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## Response to Request for Information

*Cislunar Science and Technology Subcommittee*
*National Science and Technology Council*

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1. **What research and development should the U.S. government prioritize to help advance a robust, cooperative, and sustainable ecosystem in cislunar space in the next 10 years? And over the next 50 years?**

Broadly speaking, the sustainability of continued lunar activities might be thought of in three dimensions: **programmatic, environmental, and economic**.

The cislunar environment is a domain beyond state territory and (*via* Article I of the 1967 Outer Space Treaty) open to all states to access, explore, and utilize. As a shared domain open to access and use by all, the concept of sustainability must guide actions there. Cislunar sustainability has analogous elements to sustainability elsewhere, including in terrestrial development. Consequently, cislunar sustainability encompasses not just ensuring economic viability, but taking into account the context of any proposed activities, their implications for other actors and how those other actors will perceive and react to them, and the needs of future actors and future generations accessing and utilizing the shared cislunar environment. As such, efforts by one nation – especially a pioneering nation undertaking activities for the first time – will have a tremendous precedential importance. All aspects and implications of proposed activities must be intentionally and rigorously considered beforehand. Specifically, if the cislunar environment is to be a cooperative and sustainable ecosystem, it is important that the United States engage with China on these matters, as these are the two primary actors in this emerging domain.

Operating safely in the context of this unique domain must be a key consideration, including the safety of individual missions and the need to avoid harmful interference with other missions and activities. As more operators become active in lunar orbit, and on the surface, the need increases to develop space situational awareness, space traffic coordination practices, and orbital debris mitigation practices specifically for cislunar and lunar operations.

One specific area of cislunar sustainability that needs more R&D focus is the issue of **orbital debris mitigation for lunar orbits**. Over the last few decades, the United States has played a

key role in conducting scientific research that supported the development of international standards to mitigate the creation of orbital debris from human activities in Earth orbit. As we expand those activities out to cislunar space and lunar orbit, orbital debris mitigation will also become a growing concern there as well. The US will need to lay the research foundations for a new set of cislunar orbital debris mitigation guidelines that take into account the unique dynamics and characteristics of the cislunar space environment.

A second specific area needing more R&D focus is the **development of space situational awareness (SSA) capabilities for the cislunar domain**. Current SSA capabilities are almost entirely focused on tracking and monitoring human space activities and understanding the space environment from geostationary orbit and lower. Moreover, these capabilities were largely designed to meet national security requirements and not safety of spaceflight or other requirements to meet other national requirements (such as supporting safety of spaceflight or monitoring commercial activities). Research on what these requirements should be for cislunar space is urgently needed now to help inform future SSA architecture designs. One additional task might be conducting a survey of existing orbital debris that could impact or is orbiting the Moon to have a more comprehensive situational awareness of the cislunar region. Additionally, it should be a priority to share lunar SSA data as much as possible for spaceflight and cislunar safety reasons, and this transparency should be incorporated into the SSA frameworks as they are being developed.

A third area that will continue to require further research and development efforts is **management and mitigation of the impact of lunar dust on safe and sustainable operations**. Lunar dust distributed by human or robotic activities on the lunar surface, for example landings of spacecraft, can be potentially harmful to other operations and activities on the Moon. Mitigation of the impacts of lunar dust will be an important element of ensuring safe and sustainable lunar activities. Mitigation approaches such as hardened, shared landing pads will require further research.

Common throughout these lunar sustainability challenges is the importance of **developing practical approaches to interoperability, safety standards, registration practices, and other coordination tools** for lunar activities. Initiatives such as the Global Expert Group on Sustainable Lunar Activities (GEGSLA) are working to identify approaches to address these and other aspects of lunar sustainability.[1]

[1] Global Expert Group on Sustainable Lunar Activities (GEGSLA), https://moonvillageassociation.org/global-expert-group-on-sustainable-lunar-activities-gegsla/

**2. What key technical standards are most useful to develop in support of activities in cislunar space, and how could these standards enable and support a vibrant and sustainable cislunar ecosystem?**

Any technical standards to enable and support a vibrant and sustainable cislunar ecosystem will develop within an already existing larger regulatory framework formed at the international level by the 1967 Outer Space Treaty and supplemented by initiatives such as the Artemis Accords.

