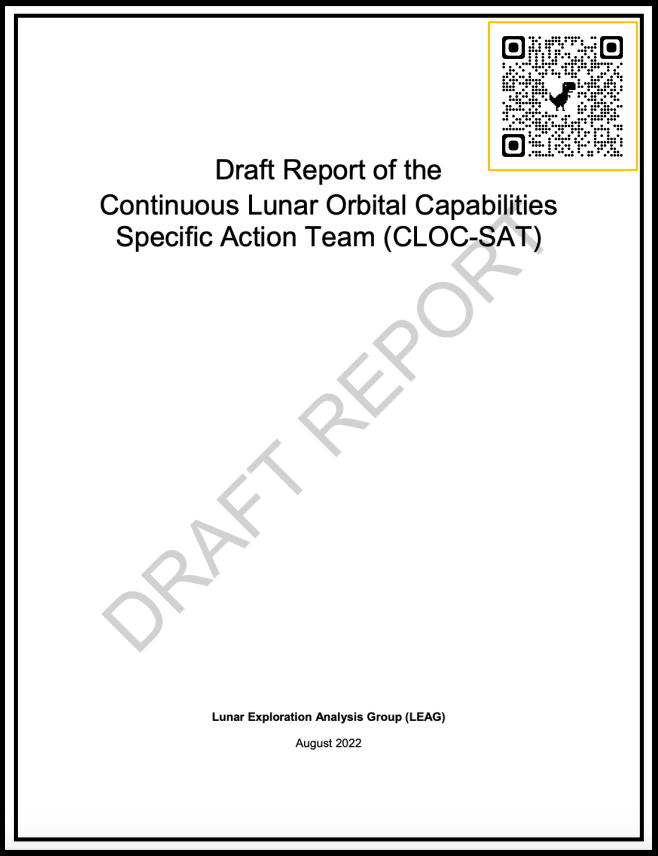
**Areas of focus: Identify…**

- Investigations to be carried out in future
- Capabilities needed for landed science/exploration activities
- Measurements and capabilities common to/cross-cut different mission directorates
- New types of measurements enabled by modern technology



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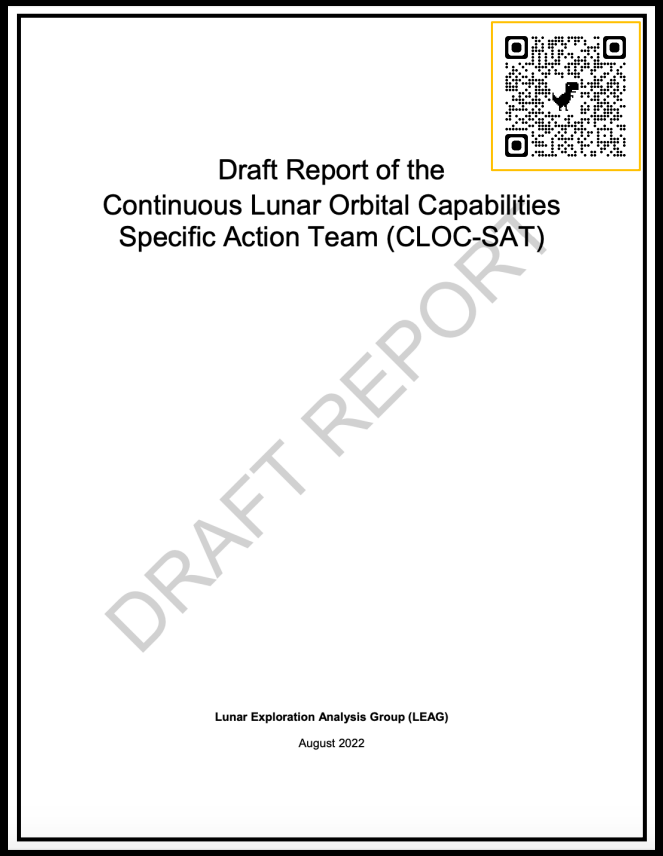

