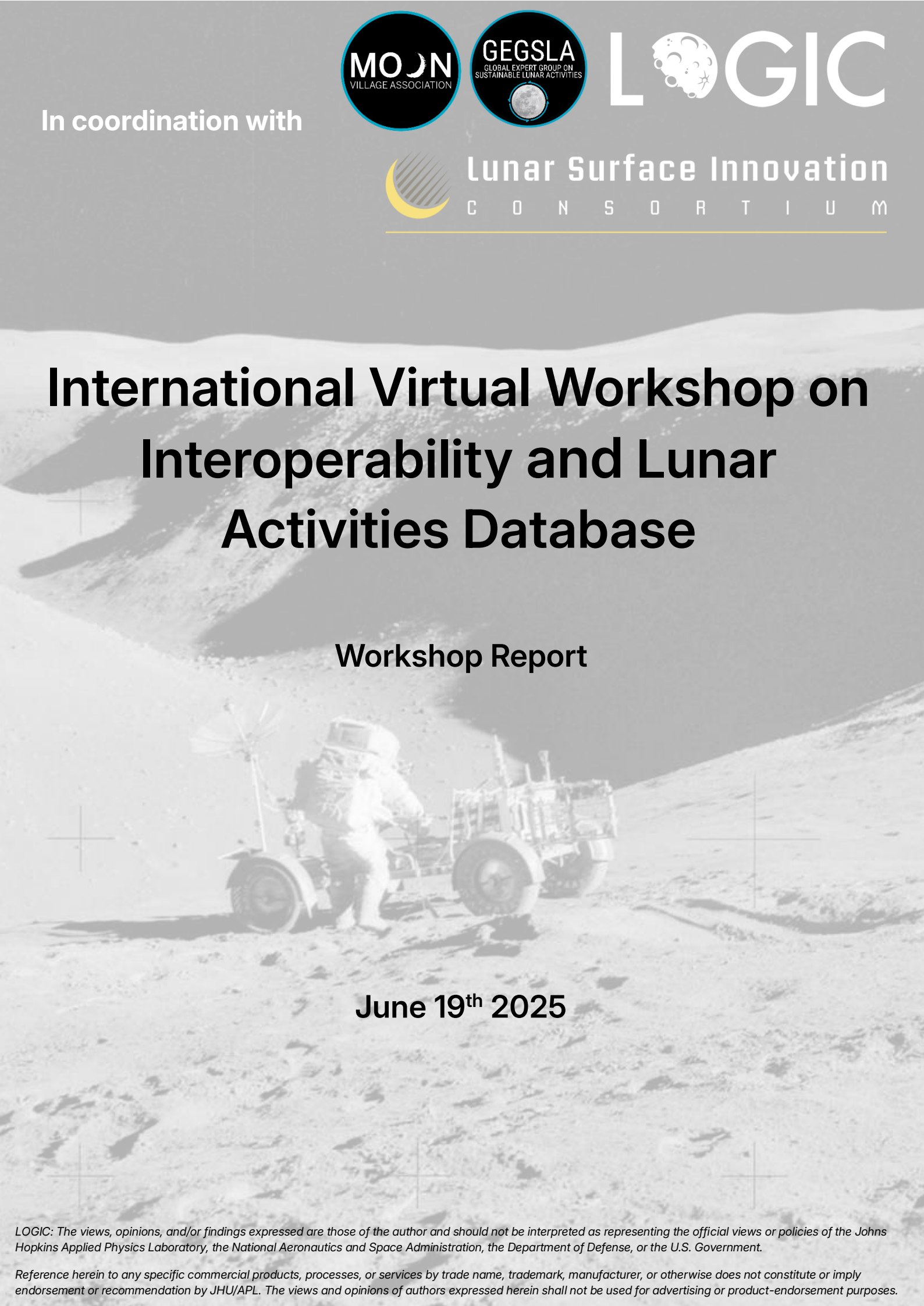
In coordination with

International Virtual Workshop on Interoperability and Lunar Activities Database

Workshop Report



June 19th 2025

Workshop Lead:

Ekaterina Seltikova, Space-Tech and Innovation Consultant / Founder, Parsec Scale

Support:

Marchel Holle, US Government Affairs Lead, ispace-U.S.

