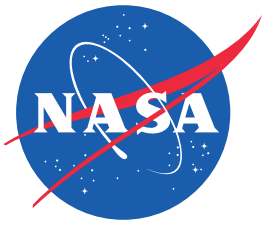

Office of Technology, Policy, and Strategy

Artemis, Ethics and Society: Synthesis from a Workshop

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Executive Summary

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Purpose and Goals

As NASA plans and implements its Artemis and additional Moon to Mars activities, it will set precedents in spaceflight for decades to come. Including ethical and social considerations in Artemis planning will improve the likelihood that the future we create is one where humanity collectively wants to live. A wide range of stakeholders have called for NASA to address ethical and societal issues, notable examples being the U.S. National Academies' recent Planetary Science and Astrobiology decadal survey and the U.S. National Science and Technology Council's cislunar strategy. To begin to answer those calls, NASA convened a workshop focused on two key study questions: 1) How should NASA consider the ethical, legal, and societal implications (ELSI) of the Artemis and Moon to Mars efforts?; and 2) What are the key ethical and societal implications that need consideration? These questions can be considered as NASA pursues a series of increasingly complex Artemis missions that will enable human exploration to the Moon and Mars.

Methodology

NASA's Office of Technology, Policy, and Strategy (OTPS) hosted the Artemis and Ethics workshop April 12-14 at Agency Headquarters in Washington, DC. The workshop marks an initial foray into a topic that neither OTPS nor NASA have significantly engaged with outside of a few selected areas, such as NASA's study of the societal implications of the Apollo program during the 1960s and the Agency's astrobiology activities. OTPS invited 55 participants across a relevant and diverse range of disciplines, many of whom did not know each other in advance. These participants spanned social science, humanities and technical fields, and included policy actors and scholars, philosophers, historians, sociologists, communications studies scholars, lawyers, engineers and scientists. OTPS invited experts from these disciplines because each has an important perspective for understanding the ethical and societal implications of spaceflight. Interdisciplinary perspectives were sought to better explore the many facets of how

NASA and the space community should consider ethical and societal implications of space activities tied to Artemis and the Moon and Mars.

Over the two-and-a-half-day workshop, participants listened to talks and engaged in brainstorming sessions on key ethical challenges in spaceflight, how ethical questions were handled in other scientific endeavors like the Human Genome Project, broader social challenges, and possible policy options to address these concerns.

We developed this report by systematically analyzing the conversations and inputs from participants, including qualitative coding of the presented topic themes. This analysis yielded a map of ELSI areas identified and discussed at the workshop. This informed key observations about the nature of ELSI for Moon to Mars activities and possible options for addressing them. This executive summary summarizes those observations, while the main report body discusses the underlying details and mappings we used to understand the discussions.

Observations for Considering Ethical, Legal, and Societal Implications of Artemis

We drew four main observations from the workshop discussions.

Observation 1

Participants identified key questions across cross cutting areas:

a) Sharing the benefits of space activities: How should NASA work to the "benefit of all [humankind]," which is part of its mandate under the original Space Act that created NASA? Who is included in that statement and how should they be involved? How can NASA know who benefits from Artemis?
b) Reflecting on core values for exploration: How do we ensure that the values we bring to space are those we want as the basis of future exploration? The principles and goals that organizations use in their practices represent the values that are most likely to shape new engineered systems. It can be difficult to identify these values, especially those held by non-space actors.
c) Sustainability: Defining sustainability on the Moon is a complex challenge, as sustainability discussions in a terrestrial context, with questions of balancing conservation against societal needs, do not necessarily apply. The workshop also cited environmental impacts of space activities (including launches) on Earth.
d) Balancing shared access: Participants identified many operational challenges to prioritizing access to key sites, deconflicting activities, avoiding contamination, and

maintaining heritage sites. A recent OTPS analysis[1] explored many of these practical concerns, which feed into broader ethical and societal implications.

e) **Addressing cultural sensitivities:** Participants identified cultural sensitivities surrounding payloads and activities on the Moon, which is viewed as sacred by many cultures worldwide. This may affect perceptions of increased NASA activity on the Moon for resource utilization and other goals.

Observation 2

Participants mapped out many cultural and practical challenges to identifying and addressing ethical and societal implications of Artemis and Moon to Mars activities.

a) **Cultural challenges integrating social science with space engineering.** Social scientists, humanities scholars, and technical staff initially struggled to communicate effectively due to the vastly differing languages of the expertise at play. Many NASA staff lacked a framework to engage on these ethical issues, and some social science and humanities scholars lacked context for how decisions are made internally at NASA. A recommendation from some participants was to increase cross-pollination between the social scientists and NASA Headquarters personnel.

b) **Cultural challenges toward engineering versus reflection.** NASA and other space organizations have a culture that often prioritizes moving forward efficiently versus more careful reflection and public engagement. Getting space practitioners to focus on long-term societal impacts, versus narrower scientific or technical problems, requires an attempt at culture change.

c) **Practical challenges in enabling reflection**. Dedicated resources to study the ELSI of Artemis might be drawn from resources needed to accomplish a mission. Some participants also noted that NASA can have many unfunded mandates, despite large budgets for space activities. Dedicating resources or staff time to focus on societal and ethical challenges requires balancing to accomplish NASA's planned missions.

d) **Practical challenges with diffuse responsibility and control**. Many Artemis ELSI are outside of NASA's full control due to the involvement of international and commercial actors. These ELSI include questions about who might get access to specific lunar surface regions first, and whether those sites are maintained for future generations.

e) **Practical challenges in anticipating future ethical and societal concerns.** Pressing ethical issues may emerge unexpectedly as a second-order effect of NASA decisions. In light of this, proactive exploration of future ethical and societal issues is needed. For example, a cultural sensitivity about commercial payloads with human remains flying alongside NASA Commercial Lunar Payload Services (CLPS) deliveries is a key example discussed in the

[1] Swiney, Gabriel and Amanda Hernandez. 2022. Lunar Landing and Operations Policy Analysis. NASA Report ID 20220015973.

report and involves diffuse responsibilities. While NASA has said it would not send human remains to the Moon without consulting U.S. tribal nations, the CLPS initiative's funding of commercial deliveries on private landers has enabled non-NASA payloads, including human remains to become manifested on these private flights. Some cultures see the Moon as having spiritual significance and believe placing human remains on the Moon can disturb the sanctity of the Moon.

Observation 3

A community of researchers working on ELSI is interested in ongoing engagement with NASA and the space community on these topics.

OTPS brought together many disciplines across social science, humanities, and technical fields. These disciplines haven't worked together before in the context of space exploration. The workshop helped integrate these external disciplines, enabling participants both inside and outside NASA to understand each other's perspectives. Several participants discussed creating their own non-NASA community to build on the discussions at this event.

Observation 4

Participants discussed a range of options that NASA and the space community may use to address the ethical implications of Artemis. These reflect participants views and are not recommendations from NASA:

a) The following are examples of methods suggested by participants for how NASA could address ELSI:
   i. Policy: ELSI expertise can be integrated into existing policy structures such as federal advisory committees, creating incentives for responsible actions, and using public values to determine NASA goals.
   ii. Management: NASA's internal management can better focus on ethical/societal implications through clarity about the importance of ethical reflection, recognizing societal impacts in systems engineering, better utilizing the formal NASA Strategic Plan and Performance reporting processes to capture ethical issues, and budgeting to support ELSI capability.
   iii. Research: NASA can establish a capability to address research questions in this area, and – to access this appropriately – create frameworks to help guide future activity, such as sustainability, stewardship, and equity. The workshop identified participatory assessments with the public and other key stakeholders to create a map of public values as a way to get relevant information to decision-makers.
   iv. Conversations: This refers to engaging with the public, social science and humanities experts, and under-represented groups as well as those in technical fields. These conversations matter symbolically and practically as a way to

exchange ideas and values between NASA and others and can indirectly shape management and policy.

v. Education: There are ways to improve insight on ethical/societal issues for existing space practitioners, students, and the general public.

b) Participants suggested that key models that NASA and the space community can consider are the U.S. Human Genome Project's funding of ELSI research and the European Commission research programs for Responsible Innovation.

c) Some of the policy options discussed in the report would require no dedicated funding (such as changing decision processes), whereas others, such as public consultations or dedicated research, would. Some combination of these activities seems likely to be of value, but also would come with a tradeoff of impacting already budget-constrained programs and projects at NASA and elsewhere.

Conclusion

The insights captured in this report can raise awareness within NASA and the broader space community of the ethical implications that might arise in future Moon to Mars planning and ways to address them. Continued dialog and engagement with the various disciplines and perspectives represented in this report has value and is of a strong interest among social science and humanities scholars as well as reflective space practitioners.

OTPS has forward work plans that will incorporate insights from this report. OTPS is formulating a new internal study to identify key policy questions likely to emerge leading up to the Artemis III mission, the first human landing on the Moon in more than five decades. OTPS will consider potential decisions with ethical and societal implications as part of that study and subsequent discussions with NASA leadership. Separately, OTPS is formulating ways to converse on these topics with NASA's international partners, understanding how they feel ELSI should be considered. OTPS is keen to receive feedback on the ideas captured in the report, which will be discussed at upcoming events such as the AIAA ASCEND conference and the Lunar Exploration Advisory Group, among others.

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NASA's Past and Current Engagement on Ethical, Legal, and Societal Implications (ELSI) of Space Exploration

The National Aeronautics and Space Act of 1958 states that "activities in space should be devoted to peaceful purposes for the benefit of all [humankind]." Assessing how NASA's Moon to Mars work benefits "all humankind" can be complex. NASA has a long tradition of forward-thinking research, including research on the ethical and societal impacts of the Apollo Program in the 1960s,[2] and a 2007 historical volume on the Agency's societal impact. NASA also has a history of exploring potential ethical and societal impacts of astrobiology research, primarily the implications of finding extraterrestrial life.[3] NASA has enlisted outside thinkers to speculate on the future of humanity.[4] Other U.S. government activities have included research on the ethical and societal aspects of science in general, such as the Human Genome Project. NASA has not, however, systematically addressed the societal and ethical implications[5] of human exploration, including the ongoing Moon to Mars effort.

Recent years have brought several calls for research on the ethical and societal aspects of NASA's Moon to Mars work. Some of NASA's international partners highlighted the need for broader engagement at the 2022 Moon to Mars Objectives workshop in London; so did the 2022 summary report from a Lunar Surface Science workshop on Inclusive Lunar Exploration.[6] The latter called for research on how to integrate existing expertise in the social sciences and humanities into NASA decision-making. The National Academies' recent Planetary Science and Astrobiology Decadal Survey said NASA should study the ethics of planetary in-situ resource

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[2] Coopersmith, J., 2008. Great (Unfulfilled) Expectations: To Boldly Go Where No Social Scientist or Historian Has Gone Before. In: Steven Dick (ed), *Remembering the Space Age.* NASA Special Publication 4703, p.135. Coopersmith argues that the effect of these efforts didn't have a chance to succeed, but they did bring in interested groups of scholars to discuss these issues.

[3] NASA has done societal and ethical implications research focused on astrobiology, specifically addressing implications of the possible future discovery of life. Planetary protection is also another area where NASA has thought about ethical implications proactively. For astrobiology research, see Roth, C.B.N. and Shindell, M., 2007. Workshop Report: Philosophical, Ethical and Theological Implications of Astrobiology. AAAS; and Dick, S.J. 2018. Astrobiology, Discovery, and Societal Impacts. Cambridge University Press.

[4] In the early 2000s, NASA administrator Dan Goldin directed study of the future of humanity in 100 years. They brought in sci-fi authors, academics and others to examine the future of humanity across 100 years. Rejeski, D. and Wobig, C., 2002. Long-term goals for governments. foresight, 4(6), pp.14-22.

[5] Some have criticized research on Ethical, Legal and Societal Implications work by stating that 'implications' assumes that technical decisions will occur regardless of what ethical concerns are raised, which raises risks of 'ethics washing,' or insincere engagement. NASA seeks to sincerely reflect and make decisions based on the results of this research, and as such using the word 'implications' is not meant to reflect a one-way approach to listening to ethical issues. Also, there can often be implications of specific decisions, including decisions not to engage in work in a particular area.

[6] Bennett, K.A. and P. Prem. 2022. Reflections from the Inclusive Lunar Exploration Lunar Surface Science Workshop. *Advancing IDEA in Planetary Science.* P. 2048. Available at: https://ui.adsabs.harvard.edu/abs/2022LPICo2679.2048B/abstract

utilization.[7] (Many of the topics identified in the ethics-related white papers that led to that recommendation were the subject of presentations and discussion at the Artemis and Ethics workshop).

NASA has been working to codify the need to assess ethical and societal implications in ways that reflect a significant realignment and structuring of Agency goals. In September 2022, NASA released its latest Moon to Mars Objectives report, which was updated and expanded based on solicited input from individuals, industry, academia and international space agencies.[8] These updated objectives elevate science to a higher priority than had historically been the case for human exploration programs and centered some of the rationale for human exploration on benefits including improvements to the human condition, economic growth, and scientific return. These benefits are described in detail in an April 2023 NASA document on the Moon to Mars strategy.[9]

Of particular relevance, the Moon to Mars Objectives report had "responsible use" as a recurring tenet (RT-6) of how NASA will explore, stating that NASA will "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." This raises questions about the definition of responsible behavior, which requires an understanding of the societal and ethical implications of NASA's activities. In the 2023 Architecture Definition Document, NASA stated that "the responsible use of the Moon to Mars architecture may require deeper scrutiny of cultural and societal implications of future exploration."[10] The Artemis and Ethics Workshop and the analysis in this report represents an initial effort to help advance understanding in that area, which will inform continued refinement of NASA's Moon to Mars plans.

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[7] National Academies of Sciences, Engineering, and Medicine, 2022. Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032, p. 19-6: ""NASA would benefit from convening a team of experts to review the ethics of planetary ISRU and determine optimal plans and processes to ensure sustainable and responsible resource utilization. Humans are the trustees of our planetary environments for future generations. "Note: Decadal surveys are high profile and significant external studies that are used by NASA, Congress and other key stakeholders such as the scientific community to select future missions. The current report authors are not aware of a similar point about ethics being made in a past Decadal Survey.

[8] The process to create the Moon to Mars objectives solicited input from industry, academics and the general public, through a broad call to which anyone could provide input. NASA reviewed this material and then worked with some commenters as part of revising the final objectives. They are captured in: NASA, 2022a. NASA's Stakeholder Collaborations Help Inform Moon to Mars Planning. RELEASE 22-098. Link. NASA 2022b. Moon to Mars Objectives. September 2022. Link.

[9] NASA 2023a. NASA's Moon to Mars Strategy and Objectives Development: A blueprint for sustained human presence and exploration throughout the solar system. NP-2023-03-31-3115-HQ.

[10] NASA 2023b. Moon-to-Mars Architecture Definition Document. Exploration Systems Development Mission Directorate. NASA/TP-20230002706. Page 108.