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    - Implementation
      - Range of orbits and satellite type
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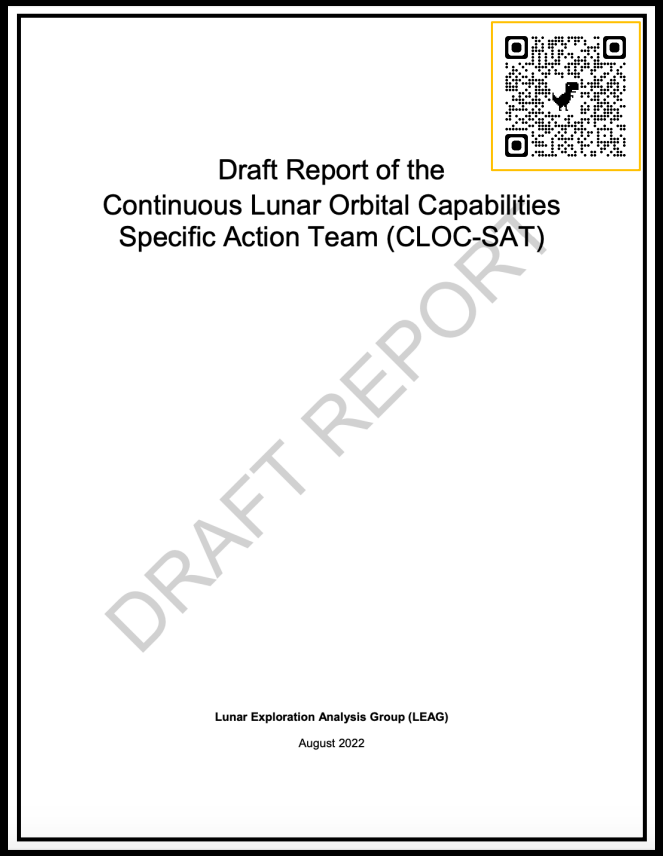

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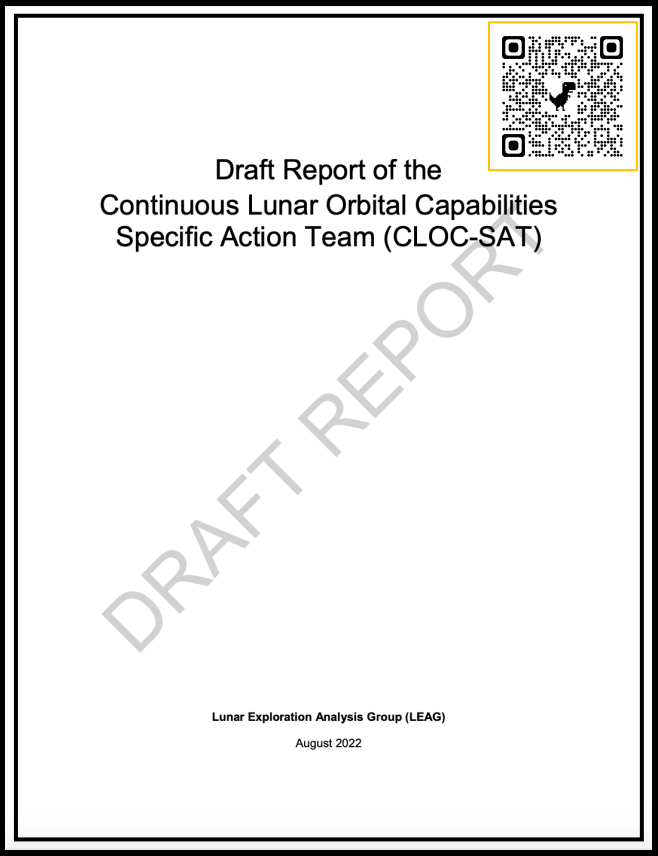
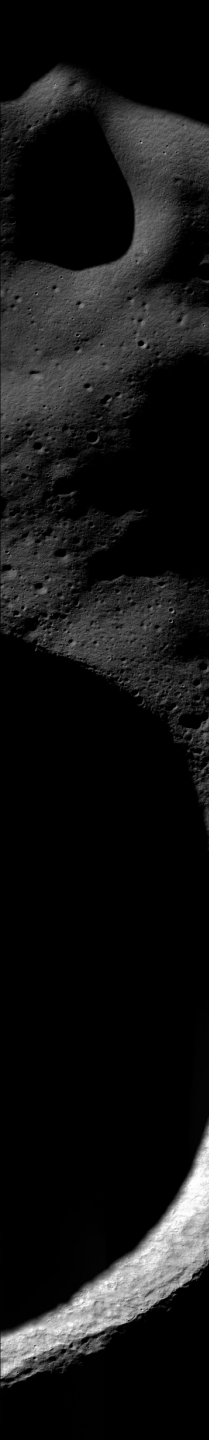
*Continuous lunar orbital capabilities are essential to moving forward during the coming decades of international science and exploration of the Moon and plans must be made to ensure continuity.*