Timothy Cichan, Space Exploration Architect, Lockheed Martin

Wesley Fuhrman, APL Lead, Lunar Surface Innovation Initiative, Johns Hopkins Applied Physics Laboratory

Daniel Meidenbauer, APL Program Manager, Lunar Operating Guidelines for Infrastructure Consortium (LOGIC), Johns Hopkins Applied Physics Laboratory

Kristin Jaburek, APL Consortium Director, Lunar Operating Guidelines for Infrastructure Consortium (LOGIC), Johns Hopkins Applied Physics Laboratory

Glafki Antoniou, Operations Manager, Moon Village Association

Moderators:

Ekaterina Seltikova, Parsec Scale

Marchel Holle, ispace-U.S.

Timothy Cichan, Lockheed Martin

Kristin Jaburek, Johns Hopkins Applied Physics Laboratory

Jason Arcido, Johns Hopkins Applied Physics Laboratory

Report prepared by: Ekaterina Seltikova

Email in case of questions: ekaterina@parsecscale.com

Photo on the title page: Apollo 15 Commander Dave Scott and the LRV at Hadley Rille, NASA Archive, NASA Photo ID AS15-85-11451

WORKSHOP'S AGENDA

15:00 CEST / 9:00 ET – Introduction – (welcome, GEGSLA / MVA, LOGIC & LSIC presentation)
15:15 CEST / 9:15 ET – Expert panel
16:10 CEST / 10:10 ET – Transition to Zoom breakout rooms and Miro boards and Pause
16:30 CEST / 10:30 ET – Work in breakout rooms and Miro boards
17:20 CEST / 11:20 ET – Presenting the outcomes
17:45 CEST / 11:45 ET – Q&A / Open floor session
18:10 CEST / 12:10 ET– Conclusion and Next steps

Overall workshop duration: 3h 30

MAIN GOALS

The workshop aims to:

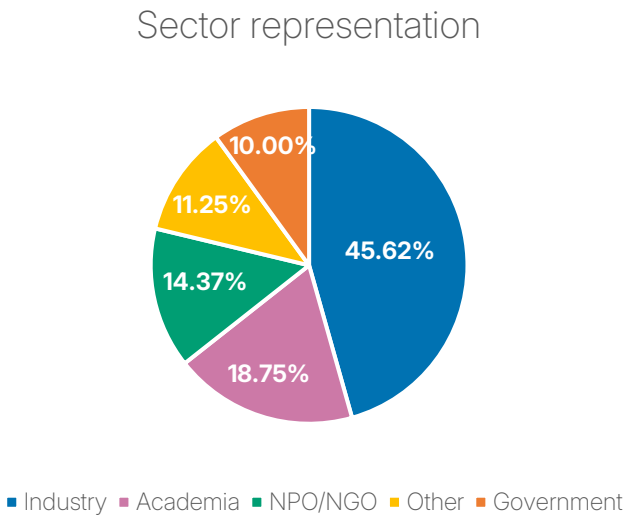
- establish international community to work on interoperability;
- identify what are the elements of lunar activities database;
- establish / decide on a coordination system and a leading body

STATISTICS

We received 160 registrations from 35 countries with majority coming from the US.

Detailed breakdown depending on the country:

United States – 89, Canada – 12, China – 6, India – 6, France – 5, Romania – 4, Nigeria – 3, Luxembourg – 3, Germany – 2, United Kingdom – 2, Greece – 2, Netherlands – 2, South Africa – 1, Australia – 1, Egypt – 1, United Arab Emirates – 1, Portugal – 1, Nicaragua – 1, Japan – 1, Venezuela – 1, Serbia – 1, Spain – 1, Kenya – 1, Ethiopia – 1, Kazakhstan – 1, Switzerland – 1, U.S. Minor Outlying Islands – 1, Trinidad and Tobago – 1, Turkey – 1, Hungary – 1, South Korea – 1, Pakistan – 1, Italy – 1, Morocco – 1, Israel – 1.