Workshop Goals and Study Questions

The key study questions for the workshop were: 1) How should NASA consider the ELSI of the Artemis and Moon to Mars efforts?; and 2) What are the key ethical and societal implications that need consideration?

Given this context, OTPS planned and hosted the Artemis and Ethics workshop April 12-14, 2023. We will briefly summarize the planning process here. Full details are in Appendix B.

OTPS focused the workshop on studying and framing how to address long-term ethical and societal aspects of Artemis and the Moon to Mars effort. Such insights could support NASA's vision for sustainable and responsible exploration, as robust and transparent ethical dialog helps enable long-term shared visions and public benefit. OTPS also sought to identify best practices for conducting such research, as well as to create a map of key ethical and societal issues in the Moon to Mars effort.

The workshop intentionally solicited a variety of viewpoints on how to approach the key questions and issues and was not meant to produce a consensus perspective. For speakers and discussion participants, we solicited different views and rationales that we thought would be relevant, though we did limit the scope to Moon and Mars exploration.[11] OTPS invited 55 participants across a diverse set of disciplines, and most did not know one another in advance. These participants represented social science, humanities and technical fields, and included policy actors and scholars, philosophers, historians, sociologists, communications studies scholars, lawyers, engineers and scientists. Through this diversity we hoped to explore many facets of how NASA should consider ethical and societal implications. Given the past challenges of infusing ethical and societal impacts research into practice,[12] 20 of the invitees were NASA civil servants from a variety of offices and programs – not just Artemis – and OTPS asked them to engage from their personal perspectives. The idea was to identify new

[11] OTPS focused content on Artemis and Moon to Mars, and as such excluded from analysis broader issues facing NASA; for example, we did not focus on space activities in Low Earth Orbit and on the International Space Station, nor did we focus on purely robotic exploration as done by NASA's Planetary Science Division. OTPS also tried to focus on broader ethical and societal implications discourse and did not solicit presentation on specific issues such as safety and its associated ethical impacts. Given that NASA has other organizations responsible for Diversity, Equity, Inclusion and Accessibility (DEIA), OTPS did not focus on soliciting DEIA presentation writ large. DEIA issues of course emerged in discussion from the workshop, given their importance for societal impact. For readers interested in DEIA as a topic, see NASA 2022. NASA Strategic Plan for Diversity, Equity, Inclusion and Accessibility: Fiscal Years 2022-2026. Link.

[12] Some have argued that few practitioners have taken the results of ethical and societal impacts research into practical account. It is unclear whether this is due to insufficient resources or due to the challenge of doing practically-relevant ethical research. See Sullivan, M., 2018. The Expansion of Science Policy in the United States in Three Cases: rDNA Research, The Human Genome Project, and the National Nanotechnology Initiative (Doctoral dissertation).

understandings of the ethics of exploration of the Moon and Mars and possible actions that could be accomplished by NASA.

We sought to take advantage of the diverse viewpoints through extended discussions and brainstorming sessions. The goal was to better understand how NASA's Artemis and Moon to Mars activities should consider ethical and societal implications. In the first brainstorming session, for example, we asked participants to write thoughts on sticky notes to highlight ethical and societal topics or implications of Artemis that they felt were important or that merited deeper conversation during the workshop. This approach was intended to provide a quick map of ethical perspectives and issues across the varied disciplines. A later session focused on mapping out practical challenges and opportunities for considering these societal and ethical issues. Results from both sessions are discussed below and in dedicated appendices.

Given that this is an initial exploratory study, we do not make formal recommendations but rather map out the range of options that might be available to NASA and other space actors that want to more deeply explore this area. While the foregoing captures our intent and approach to organizing the workshop, we emphasize that the views expressed by the workshop participants do not necessarily reflect the views of NASA or the United States Government. Our formal invocation of "OTPS" in this report indicates when statements are being made officially on behalf of NASA, whereas other discussions reflect only views of the participants and the report authors as individuals.

Key Discussion Themes and Insights

The following very briefly summarizes some of the key themes from the workshop, which are discussed at greater length in Appendix C.

Across the various brainstorming and discussion sessions, multiple, open exchanges occurred. NASA participants were encouraged to share their personal views on these issues, and many engaged with empathy. Some of the external speakers noted about how NASA staff engagement helped them understand the practical challenges in considering these topics inside the Agency. Early-career NASA participants also engaged significantly.

The discussions highlighted the challenges in assembling a group with diverse expertise. While some participants were familiar with the work of others within their fields, many were not well acquainted with the frameworks of scholars from different disciplines. The presence of scholars who had previously studied ELSI, along with those involved in responsible innovation research, brought diverse perspectives and tools for addressing the ethical and societal implications of spaceflight. The presence of non-governmental organizations, such as the Just Space Alliance, For All Mankind, and Open Lunar Foundation, enriched the conversation. There were many university researchers whose affiliations are noted in the participant list appendix.

The workshop discussions covered key conceptual and practical challenges. Many international and commercial actors are interested in or engaged at the Moon, and many participants saw NASA as an orchestrator of the emerging lunar economy given its funding of cislunar activities, despite its lack of regulatory authority. Complex issues such as environmental impacts to the Moon from sustained human activity were discussed, along with challenges in thinking about or even defining sustainability in the lunar context.

The discussion extended to **justifying the benefits of human exploration**, with one speaker arguing that empirical assessments have not sufficiently demonstrated the societal benefits that would justify the cost of human exploration. Several speakers emphasized the need for clarity in the fundamental values guiding space exploration and actions. Various participants also underscored the importance of international collaboration, understanding the reasons behind exploration, and refining the values underlying the Artemis efforts.

Insights were shared on the unique cultures within NASA and on **the influence of societal and local culture on the interpretation of ethical issues**. There was emphasis on the importance of team cohesion and the need for context-sensitive approaches to ethical issues. Another theme was **funding opportunities and constraints for ethical and societal implications research**, with these discussions highlighting existing conference grants (e.g., Topical Workshops, Symposia, and Conferences (TWSC)), ROSES solicitations,[13] and the EU's past practice of dedicating a percentage of total funding to societal and ethical issues.

Suggestions for how NASA and other space actors could focus on ethical and societal challenges included implementing **more structured public input** in strategic planning and **incorporating ethical and societal implications** into specific Agency planning processes and operational procedures.

Participants noted that NASA's **operational decisions can have unintended consequences**, a prime example being issues surrounding flying human remains to the Moon aboard NASA-funded but commercially operated spacecraft. Tribal nations raised concern when NASA's Lunar Prospector spacecraft crashed into the lunar surface in 1998 with human remains aboard, prompting NASA to apologize and promise not to do that again without prior consultation with indigenous peoples and others.[14] One workshop participant said some lunar community members have voiced concerns about private companies manifesting human remains on CLPS delivery missions to several key stakeholders, and claimed that no

[13] Research Opportunities in Space and Earth Science (ROSES-2023). These are major annual procurements used by NASA for research.
[14] Volante, Enric. "Navajos Upset After Ashes Sent to Moon; NASA Apologizes." The Spokesman-Review. January 15, 1998. This story was recently cited in Bennett and Prem (2022), op cit.

stakeholder felt able to do anything. Some participants were troubled by what they saw as diffuse responsibility, and by the idea that no regulatory mechanism exists for such missions that takes ethical considerations into account. NASA funds CLPS missions but lacks regulatory authority with respect to privately manifested payloads and might not have contractual authority to keep culturally sensitive private payloads off the manifests.

Map of Key Ethical and Societal Implications

OTPS created an initial map of ethical and societal implications tied to Artemis and the Moon to Mars effort. We did this through a brainstorming session where participants wrote thoughts on sticky notes describing ethical and societal implications. Participants identified approximately 140 ethical or societal topics or implications, current and future, related to NASA's Moon to Mars activities. Participants were then asked to mark with a sticker the sticky note ideas they thought were the most significant for NASA and the space community to consider. We (the report authors) documented and reviewed all ideas to synthesize the key implications or categories.

Table 1 shows a map of those key categories and implications. We show representative examples of the ideas that comprise each category but recognize that they represent only potential challenges raised by individuals, and their inclusion in this report does not reflect an endorsement by NASA or the U.S. Government. A complete list of ideas presented during the first brainstorming session can be found in Appendix E.

Table 1: Summary of Key Ethical and Societal Issues (with selected examples provided by participants with edits for clarity. Inclusion of participant ideas does not represent an endorsement by NASA or the U.S. Government.)

Topics	Sample ideas
Defining Ambiguous Terms	Definition of "accessibility" (about who is able to go to space)
	Definition of "sustainable" (on the Moon and Mars)
Who Makes Decisions and Communicates with the Public	How should heritage sites or other areas of significance be selected for protection? Who decides what is worth protecting?
	When NASA asks for community input, how can they ensure they connect broadly with diverse groups?
	Public values not incorporated purposefully into NASA strategy, program budget
	How should NASA communicate to the public how the Agency is thinking about social and ethical issues related to Artemis?
	What does the public think?
Differing Cultural Values	How can NASA best be aware of all cultural issues surrounding human space exploration?
	How does this process/workshop add to present processes where values/ethics are "baked" into regular governing/"democracy," etc.?
	Differing cultural understandings of the Moon
	Societal challenge: Everyone has different views and there will always be someone who opposes
Sharing Benefits	Inequality: How are benefits distributed?
Environmental Ethics	How can environmental ethics be integrated?
	As space exploration continues to grow, are we being mindful of its impact on the environment?
Historical Values and Colonialism	Mismatch between rhetoric of why we go to space and the reality of how we have actually explored space
	Not repeating the mistakes of colonialism
Policy and Governance	How are we going to resolve a conflict? What happens if two entities want to operate in the same patch?
	How do we engender long term responsibility for activities taken by companies and governments?
	Can we devise rules for space mining incrementally (i.e., learn as we go) or must they all be spelled out beforehand?
	What can we send to the Moon? (Currently, the public can buy payload space on a private lander for any payloads)
	Legal framework to enforce ethical compliance
Reflective Capacity by Practitioners	ELSI absorptive capacity inside NASA
Flexibility for Change	Is Artemis "too big to fail?" (i.e., will Artemis continue despite concerns about goals or ELSI?)
	Is Artemis "too small to succeed?" (i.e., should the Artemis vision transcend the Moon and Mars)?
Diversity, Equity, Inclusion, and Accessibility (DEIA)	What happens if someone is disabled during a long-duration mission?
	Create a 53rd Space Grant for National Native American Space Grant
Education and Workforce	Engineers/scientist receive little to no ethics training; they are focused on technical aspects only.
	Lack of humanities/social scientists integrated as team members

We organized the inputs from the first brainstorming session into the following **topic** categories based on our understanding of their ethical intent, with examples included in Table 1 above:

- **Defining Ambiguous Terms** (Approximately **4.21%** of the condensed list of ethical ideas presented at the workshop[15])
- **Who Makes Decisions and Communicates with the Public** (Approximately **12.63%** of the condensed list of ethical ideas presented at the workshop)
- **Differing Cultural Values** (Approximately **11.58%** of the condensed list of ethical ideas presented at the workshop)
- **Sharing Benefits** (Approximately **2.11%** of the condensed list of ethical ideas presented at the workshop)
- **Environmental Ethics** (Approximately **13.68%** of the condensed list of ethical ideas presented at the workshop)
- **Historical Values and Colonialism** (Approximately **7.37%** of the condensed list of ethical ideas presented at the workshop)
- **Policy and Governance** (Approximately **23.16%** of the condensed list of ethical ideas presented at the workshop)
- **Reflective Capacity by Practitioners** (Approximately **8.42%** of the condensed list of ethical ideas presented at the workshop)
- **Flexibility for Change** (Approximately **3.16%** of the condensed list of ethical ideas presented at the workshop)
- **Diversity, Equity, Inclusion, and Accessibility (DEIA)** (Approximately **9.47%** of the condensed list of total ethical ideas presented at the workshop)
- **Education and Workforce** (Approximately **4.21%** of the condensed list of ethical ideas presented at the workshop)

To guide our comprehension and analysis of ethics concerns during the topical organization process, we also grouped the condensed list of 95 ideas into four **themes**: Decision Process, Theoretical, Forecasting, and Substantive Issues. Some ideas fell into two categories and were counted for both thematic categories in the statistics below. The individual thematic categories are defined below:

- **Decision Process:** The process by which NASA or other relevant policy-making agencies make decisions. For NASA, this could include changing how decisions are

[15] Originally, there were approximately 142 ideas identified but the list was condensed to 95 ideas by study leads due to similarities between topics or judged appropriateness to the study. The condensed list represents these 95 ideas.

made, such as modifying what information is considered, who is consulted and how decision-makers weigh options and ultimately decide. Approximately **38.6%** of the 95 ethical ideas presented at the workshop relate to the decision process theme.

- **Theoretical:** A framework or set of values that can help guide future decisions on a topic. This can include desired end states such as 'being sustainable' or represent concepts and approaches for considering future Artemis and Moon to Mars issues. Approximately **34.2%** of the 95 ethical ideas (the largest percentage per theme) presented at the workshop relate to the theoretical theme.
- **Forecasting:** Uncertainty about the future and how people, space agencies, companies and other actors in the lunar space will behave after Artemis and Moon to Mars plans are finalized. Approximately **13.16%** of the 95 ethical ideas presented at the workshop relate to the forecasting theme.
- **Substantive Issues:** Specific dilemmas or choices that NASA and/or other space actors will face that have important ethical or societal implications. These topics may be well-suited for future discussion by decision makers. Approximately **14.04%** of the 95 ethical ideas presented at the workshop relate to the substantive theme.[16]

Figure 1 depicts an analysis of ethical and societal implications organized by **topic** and **theme.** This figure helps identify areas that might benefit from more theoretical research or deeper discussion of process changes, and which areas deal with significant unknowns about the future. This was used as a tool to help think about these topics and informed how we structured some of the observations noted in the Executive Summary. We hope that academics and space practitioners can benefit from reflecting on this map as they envision their future work. We don't call out 'substantive issues' in this diagram, as those topics usually involved multiple themes.

[16] Some ethical ideas fell into *two* thematic categories and were counted for both categories. The theme percentages for each ethical idea only in *one* thematic category are as follows: Decision Process – 26.32%, Theoretical – 30.53%, Forecasting – 14.74%, and Substance Issues – 8.42%. The remaining 19.99% of ethical ideas are those which fell in two categories: Decision Process and Theoretical – 10.53%, Decision Process and Forecast—1.05%, and Decision Process and Substantive Issues—8.42%.