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- **White House Office of Science and Technology Policy on behalf of Cislunar Science and Technology Subcommittee of the National Sci. and Tech. Co.**
  - "input to help inform development of a national science and technology strategy on U.S. activities in cislunar space"
  - "Robust, cooperative, and sustainable ecosystem in cislunar space"
  1. Research and development priorities for the next 10 years? … 50 years?
  2. Key technical standards to develop
  - Executive Committee response submitted to RFI

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  - Overview; Mercury and Moon Panel; Human Exploration; Endurance-A concept; Technology
  - Accessible Virtual Meeting https://www.youtube.com/watch?v=U1odBPj7g2E
  - Most questions received relevant to:
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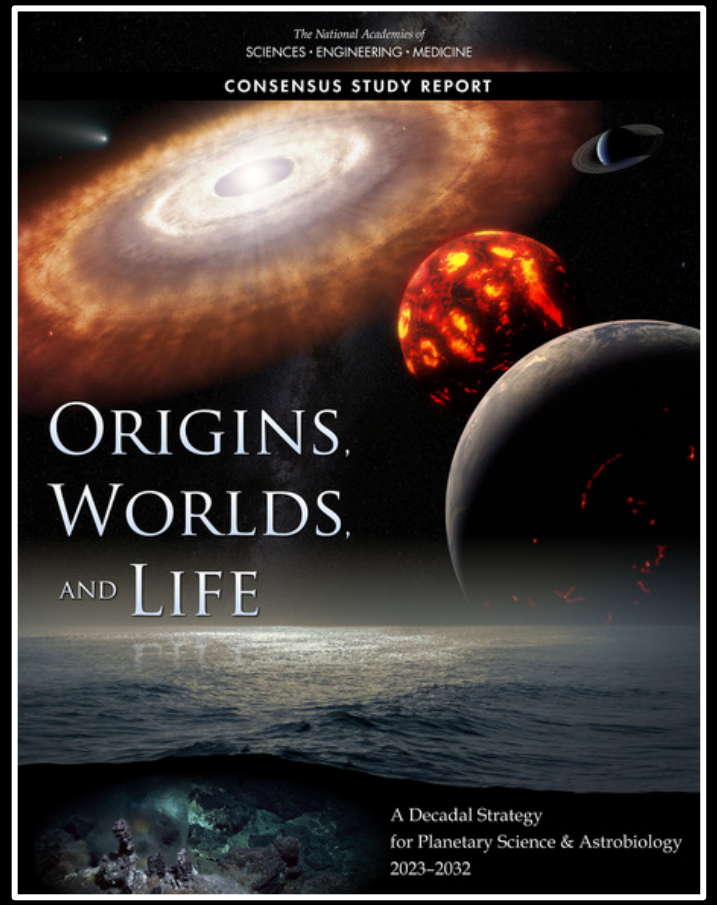
    - Artemis, Commercial Lunar Payload Services (CLPS), and broader lunar exploration and strategy *[7Q | 77 upvotes]*