The largest proportion of registrations came from the Industry sector, comprising 73 participants (45.62%). Academia accounted for 30 participants (18.75%), marking it as the second-largest group. The NPO/NGO sector was represented by 23 participants (14.37%). Government attendees totaled 16 (10.0%), pointing to an interest from policy makers, public sector officials, or regulatory bodies. The 'Other' category accounted for 18 participants (11.25%).

INTRODUCTION

The event opened with three briefings from organizations that supported the workshop. Although each organization has a distinct mandate, the speakers collectively underlined a shared commitment to interoperability first and to making lunar data openly usable long before hardware is on the surface.

Giuseppe Reibaldi
MVA / GEGSLA

Kristin Jaburek
LOGIC

Wesley Fuhrman
LSIC

Moon Village Association (MVA) / Global Expert Group on Sustainable Lunar Activities

Giuseppe Reibaldi traced the origins of the MVA back to 2017, describing it as a neutral, non-governmental platform that convenes agencies, industry, academia and the public to tackle cross-cutting lunar governance issues. He explained how the MVA incubated the Global Expert Group on Sustainable Lunar Activities (GEGSLA) in 2022, bringing together more than forty national representatives. In 2023 the group published the landmark "Recommended Framework and Key Elements for Peaceful & Sustainable Lunar Activities," which now serves as an informal reference for many Article XI information-sharing discussions. GEGSLA has entered an operational phase with three active working groups - Environmental Protection, Technical Coordination and Multi-Stakeholder Coordination. Reibaldi urged participants to use the workshop to "build the bridge from principles to practice" and to identify concrete next steps for the Lunar Activities Database.

Lunar Operating Guidelines for Infrastructure Consortium (LOGIC)

Kristin Jaburek introduced LOGIC as an international consortium launched in 2024, funded by DARPA and managed by the Johns Hopkins Applied Physics Laboratory. LOGIC already counts 1000+ members spanning commercial, government, academic and non-profit sectors. Its mission is to catalogue, adapt and - where gaps exist - author interoperability standards so that future lunar infrastructure (power, comms, PNT, ISRU) can function as a cohesive system. LOGIC operates monthly community working groups and publishes public-facing draft recommendations on its website. Highlighting the consortium's move from analysis to action, Kristin announced an upcoming community-led experimentation campaign that will test key interface standards in hardware-in-the-loop demonstrations. She invited workshop participants to join LOGIC's mailing list and to "pressure-test" proposed data fields for the Lunar Activities Database.

Lunar Surface Innovation Consortium (LSIC)

Wesley Fuhrman positioned LSIC as NASA STMD's five-year-old community dedicated to advancing the technology side of lunar surface systems. With hundreds of members - including many also active in LOGIC and GEGSLA - LSIC provides roadmapping workshops, technical interchange meetings and grant-funding "sandboxes" to accelerate innovation. Wesley stressed that standards and technology development must co-evolve: "you can't standardize what hasn't been invented, but clear interface definitions unleash innovators on either side of the boundary." He closed by encouraging attendees to view the Lunar Activities Database as a living tool that will both consume LSIC test data and inform future technology priorities.

EXPERTS PANEL

Aarti Holla-Maini
(video message)
Director, UN Office for Outer Space Affairs

Mehak Sarang
Director of Industry Integration, Open Lunar Foundation

Frederick A. Slane
Executive Director, Space Infrastructure Foundation

Ulpia-Elena Botezatu
Co-Chair, Action Team on Lunar Activities Consultation

Marchel Holle
US Government Affairs Lead, ispace-U.S.