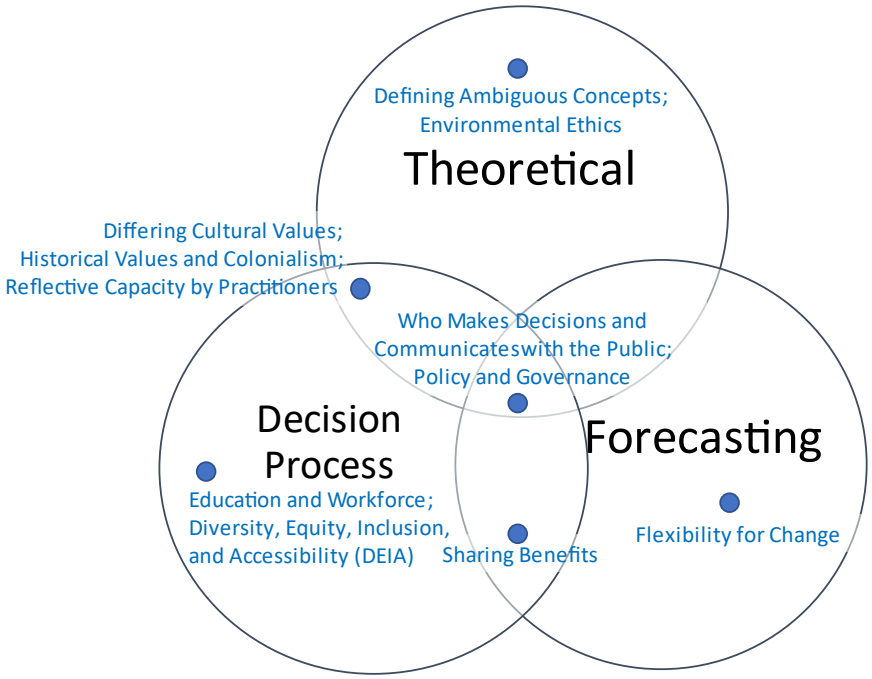

Figure 1: Diagram of ethical and societal implications organized by topic (blue font) and theme (labeled circles).

We evaluated topics marked as significant by workshop participants as well as those that we as study leads and authors believed were important. Examples are found in Table 1 above. The rest of this section discusses some key takeaways from our analysis.

Most of the ethical issues flagged by participants and study leads alike fell within the "Policy and Governance" topic area. Two examples are "How do we engender long-term responsibility for actions taken by companies on governments" and "What can we send to the Moon?"

The single ethical issue most frequently flagged by individual participants, "Not repeating the mistakes of colonialism," fell under the "Historical Values and Colonialism" coding category. It had a total of eight stickers. The second most flagged idea, with seven stickers was "Differing cultural understandings of the Moon." Tied for third, each with five stickers, were a number of issues listed below:

- "Which are the main imaginaries [visions, goals and worldviews] about space exploration at global south?"
- "How do we design vessels and habitats that can accommodate people with disabilities"
- "What does the public think?"
- "How to arrive at shared definitions of equity and benefit sharing"
- "Definition of sustainable"
- "Potential for militarization of the lunar surface driven by economic protection"
- "Environmental ethics can be integrated how?"

- "Debris Management/Waste Removal etc."

The overall diversity of topical categories reveals the enormity of societal and ethical issues surrounding the Artemis and Moon to Mars endeavor.

Finally, while the discussions outlined above focused on categories for different kinds of ethical matters, many flagged items dealt with specific topics that require specific decisions. We referred to these as "Substantive Issues," examples of which include:

- How should heritage sites or other areas of significance be selected for protection? Who decides what is worth protecting?
- "Water" (as in access, sharing, and regulation)
- What can we send to the Moon? (mentioned in the context of lunar burials)
- What happens if someone is disabled during a long-duration mission?

Many of these questions may require formal decisions in the near term, while implicit decisions are being made now that will shape future action.

Discussion of Policy, Management and Research Options

The workshop held focused discussions asking participants to identify challenges to addressing ELSI inside NASA as well as potential solutions. We grouped the resulting suggestions into five categories: management, policy, research, conversations, and education. These categories, along with sub-themes and descriptions, are shown in Table 2 below. The details are captured in Appendix D.

Table 2: Summary table of the management, policy, research, conversation, and education policy options identified in the workshop

Category	Theme	Description
Management	Accountability	Making ethical commitments clearly and publicly
	Budget	Allocating funding to grow ELSI capability
	Contractual	Mechanisms to shape contractor behavior
	Internal Agency Changes	Encouraging reflection via performance plans, other
	Leadership	Clear expectations of responsibility from leadership
	Reporting	Use formal strategic plan reporting to guide/report ELSI

Category	Theme	Description
	Staffing	Hire new ELSI expertise into NASA
	Strategy	Incorporate reflections on ELSI issues into high-level strategy
	Systems Engineering	Include societal impact in requirements, define clearly
Policy	Advisory process	Add ELSI experts to NASA Advisory Council, other
	Incentives	Incentivize ELSI inclusion in and outside of NASA
	Collaborations	Multi-stakeholder collaboration, including under-represented groups
	Planetary Protection	Explore ELSI connections to planetary protection
Research	Benchmarking	Identify practices of other agencies and countries
	Capability	Funding for and access to ELSI experts
	Convening mechanism	Mechanisms to involve researchers on ELSI issues
	Framework	Research on specific thematic issues, i.e., sustainability
	Public Value Mapping	Mapping public values, using inputs to inform decisions
	Motivating ELSI	Provide evidence that shows the value of ELSI through proof-of-concept implementations
Conversation	Convening mechanism	Bringing different groups and perspectives together to converse
	Inter-disciplinary	Discussions across disciplines (e.g., social science, humanities, and technical fields)
	International	Discussing ELSI with international actors
	Intra-NASA	Internal to NASA, across leadership and workforce
	Public and science	Between space actors and broader society
Education	Public	Enhance ELSI awareness in space activities

Category	Theme	Description
	Practitioner-focused	Training current space practitioners, including NASA staff
	Student-focused	Training next generation of STEM and social scientists
	Practitioner- and student-focused	For both students and practitioners

The broad map of ways to address societal and ethical impacts of Artemis and Moon to Mars is shown below[17]. While these participant suggestions focused on NASA, the broader space community can consider comparable approaches.

Policy Options: There are ways to involve ELSI considerations and expertise in existing policy structures. Representative ideas here included:

- *Advisory committees and a "NAC for ethics":* Some workshop discussion focused on the role that federal advisory committees play in shaping NASA's suggestions. A NASA employee suggested that participants find a way to convince the NASA Advisory Council (NAC) to recommend ethical approaches to space exploration, as formal requests for input by advisory groups require responses from government agencies. For Moon to Mars activities, the Lunar Exploration Analysis Group was identified as one of the core external advisory bodies. There were variations on this advisory group idea: One participant suggested creating a NAC committee dedicated to ethical reflection. Additional reflection on ethics from advisory committees could provide non-programmatically biased advice and recommendations on ELSI matters related to the Agency and its programs. It could also find ways to incorporate public values into NASA goals.
- *Diverse collaboration:* NASA can work with traditionally underrepresented groups in the space community, such as Tribal Nations and developing countries, to identify ethical considerations for future missions that otherwise might be overlooked, as was suggested by a speaker from a Tribal Nation. The same participant also suggested using holistic ecological frameworks to better consider environmental due regard.
- *Funding community capacity:* NASA could fund social scientist participation in space exploration ethics conferences to grow the community and sustain the discussions from the workshop. One non-NASA scientist said NASA has funding opportunities to

[17] Our concept of 'map' here is a deliberate variation from public value mapping: Bozeman, B. and Sarewitz, D., 2011. Public value mapping and science policy evaluation. Minerva, 49, pp.1-23.

organize topical workshops (e.g., TWSCs), which could sustain the ethics and spaceflight discussion, with particular respect to the Artemis endeavor. Inside NASA, if more staff had capability in this area, it could be easier to better inform operations by NASA and the broader space community.

Management Options: The workshop discussed ways in which NASA's internal management efforts could better focus on ethical and societal implications of programs and missions. Participants suggested management options including:

- *Clarifying of role of ethics at NASA:* As suggested by one workshop participant, NASA leadership can clarify the importance of ethical reflection in missions and programs. This could include defining "ethics" for NASA, making ethics a guiding NASA value and implementing ethics into a systems design framework.
- *Encouraging greater social science integration:* One speaker presented on ways NASA can integrate the social sciences into team settings for missions. One of this speaker's suggestions was to identify opportunities within a mission's technical process to address ethical issues as they arise. The speaker also described how "value-lever" moments, like realizing that a space mission patch could have colonialist symbolism, can force participants to address the value frameworks they are operating under. This opportunity to discuss values can lead to social change, according to this speaker.
- *Inserting ethics in the NASA strategic planning process:* One participant discussed how social values and ethics considerations can be inserted into NASA's formal strategic plan and performance reporting process. Another participant said an effective way to integrate ELSI at NASA was through structured engagement with social science experts versus obligatory and perfunctory funding of ELSI activities such as continued workshops. Another suggested that structured participatory technology assessment could illuminate public views for consideration by NASA staff.
- *Incentivizing responsible behavior and collaboration*: In a brainstorming session, a participant suggested that NASA create industry incentives for working with under-represented groups.
- *Expanding ethical analysis activities by space practitioners:* Having space practitioners spend time reflecting on ethical and societal implications can require time and dedicated research frameworks. A participant recommended that ethical and societal inputs, in order to be prioritized, be defined in ways that can be put into staff performance plans and considered accordingly.
- *Adding ethical considerations to planetary protection policy:* A participant in a brainstorming session suggested that NASA leadership include ethics, in addition to the preservation of future science, as a driver of planetary protection policy.

Research Options: Workshop participants discussed how further spaceflight ethics research can inform how NASA and other space agencies create frameworks to guide future activity in areas like sustainability. Below is a list of participant-suggested actions which could be taken by researchers to advance ethical spaceflight:

- *Benchmarking with other space agencies*: One group of participants suggested during a brainstorming session a strategy of ethical benchmarking with other space agencies' practices. Researchers could compare the ethical practices and regulations of other countries, not just in spaceflight, but also in other STEM-related fields.
- *Establishing ethics research at NASA*: Some participants suggested that travel grants to attend conferences and talks on spaceflight ethics be made available to stimulate more frequent conversations between scientists and ethicists. Additionally, one participant recommended NASA begin ethical assessments of human Mars activities now to give the spaceflight community time to fully evaluate any concerns before mission development. The comment reflected sentiment that the Artemis ethics workshop was held late in that regard.
- *Further developing the ELSI frameworks and concepts for space exploration and science:* Participants during another brainstorming session said researchers interested in spaceflight ethics could further develop the field by crafting solution-oriented ethical language, developing external assessments of new ethical ideas and stances, and demonstrating the positive value of ethics.

Conversations Options: Deliberately seeking out conversations on ethical and societal implications can broaden NASA's perspectives and help decision makers understand a broader array of values and perspectives surrounding Moon to Mars issues. Several participants suggested conversations that NASA should have, including engaging with the public, social science and humanities experts, and under-represented groups as well as those in technical fields. Another participant suggested that more effort be made to include the voices of international social scientists in future ethics workshops as Artemis is engaging many international partners.[18]

Education Options: Educational options suggested at the workshop include finding ways to improve ethical/societal insight for existing space practitioners, students, and the general public. Participants suggested the following opportunities for increased education on spaceflight ethics:

[18] On June 28, 2023, the French space agency CNES announced that it will stand up a space mission ethics committee in fall of 2023 to inform the agency on spaceflight-related ethical concerns. See: https://presse.cnes.fr/fr/le-cnes-met-en-place-un-comite-dethique-des-missions-spatiales.

- *Training the next generation:* A brainstorming group suggested that ethics training be integrated into STEM education materials as well as internships and early-career in-house training. This training could serve as a foundation for future ethicists, scientists, and engineers to engage on STEM-related ethics, especially ethics surrounding the Moon to Mars effort.
- *Social science training for practicing engineers*: Provide a deeper understanding to engineers and scientists about ethical and societal contexts. One attendee described how there can be a stigma associated with social sciences and that education may be required to overcome that stigma.
- *Engineering, science and management training for ethicists*: One brainstorming group advocated technical, science and management training for ethicists and social scientists so they can think about ethics with an understanding of the technical challenges and procedures associated with space missions.
- *Speaking the Same Language*: Joint educational efforts could enable ethicists and engineers to talk about the ethics of space exploration in a common language, the lack of which was identified as a key challenge at the event.

Analysis of Observations

Over the course of the workshop, four key observations emerged. The first is the identification of the key ELSI of Artemis. The second is the mapping of cultural and practical challenges to identifying and addressing ELSI for Artemis. The third is that a diverse community of researchers are interested in engaging in these topics. The fourth is there are a range of policy options to address ELSI, some that have domestic or international heritage.

Observation 1

The key ELSI of Artemis involve sharing the benefits of space exploration, reflecting on core values for exploration, sustainability, balancing shared access, and addressing cultural sensitivities around lunar payloads and activities.

The Outer Space Treaty, National Aeronautics and Space Act, and Artemis Accords all call for space exploration to be done for the *benefit of all humankind.* However, what that means for NASA is very much open to interpretation, and there are many questions that this simple statement raises. For example, how does NASA work toward that? Who is included in that objective and how should they be involved? How can NASA know who benefits from the Moon to Mars effort? These questions were central to a number of the presentations and discussions throughout the workshop. Many groups feel left out of the conversation or do not understand how they are affected by broader exploration endeavors. A speaker from a disabled population described the benefits of including disabled people as astronauts and mission designers, while a speaker from an indigenous group advocated engagement with those populations. Appendix

C has more detailed descriptions of all of the talks. There were also multiple calls for NASA to organize and engage with more citizen forums to help understand how people uninvolved with the space community view NASA and its plans.

Discussions on *core values for exploration* boiled down to a single question: How do we ensure that the values we bring to space are those we want as the basis of future exploration? While much of what is done in space will reflect what is done on Earth, participants identified the opportunity inherent in space exploration to establish new norms of behavior. Participants highlighted the need to avoid past mistakes and to be very clear about our values as we go about exploring in the future. One speaker gave a presentation on anti-colonialism, and the need to actively remove the colonial mindset as we set out to explore space, beyond just avoiding colonial narratives from discussions. Another participant suggested we alter how we view outer space resources, consider how to create a better society in space, and talk about space exploration using principle-based analogies and metaphors instead of historical ones.

Sustainability was another key issue raised by participants. Defining sustainability on the Moon is a complex challenge, as terrestrial discussions of sustainability, with questions of balancing conservation against inter-generational societal needs, do not necessarily apply to the Moon. There were discussions on how to meet the needs on Earth for space-based resources while not devastating the environment of these other bodies. One participant pointed out that Earth is also a celestial body and questioned why it should be treated differently from the others. There was also the common question of what sustainability means, as its definition in policy documents can be vague or mean many different things. Participants also discussed the environmental impacts of space activities (including launches) on Earth.

Participants identified many operational challenges to prioritizing *access to key sites*, deconflicting activities, avoiding contamination, and maintaining heritage sites as important. For example, areas of scientific and resource interest on the Moon are limited. Some participants called for formal discussions on how to allocate and manage access to these high-value sites, including the rights of first arrivers and site preservation for subsequent visitors. A recent OTPS analysis[19] explored many of these practical concerns, which feed into broader ethical and societal questions.