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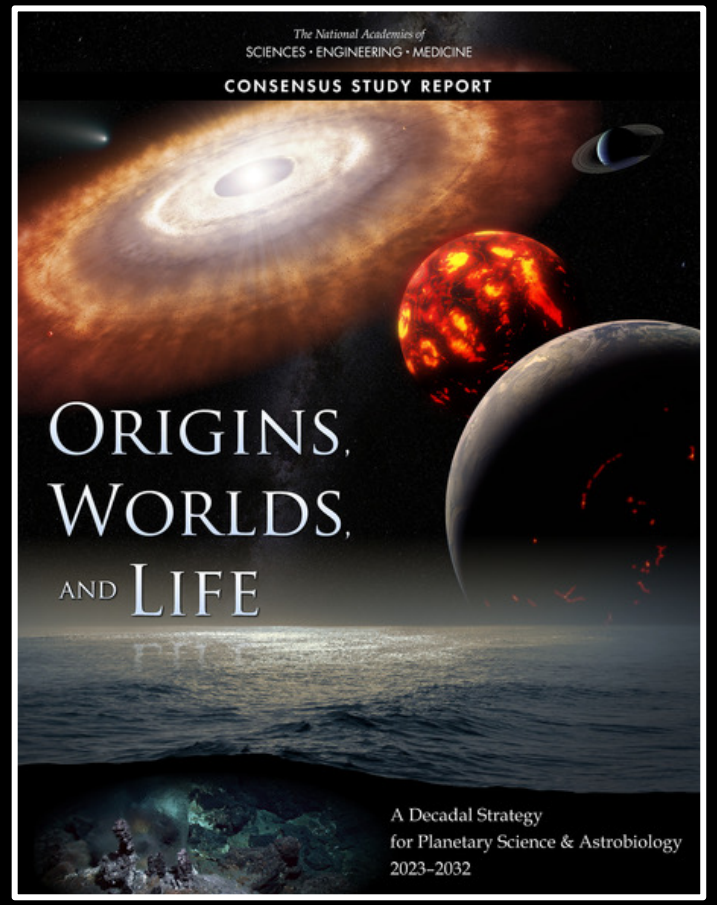
- **The Decadal Survey strongly highlights the value of lunar exploration, both human and robotic, for ALL of planetary science.**



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- **Decadal Survey highlights need for setting science goals and objectives at the Moon through coordination between NASA and non-NASA community**
  - Ch 22 Finding: "A structured approach to setting science goals and measurement objectives at the Moon, led by the lunar science community … would allow for scientific prioritization and coordination of lunar missions, instrumentation, landing site selections, and other activities performed within LDEP." *[p22-14]*
  - Ch 22 Recommendation: "The advancement of high priority lunar science objectives, as defined by PSD based on inputs from this report and groups representing the scientific community, should be a key requirement of the Artemis human exploration program…" *[p22-14]*