Ekaterina Seltikova
Moderator and Founder, Parsec Scale

The expert panel opened with a video message from Aarti Holla-Maini. The director of UNOOSA stressed out the need to ensure the compatibility and interoperability between systems and infrastructure. Interoperability standards - covering essentials such as life-support and PNT - should emerge through an inclusive, collaborative process rather than one party's standards being imposed on others. She commended the community-driven efforts of GEGSLA, LSIC and LOGIC and explained how the UN Office for Outer Space Affairs (UNOOSA) is elevating these discussions through its new "One Moon for All" program. Recent examples include the first UN Conference on Sustainable Lunar Activities, which paved the way for ATLAC (the COPUOS

Action Team on Lunar Activities Consultation), and progress on an online Article XI information-sharing database. The message to participants is clear: 1) align with existing COPUOS and UNOOSA initiatives to avoid duplication and amplify impact; 2) provide expert input so that industry and civil-society perspectives influence multilateral decisions. 3) embrace a synergistic, complementary approach - building on one another's work - to achieve a peaceful, sustainable, interoperable lunar future under a shared vision of "One Moon for All."

What would 'interoperability done right' look like in 2030 ?

After the insights from Aarti Holla-Maini the panel followed with a question from a moderator: "What would 'interoperability done right' look like in 2030 ?" Mehak Sarang, representing Open Lunar Foundation, provides a following framing: "For us, interoperability done right means that all lunar actors, whether public or private, can access, contribute to, and adopt interoperability standards and practices.". She argued that standards must reduce mission risk and prevent duplication of effort or investment, and enable responsible coordination without handing control to a single authority / body. Openness, collaboration and transparency are also one of the elements. "I think the question we have to ask ourselves is from now until 2030, what is the vision that we can set now. That allows us to actually give practices to these actors to implement those principles and lead to a truly interoperable practice and community."

Frederick Slane reminded participants that achieving formal international standards - particularly through the International Organization for Standardization (ISO), which the UN chartered in 1947 - follows a rigorous process that typically takes three to eight years from concept to publication. There is already a body of experts - ISO (164 technical committees), but each country need to engage its own national standards body (e.g., ANSI-NIST in the United States) early since the member bodies from nations are the national standards bodies from each country, so be in touch with your national standards bodies and articulate the need for creating the standards for specific activities. At the same time Frederick Slane poses a question "What is interoperability in a lunar environment?". There is a need to ask this question, come up with a stated objective to be able to break the problems down into manageable pieces. Again, we already have the actual body of experts that are ready to contribute and to help the industry to move forward.

Marchel Holle spoke from a commercial operator's standpoint. Integrating bespoke customer payloads already consumes significant time and money; layering interoperability requirements on top therefore carries an opportunity-cost that companies must justify. To accelerate adoption, he proposed that monetary incentives offset the up-front resource burden of attending workshops and investing in standards work. He warned that without early, coordinated action the lunar community risks a chaotic "lunar babble" (he mentions that he heard this concept from Paolo Pino (Volta Space)): dozens of missions unable to share power, communications or data, wasting tens of millions of dollars on non-integrable systems - "This is such a big missed opportunity". Yet, he also cautioned against prescribing standards too early. The sector is still learning about critical factors such as plume-surface interactions and safety zones dimensions; locking in architectures prematurely may stifle better solutions.

Ulpia Botezatu outlined the UN's evolving consultation framework for lunar activities. Adopted at the 2024 COPUOS plenary, ATLAC facilitates focused, expert-level exchanges aimed at improving consultations related to lunar activities considering different options, like whether to recommend a new international coordination mechanism. The team's initial work-plan prioritizes: consultation and awareness-raising; information and knowledge sharing; preservation of lunar activities; and interoperability, explicitly tied to information-sharing requirements. Ulpia invited

workshop participants to access ATLAC documents via the UN website and offered to assist in aligning community efforts with COPUOS processes.

Lessons learned: existing solutions

Frederick Slane urged the workshop to inventory existing technical standards before drafting new ones. He highlighted the Consultative Committee for Space Data Systems (CCSDS) - a 40-year-old coalition of space agencies that maintains ≈ 140 free standards covering communications, security, cross-support and even in-space wireless communication. CCSDS documents are "double-hatted" into ISO, and while CCSDS materials are free to download, ISO standards comes with a cost (≈ 180 fee-based ISO space standards, spanning design engineering, interfaces and verification, operations and environment, program management & quality, materials & processes, space (orbital) debris, enterprise architecture, etc.). He noted that industry-led efforts such as CONFERS (on-orbit servicing) have already flowed into this system, proving it can absorb new domains.