There are *cultural sensitivities* surrounding certain payloads and activities on the Moon, which is viewed as sacred by many. This may affect perceptions of increased NASA activity on the Moon for resource utilization and other activities. Flying human remains aboard commercial lunar missions is a key emerging issue that highlights the challenges associated with diffuse

[19] Swiney, Gabriel and Amanda Hernandez. 2022. Lunar Landing and Operations Policy Analysis. NASA Report ID 20220015973.

responsibilities for space activities, as well as how NASA's operational decisions can have unintended consequences. Several in the lunar exploration and science community have expressed concern for the last few years about the possibility of human remains being sent to the Moon via a private mission, on a lander partially funded by NASA's CLPS initiative. Remains placed on a NASA spacecraft that crashed into the Moon in 1998 caused concern among tribal nations, for example, prompting NASA to pledge not do it again without consultation.[20] One participant cited concerns over plans to manifest human remains on an upcoming commercial lunar mission, suggesting there is benefit to proactive action to address such concerns.

Observation 2

Participants mapped out many cultural and practical challenges to identifying and addressing ELSI within Artemis and Moon to Mars.

One of the major cultural challenges identified was that social scientists, humanities scholars, and technical staff *struggled to communicate effectively*, at first due to the vastly differing languages of expertise at play. NASA staff lacked a framework to engage on ethical issues, and some social science and humanities scholars lacked understanding of how decisions are made internally at NASA, or externally across the Executive and Legislative branches of the U.S. Government. Even within NASA the same word can mean different things depending on the context, so bringing together so many different fields inherently presents communication challenges. Cultural differences between the various fields led to occasional misunderstandings during the workshop. A recommendation from some participants was to increase cross-pollination between the social scientists external to NASA and NASA Headquarters personnel.

Another cultural challenge identified by participants is that space practitioners at NASA and elsewhere can have a culture that prioritizes *moving forward efficiently versus more careful reflection and engagement* with others. Engineers and scientists can become narrowly focused achieving what is possible or meeting deadlines. Getting space practitioners to focus on long-term societal impacts, versus narrower scientific or technical concerns, requires an effort at cultural change. This issue is not unique to the space community; it reflects the broader American culture, which creates additional challenges to addressing it at the NASA level.

Participants cited *funding* as another major practical concern. It costs money for ethicists and social scientists to do their work and to train students but dedicating resources to study the ELSI of Artemis could draw funding away from the missions themselves. Some participants also noted that NASA can have many unfunded mandates, despite its large budgets. Funding new

[20] Volante, Enric. "Navajos Upset After Ashes Sent to Moon; NASA Apologizes." The Spokesman-Review. January 15, 1998.

tasks like studying the ELSI must be balanced with Artemis mission needs. Many of the proposed solutions discussed in Observation 4 require some level of investment.

Another distinct practical challenge identified by participants is that many *ELSI challenges are outside of NASA's full control* given international and commercial involvement in Artemis. Examples include who gets access to specific regions first, and whether those sites must be maintained for future generations. Other issues, such as the impact of frontier narratives and a colonial mindset, are cultural and might require societal transitions beyond what any one agency can control. Assignment of responsibility for issues like private mission regulation is another significant challenge, as different actors have their own areas of responsibility that may not always line up with the required authorities.

Additionally, there were questions about *when is it too early to try to effect change, or when is it too late?* Participants engaged in significant debates over when NASA should consider ethical issues as it plans out programs. Some called for ethical reflection earlier in program life cycles, when it is easier and less costly to identify and mitigate potential issues. This also would allow the larger community to feel heard and valued. But reflecting on such issues earlier in a project takes time and can be difficult to do so accurately.

Finally, participants noted that *pressing ethical issues may emerge unexpectedly,* as a second-order effect of past NASA decisions. To avoid this, proactive exploration of future ethical and societal issues is needed. The earlier discussion on human remains on private landers being partially funded by CLPS is a key example of unintended consequences: CLPS's planners likely did not anticipate this being an issue, but it emerged as commercial plans came together. There likely will be other unintended consequences of decisions NASA makes today that could affect the variety of ethical topic areas discussed in this report.

Observation 3

A community of researchers working on ELSI is interested in ongoing engagement on these topics.

OTPS brought together many disciplines – policy actors and scholars, philosophers, historians, sociologists, communications studies scholars, lawyers, engineers and scientists – that haven't worked together before. The workshop integrated these disciplines, helping the participants understand each other's perspectives. Several discussed creating their own non-NASA community to build on the discussions at this event. With all participants' consent, NASA is sharing their contact information so they can do so if they so choose.

Observation 4

Participants discussed a range of policy options to address ethical implications of Artemis, some with heritage in other U.S. Government agencies and international sources.

Throughout the workshop, but especially during a dedicated brainstorming session, participants were asked to think about solutions to the problems that they were identifying. We, the report writers, compiled those suggestions and grouped them into the 5 broad categories listed below. It is important to note that we are not making recommendations, but merely identifying options that individual participants introduced. More detail on all of the suggested options can be found in Appendix D.

1. Policy: These options include involving ELSI expertise in existing policy structures such as federal advisory committees, creating incentives for responsible actions, and using public values to determine NASA goals.
2. Management: These options include ways in which NASA's internal management can better focus on ethical/societal implications, from leadership clarity about the importance of ethical reflection, to recognizing societal impacts in systems engineering, to better utilizing the formal NASA Strategic Plan and Performance reporting processes to capture ethical issues, to budgeting to support ELSI capability.
3. Research: These options include ways to establish a capability for addressing research questions in this area, and for NASA to access this appropriately; and creating frameworks to help guide future activity, such as sustainability, stewardship, and equity. Participatory assessments with the public and other key stakeholders to create a map of public values was offered as a way to get relevant information to decision-makers.
4. Conversations: This entails engaging with the public, social science and humanities experts, and under-represented groups as well as those in technical fields. These conversations matter symbolically and practically as a way to exchange ideas and values between NASA and others and can indirectly shape management and policy.
5. Education: This involves ways to improve insight on ethical/societal issues for existing space practitioners, students, and the general public.

Participants suggested that models on which NASA and the space community could base their ethics work include the Human Genome Project's funding of ELSI research, and the Responsible Innovation work funded by the European Commission. Two speakers presented on the Human Genome and Responsible Innovation models, respectively, and summaries of their talks can be found in Appendix C.

Some of the policy options, detailed above in the Discussion of Policy, Management, and Research Options section, require no dedicated funding, an example being changing decision processes within NASA. Others, such as public consultations or dedicated research, would require budget allocations. Some combination of options might be of value but must be

balanced against the needs of already budget-constrained programs and projects at NASA and elsewhere. Even policy options that require no direct funding likely would have indirect costs, as altering processes is rarely a smooth process.

Conclusion

The Artemis and Ethics workshop identified important issues for reflection as well as potential paths NASA and other space actors could take to address them. We highlighted key themes and lessons from the workshop and our analysis, though we are not making formal recommendations for action. We caution again that the views and options described in this report represent those of the participants at the workshop, and do not necessarily reflect the views of NASA or the U.S. Government.

In identifying ethical and societal implications, we mapped key ELSI topics to theoretical, process, and forecasting themes. Engineers and space practitioners could proactively consider this map as they formulate and implement their work for Artemis and the Moon to Mars effort.

The workshop revealed challenges to making research concepts accessible across disciplines as well as to NASA staff. NASA could consider creating synthesized frameworks for addressing these issues in the systems development and mission planning life cycle.

We summarized a range of options proposed by participants for more proactively addressing these concerns, looking at potential conversations, research options, policy process options, and management process options. Some of these would require no funding; others would. Some combination of these activities may be of value.

Regarding specific ethical issues identified at the workshop, participants raised the possibility of needing a framework for thinking about commercial norms of behavior in space, especially if capabilities are being fielded or developed with NASA funding.

Future Work

OTPS has forward work plans that will incorporate insights gained from this report. OTPS is formulating a new internal study to identify key policy decisions that will emerge leading up to the Artemis III mission. OTPS will consider decisions with ethical and societal implications as part of that study and include discussion of those with NASA leadership. Separately, OTPS is formulating ways to converse on these topics with NASA's international partners.

Research on these themes could also be expanded to other areas at NASA, although no additional activities have been formally decided on at this time. Collectively across its Mission Directorates, NASA deals with many policy issues that have ethical implications, including

potential benefit/harm to different sectors of society.[21] By understanding how to reflect on these issues in making decisions on Artemis, NASA can avoid unintended consequences stemming from cultural perceptions of human exploration of the solar system and better focus on core values and benefits to society.

[21] While not discussed at the workshop, NASA does track other areas facing ELSI challenges, with unintended societal impacts of mega-constellations being a recent topic of interest. Industry led development of what has now become mega-constellations of satellites in space, with some NASA encouragement in technology development. However, these mega-constellations have led to an impact on ground-based astronomers, who deal with optical interference from the satellites, and are concerned about the future of ground-based astronomy. The question of how to resolve this and who is responsible is complex and draws on many actors outside of NASA (NSF, university astronomers, private mega-constellation providers such as SpaceX, etc). Significant academic literature has already explored this topic, including: Venkatesan, A., Lowenthal, J., Prem, P. and Vidaurri, M., 2020. The impact of satellite constellations on space as an ancestral global commons. Nature Astronomy, 4(11), pp.1043-1048.

Appendix A: Participants

The table below contains all of the workshop participants. Everyone engaged in the brainstorming sessions and discussions. For those who had an organizer, speaker, or support role, that is noted in the fourth column. We list the type of background that we were seeking in inviting the participant: Social Science and Humanities (SSH), Physical Science and Engineering (PSE), and Policy or Program Management (PPM).

Attendee	Affiliation	Background	Role
Afreen Siddiqi	MIT	PSE	Speaker
Akshay Prasad	NASA SMAB	PSE	
Alissa Haddaji	The Space Consortium	SSH	
Alyse Beauchemin	NASA OTPS	SSH	Organizer
Amy Kaminski	NASA STMD	PPM	
Avery Sen	SenSound, ex-NOAA	PPM	
Becky Mcauley Rench	NASA SMD	PPM	
Dan Hawk	Oneida, Galaxyz LLC	PPM	Speaker
Daniel Vizuete	FLASCO Ecuador	SSH	Speaker
Danielle Wood	MIT	SSH	
Darshan Karwat	Arizona State University (ASU)	PSE	
David Reinecke	AAAS S&T Policy Fellow	SSH	
David Tomblin	UMCP	SSH	
Ellen Gertsen	NASA OTPS	PPM	
Erika Nesvold	Just Space Alliance	SSH	Speaker
Eswaran Subramanian	CMU	PSE	
Frank Tavares	Independent Scholar	SSH	
Gabe Merrill	NASA OTPS	PSE	Support
Gerald Sanders	NASA STMD	PSE	
Grace Wusk	NASA OTPS	PPM	Support
Jake Bleacher	NASA ESDMD	PPM	
Janet Vertesi	Princeton	SSH	Speaker
Jared Owens	ASU	SSH	
Jay Falker	NASA GSFC	PSE	
JS Johnson-Schwartz	Wichita State	SSH	Speaker
Jessica O'Reilly	Indiana University	SSH	Speaker
Jessy Kate Schingler	Open Lunar	PPM	Speaker
Jonathan Coopersmith	Texas A&M	SSH	
Jordan Bimm	University of Chicago	SSH	
Julia Cline	NASA LaRC	PSE	
Katie McBrayer	NASA OTPS	PSE	Organizer

Attendee	Affiliation	Background	Role
Kelly Smith	Clemson	SSH	
Ken Wright	NASA OTPS	PPM	Support
Laura Delgado Lopez	NASA OTPS	PPM	Support
Laura Ratliff	GWU	PSE	
Linda Billings	Consultant	SSH	Speaker
Mahmud Farooque	ASU	SSH	Speaker
Mark Lupisella	NASA	PSE	
Matt Wisnioski	Virginia Tech	SSH	Speaker
Michelle Hanlon	For All Moonkind	SSH	Speaker
Natalie Treviño	Open University	SSH	Speaker
Nate McIntyre	NASA ESDMD	PPM	
Nicole Piontek	NASA SMAB	PSE	
Nujoud Merancy	NASA ESDMD	PPM	
Parvathy Prem	APL	PSE	Speaker
Rene von Schomberg	KWTH, retired EC	SSH	Speaker
Ryan Watkins	NASA SMD	PPM	
Shannon Conley	James Madison	SSH	Speaker
Sheri Wells-Jensen	Library of Congress	SSH	Speaker
Steve Garber	NASA History	SSH	
Teasel Muir Harmony	National Air and Space Museum	SSH	Speaker
Tiffany Smith	NASA Office of the Chief Engineer	PPM	
Zachary Pirtle	NASA OTPS	PPM	Organizer

Appendix B: How NASA Formulated the Artemis and Ethics Workshop

Workshop scope: The event was called "Artemis and Ethics Workshop," where 'Ethics' connotes broader research on ethical and societal implications. Using 'Ethics' in this expanded sense matches a large body of research within engineering ethics that contrasts micro-ethics with macro-ethics[22]. Micro-ethics focuses on individual's decisions, such as whether to blow the whistle on harmful actions by others or to accept a certain level of personal risk. Macro-ethical issues (as elaborated by Herkert 2001[23]) concern the impact of decisions more broadly on society, and identifying ways to evaluate the consequences, inherent ethical characters, and intended goals underlying specific decisions.[24]

Focus: OTPS focused the workshop design on studying and framing how to address the long-term ethical and societal aspects of Artemis. Such insights could support NASA's vision for sustainable and responsible exploration, as robust and transparent ethical dialog helps enable long-term shared visions and public benefit. OTPS also sought to identify best practices for conducting such research, and to map key ethical and societal issues within Moon to Mars efforts. OTPS staff studied key literature on space and society and on the ELSI research that the U.S. government has funded over the past decades.[25]

For speakers and discussion participants, we solicited different views and rationales that we deemed relevant for thinking through the ethics of Moon to Mars. OTPS focused the content on Artemis and Moon to Mars, and as such excluded from analysis broader issues facing NASA:

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[22] We do not provide a more detailed of ethics research in this report. Key resources for understanding schools of ethical reflection can involve consequentialist approaches (that evaluate the impact of decisions based on their consequences); deontological approaches of ethics (that evaluates actions on their own inherent method and merit); and virtue ethics approaches, that focus on the values and principles that feed into actions. For basic overviews of specific ethical schools, see the relevant entries in the Stanford Encyclopedia of Philosophy.
Recent overviews of ethics research in the area of technology and engineering include: Michelfelder, D. and Doorn, N., 2021. The Routledge handbook of the philosophy of engineering. Routledge-Taylor & Francis Group. Steen, M. 2023. Ethics for People Who Work in Tech. CRC Press. Vallor, S., 2016. Technology and the virtues: A philosophical guide to a future worth wanting. Oxford University Press.

[23] Herkert, J.R., 2001. Future directions in engineering ethics research: Microethics, macroethics and the role of professional societies. Science and engineering ethics, 7, pp.403-414. Herkert's work on macro-ethics is key for how we approached defining the topic.

