Inclusive Lunar Exploration

Lunar Surface Science Workshop Virtual Session 13 (LSSW-13)

January 26–27, 2022

Summary

This report summarizes findings from the Lunar Surface Science Workshop Virtual Session 13: Inclusive Lunar Exploration. The report consists of a brief introduction to the workshop and the report structure, followed by summaries of the six workshop sessions, and a synthesis section discussing the following key findings:

1. Challenges related to diversity and inclusion in the planetary science community have already been demonstrated.
2. To make further progress in addressing these issues, IDEA (inclusion, diversity, equity, and accessibility) work must be directly funded and explicitly valued.
3. There are community members who have been working towards a more equitable and diverse workplace for decades, and many beneficial actions could be taken to advance these goals.
4. There is wide-ranging and deep expertise in questions related to ethical and responsible lunar exploration that should be given due consideration in decision-making processes.
5. Inclusive lunar exploration could be advanced by recognizing, building, and strengthening relationships between NASA (and other space agencies) and Indigenous Nations.
6. Broad, international engagement, mutual respect, and accountability are essential for peaceful and ethical lunar exploration.
7. There are major science questions and important technology challenges that should be addressed to enable responsible lunar exploration.

We also include a brief Postscript discussing how the findings of this workshop relate to recommendations in the 2023–32 Planetary Science and Astrobiology Decadal Survey, a guiding document for lunar and planetary exploration over the coming decade. The workshop program (with links to recordings) and a selection of participant comments are included as Appendices.

1. Introduction

What does it mean to explore the Moon responsibly, ethically, and inclusively? The goal of the Lunar Surface Science Workshop on Inclusive Lunar Exploration (LSSW-13) was to engage the lunar community in conversation around this question. These conversations about who is and is not in the room, how we treat each other, how we relate to the Moon, and shape the future, are a key part of planning for the coming years. With many lunar missions on the horizon, including commercial and crewed activities, discussions must begin now if these themes are to be woven into future exploration strategies.

Institutional support for the LSSW series comes primarily from NASA. Together with safety, integrity, teamwork, and excellence, inclusion is one of the agency's core values[1]. The lunar community extends beyond NASA, including scientists, engineers, social scientists, commercial actors, policy makers; this workshop sought to include a broad cross-section of these community members. We also recognize the need to consider past and future generations when making decisions in the present.

2. Structure of this Report

LSSW-13 was a virtual meeting that consisted of three sessions each day, over two days (January 26–27, 2022). Sessions consisted of both invited and contributed presentations, with moderated discussions between participants at the end of each session. The workshop program, with links to recorded talks and discussions, is included in Appendix A. Appendix B includes links to a transcription of participant comments from the collaborative virtual whiteboards used to facilitate discussions.

The remainder of this report consists of brief summaries of each session, followed by a synthesis of key findings and reflections from the workshop. Given the range of institutional contexts and diversity of opinions on some issues within the lunar community, the outcomes of LSSW-13 are framed as findings rather than recommendations, although several potential courses of action to address specific issues are highlighted.

This report is intended as a summary and a starting point for continued conversations; it is not a comprehensive review or exploration of the wide-ranging topics that were discussed, drawing on the deep expertise and experience of speakers and participants. We invite readers to join us in reflecting on how we can continue to engage with each other, and how each of us can take action to build more inclusive and ethical spaces.

[1] NASA HQ Status Report, July 23, 2020; NASA DEIA Strategic Plan, FY 2022-26.

3. Session Summaries

3.1. Day 1

The first day of the workshop focused on the theme of inclusion, diversity, equity, and accessibility (IDEA, also referred to as DEIA or EDIA) in the lunar science and exploration workforce, across three sessions, titled "Understanding Our Community", "Creating Systemic Change", and "Pathways and Bridges."

3.1.1. Understanding Our Community

This session focused on the status of diversity and inclusion in planetary science and exploration, including discussions of barriers to belonging and participation. Following an introduction by LSSW-13 Co-Chairs Dr. Kristen Bennett and Dr. Parvathy Prem, the workshop began with a presentation by Dr. David Draper (Deputy Chief Scientist at NASA HQ) on DEIA at NASA, affirming leadership commitment to intentional inclusion, reflected in the agency's strategic goals and objectives.

In the first talk of the session, Dr. Julie Rathbun and Dr. Edgard Rivera-Valentín presented the results of a recent demographic survey of the planetary science community in the United States,[2] showing that women and people of color remain underrepresented in the community. While there have been gains in the representation of women and Latinx scientists over the past decade, the percentage of Black planetary scientists has remained low. The speakers emphasized that the lack of diversity in the field is sufficiently well-demonstrated, and that the critical next step is to focus on implementing evidence-based strategies. They also highlighted the importance of considering intersectional identities, and backing these efforts with long-term support/funding.

Jackelynne Silva-Martinez and Dr. Herbert Silva addressed the status of diversity and inclusion in the aerospace industry, and reviewed current strategies adopted by government institutions, the commercial sector, and professional associations. Silva-Martinez and Silva highlighted the increased emphasis on leadership development training for students and the availability of professional development training in workplaces, and stressed the need for individual training to be accompanied by measurable, institutional policy changes. They also provided recommendations on how aerospace leaders can promote a more diverse and inclusive organizational culture, especially in light of plans to return to the Moon in a sustainable manner.