Minimum data fields

Mehak Sarang delivered a detailed preview of Open Lunar's flagship "Lunar Ledger" registry, scheduled to go live in the autumn of 2025. She argued that while launch mass is still extraordinarily expensive, every kilogram sent to the Moon must "amplify and assist" others - and that can only happen if mission-critical information is discoverable and interoperable now, not later.

The Ledger will serve as a central, voluntary repository of mission data, starting with assets that are already operating or expected online within the next two years. To lower the barrier to entry and minimize controversy, the initial schema captures only high-value, safety-relevant fields that require minimum coordination: 1) Landing/impact coordinates or orbital plane, 2) Planned activity type and operational timeframe, 3) Operator identity and emergency contact, 4) General operational area. Fields such as detailed trajectories, payload specifications and end-of-life plans are deliberately deferred until trust is established.

Design principles are modularity and full voluntariness. Commercial partners choose what to share, yet the architecture allows contributors to expand over time, for example, by uploading radio-interface standards for a future relay. Sarang positioned this incremental approach as a catalyst for the wider Lunar Activities Database conversation: by solving immediate coordination problems, the Ledger will seed the habit of data sharing and open the door to richer standards as lunar activity scales.

Operator's view of data gaps

Marshall emphasized the growing complexity and potential conflicts in lunar activities over the next few years. He noted that while today's concept of interoperability, such as one rover plugging into another lander, may seem far-fetched due to the sparse distribution of landers, the future will be different. With over 100 planned missions from more than 35 countries and the advent of frequent lunar transport (e.g., Starship-class vehicles), the density of operations on the Moon will increase significantly, leading to more conflicting activities.

He identifies a critical need to understand and share data on plume impingement, especially as larger landers begin landing. Questions arise about how much regolith is lofted into the exosphere, whether it affects satellite performance, and how it compares to similar phenomena on Earth.

Marshall then addressed a key tension between transparency and proprietary data in the context of commercial lunar operations. He acknowledged the value of data related to lunar resources, such as location and quality of resources, highlighting that such data is highly valuable and non-perishable. Unlike on Earth, where legal frameworks exist to claim mineral rights, lunar missions lack such mechanisms, making possession of data a critical competitive advantage.

As missions become more complex and commercial, Marshall foresees challenges in balancing information sharing. While stakeholders may agree on sharing basic mission details (e.g., location, timing, activities), there will be uncertainty over how much proprietary information should be disclosed. He highlights this as a tension between the Open Space Treaty (OST) ideal of transparency and the practical need for companies to protect their competitive edge, whether it relates to mission locations, radio systems, or propulsion technologies. He concluded by recognizing no clear solution exists yet, but stresses the importance of addressing this balance to ensure effective and cooperative lunar activities.

ATLAC and Knowledge from the industry community

Ulpia emphasizes the importance of involving industry, academia, and expert communities in the activities of ATLAC. She explained that currently, the group is in an early phase where UN member states are still finalizing the work plan and list of potential priority topics for discussion.

She noted that once this phase is completed, hopefully by next week when COPUOS (Committee on the Peaceful Uses of Outer Space) starts, the ATLAC will shift from being tied to the member states to being more connected to a list of appointed delegates. This delegate list is still open, and member states are responsible for selecting the individuals or institutions, from industry, government, or academia, that they wish to invite.

In addition, Ulpia explained that discussions will be opened to experts, depending on the specific topics identified for discussion. The goal is to invite experts from diverse sectors to contribute their positions and insights, but this will occur in a later stage of the process.

Intellectual property

Frederick Slane responded to Marshall's earlier remarks by highlighting a key issue—intellectual property (IP). He underscores the importance of IP management in the context of technical standards, referencing a Harvard Business School study that analyzed how organizations handle internal IP while also interfacing with a broader community.

Slane introduced the idea that a technical standard can function as a "block" of intellectual property—essentially acting as a buffer zone between the public domain and private entities. This interface allows commercial entities to engage with the wider community while still protecting their proprietary interests.

