

National Aeronautics and Space Administration

Responsible Exploration

Ethical, Legal, and Societal Implications of the Artemis campaign and NASA's Moon to Mars Architecture

Introduction

NASA's Moon to Mars Objectives, established in 2022, include recurring tenets that provide guidance for how NASA should explore. The sixth recurring tenet reads, "Conduct all activities for the exploration and use of outer space for peaceful purposes consistent with international obligations and principles for responsible behavior in space."

NASA's Architecture Definition Document, in its discussion of how the recurring tenets shape NASA's Moon to Mars Architecture, calls for considering the responsible use of space from legal, policy, ethical, and societal perspectives.^[1] The document establishes the specific systems engineering approach that NASA uses to achieve its Moon to Mars Objectives, but inclusion of ethical, legal, and societal implications (ELSI) into the agency's Moon to Mars Architecture remains an open area of analysis.

NASA considers ELSI important to exploration. NASA's Moon to Mars Strategy and Objectives document outlines three pillars of exploration: science, inspiration, and national posture.^[2] Ethical, legal, and societal factors are present within each of these reasons to explore — and at their intersections.

The aerospace community has expressed significant demand for consideration of ELSI in exploration. Participants at NASA's 2022 Moon to Mars workshop in London considered a range of ELSI topics, including public communications, responsible use, and disposal of waste. Participants at the 2022 Lunar Surface Science Workshop on inclusive lunar exploration discussed challenges related to diversity and inclusion in the lunar community.^[3] Additionally, the 2023–2032 Planetary Science and Astrobiology Decadal Survey by the National Academy of Sciences recommended that NASA solicit expert views about the ethics of planetary in-situ resource utilization.^[4]

While NASA has already begun considering ELSI in Moon to Mars exploration, fully infusing ELSI into the Moon to Mars Architecture will require new systems engineering frameworks and enhanced collaboration with industry, academia, and the international community. This paper summarizes recent work at NASA related to ELSI of Moon to Mars efforts to inform future architecture decisions.

Ultimately, NASA embraces its duty to responsibly explore for the benefit of humankind. ELSI issues are core to that aim.



Note: NASA is not the only organization tackling ELSI issues. Other U.S. government agencies, international organizations, and the broader space sector are having discussions about the inclusion of ELSI in space program development and execution. In the U.S., the Defense Advanced Research Projects Agency and National Science Foundation are actively considering how to incorporate ELSI into program development and contributing research. Internationally, the United Nations Office for Outer Space Affairs held a conference on sustainable lunar activities in June of 2024, which included discussion of ELSI topics and aimed to foster avenues for global cooperation.^[5]

ELSI Efforts at NASA

NASA has recently undertaken several efforts to identify ELSI for its Moon to Mars exploration campaign. This section surveys a selection of these activities, highlighting ELSI considerations and lessons learned.

Artemis, Ethics, and Society Workshop

In 2023, NASA hosted a workshop seeking input on the incorporation of ELSI into the Artemis campaign and Moon to Mars exploration.^[6] This two-and-a-half-day workshop gathered 55 participants from various fields in both technical and non-technical disciplines. This included historians, philosophers, sociologists, lawyers, and engineers, among others. The goal was to gain a breadth of perspectives on ELSI; identify ELSI considerations and implications; and source potential ideas to address them.

NASA synthesized these discussions into five key ELSI themes:

- 1. Sharing the benefits of space exploration
- 2. Reflecting on core values for exploration
- 3. Defining sustainability for lunar exploration
- 4. Balancing shared access to the lunar surface
- 5. Addressing cultural sensitivities around lunar activities

From participant input, NASA observed that key ELSI related to Moon to Mars exploration involved sharing its benefits, reflecting on core values for exploration, (e.g., sustainability, balancing shared access), and addressing cultural sensitivities around lunar payloads and activities.

In addition to identifying these ELSI, the workshop also explored ways to address ELSI at NASA and the challenges that might arise when doing so. Participants discussed policy options, management processes, educational resources, formalizing research capabilities to guide decision-making, and continuing to engage stakeholders and ELSI experts.

NASA is still formulating approaches it can implement to address ELSI. Workshop participants noted that the agency could face workforce culture challenges, resource limitations, political pressures, and other practical obstacles of unanticipated ELSI issues. Regardless of the path forward, participants expressed interest in continued ELSI dialogue between NASA and the space community.

Additional Studies

Recently, NASA has released publications considering ELSI for Moon to Mars exploration.

- A 2022 NASA paper highlighted policy considerations for landing and operating on the lunar surface; this analysis included ELSI-related topics such as protection of humanity's lunar exploration heritage and noninterference across lunar activities.^[7]
- Following this analysis, another NASA report identified 12 policy questions that can guide future deep space exploration efforts.^[8] That study included cultural and ethical considerations as a policy question, specifically

asking how NASA should ensure its activities are consistent with values of the global community. Further, it notes that ELSI policy questions often emerge early in mission and program lifecycles.