Building on the theme of diversity in space exploration, Brian Troutman pointed out that

[2] E. G. Rivera-Valentín et al. (2021), Who is Missing in Planetary Science?: A Demographic Study of the Planetary Science Workforce (doi: 10.3847/25c2cfeb.968ed505).

despite significant progress, NASA faces hiring challenges when it comes to making sure that it is representative of the wider civilian workforce. Drawing on his own experiences, Troutman spoke to the role of internships and partnerships with Minority Serving Institutions, as well as parallels in challenges faced by women and racial minorities[3]. Adeene Denton highlighted the need to think critically about the Artemis Program's objective of "landing the first woman" on the Moon, in light of institutional barriers that past and present female astronauts have faced, and advocated for emphasizing the role of cooperative teams and centering intersectional identities in exploration efforts.[4]

Several presenters and participants raised the role of mentorship, networking, and community-building in enabling successful pathways for underrepresented groups and minorities. Other barriers, such as a lack of transparency in awards and promotions, access to opportunities and information, mental health, parenthood, and bias were also discussed. This session also drew attention to a demographic imbalance that exists, with many of those involved in IDEA efforts belonging to underrepresented or minority groups.

3.1.2. Creating Systemic Change

This session focused on NASA efforts to promote inclusion at the mission team level, the social science of dynamics within low-diversity spaces, and best practices for establishing inclusive and accessible communities.

In the first talk of the session, Dr. Ryan Watkins (Program Scientist, Exploration Science Strategy and Integration Office, NASA HQ) discussed efforts to address inclusion at the mission team level with the PRISM[5] Inclusion Plan Pilot Program. Mandatory Inclusion Plans for PRISM proposals require teams to specify anticipated barriers to a positive and inclusive working environment and to develop actionable, measurable, and transferrable plans to address these barriers. Although Inclusion Plan scores are not currently incorporated into the final proposal score for PRISM (similar to the history of Data Management Plans), NASA will be reviewing the pilot program to evaluate if/how it should be modified or extended.

Next, Dr. Janet Vertesi described the social dynamics that work to maintain a lack of workforce diversity. Most planetary science spaces are skewed groups (< 15% minorities), where tokenistic dynamics prevail. These dynamics include stereotyping and identifying vocal minorities as the "problem." Vertesi stressed the importance of reaching a threshold of 15–30 percent minorities in order to achieve systemic change despite backlash from the majority, which tends to increase as the proportion of minorities increases. Vertesi also

[3] A. Eagly and L. L. Carli, Women and the Labyrinth of Leadership.
[4] C. A. Denton (2019), Untangling feminism, nationalism and space exploration in the age of Artemis.
[5] Payloads and Research Investigations on the Surface of the Moon.

pointed out that lunar and planetary exploration work often takes place in "third spaces" such as conferences, field sites, and mission teams, where institutionalized codes of conduct, diversity guidelines, and legal protections are often lacking.

Dr. Eleanor Armstrong stressed the importance of funding inclusive practices—and without a budget, inclusivity initiatives are extractive of those who are charged with implementing them. Armstrong also highlighted the core principles of creating an inclusive community that emerged from the Space Science in Context[6] meeting in May 2020 (co-organized by Dr. Armstrong and Dr. Divya M. Persaud): improving accessibility, seeking feedback from participants, taking complaints seriously, and thinking critically about building community spaces beyond institutions.

Several participants emphasized that the lack of institutional support (including funding) and positive recognition for IDEA efforts are serious barriers to progress, and detrimental to those (particularly graduate students and others early in their careers) engaged in this work, often leading to individual burnout. The importance of strong institutional protections and mentorship networks was also raised.

3.1.3. Pathways and Bridges

This session focused on inclusive professional development and how to engage a wider community with lunar science and exploration, accompanied by continued discussions geared towards sharing strategies and resources.

The session opened with a talk from Dr. Kathryn Gardner-Vandy on the Braided River STEM Workforce Development Model.[7] Whereas the traditional "Pipeline Model" of workforce development where an individual enters at the undergraduate level and is expected to follow a straight path to professorship, the "Braided River Model" acknowledges that STEM careers may follow different paths, with varied inlets (including entry from other disciplines, from community colleges, and training from outside STEM fields) and navigating varied barriers. Important considerations include recognizing who is and is not present in the stream, reconsidering what defines success or expertise (and recognizing the cultural implications of this), and demanding institutional change to address barriers to inclusion.

Dr. Sara Torres began by drawing on her own experiences to discuss the power of invitation, and how much it is needed for many students to realize their potential to enter academia. Torres also discussed the role of Culturally Relevant/Culturally Responsive Teaching in enhancing a student's learning potential by acknowledging their individuality

[6] Space Science in Context: https://spacescienceincontext.wordpress.com/.
[7] R. L. Batchelor et al. (2021), Reimagining STEM Workforce Development as a Braided River (doi: 10.1029/2021EO157277).

rather than teaching all students in the same way. This includes leveraging teachable moments and encouraging visible representation in the classroom.

Next, Dr. Caitlin Ahrens discussed the topic of making lunar science more accessible to the deaf and blind communities. Many experiences and resources that are available to a seeing or hearing person are inaccessible or less accessible to those who are blind, visually impaired, deaf, or hard of hearing. Resources for these communities are often far more expensive, hard to come by due to limited availability, or they are not made available. Ahrens discussed projects making progress in making planetary science more accessible, and best practices such as including transcripts and complete, accurate captions with online videos.

In the final talk of the session, Dr. Alexandra Matiella Novak presented the work of Planetary REACH, a NASA Science Activation team. Planetary REACH aims to help connect subject matter experts with educational resources, and planetary missions with audiences, to explicitly address the needs of diverse learners and their communities. The team is looking for more culturally responsive places to hold planetary engagement workshops, as well as more non-traditional spaces to seek broader and more diverse audiences.

3.2. Day 2

The second day of the workshop focused on the theme of ethical lunar exploration, with three sessions titled "Outer Space for All", “Technical Challenges and Solutions”, and “Accountability and Ethical Exploration.”

3.2.1. Outer Space for All

The “Outer Space for All” session was intended to highlight a range of different perspectives on space exploration – through the lenses of space law and rhetoric, and from communities with differing relationships to the sky. Conversation revolved around the meaning of ethical exploration as well as steps the community can take towards ethical lunar exploration.