[24] There is also a large body of research focused on technology assessment and responsible innovation, including the Journal of Responsible Innovation. This literature stream captures much of the 'societal implications' research that also helped inform the workshop design. Owen, R. and Pansera, M., 2019. Responsible innovation and responsible research and innovation (pp. 26-48). Edward Elgar Publishing.

[25] Note that, per footnote 5, the word 'implication' here was not meant to imply that space activities would occur regardless of ethical reflection or consideration.

For example, we did not focus on the International Space Station or other activities in Low Earth Orbit. OTPS also tried to focus on broader ethical and societal implications and did not solicit presentations on specific issues such as safety and its associated ethical impacts. Given that NASA has other organizations responsible for Diversity, Equity, Inclusion and Accessibility (DEIA), OTPS did not solicit dedicated DEIA presentations. DEIA issues of course emerged in discussion from the workshop, given their importance for societal impact[26].

OTPS invited 55 participants representing a diverse range of disciplines, many of whom did not know each other in advance, with the idea of exploring the many facets of how NASA should consider future ethical and societal implications. Given past challenges to infusing ethical and societal impacts research into practice,[27] we invited 20 civil servants from a variety of roles inside of NASA, asking them to engage from their personal perspectives. These included early-career staff as well as representatives from key Mission Directorates at NASA Headquarters, notably the Exploration Systems Development Mission Directorate (ESDMD), Space Technology Mission Directorate (STMD), and Science Mission Directorate (SMD). The rationale was that this would help identify new viewpoints or possible actions that could be considered by NASA.

OTPS made the decision to focus on U.S. domestic ELSI – which cut across multiple disciplines and lack consensus remedies – instead of pursuing a more globally diverse portfolio and approach. While there were a few international speakers with expertise on responsible innovation and international development, the U.S. focus was a known gap. Work done by other countries under the umbrella of 'responsible research and innovation' was used as a reference point.[28] Funding was a constraint on making the workshop more international in scope: Simply getting U.S. thinkers across a variety of disciplines was a significant challenge, and more international participants would have magnified that. The domestic focus nonetheless allowed for a fruitful discussion.

OTPS also recognized that the workshop would not address all possible criticisms of Artemis and Moon to Mars; it was not intended as a comprehensive examination of the ELSI of Artemis. Given the key research question of how to consider the ELSI of Artemis and Moon to Mars, our

[26] For readers interested in DEIA as a topic, see NASA 2022. NASA Strategic Plan for Diversity, Equity, Inclusion and Accessibility: Fiscal Years 2022-2026. Link.

[27] Some have argued that few practitioners have taken the results of ethical and societal impacts research into practical account. It is unclear whether this is due to insufficient resources or due to the challenge of doing practically-relevant ethical research. See Sullivan, M., 2018. The Expansion of Science Policy in the United States in Three Cases: rDNA Research, The Human Genome Project, and the National Nanotechnology Initiative (Doctoral dissertation).

[28] The European Commission had a significant research program on responsible innovation. We invited René von Schomberg to speak on this at the workshop. More related details can be found here: Von Schomberg, R., 2019. Why responsible innovation? An international handbook on responsible innovation (pp. 12-32). Edward Elgar Publishing; Stilgoe, J., Owen, R. and Macnaghten, P., 2013. Developing a framework for responsible innovation. Research policy, 42(9), pp.1568-1580.

primary focus was on processes and identification of possible issues. It was understood that NASA cannot unilaterally resolve every concern, as international law and other spacefaring nations must be included. Rather, NASA seeks to listen and engage with traditional and non-traditional stakeholders. Some workshop participants voiced specific criticisms of the Artemis Accords, focusing on the implications for future property rights in the broader solar system. This workshop does not mean to imply that NASA would pursue updating the Accords.

Brainstorming and Discussion Session Formulation

We sought to take advantage of the diverse viewpoints at the event through extended discussions and brainstorming sessions. The objective of these sessions, which included NASA staff, was to understand how NASA should consider ethical and societal issues as it pursues Artemis and Moon to Mars missions.

In the first brainstorming session, we asked participants to use sticky notes to highlight ELSI of Artemis that they felt were important or that merited deeper conversation at the at the workshop. This approach was seen as having heuristic value in that it could provide a quick map of ethical perspectives and issues from across the varied disciplines. Participants were able to place stickers on notes whose ideas they found salient or agreed with. Results from this session are discussed in Appendix E.

In the second brainstorming session, we had groups conduct breakout discussions on four topics that were prominent in the literature: A) environmental issues, B) responsibility for long-term ethical decisions; C) the role of frontier narratives and colonialism; and D) the ethics surrounding the opportunity costs of human spaceflight vs. other NASA activities. The results of this breakout session informed subsequent discussions on potential policy options.

The third brainstorming session focused on an issue that would create tension between practitioners on one hand and theoretical science and science scholars on the other. Specifically, this discussion examined the practicality of addressing deeper societal and ethical issues and also opportunities for considering these issues.

The fourth and fifth sessions followed up on key themes that emerged in the earlier discussions, most of which are captured in Appendix C. We intentionally built flexibility into these sessions to accommodate the needs of participants and give them time to raise issues that might not have occurred to us while planning.

The next two Appendices outline the results of these brainstorming sessions and detail the key ethical and societal issues that were raised, as well as potential policy and management responses.

Appendix C: Summary of Presentations and Discussions

The following summaries capture the discussions at the workshop, focusing on the key themes of each. For more details on the personal perspectives of the speakers, we recommend contacting them directly. The full workshop schedule can be found in Appendix F.

Historical context and how to consider ethical issues

Several workshop presentations provided historical context for studying ethical and societal issues. Shannon Conley, an associate professor in the Social Context of Science and Technology at the James Madison University, provided an overview of past U.S. government efforts to study ethical and societal aspects of science, focusing on the Human Genome Project, which was funded by the U.S. National Institutes of Health and the U.S. Department of Energy. This program dedicated research funding to the Ethical, Legal, and Societal Implications (ELSI) Research Program. Several ELSI research areas were pursued – such as privacy issues tied to gene sequencing – engaging diverse scholars, stakeholders, and informed practitioners, and helping to establish public trust in genetic research. Conley acknowledged criticisms that the ELSI initiative lacked ties to decision-makers and was at times insufficiently critical.[29] Conley suggested that stronger connections between NASA and broader social science communities could help avoid the pitfalls of past ELSI research.

Matt Wisnioski, a historian at Virginia Tech, discussed the challenges of addressing cultural changes across generations. He provided insights into how engineers from the 1960s grappled with greater ethical concerns and awareness. Interest in these concerns diminished over time, despite a lack of change in engineering practice, he noted. Recent years have seen newfound interest among engineers, especially related to topics such as artificial intelligence. This historical perspective highlights the importance of continuous reflection on ethical considerations in the context of lunar and Mars exploration, as well as the necessity for international collaboration to ensure responsible and sustainable development in outer space.

[29] This criticism of the Human Genome Project may have interesting implications for any NASA efforts to explore the ethical and societal implications of Artemis. Given that many future ethical decisions about Moon to Mars are outside the scope of NASA's decision authority alone, if NASA were to proactively think about ethical and societal impacts, to what extent does it need to be sharing this information with other decision makers, both in the commercial sector as well as internationally? What feedback loops need to exist across multiple levels of decision-making?

René von Schomberg, former civil servant, philosopher, and senior research fellow at the Kate Hamburger Kolleg, RWTH Aachen University, and a retired civil servant from the European Commission, presented on how ethical considerations inform responsible state, market, and research innovation behaviors. Within responsible state behavior, von Schomberg said, there are questions about overall state/societal benefits, international collaboration, and responsible conduct. Within responsible market behavior, there are questions related to safety, efficacy, quality, competitiveness and macro-economic advantage, he said. Within responsible research and innovation, von Schomberg said there are questions regarding acceptability, sustainability, social desirability and transparency. He concluded by making a case for anticipatory governance.

In terms of public engagement, science policy scholar Mahmud Farooque of Arizona State University and engineering and society scholar David Tomblin of the University of Maryland, College Park, emphasized a reflective approach to public participation in science and technology. Their talk highlighted the importance and value of including the public in science and technology planning discussions and suggested that participatory technology assessments be employed as a means of brokering this engagement. They discussed recent efforts in participatory technology assessment, which is a structured approach for having members of the public learn about and provide feedback about science and technology, helping to proactively inform future decisions.

The philosopher Kelly Smith, professor at Clemson University, provided insight into framing big-picture questions while engaging with technical experts to encourage reflection. For example, Smith described the importance of ethical sensitivity and where it may be lacking at NASA. He suggested that NASA either create more partnerships with social scientists to sustain the discussion on ethics or set aside resources to discuss these issues internally through an ethics office or with an ethics officer.

Jayme S. Johnson-Schwartz, philosopher at Wichita State University, discussed bringing non-traditional voices into conversations about space ethics. Along with Erika Nesvold and Linda Billings, Johnson-Schwartz was co-editor of the book “Reclaiming Space: progressive and multicultural visions of space exploration”. She noted how chapter authors in that book brought forward perspectives from historically underrepresented groups such as black Americans, along with science fiction authors, artists, scientists, and the humanities. She discussed how different ways of thinking, at times about uncomfortable topics, are helpful for more deeply engaging on ethical issues.

Context on space policy, law, and NASA

Jessica O'Reilly, associate professor of international studies at Indiana University, provided an overview of the Antarctic Treaty, which governs interactions among multiple international

groups in Antarctica. Created in the 1960s, this consensus-based approach involves managing and controlling activities on the continent. Workshop participants drew similarities between the Antarctic Treaty and discussions surrounding lunar activities. Some attendees suggested that the consensus-based nature of the Committee on the Peaceful Uses of Outer Space (COPUOS) makes it unlikely in the short-term that significant changes will be made to lunar provisions in the Outer Space Treaty.

Michelle Hanlon, co-founder and president of For All Moonkind, discussed and identified gaps in space law relevant to the Moon, with a particular focus on how ethical considerations can help fill gaps in space law. She provided an overview of the Outer Space Treaty, the major international treaty that governs behavior in space. Hanlon believes that the Moon will serve as a benchmark for all future space mining activity and said common ethical values are needed to adjudicate competing interests in space exploration. Hanlon also said the idea of a global commons might be difficult to apply to the Moon, as it invokes language tied to the Common Heritage of Mankind from the Law of the Sea Treaty that could potentially restrict activities on the Moon. Some attendees suggested the need to develop different concepts and approaches to address environmental issues and resource sharing in the lunar context.

Although it was never ratified by the U.S., the Moon Treaty is often cited as a key milestone in space policy discussions. Teasel Muir-Harmony, curator of the Apollo Collection at the National Air and Space Museum, provided an overview of this 1960s effort to develop additional guidelines and principles for lunar activities. The U.S. was involved in negotiating the treaty, but Congress declined to ratify it due in part to private sector disagreements with some of its provisions. The Moon Treaty diverges from the Outer Space Treaty in barring private property ownership on the Moon, for example. Hanlon noted that while the Outer Space Treaty is said to be more permissive regarding property ownership, she believes it affirms that lunar activities must be done for the benefit of all humankind. Legal options exist to allow private activities on the Moon, provided it is conducted for peaceful purposes as required by the Outer Space Treaty.

Understanding how NASA operates is also critical for understanding how policy objectives might incorporate ELSI considerations. The talk of Janet Vertesi, associate professor of sociology at Princeton University provided insights about NASA that could help shape how the Agency considers societal and ethical issues. Her research on two different NASA missions, one to Mars and the other to Jupiter, revealed how the culture of each team was unique based on the personalities involved and the institutions they represented. Vertesi argued that NASA, in many ways, is a confederation of many diverse groups, without one-size-fits-all solutions or thought processes for decision-making. Calls for specific actions could be better served by identifying particular decision-makers within NASA who can consider a specific topic.

Vertesi also emphasized the importance of considering the functioning of teams and their personal feelings and thought processes to ensure good cohesion and positive outcomes. She argued that the way individual teams interpret ethical issues will depend significantly on their societal context and local culture. Approaches to dealing with ethical issues need to be sensitive to this context.

Significant Ethical and Societal Implications

Parvathy Prem, planetary scientist and staff at the Applied Physics Laboratory of the Johns Hopkins University, emphasized the importance of including experts in societal and ethical issues within the decision-making process. Her talk overviewed a report from the Inclusive Lunar Exploration workshop report, which was part of NASA SMD's Lunar Surface Science Workshop series.[30] The report calls for a deeper exploration of how to incorporate ethical considerations in the context of NASA's decision-making processes. Prem also provided an overview of key ethical issues touched on in the report, many of which were considered during the workshop and are discussed later. These included how major scientific unknowns, such as environmental impact from landings, can have important ethical implications. She called for candid conversations about why we engage in space exploration, noting that invocation of public interest as a rationale for space exploration should come with deeper long-term critical thinking about the goals for space exploration.

Another discussion centered on environmental issues and the broader challenge of adapting Earth-based policy drivers and solutions to the Moon and other future contexts. As Afreen Siddiqi, research scientist in the department of Aeronautics and Astronautics at MIT, pointed out in her talk, concepts such as sustainability on Earth are about serving human needs and balancing them across multiple generations in a world where resource constraints make it difficult to support a high quality of life both today and in the future. She said the idea of conservation could be difficult to justify in the lunar context. Siddiqi also highlighted the challenge posed by the concept of planetary boundaries, which is frequently used in Earth-focused sustainability literature: Studying interactions and movement across these boundaries, such as from the lunar surface to cislunar space, could help to explore the spheres of environmental interaction and influences. She also discussed how the unique constraints of the lunar night and day cycles could present resource sharing challenges. For example, there are few locations with near-constant sunlight near the lunar South Pole, and many missions may be competing for one of those rare spots. Beyond Siddiqi's work, there have been recent calls for exploring environmental aspects of Moon to Mars exploration, including the National

[30] Parvathy Prem and Kristen Bennett, 2022. Report: Inclusive Lunar Exploration: Lunar Surface Science Workshop Session 13. https://lunarscience.arc.nasa.gov/lssw/downloads/LSSW13_final.pdf

Academies' most recent Planetary Science Decadal Survey, which said: "NASA would benefit from convening a team of experts to review the ethics of planetary ISRU and determine optimal plans and processes to ensure sustainable and responsible resource utilization. Humans are the trustees of our planetary environments for future generations."[31]

The discussion on environmental responsibility on the lunar surface highlighted the importance of stewardship. Although the term has not yet gained significant traction, the idea of being good stewards of lunar resources and terrain merits further consideration. Jessy Kate Schingler, researcher and advisor at the Open Lunar Foundation, shared her organization's experiment in creating a property trust for lunar resources. The experiment involves notionally purchasing lunar regolith and placing it into a legally enforceable trust, ensuring long-term protection of those resources. To guide the foundation's decision-making, Schingler established a participatory body of expert advisors from diverse backgrounds, including historians and representatives from indigenous groups. This approach promotes broader input on significant issues.