He argued that this balance is critical, especially for commercial actors who must demonstrate return on investment and manage other business considerations. Slane concluded by emphasizing that commercial participation in standard development is vital to ensure their IP is protected and that they can effectively contribute to and benefit from community-wide standards.

Who can be a credible steward for standards adoption?

The group engaged in a discussion about the characteristics that a credible standards stewardship body should possess.

Mehak responded first, drawing from historical analogs and pointing to the development of internet protocols as a successful example. She noted that these standards began with a working group and were adopted through mandates by the Department of Defense, followed by community input and refinement. Mehak emphasized that collaboration is essential and recognized the varying needs of different communities. She highlighted that standards must be adaptable and subject to ongoing reform. Reflecting on her experience as a payload manager in CLIPS programs, she observed that scientists and engineers often speak different technical languages, with scientists relying on older standards and engineers adopting more modern, modular approaches. Therefore, she argued that standards should be modular, adaptive, and open to community feedback.

Fred followed by offering concise keywords: "common terms and definitions" to ensure mutual understanding, and "risk versus mission assurance," which she described as two sides of the same coin in the context of standardization.

Ulpia then added that all stakeholders must start from a place of common understanding. She explained that the work within ATLAC begins with the recognition that creating this understanding requires open dialogue. According to her, the first step is to establish a structure that is both transparent and inclusive, integrating the diverse languages, needs, and communities involved. She identified "consultation" as the essential keyword in this process.

Marshall contributed by reflecting on the challenge of balancing prescriptiveness with flexibility. He argued that a standard must be rigid enough to have significance, yet light enough to accommodate the capabilities of smaller actors, such as a five-person lunar infrastructure startup. These small companies often face resource constraints and must carefully allocate limited funding, such as SBIR grants, toward hiring and operations. If standards are too demanding, they risk excluding such participants. Marshall emphasized that standards should support, not hinder, commercial engagement, and he framed the challenge as achieving a balance between cooperation and competition.

The discussion coalesced around the concept of "balance" as a central theme: balancing the need for effective, meaningful standards with the practical needs of diverse actors, and balancing the ideals of cooperation with the realities of competition.

Incentives for undecided actors

The conversation begins with a question about what types of incentives, technical, reputational, or financial, can motivate undecided actors to adopt interoperability standards. Marshall had previously mentioned financial incentives, prompting a broader reflection on other motivating factors.

Mehak emphasized that given the high-risk nature of lunar activities, there must be a clear conversation about building resilience through interoperability. Each lunar landing currently carries significant risk, and having even minimal data exchange between assets on or around the Moon could reduce this risk. The incentive for cooperation, they argued, is that if the overall risk level does not decrease over time, funding and investment in lunar activities may diminish due to a lack of confidence in the commercial viability of such missions. Thus, cooperation is essential for proving that lunar exploration is becoming less risky and more sustainable.

Fred shared their personal experience with canceled programs, noting that 80–90% of the programs they had worked on, ranging from small to large-scale, were eventually canceled despite significant investment. They observed that governments often spend billions on such

programs but neglect to engage with the standards community, which leads to a loss of all progress when these programs fail. They suggested that capturing the knowledge and experiences, especially lessons from failures (e.g., landing issues, navigation problems, signal losses), in the form of technical standards can help preserve valuable insights. Importantly, they argued that identifying problems is as critical as identifying solutions, and that sharing experiences of what went wrong could be a fertile ground for defining future standards.

Marshall agreed, emphasizing the importance of transparency and sharing lessons learned across the community. Speaking from his experience, not as a company representative but as an observer, he noted that companies like SpaceX have pioneered a model of iterative progress and resilience, with the mindset to "never quit the lunar quest." He stressed that achieving a thriving lunar exploration ecosystem requires a collective effort: competitors must also act as collaborators to realize this shared vision.

Finally, Ulpia built on the earlier remarks by underlining that a common understanding cannot arise spontaneously; it is the product of ongoing discussions and organized engagement among various stakeholders. She proposed that forming a platform or informal organization for such discussions could be the first step toward developing technical standards. This platform would allow entities to share lessons learned, operational challenges, and future concerns, creating a collaborative space that, over time, would naturally lead to the establishment of shared standards. She concluded by noting that simply coming together and talking would be a meaningful and achievable outcome of the current discussion.