Elisha Jhoti, EDI Lead for the Next Generation Lunar Scientists and Engineers (“NextGen”, a group of graduate students, postdocs and early career scientists and engineers) gave the first talk. Jhoti summarized the NextGen-organized Lunar Exploration Ethics Panel[8], which addressed questions related to accessibility, ownership, and anti-colonial practices. Panelists and participants discussed the motivations for lunar exploration (including the question of whether current motivations are too political or militaristic), and the implications of the Artemis Accords. Discussions also focused on how to make the Moon

[8] Lunar Exploration Ethics Panel, NextGen Group.

accessible to everyone irrespective of physical and wealth barriers, and what "accessible" means in terms of developing norms and regulations.

Dr. Edythe Weeks discussed methods for including everyone in the outer space development process through space law provisions. Weeks examined the question of why diversity, inclusion, equality and representation are considered core values in outer space development, and are key to mitigating international conflict. Discussing the history of Black women at NASA (depicted in the recent film "Hidden Figures"), Weeks drew a link between the concealment of these stories and the prevalence of microaggressions and unconscious biases today, highlighting the need to think critically about our history as a community.

Next, Dr. Richard Shope spoke about some of the history of relationships and conflicts between Indigenous Nations and NASA. Shope discussed his work towards building trust between Native American communities and NASA personnel in order to build understanding of the impact of activities such as the carrying of human ashes to the Moon by the Lunar Prospector mission. Building a foundation of trust and recognizing the value of bringing together Indigenous knowledge and knowledge from NASA led to relationships that supported internships at JPL and NASA Ames that immersed students from Indigenous communities in technical and scientific research.

In the fourth talk of the session, Dr. Linda Billings, spoke about the history of the rhetoric of space exploration – its long relationship to the idea of "manifest destiny" during colonial expansion, reflected in the value systems that still dominate space culture.[9] Billings emphasized that this approach towards space exploration is unlikely to change unless and until mindsets change at decision-making levels, and concluded with the thought that the way to proceed in space should be "slowly, carefully, and thoughtfully, mindful of the 1967 United Nations Outer Space Treaty and of global inequalities among nations".

The last talk of the session was a call for action from the Satellite Constellations 2 Workshop (SATCON2)[10] Community Engagement Working Group. Co-chairs of the group, Dr. Aparna Venkatesan and Dr. James Lowenthal, discussed how the sky is a shared space for everyone and described the environmental impacts of the growth of satellite constellations. Recommendations from the Working Group relevant to lunar exploration included consulting with communities around the world and discussing the disruptive nature of technologies when they are unregulated. There was a strong call for international cooperation, to treat space as a part of the environment and to understand the environmental, ethical, cultural, and legal implications of lunar exploration activities.

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[9] L. Billings (2006), Ideology, Advocacy, and Spaceflight — Evolution of a Cultural Narrative (doi: 10.1016/j.spacepol.2006.08.001).

[10] Satellite Constellations 2 Workshop: https://aas.org/satellite-constellations-2-workshop/.

3.2.2. Technical Challenges and Solutions

Talks in the "Technical Challenges and Solutions" session touched on some of the technical aspects of planning for human interactions with planetary environments, including assessing the scale of resource extraction, and mitigating and monitoring environmental impact during crewed and uncrewed activities.

The session began with a presentation by Dr. Karl Hibbitts on how the scale of ISRU (in situ resource utilization) associated with a sustained lunar presence may impact the inclusivity of that presence. Hibbitts presented an assessment of the accessibility of current ISRU technologies, and discussed the need for international collaboration (including by smaller economies) in characterizing resources such as polar water ice.

Next, Dr. Marc Avila discussed ongoing work[11] aimed at planning for a sustainable human presence on Mars, with implications for the Moon. Avila emphasized the need for research and advance planning in terms of how future settlements may and should develop in terms of planetary environmental protection, conflict mitigation, and habitat design to accommodate varied human needs.

The final two talks focused on the assessment and mitigation of adverse changes to the lunar environment. Dr. Joel Levine addressed the importance of measuring and monitoring the thin lunar atmosphere (a surface boundary exosphere) during and beyond the Artemis missions, in order to assess the impact of human exploration on the Moon. Due to its low mass, the lunar exosphere is particularly sensitive to perturbations caused by surface operations. Matthew Kuhns discussed ongoing efforts to mitigate the damaging effects of dust generated by lander plume impingement, focusing on the in-Flight Alumina Spray Technique (FAST) system. Landing pads and other dust mitigation strategies can enable future landed missions to be "good neighbors" by minimizing damage during landing to nearby assets. During discussions, participants also raised the need to understand which environmental changes are reversible and non-reversible, and address topics such as equipment recycling/repair and debris/waste management.

3.2.3. Accountability and Ethical Exploration

Speakers in the "Accountability and Ethical Exploration" session discussed policies and practices that are or could be applicable to lunar exploration, including current Committee on Space Research (COSPAR) policies and activities, and lessons from Earth on remediation after resource extraction, consensus building, and environmental law.

[11] Humans on Mars, University of Bremen.

The first talk was by Dr. Athena Coustenis and Dr. Niklas Hedman on COSPAR's Planetary Protection Policy for lunar exploration.[12] The purpose of the presentation was to highlight the roles and responsibilities of COSPAR, particularly through its Panel on Planetary Protection (PPP). The PPP seeks to avoid jeopardizing the conduct of scientific investigations due to forward contamination from spacecraft, protect Earth from hazards posed by returning spacecraft, and to develop policy based on the most current peer-reviewed research and knowledge. The speakers noted that the goal of the PPP is to enable (not prohibit) the exploration of the Solar System by promoting multilateral discussions to ensure order and predictability.