• A 2023 paper explored what it means to responsibly mine off-world. It looked to terrestrial mining for lessons learned on minimizing environmental impacts of lunar insitu resource utilization.^[9]

Space Sustainability

NASA has recently initiated other ELSI activities, which will help inform Moon to Mars Architecture decisions. In 2023, NASA's deputy administrator charged a cross-directorate team under the Space Environment Sustainability Advisory Board to create an agency space sustainability strategy.

In 2024, NASA released volume one of this strategy, which focuses on Earth orbit.^[10] That document defines space sustainability as, "the ability to maintain the conduct of space activities indefinitely into the future in a manner that is safe, peaceful, and responsible to meet the needs of the present generations while preserving the outer space environment for future activities and limiting harm to terrestrial life."

Specifically, the strategy concerns itself with the issues of orbital debris, space situational awareness, and space traffic coordination. These ELSI challenges can have profound implications on future spaceflight capabilities, especially for emerging space actors not responsible for the accumulation of space debris. As part of this strategy, NASA appointed a lead for space sustainability to enhance organizational support of these issues.

A future volume of the space sustainability strategy will address similar considerations for cislunar space. Goals set forth in that document will inform the evolution of NASA's Moon to Mars Architecture and enhance its consideration of ELSI.

Soliciting Community Feedback

In 2024, NASA released a call for proposals through the Research Opportunities in Space and Earth Sciences (ROSES) solicitation on Economic, Social, and Policy Analyses of Lunar Surface Sustainability.^[11] This opportunity seeks new ideas from non-governmental organizations that will yield insights, including proposed frameworks, for evaluating sustainability that can be factored into mission planning, policy, and strategy. NASA made two awards in July 2024, with plans to recieve briefings on research results in 2025.

NASA also welcomes feedback on how to best approach ELSI considerations as part of Architecture Concept Review workshops and associated stakeholder meetings.

The Artemis Accords

the Artemis Accords, identifying an early set of principles promoting the beneficial use of space for humanity. The Artemis Accords provide a common set of principles to enhance the governance of the civil exploration and use of outer space. The Artemis Accords reinforce the commitment by signatory nations to the Outer Space Treaty, the Registration Convention, the Rescue and Return Agreement, as well as best practices and norms of responsible behavior for civil space exploration and use.^[12]

The principles of the Artemis Accords are: peaceful exploration, transparency, interoperability, emergency assistance, registration of space objects, release of scientific data, preserving heritage, space resources [utilization], deconfliction of activities, and orbital debris [mitigation]. The Artemis Accords foster an environment of trust and cooperation where all nations can contribute to the safe and sustainable exploration of space.^[13]

Forward Work

Considering ELSI in Moon to Mars exploration requires expanded dialogue. Seeking feedback from diverse stakeholder communities — including international space agencies, academia, non-profits, and especially underrepresented communities — is core to ELSI.

Conversations with a wide range of stakeholders empower NASA to uphold its commitment to explore for the benefit of humankind. Continuing to leverage expertise in disciplines not traditionally associated with spaceflight (e.g., ethics or humanities) will better position the agency to answer questions about responsible exploration in the interest of the global community.

Considering the responsible use of space and seeking input from a broad range of perspectives and disciplines can lead to more well-rounded conversations and decisions about humanity's future at the Moon and Mars.

Summary

NASA engages with a variety of institutions and partners and will continue to pursue dialog with people and organizations representing a range of societal perspectives. NASA remains open for input on ELSI considerations via broader policy mechanisms and through its Moon to Mars Architecture process. NASA is supporting directed research on economic, policy, and social aspects of lunar surface sustainability.

NASA must champion responsible exploration when developing a Moon and Mars exploration ecosystem. This requires the agency to move beyond considering what we could do and ask what we should do. It requires a comprehensive understanding of how our exploration activities may affect others' beliefs and exploration efforts. It serves as a guide that will shape humanity's future.

Key Takeaways

Responsible use is a recurring tenet in NASA's Moon to Mars Objectives. Recurring tenets are broadly applicable across objectives and serve as practical guidance for *how* objectives should be carried out.

Incorporating the concept of responsible use into the Moon to Mars Architecture requires an understanding of the ethical, legal, and societal implications of space exploration. This means reflecting on the underlying values of exploration, responsible use of in-situ resources, cultural sensitivities of exploration efforts, and many other considerations.

NASA is pursuing research and dialogues to better understand how the agency might embrace and encourage responsible behavior in and use of space.

To ensure the Moon to Mars Architecture reflects diverse perspectives, NASA must continue to engage with academia, industry, and international partners to empower the responsible use of space.

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