Q&A session

The Q&A session began with a question for Fred about how to collaboratively advance outer space interoperability and technology standards through ISO, supported by national partners, and how to begin this dialogue at the national level. Fred responded that understanding a country's standards network is crucial. He encouraged individuals to identify their national contacts, especially within their national standards body, and to engage with those active in the community, including Fred himself. He explained that sometimes there are overlaps in work, for example between terrestrial and lunar navigation, which involves various organizations like USGS and geophysical societies. Navigating this complex network and finding one's voice within it is essential.

One of the participants noted that NASA had conducted a survey on data gaps and interference, with results published. That NASA work has since stopped, but a link was shared in the chat.

Another comment raised concerns about data sharing with COSPAR, suggesting that commercial operators should be encouraged to send more data. At a Helsinki meeting, there were complaints that U.S. claims to COSPAR were mostly routed through contract operators, which was seen as suboptimal.

Another participant thanked Fred for emphasizing that standards should focus on interfaces and secondary preparation, calling this a key aspect. Another comment pointed out that while governments and agencies think in terms of missions, commercial industry focuses on financially viable operations, suggesting a disconnect in perspectives.

Ulpia then added a final comment, building on her earlier remarks. She observed that some participating organizations reflect a U.S.-centric perspective, but global voices need to be integrated. Wearing her UN hat, she emphasized the need for common approaches and

proposed that MVA (Moon Village Association) could serve as a platform for further international consultation, especially in connection with International Moon Day.

Another chat comment reinforced the idea that identifying problems is more important than just offering solutions, since one must first understand the problem to solve it.

A question was then posed to Marshall: from an industry perspective, what makes companies willing to share information, particularly in a database? Is legal enforcement (international or domestic) helpful? Marshall responded that businesses respond to incentives, especially financial ones, which can be multifaceted. He used the space debris problem as an analogy, explaining that decades of uncoordinated action have created challenges that are now difficult to reverse. He stressed the need to act early and responsibly to reduce risk for everyone. While such actions may not yield immediate impact, they will be critical when many missions begin landing on the Moon simultaneously. At that point, there will likely be a strong wish for established structures and norms for sharing information.

Further chat comments discussed the lack of specialization in current lunar rovers and the need for infrastructure that builds on itself.

MIRO BOARDS OUTCOMES

All attendees were divided into 5 groups and were proposed a Miro board with 10 questions to work on. The set of questions was identical for all groups. Below you can find a summary of all ideas / suggestions for all 10 questions. Every group / breakout room had a moderator to organize the discussion.

***Question 1**. In your view, what are the most urgent challenges around space interoperability that justify the creation of a shared database to mitigate potential harmful interferences?*

Participants highlighted **safety, mission assurance, and environmental risks** as key drivers for developing a shared interoperability database. One major concern was **surface plume interactions**, with several respondents noting the **lack of predictive models** to assess **environmental impacts** like **lunar dust** and **electromagnetic interference**. This ties directly to the **need for rules to protect surface investments** and **operational assets**, especially in **crowded landing zones** such as the **Moon's south pole**.

Another recurring theme was the **importance of shared planning and communication**, including **letting others know operational zones and schedules** to avoid interference. This relates to **deconflicting use of preferential sites** (e.g., areas with solar power potential or scientific value) and **avoiding conjunction events** or **landing site conflicts**.

Participants also emphasized the **lack of current standards**, both in **technical systems** (like **power distribution voltages** and **communications**) and in **processes** (such as **asset tracking, navigation**, and **mapping**). They called out the need for **common standards among major space actors** (ESA, NASA, ISRO, China, Japan) and raised concerns about **interoperability of Positioning, Navigation, and Timing (PNT)** systems.

Some participants viewed the database as essential for **interoperability beyond interference mitigation**, supporting **reuse, autonomy, human-machine teaming**, and **operational**

efficiency. Others noted **financial constraints**, including the **high cost of data** and **low availability of large datasets**, particularly for early missions.