Next, Dr. John Rummel described the objectives of the COSPAR Panel on Exploration (PEX), and discussed the recommendations of the 2010 PEX-PPP Princeton Workshop[13] that aimed to highlight the process of explicitly integrating ethical considerations and environmental protection into COSPAR's planetary protection efforts and the work of PEX. He discussed a Workshop recommendation that COSPAR should maintain the existing, effective Planetary Protection Policy virtually intact, while examining in parallel how to address issues regarding the ethical considerations that are related to non-life-related science protection and future requirements for environmental management. Initial considerations from the Workshop included the conclusion that COSPAR PEX should steward that separate and parallel policy as a distinct part of its mandate.

Dr. Kathryn Hadler presented a talk titled "Leave No Trace: Remediation on the Moon after Resource Extraction" in which she discussed the role of ISRU in science and commerce, and explored the question, "What is environmental legacy on the Moon?" Hadler focused on the legacy of hardware and excavation of lunar regions, discussed terrestrial best practices, and emphasized the need to better define operations and their aftermath, including the handling of disturbed materials.

Continuing with the theme of resource extraction, Dr. Elizabeth Frank discussed a potential framework for managing tension between mining demand and impact by maintaining a Social License to Operate (SLO), in which local communities are involved in the development of a project and channels are established for communication and accountability. Frank outlined possible applications of SLO on the Moon, and emphasized the need for early, open, good-faith dialogue between all stakeholders.

The final presenter of this session was Alex Gilbert, who discussed the application of

[12] COSPAR updates its Planetary Protection Policy for missions to the Moon's surface, Jul 15 2021.
[13] Report of the 2010 COSPAR Workshop on Ethical Considerations for Planetary Protection in Space Exploration (doi: 10.1089/ast.2012.0891).

environmental policy and law to the space environment[14], and the Moon in particular. General goals of environmental law include identifying damages, accompanied by mitigation, compensation and remediation measures, as well as enforcement actions. It was noted that measures such as the requirement of environmental impact statements could be extended to the Moon if outer space were to be recognized as part of the "human environment" under the US NEPA (National Environmental Policy Act).

The discussion session included a brief but thought-provoking correspondence regarding the economic and scientific benefits of planetary resources and ISRU. Another discussion was regarding whether certain areas on the Moon could be designated as culturally important locations or allocated for ISRU/mining efforts.

4. Synthesis

4.1. Day 1

Exploration does not happen without individuals, and in conversations on the first day of the workshop, we explored questions related to how to support an inclusive, diverse lunar community. Does the lunar community face any unique inclusion-related challenges? How can we leverage the knowledge of those who have worked on these challenges in the past?

At the end of Day 1, the general feelings communicated by participants were those of exhaustion and optimism. Many of those doing IDEA work are tired. The past few years have included a global pandemic, paired with a growing awareness of IDEA-related challenges. The combination of these factors means that those who work on these issues are stretched thin between pandemic-related and IDEA-related demands on their time. However, this exhaustion is paired with excitement. There is momentum growing from the efforts being put into IDEA work. We have observed an increase in interest and in funding devoted to these challenges, and the community is hopeful that this can be a key turning point towards a more inclusive and diverse workforce. Below we list three findings that capture these sentiments. We also include a non-exhaustive list of actions that came up throughout the day as examples of what can be done to increase inclusivity in the lunar community.

1. Challenges related to diversity and inclusion in the planetary science community have already been demonstrated. Extensive work has been conducted to understand issues related to diversity and inclusion. One of the first speakers said, "We know there is a diversity problem. We don't need more demographics studies to tell us that!" [Rathbun]. These issues were highlighted again during this workshop, both in stories that were shared

[14] A. Q. Gilbert, M. Vidaurri (2021), Major Federal Actions Significantly Affecting the Quality of the Space Environment: Applying NEPA to Federal and Federally Authorized Outer Space Activities.

by participants and research that was presented by social scientists.

One example of a challenge that was brought up by Dr. Janet Vertesi is particularly important for the lunar exploration community. It is challenging to regulate "third spaces," which are non-office or home settings where work takes place (i.e., conferences, field work, mission teams). The lack of regulation of third spaces can lead to increased instances of bad behavior because there are unclear repercussions, and/or increased levels of informal interactions (i.e., word of mouth, who-you-know) that are barriers to inclusion. Lunar exploration often happens in third spaces at the intersection of institutions, agencies, and industry, which presents a challenge: Who is responsible for instituting guidelines in these lunar exploration spaces?

Another aspect of this reflection is the acknowledgment that despite the fact that diversity and inclusion challenges have already been demonstrated, an additional challenge is from people who refuse to acknowledge these problems. Workshop participants noted this issue, saying "Unless something happens to you, it does not exist." and "The biggest challenge I've faced is from folks who just don't care. Because of their privileged positions, they don't see the problems."

2. To make further progress in addressing these issues, IDEA work must be directly funded and explicitly valued. Now that more people are aware that there is a problem and communities are starting to focus on addressing these issues, it is critical that the work being done is adequately compensated. For individuals who conduct grant-supported research, this means that the time an individual spends working on IDEA efforts is paid for, rather than working uncompensated extra hours. Expecting this work to happen without designated funding means that it is either exploitative, or it will fail due to lack of support. As Dr. Eleanor Armstrong said, "An inclusive practice without a budget is not inclusive, it is extractive." While there is likely not enough funding to tackle all the IDEA-related challenges in our field, it is imperative to start somewhere.