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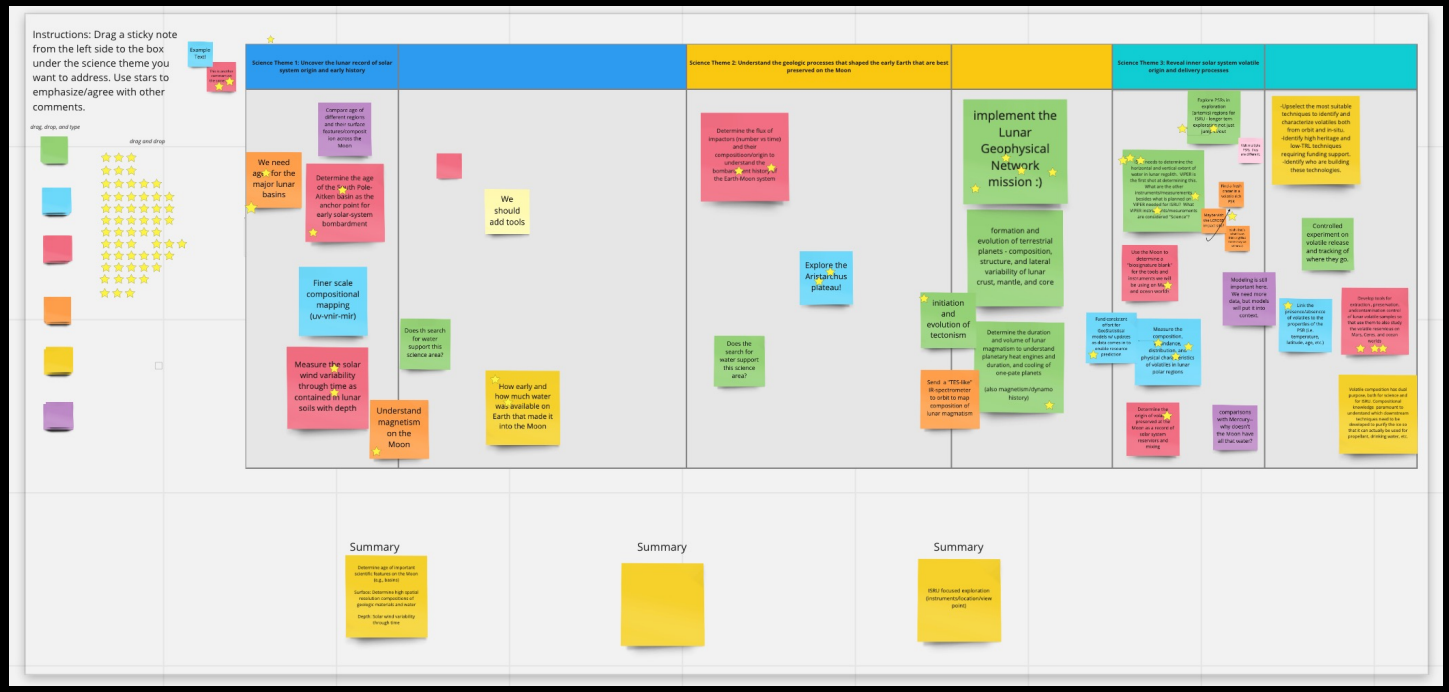
- **LEAG began an action response to the Decadal regarding science goals at the annual meeting**
  - "in-class" activity guided by Box 22.2 of the Decadal




**BOX 22.2 Science Themes for Lunar Exploration**

The central goal of a science-driven program of lunar discovery and exploration is to reveal the history of major events and processes that have shaped the Earth–Moon system and the solar system. The committee prioritizes three overarching Science Themes that address (1) Solar System History, (2) Geologic Processes, and (3) Water and Volatiles.

**Science Theme 1**: **Uncover the lunar record of solar system origin and early history.** The Moon's composition, structure, and ancient surface preserve a record of early events: from the giant impact that produced the Earth–Moon system to ongoing bombardment as life on Earth emerged and evolved.

*The Moon's composition and physical properties constrain how the Earth–Moon system formed, while its ancient surface preserves the primordial history of asteroid and comet impacts and other processes. This record holds clues to environmental conditions on Earth as life emerged that have been all but erased on the Earth. Analyses of returned lunar samples also provide the basis for a chronology used to understand the sequence and timing of events across the solar system. Key questions remain about the nature of planet formation in the inner solar system, early bombardment, and related hypotheses of giant planet orbital migration. While exploration of other worlds can contribute to addressing these questions, the Moon will remain unique in its ability to provide accessible ground-truth constraints on terrestrial planet assembly and solar system bombardment history and chronology.*

**Science Theme 2**: **Understand the geologic processes that shaped the early Earth that are best preserved on the Moon**. The Moon retains a record of processes that set the evolutionary paths of rocky worlds, including volcanism, magnetism, tectonism, and impacts.