Narratives that once were used to justify space exploration emerged from problematic colonial histories. Natalie Treviño, postdoctoral researcher at the Open University specializing in decolonial theory, emphasized the importance of understanding historical injustices and ensuring that the underlying values and rationale for space exploration are honest and well-founded to prevent perpetuating past injustices. Treviño specifically addressed the danger of extending the harm of coloniality—the longstanding power relations resulting from colonialism—to space. She described how past motivations for Western exploration were rooted in political and economic interests, with no regard for the negative consequences to the environment and certain groups of people. In conclusion, she drew parallels between the Artemis initiative and the Artemis Accords, suggesting that the latter promote "colonialist values under a peaceful narrative" in their effort to create a lunar economy.

Daniel Vizuete, research associate at the CTS Lab of FLASCO Ecuador with expertise in political sociology and biotechnical engineering, summarized the current scope of space activities in Latin America, claiming the region's space spending is declining compared to African countries and that Latin America has just 135 satellites, the majority belonging to just four countries. No Latin American countries have an independent human spaceflight capability. He also noted how some scholarship in international relations has discussed the negative power dynamics associated with developing countries trying to closely follow industrialized

[31] National Academies. 2022. "Chapter 19: Human Exploration." In *Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2033* [Prepublication Copy – Subject to Further Editorial Correction]. National Academies Press: Washington DC.: pg. 19-6.

countries. He also discussed the pros and cons for Latin American countries of embracing the Artemis Accords. He explored how a society's high-level visions for what it wants out of space can shape its engineering activities and described how Latin America has tried to create its own space visions. Vizuete argued that growing future exploration efforts in Latin America should include continued reflection on a unique Latin American vision for space and recommended against Latin American countries joining the Accords.

Erika Nesvold, astrophysicist and co-founder of the JustSpace Alliance, said NASA must balance its relationship with the profit-driven commercial sector with its mandate to benefit "all [humanity]". She also said there can be a tension between benefitting all humanity and advancing the U.S.'s strategic interests, including its space capabilities. Nesvold cited the creation of the Artemis Accords outside the UN legal system as evidence of the U.S.'s ambiguous perception of itself as either a leader or partner in spaceflight. She asserted that it cannot be both in such an endeavor, while others disagreed, leading to a discussion in the Q&A period. The U.S., Nesvold said, must answer two fundamental questions: 1) Why is American leadership a benefit for all humanity?; and 2) How can the U.S. balance competing commercial, civil, and international space interests?

Another key ethical issue is opportunity costs. Linda Billings, a communications scholar and consultant, challenged the value of multi-billion-dollar space missions when the money could be spent elsewhere to benefit humanity. Billings called for more participatory technology assessments and studies on the impact of spaceflight on the human condition and how human spaceflight can or should be justified. She also criticized the influence of commercial companies in determining how civil spaceflight is implemented.

Daniel Hawk, a space activist and member of the Oneida Tribal Nation, and who co-founded Galxyz LLC, a science-based educational tools company, gave a wide-ranging talk about indigenous peoples in the United States and their engagement with space exploration. For space exploration to be transformative for people on Earth, indigenous people must be active and engaged, Hawk said. Hawk said some space education and outreach efforts lack adequate funding or technical rigor to meaningfully engage indigenous tribes. He highlighted NASA's historical lack of engagement with certain indigenous groups and cited his ongoing efforts to establish a NASA Office of Tribal Affairs as a possible way to support indigenous space capabilities.[32]

[32] Part of Hawk's call for a coordination office on Tribal affairs for space was claimed as a way to help with ITAR issues that would allow tribes to communicate across national boundaries, which is a topic Hawk has worked on. He also laid out principles for more deeply considering due regard across space actors.

Hawk also offered thoughts on three ethical and societal implications of Moon to Mars exploration. First, he noted the major concern and perceived harm generated by NASA's 1998 Lunar Prospector mission, which crashed into the lunar surface with human remains on board. This offended some indigenous nations for whom the Moon holds spiritual significance. Second, he noted how the naming conventions for many lunar geographic features ignore names that indigenous peoples have created for the surface of the Moon. Lastly, he offered that non-traditional and holistic ways of thinking among Tribal Nations could inform complex future exploration requirements, particularly with respect to territorial rights and environmental impact[33].

As an academic expert on disability and space, Sheri Wells-Jensen—the 2023 Baruch S. Blumberg NASA/Library of Congress Chair in Astrobiology, Exploration, and Scientific Innovation—spoke about the ethical and practical necessity to reconsider the definition of "the right stuff" for future astronauts. She offered insight into possible best practices for including populations with disabilities in spaceflight and into the ethical implications of astronauts becoming disabled during spaceflight. Wells-Jensen challenged the audience to consider that including disabled populations in space exploration is not a purely medical issue but also an engineering, policy, budgetary and moral issue. She argued that various research, engineering, and programmatic communities have a role to play. She also said including disabled people in space missions should be viewed not as a risk, but rather as a means of risk mitigation and accessibility for astronauts, as any astronaut could be injured on a mission and become disabled. Wells-Jensen stressed the need for more research on standards for accessibility in spaceflight that could be shared at conferences or popular space events like launches. She argued that not embracing disabled astronauts in humanity's long-term future on the Moon and Mars would be a moral failing. Lastly, Wells-Jensen suggested that NASA could employ access officers to ensure access to space missions for the disabled.

Challenges and opportunities for considering ethical and societal issues

The breakout sessions yielded useful discussions about specific challenges to considering societal and ethical issues in space exploration.

Some participants offered ideas to help address these challenges. Avery Sen, a former staffer at a science-focused federal agency and now in the private sector, noted that agencies spend significant resources creating strategic plans and then assessing performance against those

[33] Although not discussed at the workshop, the authors note that one forum for additional conversation may be through NASA's Tribal Consultation and Coordination, which is described here: Link.

plans.[34] This process could be influenced through more structured public input and review, which might help in prioritizing attention to the ethical and societal implications of Artemis. Others highlighted the potential benefit of policy shifts such as incorporating ethical considerations into civil servant performance plans and training as well as into acquisition decisions.

The workshop explored the topic of distributed responsibility for key ethical issues in space exploration. Several participants noted that NASA, as a civil space agency, does not have regulatory authority over private activity in space but does manage its own missions, including those that rely on commercial services.[35]

Some participants described the ambiguity surrounding the regulatory and ethical responsibility for private payloads on the Moon, especially when those payloads are on NASA-funded CLPS deliveries. One participant at the workshop said they discussed concern about privately manifested payloads of human remains alongside CLPS deliveries with NASA staff and with a relevant CLPS provider. It was reported that while both were sympathetic, it appeared that neither group felt they had the authority to take action to remove human remains from the mission manifests. This raises the question of who is responsible for private sector activities carried out in conjunction with NASA's Artemis work. Participants discussed how NASA is not a regulatory agency, and the Federal Aviation Administration's licensing authority in space is limited to launch and re-entry vehicles. This apparent lack of regulatory authority – and perhaps by extension ethical responsibility – for lunar activities was anathema to some workshop participants given NASA's role as the primary source of funding for CLPS missions. Some felt that NASA should be prepared to deal with these kinds of concerns regardless of what happens with current proposals to fly human remains on CLPS missions. Workshop participants said NASA has the technical expertise and public interest necessary to have a holistic vision of the Moon and Mars' future. Consequently, despite lacking regulatory authority, some argued NASA should be cognizant of its de-facto ethical responsibility as an orchestrator of the emerging lunar economy.

Both consultant Linda Billings and JS Johnson-Schwartz advocated participatory technology assessment approaches to obtain more structured public input.[36] Rene von Schomberg said

[34] NASA's formal strategic plan is NASA 2022. NASA Strategic Plan 2022. Link. Its performance reporting plan is NASA 2023. FY2024 Volume of Integrated Performance. Link. Both activities are required by the Government Performance Reporting Act (GPRA).

[35] Many processes shape and influence what missions NASA takes on and how it implements them ranging from Congressional legislation, Executive direction, federal advisory councils, and structured studies such as the National Academies of Science, Engineering and Medicine's Decadal Surveys for science.

[36] A reference for participatory technology assessment is: Kaplan, L.R., Farooque, M., Sarewitz, D. and Tomblin, D., 2021. Designing participatory technology assessments: a reflexive method

the European Union utilizes participatory approaches, among others, in its responsible innovation framework. In this context, the European Union employs a variety of research methods and provides funds to create knowledge that can help shape future science and technology outcomes.

Considering funding for ethical and societal implications research

There was an initial discussion on funding, with some speakers who have written on these societal and ethical topics voicing concerns about funding and the potential to grow a community that works in this area. Other participants suggested that if sufficient prestige were granted by universities for social scientists to serve on unfunded advisory groups (such as the NAC), then social scientists might have the support to share their research in ways that could impact policy and technical planning. However, the viability of encouraging social science engagement with practitioners remained uncertain. Social science and humanities funding tied to space and society research is much less established than traditional space science fields themselves.

Some participants suggested targeting existing funding opportunities, such as research conference grants that could fund individual ELSI workshops. Some participants said that other potential funding opportunities could be found in Research Opportunities in Space and Earth Sciences (ROSES) solicitations, which are standard annual calls for specific research.

René von Schomberg mentioned that the European Union has, at times, dedicated a percentage of total funding for a particular scientific or technological area to societal and ethical issues. Shannon Conley noted how the Human Genome Project spent three percent of its funding on ELSI-related work. While many suggested that NASA should invest more money on ELSI research, Janet Vertesi noted that, despite seemingly large budgets, the Agency has many unfunded mandates that are significant and challenging to accommodate. She said NASA constantly receives requests from various parts of the space community and elsewhere for funding and support. Unfunded mandates and the vagaries of long-term planning often make it challenging to address ethical concerns that arise during missions.

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for advancing the public role in science policy decision-making. Technological Forecasting and Social Change, 171, 120974. The commentators also said they were reacting to some NASA-funded cooperative work, including: Tomblin, D., Pirtle, Z., Farooque, M., Sittenfeld, D., Mahoney, E., Worthington, R., Gano, G., Gates, M., Bennett, I., Kessler, J. and Kaminski, A., 2017. Integrating public deliberation into engineering systems: Participatory technology assessment of NASA's Asteroid Redirect Mission. Astropolitics, 15(2), pp.141-166.

The discussion also touched on the potential ELSI of NASA's Commercial LEO Destinations (CLD) private space station development effort, particularly with respect to the role of disabled astronauts in space.

How to justify and show the benefit of NASA

An unanticipated brainstorming topic explored the justification for human exploration, including what level of empirical data and understanding would be sufficient for validation. This discussion emerged from Linda Billings' critique of human spaceflight, in which she argued that human exploration is not worth the opportunity cost and has not been justified by empirical data that proves its benefits to humanity. There was a broad discussion of whether research has definitively demonstrated the value of pursuing space exploration, but many claimed that there were only partial, incomplete, and competing justifications for why space exploration should be pursued[37].

A follow up discussion emerged on what an acceptable justification for human space exploration should be. It began when a space scientist said that they are often questioned on why NASA does space exploration with humans in addition to robotic exploration. Many whom he speaks to feel that insufficient scientific research is performed on human spaceflight missions. The scientist said his justifications often fall short with scientific audiences, and asked Linda Billings what she believes would be sufficient. Billings suggested participatory technology assessment could begin to provide an answer. NASA experimented with participatory technology assessment in 2014,[38] allowing members of the public to learn about competing goals for space mission planning and to then weigh in on the topic.

This breakout session ended up focusing on a variety of empirical techniques that could be developed to explore the impacts of NASA's activities on society. Some participants noted that there are already many existing legislative mandates for continuing human exploration, which arguably makes NASA's reflection on this issue irrelevant. Others noted that justifying human spaceflight might require high-level deliberations weighing the opportunity costs of that activity against other priorities, possibly across the entire U.S. federal budget.

[37] Relevant resources here also include: Johnson-Schwartz, J.S., 2017. Myth-free space advocacy part I—The myth of innate exploratory and migratory urges. Acta Astronautica, 137, pp.450-460. Johnson-Schwartz, J.S. 2017. Myth-free space advocacy Part II: the myth of the space frontier. Astropolitics, 15(2), pp.167-184. Billings, L., 2006. How shall we live in space? Culture, law and ethics in spacefaring society. Space Policy, 22(4), pp.249-255.

[38] Bertrand, P., Pirtle, Z. and Tomblin, D., 2017. Participatory technology assessment for Mars mission planning: Public values and rationales. Space Policy, 42, pp.41-53.

Concluding Themes

The Artemis and Ethics workshop brought together a diverse group of experts, fostering insightful discussions on the societal and ethical implications of NASA's Moon to Mars effort. The event focused on addressing interdisciplinary challenges, incorporating various perspectives, and identifying ways to influence future decisions through meaningful reflection. The conversations explored the complexities of applying Earth-based environmental concepts to lunar contexts, as well as the importance of considering local cultural and institutional factors in addressing ethical issues. By engaging scholars and practitioners alike, the workshop facilitated a meaningful exchange of ideas and highlighted the importance of continued reflection and dialogue on these critical topics.

One workshop participant cited claims that the Artemis Accords promote a view of lunar property that may encourage significant privatization and propagate a capitalist system in space. Some view this as a desirable future, whereas critics say that this can enable repetition of missteps that can occur when past economic systems were not regulated. NASA staff noted that the Agency is aware of these criticisms and that the workshop's purpose was not to adjudicate specific ethical questions but rather to explore how NASA should consider societal and ethical implications in broader contexts. Multiple attendees emphasized that these issues are much broader than NASA and the U.S. government, requiring international collaboration and awareness.

As the workshop continued, participants delved into the long-term policy issues and ethical considerations surrounding lunar and Mars exploration. NASA's architecture campaign segment of “Sustained Lunar Evolution” was cited as a critical aspect of the Agency's future technical planning.[39] Although ELSI are not currently a major priority, some argued that NASA will need to adapt its approach to the evolving ethical landscape. This includes considering ethical issues in Earth-based operations and LEO activities.

Numerous speakers cited a need for clarity in the fundamental values guiding exploration and related activities. Anti-colonialist scholar Natalie Treviño, along with others, emphasized the importance of understanding the reasons behind exploration and the actions taken in pursuit of those goals. Others affirmed that the broad principles and values underlying the Artemis program may help shape a more positive future for space exploration and said continuing to refine those values is desirable.

[39] NASA’s formal Moon to Mars architecture planning process breaks down future space activities into campaign segments. For more details, see: https://www.nasa.gov/MoonToMarsArchitecture/

Appendix D: Management and Policy Process Approaches for How NASA Should Consider Ethical and Societal Aspects of Artemis

Over the course of the workshop, participants were encouraged to not only discuss ethical concerns but also to think about what options might be available to address those concerns. Many of the suggestions were about how to create systemic change within NASA to make these sorts of discussions a natural part of the process. Others were about specific engagement opportunities for the spaceflight community and ELSI scholars. Some were suggestions for how to handle specific problems. The following summarizes the suggestions made during the course of the workshop. As iterated in the report's main body, these reflect the suggestions of individuals and do not represent views or a commitment by NASA.