Equally as important, these efforts must be tangibly valued. This includes making IDEA efforts part of annual performance plans and evaluation metrics. The people who do IDEA work are often part of minority groups. Given that this work does not generally count towards promotion potential, this can result in this group of people having a harder time achieving promotions and/or having to do additional work. One participant noted that they felt like they needed to work overtime because they were attending this workshop, while another wrote that as an early career researcher everything they do is judged for its promotion potential, and anything that does not result in a publication (like much IDEA work) is detrimental to their progress. IDEA work is critical for advancing science and exploration, and therefore it should not be detrimental to an individual's career to engage with this work.

3. There are community members who have been working towards a more equitable and diverse workplace for decades, and many beneficial actions could be taken to advance these goals. Workshop speakers and participants brought decades of experience to the table, and many thoughtful ideas for how to address issues related to diversity and inclusion were discussed. Dr. Richard Shope noted that "elders in the community have been having these conversations and working on issues and they should be included and reached out to for some continuity for the next generation."

A non-exhaustive list of actions and solutions that could be taken to increase diversity and inclusion in the lunar community includes:

1. *Develop strong mentorship networks and support systems.* Social connections and relationships are important; however, this can be a barrier people from underrepresented groups must overcome. Mentoring programs can help overcome this barrier. NASA internships are important to continue, especially programs such as MUREP that engage underrepresented communities [Troutman].

2. *Create a central location for information and opportunities.* This reduces reliance on word-of-mouth and who-you-know, which is exclusionary.

3. *Utilize the power of invitation.* Some students (especially underrepresented or underserved students) do not realize that planetary science can be an option for them until they are explicitly invited into the community [Torres].

4. *Devote time and money to building new relationships.* To reach broader audiences or underserved communities, we must spend time building the relationships with these communities. Participants noted: "I would really like to see us engage with communities on a more equal footing, rather than acting as though we're doing them a favor" and "Start a relationship first: don't go to a community with an immediate "ask" or "invite" which can feel extractive." We must recognize that to achieve this broader reach, we need to invest in relationship building without expecting immediate tangible outcomes. Relationships are generally intangible, but incredibly valuable.

5. *Create an Office of Tribal Relations at NASA.* Also discussed in findings from Day 2.

6. *Use the braided river model[15] to redefine what success means [Gardner-Vandy].* Becoming a tenured professor is not the only way to achieve success in our field.

7. *Provide training to employees/community members.* This may include mental health training, especially in academia for students/professors, anti-harassment training,

[15] R. L. Batchelor et al. (2021), Reimagining STEM Workforce Development as a Braided River (doi: 10.1029/2021EO157277).

and/or leadership training, and especially diversity-focused leadership training.

8. *Include IDEA efforts as part of annual performance plans and tenure/promotion/pay raise evaluations.*

9. *Support caregivers (childcare, elder care, etc.).* Provide nursing and childcare support at conferences. Parents and caregivers are sometimes not given opportunities because people assume they will not be available. Do not assume. Extend collaboration and other invitations to caregivers.

10. *Hire social scientists and IDEA experts who have been studying these issues for decades.* One participant noted this: "PIs are already expected to be experts in non-science topics (e.g. engineering). PIs need to be well-versed in DEIA, but not be experts, they can hire DEIA experts just like they employ engineers."

11. *Create diverse teams.* If your team consists of less than 15% minorities, tokenism will be in play. Above 15% minorities, expect backlash to occur and persevere through it. Aim for at least 30% of minorities on your team in order to achieve the benefits of a diverse group. [Vertesi]

12. *An institution should have (at minimum) a code of conduct, formal reporting chains, access to trainings, and diversity statements and guidelines.*

13. *Recognize so-called "third spaces" and how their informal nature can be exclusive and potentially harmful [Vertesi].* For example, a discipline that prides itself on friendliness, openness, and social drinking will naturally exclude people who cannot perform this informality appropriately (i.e., what if someone does not want to or cannot drink alcohol?). To mitigate these issues, the community can establish new norms and guidelines for behaviors in third spaces (i.e., make sure there are codes of conduct for all conferences, mission teams, field work, etc.) and ensure harassment claims are taken seriously and addressed.

14. *Consider accessibility needs for your space and/or community and recognize that not all access needs are the same [Armstrong].* Talk to people in your community and match the access needs in the community right now (listen and address issues). This includes providing caregiving funding, considering colleagues that are geographically disparate, and thinking about the cost of meetings.

15. *Create more outreach products that are accessible for the deaf and blind communities [Ahrens].*

16. *Spread the IDEA workload.* More progress will be made if many people are doing a little bit, rather than a few people doing the bulk of the work. As one participant stated: "There is a lot of expectation for minorities in the field to be doing the majority of the

EDIA work alongside their research/studies which puts added pressure/guilt to balance everything in an already challenging environment. I hope that everyone can be involved in EDIA work, not just minorities, especially in academia."

4.2. Day 2

Discussions within the lunar exploration community often focus on the technical aspects of our work, but whether or not we acknowledge it, this work is informed by ethical ideas of what is acceptable, desirable, or worthy of consideration. One of the aims of LSSW-13 was to engage the lunar community in identifying and discussing these ideas, rather than leaving them as unquestioned assumptions. The four findings below reflect these discussions.

1. There is wide-ranging and deep expertise in questions related to ethical and responsible lunar exploration that should be given due consideration in decision-making processes. Current lunar activities are driven by ideological, economic, and scientific interests; and the workshop raised questions related to each of these motivations.

Several workshop participants noted that the narrative of lunar exploration as "space colonization" is problematic, but also accurately describes the current dominant culture of space exploration. Space ethics and cultural astronomy are active fields of study with strong scholarly communities, yet experts in these areas are not part of decision-making processes at NASA and many other institutions. (NASA has a Chief Economist, but not, as speaker Dr. Linda Billings noted, a Chief Ethicist.) This has tangible consequences for the language and culture of space exploration, which directly impact who is included and excluded in our professional spaces and imagined futures.