*The Moon is amongst the rocky worlds of the solar system that best preserve ancient geologic processes. Like the terrestrial planets, including Earth and Mars, the Moon started as a partially (or completely) molten world. As the magma ocean cooled, it produced the Moon's current differentiated structure, including a crust, mantle, and partially molten core. While differentiation is a ubiquitous process, most other worlds have a poorly preserved record of these early epochs—making the Moon one of the best locations to understand these processes. Even as the Moon's geologic activity waned, volcanism of varied styles and chemistries persisted, impacts and tectonism reshaped the crust, and radiation processes weathered its surface—all of which are relevant to worlds across the solar system.*

**Science Theme 3**: **Reveal inner solar system volatile origin and delivery processes.** The Moon hosts water and other volatiles in its interior, across its surface, and in ice deposits at its poles, providing a record that may help constrain the origins of Earth's oceans and the building blocks for life, as well as ongoing volatile delivery processes.

*The Moon holds a record of volatiles obtained throughout its history. Primordial volatiles contained in the Moon's interior suggest that water was retained even through the energetic Moon-forming impact. At the surface, volatiles migrate in an active cycle and are trapped in permanently shadowed regions near the poles, processes that occur at bodies with tenuous atmospheres across the solar system. The origin, composition, concentration, and distribution of the Moon's volatiles remain uncertain. Determining the source(s) of the Moon's water and other volatiles may shed light on the source(s) of Earth's water and on mechanisms that act as ongoing sources of volatiles in the present day. Lunar volatile reservoirs also have implications for in situ resource utilization by human explorers.*

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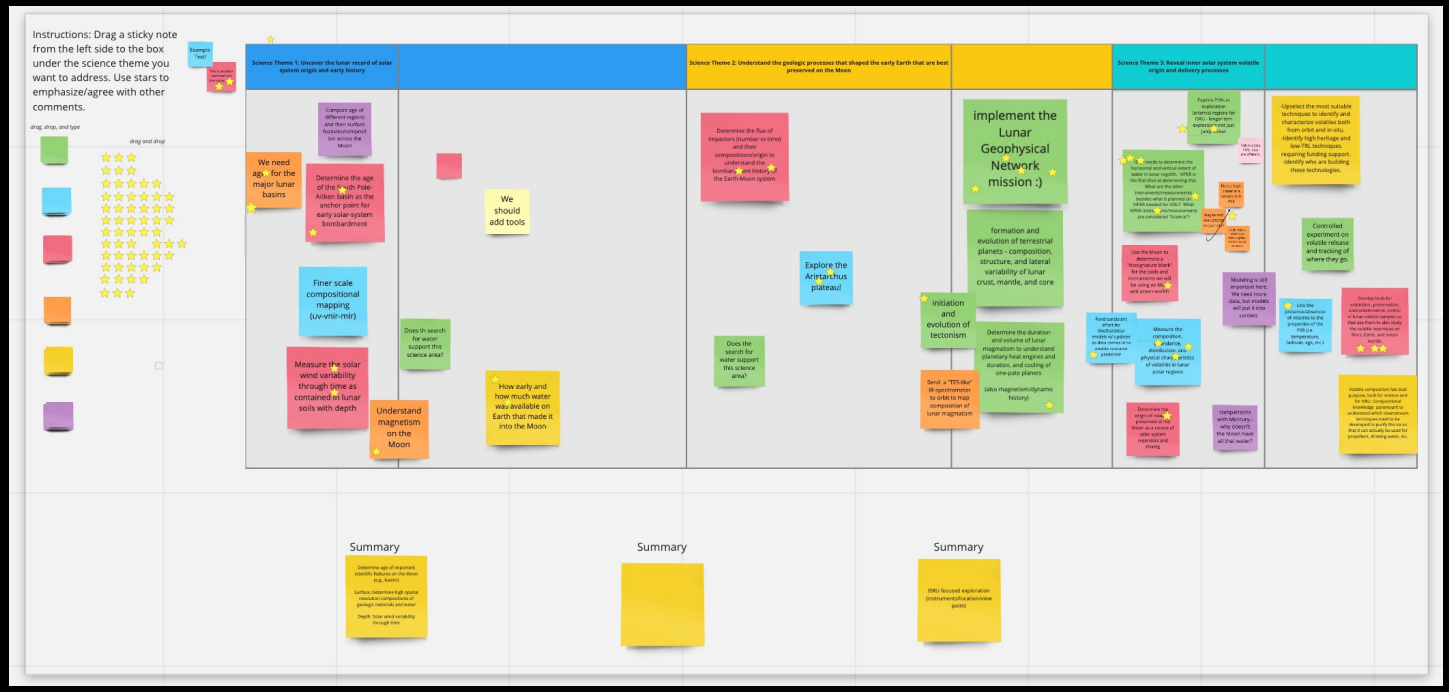