Table 3: Definition of policy options available to address ELSI, as proposed by workshop attendees

	Description
Research	This involves new efforts that require critical thinking and evaluation.
Conversation	Bringing different groups into the conversation can change individual perspectives and shape broader perspectives. Conversations are mapped separately from Management considerations or other Policy actions, because they push and shape the perspectives of all those involved.
Education	This involves specific strands of NASA work that involve training students or the existing workforce. Educational efforts can include helping people learn to perceive and care about ethical aspects and perspectives.
Policy process	This involves how NASA leadership makes decisions and provides input into future programs and perspectives.
Management Process	This deals with the perspectives that NASA managers and systems engineers must consider as they guide mission ideas from early formulation into actual flight activities. This can also involve a specific decision that cuts across policy, management and research contexts.

This coding led to the one-page summary of analysis that can be seen in Table 2 in main body of the report. Table 4 is the overall summary of all written comments and many noted comments from conversation.

Table 4: Coding applied to all noted action item options from the workshop event; light editing for clarity performed.

Category	Sub-Category	Policy option
Conversation	Convening Mechanism	Convene conversation using NASA funding opportunities: topical workshops, symposia, and conferences (TWSCs)
Conversation	Convening Mechanism	Invite non-traditional attendees to conferences (directed invites are powerful). Provide travel grants to each other's conferences, keynote talks, etc.
Conversation	Inter-disciplinary	Encourage more frequent conversations between scientists and ethicists
Conversation	Inter-disciplinary	Communicate the value proposition of integrating social scientists (build trust)
Conversation	Inter-disciplinary	Talk directly with the science and engineering community to hear what issues concern them (workshops)
Conversation	International	Continue conversations with international partners
Conversation	Intra-NASA	Engage high level officials in these conversations
Conversation	Intra-NASA	Establish continuity between administrations via email list or similar so progress is not lost every 4-8 years
Conversation	Public and Science	Continue conversations on science and ethics with the public
Education	Outside NASA	Train scientists and engineers in social studies/science in school (Give engineers the frameworks and case studies to realize their sociological impacts)
Education	Practitioner- and Student-focused	Train scientists in ethics and ethicists in science/engineering
Education	Practitioner- and Student-focused	Use case studies to educate and invoke emotional reasons to care about ethics (Study what is so well done in the Normalization of Deviance/Columbia Accident trainings—these are very impactful on NASA employees)
Education	Practitioner- and Student-focused	Educate practitioners and students about collective ethics, group outcomes

Category	Sub-Category	Policy option
Education	Practitioner-focused	Make training resources via SATERN emotionally engaging, like the Challenger or Institutional Silence programs
Education	Practitioner-focused	Teach how to bring ethics/social sciences in from the start as an engineering consideration (e.g., design solar panel to be "efficient" or manage environmental footprint)
Education	Student-focused	Institute early career in-house training/internships
Education	Student-focused	Create academic training for social scientists, science, technology, and society scholars for jobs that aren't academic
Management	Accountability, Reporting	Allow and encourage public reporting on ethical considerations
Management	Budget	Devote a small percentage of budget to finance a charter on social/ethical issues
Management	Contractual	Integrate ethics/social sciences into contractual arrangements
Management	Internal Agency Changes	Institute ethics-related evaluations for NASA workforce, including SES staff, with involvement of stakeholders
Management	Internal Agency Changes	Institute ethics-related performance review grading metrics for staff
Management	Leadership	Support champions, insiders within NASA who advocate for this kind of work
Management	Leadership	Increase awareness of science and engineering codes of ethics
Management	Leadership	Integrate ethical discourse with stakeholders into strategic planning
Management	Reporting, Strategy	Take ethical considerations seriously in strategic planning and program budgeting
Management	Staffing	Hiring: Make positions available for social scientists, physical scientists, and engineers with relevant training (in science technology and society studies or policy)
Management	Staffing	Give professional recognition to social scientists at the same level as engineers (legitimize career path and encourage recruitment of NASA careers in the social sciences)
Management	Strategy	Incorporate ethical and social implications in review governance
Management	Strategy	Institute top-down expectations and make them part of NASA values, but make them real - not lip service

Category	Sub-Category	Policy option
Management	Strategy	Increase end-to-end ownership of space missions and subsystem design, and increase ethics training for project managers
Management	Systems Engineering	Define clear requirements that reflect ethically and societally responsible exploration
Management	Systems Engineering	Put policy experts and ethicists on the Moon to Mars Architecture team
Management	Specific Decision	Prepare technicians to be complemented (not replaced) by robots & AI
Management	Specific Decision	Astronaut selection: Have the corps be more representative of population
Management	Specific Decision	Create a dedicated lunar graveyard
Management	Specific Decision	Decide how to deal with labor issues with private partners and contractors
National Policy	External to NASA	Create a tax system for wealth redistribution for money generated in space
National Policy	External to NASA	Institute reparations
Policy	Advisory Process	Create a NASA Advisory Council (NAC) committee for ethics or a representative subcommittee reporting to Ethics Advisory Group (AG). This should be sufficiently independently run
Policy	Advisory Process	Get ethical/societal impact researchers onto NAC or ASAP
Policy	Incentives	Create incentives and codify expectations in policy to listen to diverse voices and integrate inputs
Policy, Management	Advisory Process	Create ethics forum that is tied to some incentive
Policy, Management	Advisory Process	Institute an advisory board for ethics and societal issues at NASA
Policy, Management	Capability, Advisory	Create Chief Ethics Officer position at NASA
Policy, Management	Collaborations	Develop a grass roots interest in ethical considerations

Category	Sub-Category	Policy option
Policy, Management	Collaborations	Establish multistakeholder collaborations on ELSI
Policy, Management	Collaborations	Emphasize collaborating with URM/AI/AN [under-represented minorities, American Indians, African Nations]
Policy, Management	Planetary Protection	Add ethical considerations to planetary protection policy
Research	Benchmarking	Engage with other federal agencies that integrate ethics into missions to learn from their practices
Research	Benchmarking	Benchmark against other space agencies' (or analogous partners) practices
Research	Capability	Support interdisciplinary research (e.g., through a virtual institute like Solar System Exploration Research Virtual Institute)
Research	Capability	Create regular rhythms for consultations funding for ethics considerations
Research	Capability	Leverage existing infrastructure (competencies, Congressional Budget Justification, Congress, etc.)
Research	Capability	Establish and fund ethics research at NASA
Research	Capability	Create a pool of ethicists that mission managers can call on (like with lawyers)
Research	Convening Mechanism	SSERVI: Solar System Exploration Research Virtual Institute, NASA sponsored event
Research	Framework	A club to discuss how to be a "boundary spanner," how to be transdisciplinary
Research	Framework	Find a middle ground between technology, policy, ethics, science, etc.
Research	Framework	Craft solution-oriented ethics language into policy and technical developments
Research	Framework	Reanalysis of lessons learned for past ELSI
Research	Framework	Systematize ethical considerations
Research	Framework	Investigate frameworks for long-term spaceflight that don't rely on the finite resource of lunar water ice

Category	Sub-Category	Policy option
Research	Framework, Capability	External assessments are necessary for review of and to develop new ideas on NASA's ethical responsibility and stance
Research	Motivating ELSI	Demonstrate the positive value of ethics
Research	Motivating ELSI	Show how considering societal input up front generates public support (and money); how being an ethical workplace reduces distraction – but still requires developing alternative metrics and currencies.
Research	Public Value Mapping	Conduct a participatory assessment for Mars now
Research, Policy Management	Capability	Develop a Real Time Ethical Analysis Mechanism (R TEAM)

Appendix E: What are Key Ethical and Societal Implications in Artemis and Moon to Mars?

This appendix captures some of the participants' comments that motivated the one-page summary shown above in the report in Table 1. During the first day of brainstorming, participants came up with approximately 95 ideas about possible ethical and societal implications that NASA should consider about the Artemis program and future of Moon to Mars exploration. We recognize that many different kinds of comments fall under this notion of 'idea'– we asked participants to write down important ideas or topics that should be discussed at the workshop. We label these ideas or topics, but recognize that they represent only potential challenges raised by individuals, and their inclusion in this report does not reflect an endorsement by NASA or the U.S. Government.[40] We did not edit the ideas in this table, except for clarifying notes in italics for a few of the inputs.

Table 5: Main topics identified from the workshop

Theme Grouping	Ideas or Topics	Idea (ranking by stickers)
Theoretical	Defining Ambiguous Terms	Understanding due regard
		Definition of "accessibility"
		What is harm? Narrow vs. expansive definitions
		Definition of "sustainable"
	Who Makes Decisions and Communicates with the Public	A polarized discussion pro vs. against the Artemis Accords does not equal pro vs. against NASA
	Differing Cultural Values	Societal challenge: Everyone has different views and there will always be someone who opposes

[40] Table 5 contains the majority of the topics identified from the workshop. Originally, there were approximately 142 topics identified but the list was condensed to 95 topics by study leads due to similarities between topics or judged appropriateness to the study.

Theme Grouping	Ideas or Topics	Idea (ranking by stickers)
Theoretical		Do objects in space only have value as capital? Do they also have value as spiritual or aesthetic objects?
		What ARE our guiding values for space exploration?
		Inclusion of alternative visions of space exploration
		Which are the main imaginaries about space exploration at global south?
	Sharing Benefits	How to arrive at shared definitions of equity and benefit sharing
		Inequality: How are benefits distributed?
	Environmental Ethics	How do we make the case that the lunar environment is worth protecting?
		Outer space as a commons
		Debris Management/Waste Removal etc.
	Historical Values and Colonialism	Cultures not colonies
		Mismatch between rhetoric of why we go to space and the reality of how we have actually explored/gone to/colonized space
		Not repeating the mistakes of colonialism
	Policy and Governance	What does the labor movement look like in space?
		We (humankind) can barely coexist on Earth without conflict. How do we ensure space remains conflict-free?
		Intergenerational justice
		Legal framework to enforce ethical compliance
		Parity among commercial and public interests
	Reflective Capacity of Practitioners	Ethics of sending humans to the Moon when basic human needs are not met on Earth
		Value prop. of Moon to Mars /Artemis to citizens of low socio-economic status
		How much emphasis should be placed by NASA on inspiring the next generation(s) about exploration?

Theme Grouping	Ideas or Topics	Idea (ranking by stickers)
Theoretical		Funding justification in context of opportunity cost w/ other federal funding
		Risk Posture for sending humans to Mars--how safe does it need to be?
		Why are we going to space?
Forecasting	Environmental Ethics	Hiding environmental impacts on Earth and on the Moon
	Historical Values and Colonialism	"Industrialization" in space works just like industrialization on Earth
		Potential for militarization of the lunar surface driven by economic protection
	Policy and Governance	Is "soft law" sufficient? If not, is international "hard law" feasible politically?
		Any precautions being taken by governments are undone by private companies who have been emboldened by a subservient (dependent) public sector
		How are we going to resolve a conflict? What happens if two entities want to operate in the same patch?
		Cooperation with other countries with Moon use (i.e., some may agree but others may disregard completely)
		Artemis Accords make unilateral institutions stronger or weaker? Why?
		Who is responsible if someone needs rescuing
		What happens when China lands before the USA?
	Flexibility for Change	Is Artemis "too big to fail?" *[and interpret this as Artemis cannot be influenced to reach more ethical ends?]*
		Is Artemis "too small to succeed?" *[is a more transformative vision needed for Artemis to help open up the solar system?]*
		How will employees be treated on the Moon when the employer controls life support?

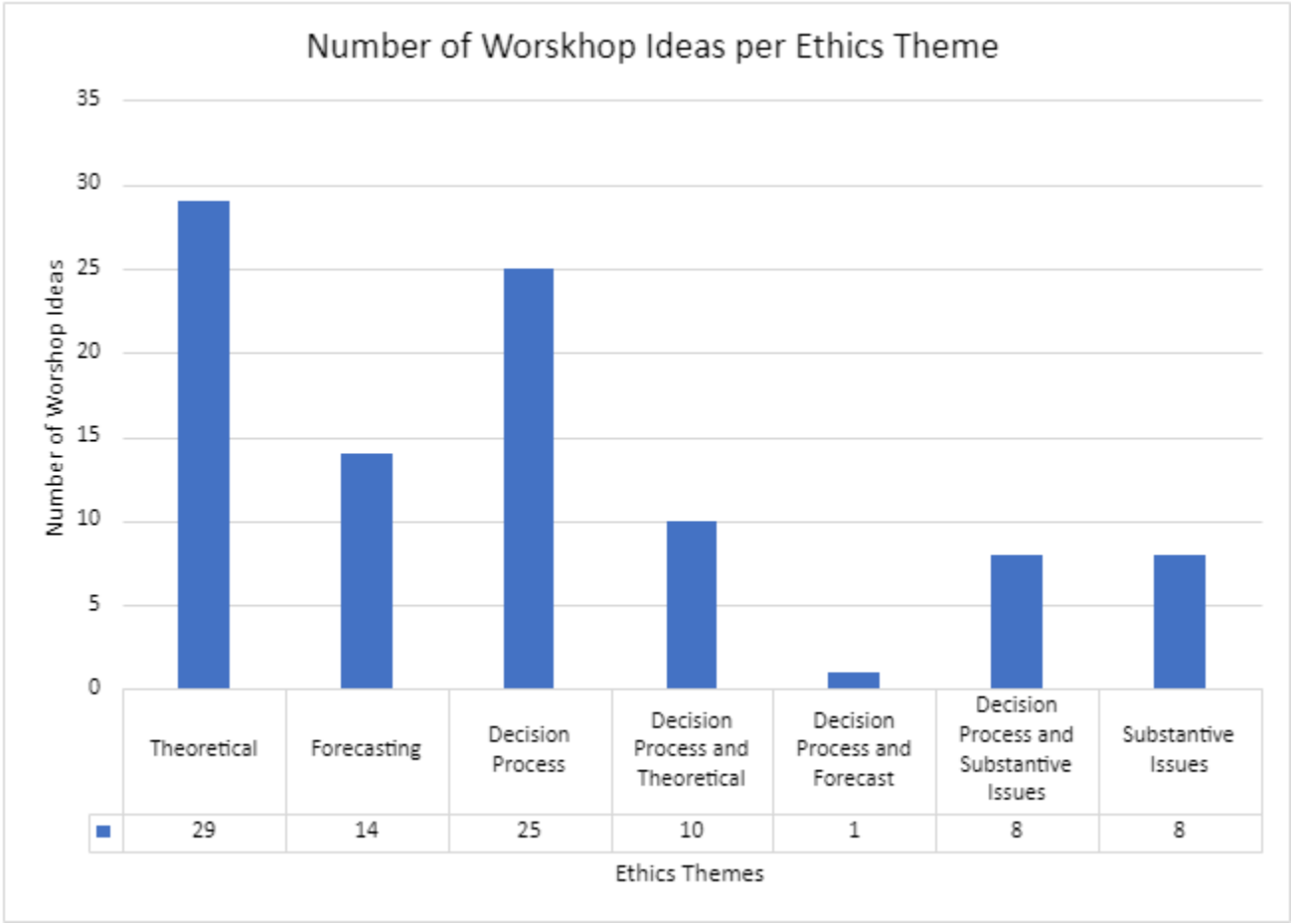
Theme Grouping	Ideas or Topics	Idea (ranking by stickers)
	Who Makes Decisions and Communicates with the Public	What does the public think?
Decision Process	Differing Cultural Values	How can NASA best be aware of all cultural issues surrounding human space exploration
		How does this process/workshop add to present processes where values/ethics are "baked" into regular governing/"democracy," etc.
		How should NASA engage with different cultural groups and social scientists on the ethics of space exploration?
	Diversity, Equity, Inclusion and Accessibility (DEIA)	Tribal nation representation in Artemis project (knowledge, industry, ethical concerns)
		Making IDEA (Inclusion, diversity, equity, access) real
		Where do we get money to do research about how people with disabilities comanage in space?
		Create a 53rd Space Grant for National Native American Space Grant
		Office of Tribal Affairs Needed
	Historical Values and Colonialism	No more snake oil or false prophets
	Policy and Governance	How do we engender long term responsibility for activities taken by companies and governments?
		How to create effective accountability outside of state jurisdiction?
		Can we implement rules incrementally for space mining (learn as you go) vs. everything before mining is allowed?
	Reflective Capacity by Practitioners	ELSI absorptive capacity inside NASA
		Ethics precedes mission new prime directive
		The ethics conversations are happening in a silo/echo chamber