Although economic considerations are often raised in the discourse around lunar exploration, these discussions are often limited. Many participants voiced concern over decisions driven solely by a narrowly defined profit motive, which does not take into account the body of scholarly research and grassroots knowledge related to community stewardship and shared management of resources, as well as operational frameworks for terrestrial resource extraction, such as the concept of a social license to operate [Frank] and best practices for environmental remediation [Hadler]. One way to integrate these expanded economic considerations into discussions may be through forums akin to the LEAG Commercial Advisory Board[16].

Meanwhile, discussions regarding "science protection" often struggle with the question of how to relate to environments without past or present biological life. This has been a

[16] LEAG Commercial Advisory Board: https://www.lpi.usra.edu/leag/cab/.

subject of discussion for over a decade[17] and has only grown in importance.

2. Inclusive lunar exploration could be advanced by recognizing, building, and strengthening relationships between NASA (and other space agencies) and Indigenous Nations.

Several speakers [Shope, Venkatesan, Lowenthal] and participants mentioned that there is a history of both conflict and relationship-building between space agencies and Indigenous Nations that is directly relevant to lunar exploration.

In 1998, after NASA's Lunar Prospector launched carrying (in addition to its science payloads) the cremated remains of planetary scientist Dr. Eugene Shoemaker, the Navajo Nation issued a statement objecting to this action as deeply disrespectful to cultural practices of many, including Indigenous Nations. In response, NASA apologized and gave a commitment that "if we ever discuss doing something like this again, we will consult more widely and we will consult with Native Americans."[18] Some of the trust-building work that followed this incident led to long-lasting relationships between NASA and some Indigenous communities [Shope]. However, current plans by several commercial actors to transport human remains to the Moon in the near future raise the thorny question of how NASA balances its relationships with commercial partners and Indigenous Nations, illustrating the need for more participatory decision-making.

One recommendation from workshop participants is that NASA follow other Federal agencies in establishing an Office of Tribal Relations to build and sustain relationships with Indigenous Nations. The establishment of such an Office could also provide clarity on other issues; for instance, one workshop participant noted that "northern Arizona has been a place where astronauts and planetary scientists train, and not always with a clear discussion or inclusion of the significance of that landscape to Indigenous people."

Indigenous Nations across the world have some of the most long-standing relationships to land and sky on the planet, and this deserves respect and recognition in decision-making processes. This has been recognized by some international partners: for instance, New Zealand noted upon signing the Artemis Accords that it takes "responsibilities of kaitiakitanga of the space environment seriously,"[19] acknowledging the Māori principle (kaitiakitanga) of guardianship and conservation.

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[17] Report of the 2010 COSPAR Workshop on Ethical Considerations for Planetary Protection in Space Exploration (doi: 10.1089/ast.2012.0891).

[18] Navajos Upset After Ashes Sent To Moon; Nasa Apologizes, The Spokesman-Review, Jan 15, 1998.

[19] Space exploration soars with Artemis Accords, NZ Govt., Jun 1, 2021.

3. Broad, international engagement, mutual respect, and accountability are important for peaceful and ethical lunar exploration. There was a strong sense at the workshop that broad-based, international consensus on a code of conduct for lunar exploration, rights and responsibilities, and accompanying accountability measures is vital.

Speaker Dr. Edythe Weeks made the point that technical and military prowess do not guarantee a lasting peace, and that multilateral consensus is required to prevent conflict. Several participants raised the issue that the bilateral Artemis Accords are currently limited to a few nations. There was also discussion of the need for space policy-making frameworks that involve countries without institutionalized space programs and consider intergenerational equity, and a strong motivation to, as one participant noted, "change the narrative from frontierism to community."

There are also important sociopolitical and policy questions that deserve wider deliberation, such as how existing environmental policies apply to space environments [Gilbert] and whether mining and other activities "benefit most or all of humanity, or reinforce existing power/economic gradients" [Venkatesan]. International scientific organizations such as COSPAR have an important role to play in these dialogs [Coustenis, Hedman, Rummel], without replacing the need for broader engagement beyond the scientific community.

4. There are major science questions and important technology challenges that should be addressed to enable responsible lunar exploration.

Understanding how to operate responsibly in the lunar environment requires an understanding of the environment itself. One participant at the workshop noted that, "It is impossible to responsibly manage a resource you don't understand. Lunar ice falls in the "we don't understand" category. Several currently planned activities aim to better understand the origins of lunar water and its viability as a resource, but there are also other important gaps in our scientific understanding and technical readiness.

Workshop participants discussed the importance of long-term environmental monitoring to understand not only the impact of the environment (dust, radiation, etc.) on human activities, but also the impact of human activities on the lunar environment, particularly the tenuous lunar exosphere [Levine] and their scale relative to natural processes.

Other key themes that emerged were (i) the importance of long-term planning – addressing issues such as orbital/surface debris management, equipment repair and reusability, waste management, and remediation at the outset rather than as an afterthought; and (ii) the reciprocity of environmental sustainability on Earth and the Moon – there are lessons from Earth that can be applied to the Moon, and there will likely be lessons learned from the

Moon that we can bring back to Earth. More directly, as one participant noted, "environmental sustainability also needs to include any consequences for the Earth/climate because of the production of space exploration equipment."

5. Author Contributions and Acknowledgements

LSSW-13 Co-Chairs Dr. Kristen Bennett and Dr. Parvathy Prem developed the workshop program and led the writing of this report, with critical input in the form of detailed notes and session summaries from Dr. Caitlin Ahrens, Nandita Kumari, Lori Pigue, Dr. Alex Sehlke, and Christian Tai Udovicic. This workshop would not have been possible without the support of the LSSW Organizing Committee and logistical support from NASA, LPI, and SSERVI – and, of course, the active participation of our excellent presenters and over 200 attendees.