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Science Theme 1: Uncover the lunar record of solar system origin and early history

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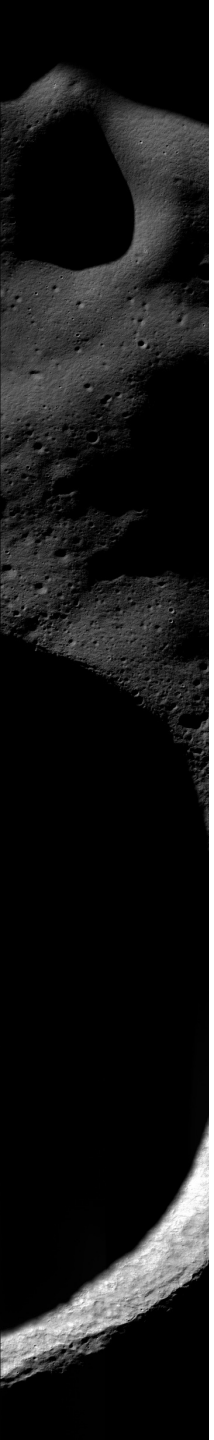

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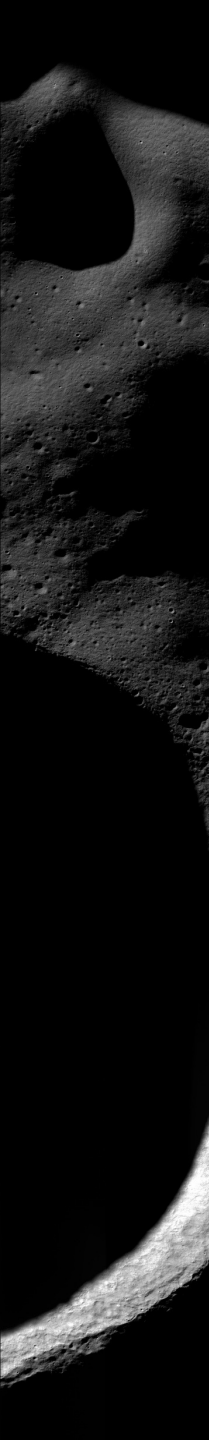

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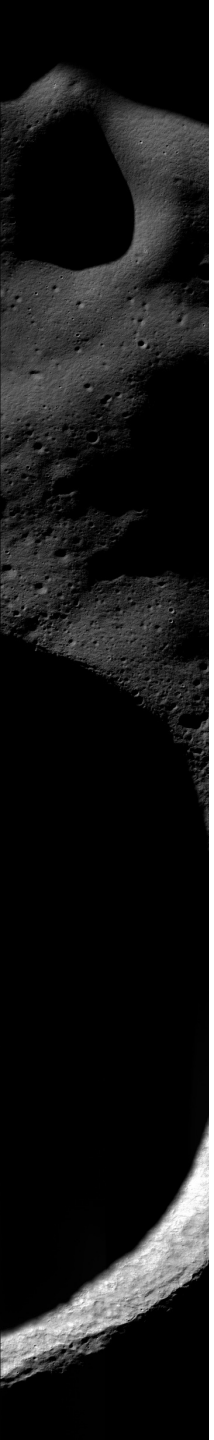