The first consideration is whether that behavior complies with the state's international legal obligations – especially with the principles of cooperation and mutual assistance, the obligation of paying due regard to the corresponding interests of other states in the exploration and use of the Moon, and the obligation to avoid harmful contamination of celestial bodies – all found in Article IX of the 1967 Outer Space Treaty. Article IV of the Outer Space Treaty also requires that the Moon be used for "exclusively peaceful purposes", and that "the establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden."

Additionally, any authorizing government should reflect on whether the proposed cislunar activity fosters cislunar sustainability over the long term, or whether it might hinder cislunar sustainability in terms of establishing precedents that allow one actor to conduct activities that would be prohibitively unsustainable if allowed for all. They should also reflect on how the United States and its space sector would respond to other actors doing the same activity. Standards set what the practice is and can exist as a benchmark as to what behavior is acceptable or expected. Lunar standards driven by the US government should serve as this type of benchmark.

Thankfully, the Artemis Accords takes the first step in guiding the development of any technical standards to support a vibrant and sustainable lunar ecosystem.[2] The Artemis Accords reiterate fundamental principles in the Outer Space Treaty and clarify and codify newer principles that advance the law in a sustainable fashion. Various sections of the Artemis Accords reiterate and strengthen existing principles of international space law. These include Peaceful Purposes (Section 3); Emergency Assistance (Section 6); Registration of Space Objects (Section 7); Release of Scientific Date (Section 8). Section 11 on Orbital Debris reiterates existing US and international rulemaking, including the 2019 Long-term Sustainability Guidelines, adopted by the UN Committee on the Peaceful Uses of Outer Space.[3] Other sections of the Artemis Accords advance sustainability concepts not explicitly found in international space law. These include Transparency (Section 4); Interoperability (Section 5); Preserving Outer Space Heritage (Section 9); Space Resources (Section 10); and Deconfliction of Space Activities (Section 11).

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[2] Artemis Accords, https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf

[3] Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space, https://www.unoosa.org/oosa/en/oosadoc/data/documents/2021/stspace/stspace79_0.html

Various sections of the Artemis Accords can be strongly tied to advancing cislunar sustainability, and these can serve as solid foundations for developing technical standards. For example, the registration of space objects provides not just a method of securing the extraterritorial application of national jurisdictional powers, but also serves as a transparency and confidence-building mechanism to other states active in the domain – clarifying which state or states are internationally responsible for which space objects. Registration fosters transparency and even interoperability amongst actors. A clear, efficient, updated, and maintained national registry of space objects should be a priority for technical standards development.

Articles I, III, V, and XI of the Outer Space Treaty all speak of international cooperation in the scientific investigations of outer space. Therefore, the release of scientific data, found in Section 8 of the Accords, aligns with existing space law. Building requirements on the release of scientific data into national standards would therefore foster cislunar sustainability.

Building on from interoperability (Section 5), the requirements preserving outer space heritage (Section 9), space resources (Section 10), and the deconfliction of space activities (Section 11) all align with norms which require that the Moon should be used exclusively for peaceful purposes, the principles of cooperation, mutual assistance, and due regard, and the obligation to avoid harmful contamination of the Moon.

In licensing national lunar activities (whether governmental or private), considerations of preserving historic human heritage sites and hardware on the Moon, as well as allowing space resource use (while not falling afoul of national territorial appropriation of lunar locations) and of protecting activities with safety zones in a peaceful and sustainable manner, will involve well-considered and nuanced policy to guide the development of technical standards.

The above elements form a broad basis for cislunar sustainability, but it remains to national actors to clarify these norms on a regulatory and technical level. It is crucial that the United States demonstrate leadership on establishing these norms to ensure the long-term sustainable use of cislunar space for all.