6. Postscript: Connections to the Decadal Survey

This postscript was added to highlight connections between the outcomes of LSSW-13 and the 2023–32 Planetary Science and Astrobiology Decadal Survey – a guiding document for lunar and planetary exploration over the coming decade. At the time that LSSW-13 was held, the Decadal Survey report[20] was under preparation. While this timing meant that this workshop report could not be submitted to the Decadal Survey committee, nor could the Decadal Survey contents be discussed at the LSSW, many of the findings discussed above are related to recommendations made by the Decadal Survey. In particular, LSSW-13 Findings 1, 2, and 3 can be traced directly to findings and recommendations in Chapter 16 (State of the Profession) of the Decadal report. The State of the Profession chapter also highlights the need for "thoughtful engagement and the creation of genuine relationships" with Indigenous Nations, as discussed in LSSW-13 Finding 5. The importance of international cooperation and coordination (LSSW-13 Finding 6) is discussed in numerous contexts throughout the Decadal Survey. Some of the science questions and technology challenges discussed in LSSW-13 Finding 7 are also discussed in the Chapter 19 (Human Exploration) of the Decadal report. Finally, LSSW-13 Finding 4 is supported by text in the Human Exploration chapter that notes: "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."

[20] Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032.

Appendix A

The program for LSSW-13, together with links to recorded sessions (hosted on YouTube, with closed captions available), is included below. Presentations were recorded unless presenters requested otherwise. Recordings are also archived at: https://lunarscience.arc.nasa.gov/lssw/inclusive-lunar-exploration/.

Wednesday, January 26, 2022

Time (PST)	Time (EST)	Speakers (*)	Title
INTRODUCTION [Link to recording]			
9:00 a.m.	12:00 p.m.		Welcome
9:05 a.m.	12:05 p.m.	Kristen Bennett, Parvathy Prem	Workshop Overview, Goals, and Ground Rules
9:15 a.m.	12:15 p.m.	Dave Draper	Diversity and Inclusion at NASA (Invited)
UNDERSTANDING OUR COMMUNITY [Link to recording] Session Chairs: Christian J. Tai Udovicic, Kristen Bennett Documentarian: Alex Sehlke			
9:25 a.m.	12:25 p.m.		Session Introduction
9:30 a.m.	12:30 p.m.	Edgard Rivera-Valentín, Julie Rathbun	Who is Missing in Planetary Science? (Invited)
9:40 a.m.	12:40 p.m.		Q&A
9:45 a.m.	12:45 p.m.	Jackelynne Silva-Martinez*, Herbert Silva	Diversity and Inclusion in the Aerospace Industry
9:52 a.m.	12:52 p.m.	Brian Troutman	Diversity in Space Exploration
9:59 a.m.	12:59 p.m.	Adeene Denton	Untangling Feminism, Nationalism, and Space Exploration in the Age of Artemis
10:06 a.m.	1:06 p.m.		Q&A
10:11 a.m.	1:11 p.m.		Discussion: Sharing Stories and Experiences
10:40 a.m.	1:40 p.m.		Break
CREATING SYSTEMIC CHANGE [Link to recording] Session Chairs: Lori M. Pigue, Parvathy Prem Documentarian: Christian J. Tai Udovicic			
11:10 a.m.	2:10 p.m.		Session Introduction
11:15 a.m.	2:15 p.m.	Ryan Watkins	Promoting Inclusive Work Environments: PRISM Inclusion Plan Pilot Program (Invited)
11:20 a.m.	2:20 p.m.	Janet Vertesi	Social Science Insights for a Diverse Lunar Workforce (Invited)
11:30 a.m.	2:30 p.m.		Q&A

Time (PST)	Time (EST)	Speakers (*)	Title
11:35 a.m.	2:35 p.m.	Eleanor S. Armstrong	Communities and Public Narratives (invited)
11:45 a.m.	2:45 p.m.		Q&A
11:50 a.m.	2:50 p.m.		Discussion: Sharing Strategies and Resources Part I
12:15 p.m.	3:15 p.m.		Break
PATHWAYS AND BRIDGES [Link to recording] Session Chairs: Nandita Kumari, Kristen Bennett Documentarian: Lori M. Pigue			
12:40 p.m.	3:40 p.m.		Session Introduction
12:45 p.m.	3:45 p.m.	Kathryn Gardner-Vandy	The Braided River STEM Workforce Development Model: Applications for Lunar Science (Invited)
12:55 p.m.	3:55 p.m.		Q&A
1:00 p.m.	4:00 p.m.	Sara Torres	Exploring the "How" of Contributing to Equity, Inclusion, Diversity in the Lunar and Planetary Community (Invited)
1:10 p.m.	4:10 p.m.		Q&A
1:15 p.m.	4:15 p.m.	Caitlin Ahrens*, C. Runyon	Bringing Lunar Science to the Deaf and Blind Communities
1:22 p.m.	4:22 p.m.	Alexandra Matiella Novak*, A. Shaner, C. Shupla, L. A. Rubino-Hare, S. Shebby, S. Buxner	Preparing for More Inclusive Public Engagement
1:29 p.m.	4:29 p.m.		Q&A
1:34 p.m.	4:34 p.m.		Discussion: Sharing Strategies and Resources Part II
1:54 p.m.	4:54 p.m.		Reflections
2:00 p.m.	5:00 p.m.		Adjourn

Thursday, January 27, 2022

Time (PST)	Time (EST)	Speakers (*)	Title
OUTER SPACE FOR ALL [Link to recording] Session Chairs: Caitlin Ahrens, Parvathy Prem Documentarian: Nandita Kumari			
9:00 a.m.	12:00 p.m.		Welcome
9:05 a.m.	12:05 p.m.	Kristen Bennett, Parvathy Prem	Day 1 Recap, Goals, and Ground Rules Reminder
9:10 a.m.	12:10 p.m.		Session Introduction