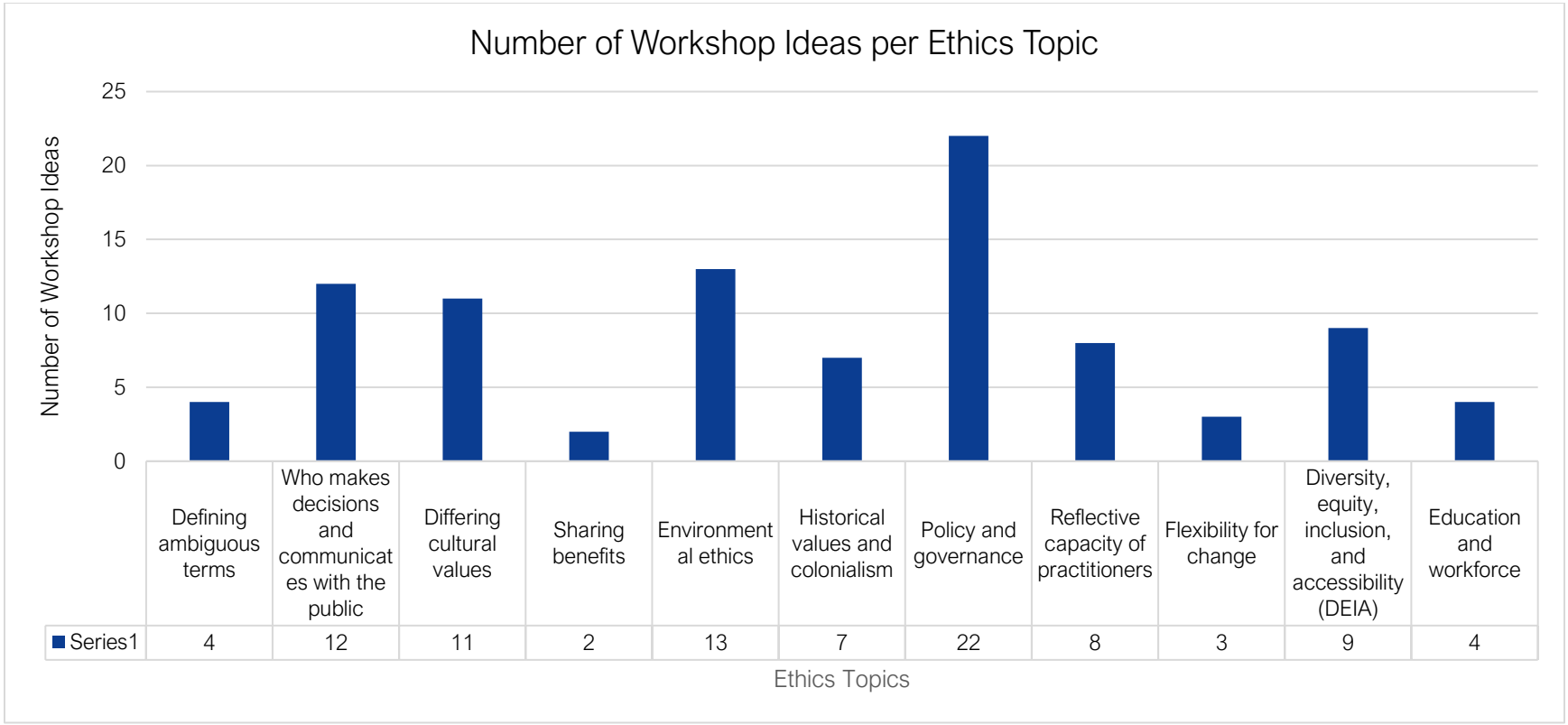
Theme Grouping	Ideas or Topics	Idea (ranking by stickers)
Decision Process	Who Makes Decisions and Communicates with the Public	Who gets to make decisions about what happens in space?
		When NASA asks for community input, how can they ensure they connect broadly with diverse groups?
		How are Artemis crews selected?
		Do we have all the information we need to make good decisions?
		Public values not incorporated purposefully into NASA strategy, program budget
		In what ways should NASA communicate to the public how the Agency is thinking about social and ethical issues related to Artemis?
	Education and Workforce	Integration of social scientists and ethicists into the Artemis project
		Engineers/scientist receive little to no ethics training. Focused on technical aspects only.
		Lack of humanities/social scientists integrated as TEAM members
		Opportunity to bring scientists, humanities/soc. science and stakeholders/public together w/scenario workshops
Decision Process, Theoretical	Differing Cultural Values	Differing cultural understandings of the Moon
		Consensus and goals of nations and people in Africa and diaspora on Moon to Mars
		Broader values: vulnerability of Earth, ethics as driving force rather than "evaluative"
	Diversity, Equity, Inclusion, and Accessibility (DEIA)	How do we design vessels and habitats that can accommodate people with disabilities
		There are any opportunities for regional space agencies like ESA or Latin American and Caribbean Space Agencies (LACSA) at Artemis Accords or 'New Space ' Era?
	Environmental Ethics	Environmental ethics can be integrated how?
		As space exploration continues to grow, are we being mindful of its impact on the environment?
	Historical Values and Colonialism	Collective mobilization knowledge from cultural, historical, and scientific perspectives. (non-colonizational)

Theme Grouping	Ideas or Topics	Idea (ranking by stickers)
Decision Process, Theoretical	Policy and Governance	How do we build norms for responsible behavior that don't feel like U.S. imposition on other countries?
	Who Makes Decisions and Communicates with the Public	Public value integration
Decision Process, Forecasting	Policy and Governance	If we arrive at equitable practices, how do we enforce them?
Decision Process, Substantive Issues	Who Makes Decisions and Communicates with the Public	How should heritage sites or other areas of significance be selected for protection? Who decides what is worth protecting?
Substantive Issues	Diversity, Equity, Inclusion, and Accessibility (DEIA)	Do we need to reserve parts of the Moon for developing countries?
		What happens if someone is disabled during long duration missions?
	Environmental Ethics	Can we/should we design parks as areas of preservation on the Moon? (Maintaining/preserve historical/cultural significant sites on Moon, Mars, etc.)
		"Landfills" on other celestial bodies; (Envir-orbital debris); [Where do we put our trash?]
		International planetary protection issues? (Sample return)
		As we place emphasis on reducing the effects of climate change, we need to be mindful of ensuring we don't make the same mistakes again on other bodies.
		What rights would microbes on Mars have?
		To what extent should we extract lunar resources?
Substantive Issues, Decision Process	Environmental Ethics	To what extent should we extract lunar 'resources'?

Theme Grouping	Ideas or Topics	Idea (ranking by stickers)
	Policy and Governance	Will scheduling or sequencing of activities help reduce concerns w/ISRU?
		If someone dies, what happens to their body? And how does this change for Moon vs. Mars?
		Water *[we assume this is about who has access, regulation, sharing]*
		How can you build a facility without claiming property or territory?
		What can go to the Moon? (Right now, you can buy a spot on a lander and send whatever you want)
	Who Makes Decisions and Communicates with Public	How to make sure this event doesn't simply become "good PR" for the Artemis Accords?
Decision Process, Substantive Issues	Who Makes Decisions and Communicates with the Public	How should heritage sites or other areas of significance be selected for protection? Who decides what is worth protecting?

The graphs below depict the number of ethical ideas presented at the workshop per theme and topic based on the data shown above and our coding approach discussed in the main report text. These data visualizations help to illustrate the diversity of topics presented at the workshop, and that the most commonly discussed ideas were theoretical.




Number of Workshop Ideas per Ethics Topic
Number of Workshop Ideas
25
20
15
10
5
0
Defining ambiguous terms
Who makes decisions and communicates with the public
Differing cultural values
Sharing benefits
Environmental ethics
Historical values and colonialism
Policy and governance
Reflective capacity of practitioners
Flexibility for change
Diversity, equity, inclusion, and accessibility (DEIA)
Education and workforce
Series1
4
12
11
2
13
7
22
8
3
9
4
Ethics Topics

Appendix F: Artemis and Ethics workshop agenda

Artemis Ethics Workshop Agenda		
Day 1: April 12, 2023		
Time	**Topics**	**Presenter(s)**
8:00 AM	Welcome Remarks	Ellen Gertsen, Deputy Associate Administrator, OTPS
	Kickoff and Purpose	Dr. Zachary Pirtle, OTPS
8:30 AM	Legal and ethical context for lunar activities	Michelle Hanlon, For All Moonkind
	Recent Calls for Ethical Investigation	Dr. Parvathy Prem, Applied Physics Laboratory
9:30 AM	On Fundamental Narratives for Space	Dr. Natalie Treviño, Open University
		Daniel Hawk, GALXYZ, LLC
10:30 AM	**Break**	
10:45 AM	Lessons Learned from Ethical, Legal, Society Aspects (ELSA) research in the U.S. Government	Dr. Kelly Smith, Clemson University
		Dr. Shannon Conley, James Madison University
11:45 AM	**Lunch Break then return to 2E39**	
12:30 PM	Brainstorming Session #1	Full Group Participation
1:45 PM	Environmental Issues and History	Dr. Afreen Siddiqi, MIT
		Dr. Teasel Muir-Harmony, National Air and Space Museum
2:45 PM	**Break**	
3:00 PM	Ethics of Opportunity Costs in Exploration	Dr. Linda Billings, Consultant
	Past Ethics: 'Responsible' Technologists from Apollo to Artemis	Dr. Mathew Wisnioski, Virginia Tech
4:00 PM	Discussion Session #2	Small Group Participation

Artemis Ethics Workshop Agenda		
Day 2: April 13, 2023		
Time	**Topics**	**Presenter(s)**
8:00 AM	Lessons in Implementing "Responsible Innovation"	Dr. René von Schomberg, former EC
	"Participatory Technology Assessment" Research	Dr. Mahmud Farooque, Arizona State University
		Dr. David Tomblin, University of Maryland, College Park
9:00 AM	**National Air and Space Museum Guided Tour**	
11:30 AM	**Lunch Break (then return to 2E39)**	
12:30 PM	Brainstorming Session #3 "Can This Be Practical?"	Small Group Participation
1:45 PM	Different Bodies in Moon to Mars	Dr. Sheri Wells-Jensen, Library of Congress
	Global South and Equity Concerns	Daniel Vizuete, FLASCO Ecuador
2:45 PM	**Break**	
3:00 PM	On Equity	Dr. Erika Nesvold, Just Space Alliance
3:40 PM	Discussion Session #4	Group Participation
Day 3: April 14, 2023		
Time	**Topics**	**Presenter(s)**
8:00 AM	How Social Science Can Be Done on NASA Teams	Dr. Janet Vertesi, Princeton University
9:00 AM	Deconstructing Key Myths in Human Spaceflight	Dr. J.S. Johnson-Schwartz
9:30 AM	**Break**	
9:45 AM	Policy Framings on Environmental Issues	Jessy Kate Schingler, Open Lunar
	Values in Antarctic Research	Dr. Jessica O'Reilly, Indiana University
11:00 AM	Discussion Session #5	Group Participation
12:00 PM	Closing Comments	
12:30 PM	**Workshop Ends**	

Appendix G: Acknowledgments

Several OTPS colleagues were pivotal in helping to moderate portions of the workshop events, including Gabe Merrill, Gabriel Swiney, Grace Wusk, Ken Wright, and Laura Delgado-Lopez (an SMD staff member previously detailed to OTPS).

NASA is thankful to Teasel Muir Harmony and the National Air and Space Museum for hosting curator-guided tours of the museum for workshop attendees. These tours provided critical opportunities for participants to converse among themselves and to also consider relevant societal impacts.

The Mission Directorate Points of Contact for the study were helpful in creating the workshop, and in helping to review and share the resulting insights from the workshop. They are:

- Space Technology Mission Directorate: Amy Kaminski, Jenn Gustetic
- Exploration Systems Mission Directorate: Jacob Bleacher, Nujoud Merancy
- Science Mission Directorate: Ryan Watkins, Debra Needham.

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Appendix H: Acronyms

Acronym	Definition
CLPS	Commercial Lunar Payload Services
EC	European Commission
ELSA	Ethical, Legal and Societal Aspects (revised framing for ELSI)
ELSI	Ethical, Legal and Societal Implications (historically tied to the ELSI funding initiative begun by the Human Genome Project)
ESA	European Space Agency
ESDMD	Exploration Systems Development Mission Directorate
ESSIO	Exploration Science, Strategy and Integration Office (in SMD)
GPRA	Government Performance and Reporting Act
GPRAMA	Government Performance and Reporting Act Modernization Act
HQ	NASA Headquarters
ISRU	In Situ Resource Utilization
LDEP	Lunar Discovery and Exploration Program (SMD program)
MEP	Mars Exploration Program
NASA	National Aeronautics and Space Administration
NASEM	National Academies for Science, Engineering and Medicine (U.S.)
OTPS	Office of Technology Policy, and Strategy (within NASA)
OSTP	Office of Science and Technology Policy (Executive Office of the President)
PSD	Planetary Science Division
pTA	Participatory Technology Assessment
ROSES	Research Opportunities in Space and Earth Sciences
RI (or RRI)	Responsible Innovation (also, Responsible Research and Innovation)
SMD	Science Mission Directorate
STMD	Space Technology Mission Directorate
STS	Science, Technology and Society Studies
UN COPUOS	United Nations Committee for the Peaceful Uses of Outer Space