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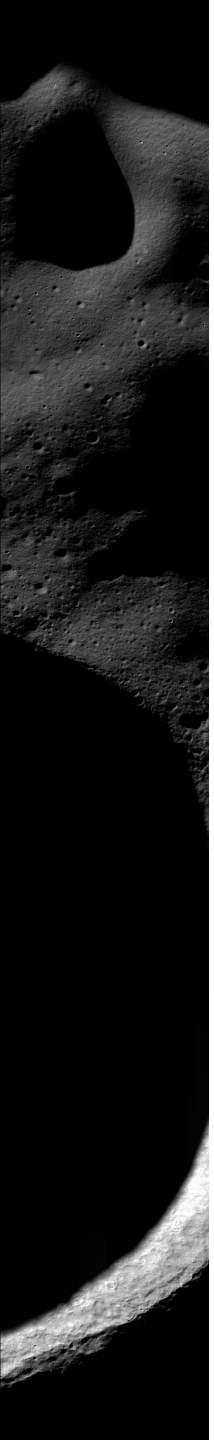

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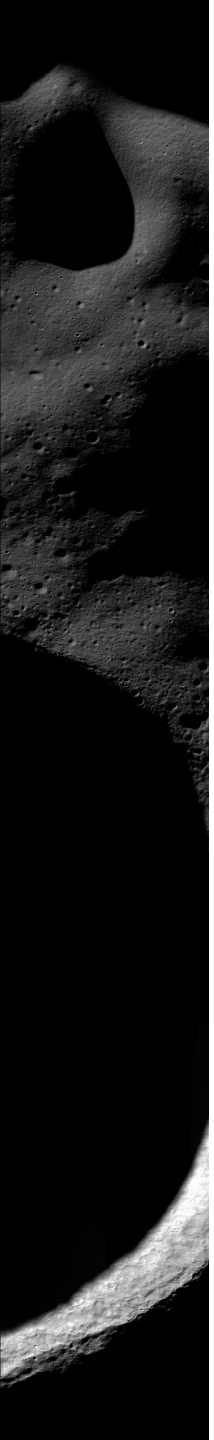

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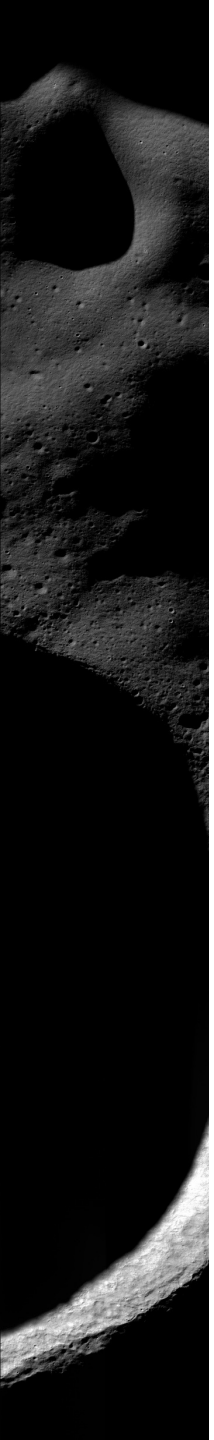

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Legend: Ecstatic | Pleased | Unsure | Concern (and areas for action) | Ready/willing to take action/facilitate

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    - Feelings towards Lunar Surface Science Workshops (LSSWs) are "complex"

# Ending on a positive note: Lots of gratitude to NASA

- For listening to the extended community:
  - Lunar Trailblazer onto rideshare
  - PRISM 3 proposers can propose landing site
  - PRISM 3 proposers have option for surviving lunar night
- Requesting feedback for Moon to Mars Objectives
- Expressing interest and excitement at CLOC-SAT
- Travel grants for early career participants
- Asking the lunar community (and LEAG) to help