Time (PST)	Time (EST)	Speakers (*)	Title
9:15 a.m.	12:15 p.m.	Elisha Jhoti*, G. D. Tolometti, A. Link, A. C. Stadermann, N. B. Treviño	NextGen Lunar Exploration Ethics Panel Summary
9:25 a.m.	12:25 p.m.	Edythe E. Weeks	Methods for Including Everyone in the Outer Space Development Processes: Space Law Provisions (Invited)
9:35 a.m.	12:35 p.m.		Q&A
9:40 a.m.	12:40 p.m.	Richard Shope	Relationships and Conflicts Between Indigenous Nations and Space Agencies (Invited)
9:50 a.m.	12:50 p.m.		Q&A
9:55 a.m.	12:55 p.m.	Linda Billings	The Language and Culture of Space Exploration (Invited)
10:05 a.m.	1:50 p.m.		Q&A
10:10 a.m.	1:10 p.m.	James Lowenthal, Aparna Venkatesan	A Call for Action from the SATCON2 Community Engagement Working Group (Invited)
10:20 a.m.	1:20 p.m.		Q&A
10:25 a.m.	1:25 p.m.		Discussion: What Does Ethical Lunar Exploration Look Like? Part 1: Perspectives
10:45 a.m.	1:45 p.m.		Break
TECHNICAL CHALLENGES AND SOLUTIONS **[Link to recording]** Session Chairs: Christian J. Tai Udovicic, Kristen Bennett Documentarian: Alex Sehlke			
11:10 a.m.	2:10 p.m.		Session Introduction
11:15 a.m.	2:15 p.m.	Karl Hibbitts	The Expected Scale of Sustained Resource Extraction from the Lunar Surface
11:22 a.m.	2:22 p.m.	Marc Avila*, C. Heinicke	Where Do We Want to Go? Sustainable Human Mars Exploration as a Guideline for a Sustained Human Presence on the Moon
11:29 a.m.	2:29 p.m.	Joel Levine	Exploring the Moon Responsibly: Monitoring the Impact of Human Activities on the Structure of the Lunar Atmosphere
11:36 a.m.	2:36 p.m.	Matthew Kuhns	Masten Space Systems' FAST Landing Pads
11:43 a.m.	2:43 p.m.		Q&A
11:50 a.m.	2:50 p.m.		Discussion: What Does Ethical Lunar Exploration Look Like? Part 2: Technical Considerations

Time (PST)	Time (EST)	Speakers (*)	Title
12:10 p.m.	3:10 p.m.		Break
ACCOUNTABILITY AND ETHICAL EXPLORATION [Link to recording] Session Chairs: Alex Sehlke, Parvathy Prem Documentarian: Caitlin Ahrens			
12:35 p.m.	3:35 p.m.		Session Introduction
12:40 p.m.	3:40 p.m.	Athena Coustenis*, Niklas Hedman*, G. Kminek, COSPAR Panel in Planetary Protection	Updates to the COSPAR Policy on Planetary Protection Regarding Lunar Exploration
12:50 p.m.	3:50 p.m.	John Rummel	COSPAR's Panel on Exploration: Current Status and Potential Futures (Invited)
1:00 p.m.	4:00 p.m.		Q&A
1:05 p.m.	4:05 p.m.	Kathryn Hadler*, K. H. Joy	Leave No Trace: Remediation on the Moon After Resource Extraction
1:12 p.m.	4:12 p.m.	Elizabeth Frank	Social License to Operate for Space Exploration
1:19 p.m.	4:19 p.m.	Alex Gilbert	Space as a Human Environment: Environmental Policy and Law for the Moon (Invited)
1:29 p.m.	4:29 p.m.		Q&A
1:34 p.m.	4:34 p.m.		Discussion: What Does Ethical Lunar Exploration Look Like? Part 3: Accountability and Policy
1:54 p.m.	4:54 p.m.		Reflections
2:00 p.m.	5:00 p.m.		Adjourn

Appendix B

Discussions at the end of each session were facilitated using the collaborative virtual platform, Miro. We created a "Miro board" for each session. Each board was divided into sub-boards where participants could respond to two discussion questions, and note down general reflections. The links below provide access to participant comments (anonymous unless participants identified themselves) transcribed verbatim from the Miro boards, with related comments/responses grouped together.

Day 1 Discussions

[Link to Miro-board comments]

Session 1 (Understanding Our Community):

- What barriers or challenges to participation and belonging have you experienced or witnessed in your career? What has or would have helped in tackling these barriers?
- What would an inclusive lunar science and exploration community look like, in your view?

Session 2 (Creating Systemic Change):
- What systemic changes would you like to see implemented at institutions engaged in lunar science and exploration?
- What successes (big or small!) have you had in enacting institutional changes? What challenges have you experienced?

Session 3 (Pathways and Bridges):
- How could those of us involved in lunar science and exploration engage more meaningfully with wider communities?
- What resources would enable you to build a more inclusive professional community? What support have you received or wished for from your colleagues?

Day 2 Discussions

[Link to Miro board comments]

Session 1 (Outer Space for All):
- What does "ethical lunar exploration" mean to you? What should the community be thinking about moving forward?
- What measures (existing or new) can be taken to carry out lunar exploration in an ethical and responsible way?

Session 2 (Technical Challenges and Solutions):
- What scientific or technical challenges do you think are most important to address to enable responsible lunar exploration?
- What aspects of the lunar environment do you think are most important to keep in mind when planning for responsible lunar exploration?

Session 3 (Accountability and Ethical Exploration):
- What socioeconomic or policy challenges do you think are most important to address to enable responsible lunar exploration? How can the lunar community support policy-making processes?
- What would an ethical and responsible future human relationship with the Moon look like, in your view?