Finally, there were mentions of **risk acceptance** in extreme environments, the **need to aid others per the Outer Space Treaty**, and the importance of **creating an evolutionary framework** for interoperability standards over time. **Safety** and **investor confidence (mission assurance)** were named as critical entry points for standardization efforts.

Question 2. *What specific types of data should be included to ensure we effectively capture and prevent harmful interferences, while adhering to the principle of 'do no harm'?*

Participants provided a detailed and multifaceted list of data types necessary for **preventing harmful interferences** in space operations. At the core, many responses emphasized the importance of **mission-specific information**, including **mission or campaign name, company and point of contact (POC), objective, launch date, landing site coordinates, operating area boundaries, operation duration,** and **status updates.** This baseline information would allow for **situational awareness** and **planning coordination**.

There was strong emphasis on **spatial and temporal data**, such as **timestamped and spatially referenced activity logs, landing times,** and **traverse routes**. **Activity descriptions** should include **location, time span, hardware used,** and **post-activity impact on the lunar surface**.

For **environmental and safety-related concerns**, participants recommended including data on **plume modeling** (e.g., **thrust vectors, exhaust composition, dust redistribution**), **radiation emissions, power beaming volumes, off-gassing and overboard venting**, and **surface alteration metrics**. **Planetary protection data** and **space weather** data were also identified as essential.

Communication data was another key focus, including **frequency bands used, communication protocols, power levels, times of use**, and **potential unintentional frequency emissions**. Similarly, **power interface specifications** (e.g., **voltage, current, routing**) were noted, along with **hardware compatibility specs** to aid in interoperability.

Several entries referenced the need for **human safety data**, such as **life-support interface details, emergency contacts**, and **activity schedules** for crewed missions. Others emphasized **scientific and environmental considerations**, like **sensitive science locations, desired expansion areas, traffic corridors**, and **geological surveys**.

Participants stressed that the database should include both **current and planned asset locations**, and also **"historic" data**, analogous to weather data, to aid **predictive modeling**. Some called attention to **externalities and surface manipulation plans** as potential sources of interference, requiring disclosure.

At a higher level, respondents acknowledged that **interference is multi-dimensional and subjective**, noting that the **definition of interference will be debated for years**. There was a call to address **form, fit, and function** data, and the **externalities relationship to successful operations**.

Finally, references were made to existing resources, and it was suggested that **telemetry, diagnostic data, camera feeds, error codes, terrain, topography**, and **stakeholder schedules** all be considered for inclusion.

Question 3. *Who should own or oversee the database (e.g., a global coalition, a specific agency, a new coordinating body), and why?*

Participants expressed a **diverse range of views** on the ideal ownership and oversight of the interoperability database, reflecting **concerns over neutrality, trust, efficiency, and technical capability**.

Several participants suggested that the database should be managed by an **international, independent, and neutral organization**, with examples including **ISO (for standards)** or a **new entity specifically created** for database oversight. Some suggested a **multi-lateral coordinating body**, possibly under **COSPAR** or an **extension of UN space governance**, with **equal representation from government, commercial, and academic sectors**. This structure would aim to **avoid nationalization, ensure credibility**, and **enable technical oversight**.

There was both support and skepticism regarding the **United Nations**. While some proposed that **UNOOSA** or **COPUOS (via ATLAC)** could play a role, others argued that the **UN is too slow-moving** and **discussion-heavy**, making it less suited for timely decision-making. In addition, the United Nations potentially do not have the funding to perform that function. Alternatives like the **International Telecommunication Union (ITU)** were also mentioned, given its relevance to space communications.

Other participants recommended the creation of a **new organization**, such as the **Lunar Development Cooperative (LDC)**, which would **provide infrastructure and enforce legally binding contracts** tied to shared standards. Some envisioned this being set up as a **non-profit**, e.g., a **501(c)(3)** if based in the United States.

Several comments proposed a **decentralized or multi-entity model**, where **various organizations (governmental and corporate)** maintain their own databases, but **interoperability is achieved through standardized terms and definitions**. One participant highlighted the **need for collective data sharing across multiple platforms**, potentially managed by **AI systems**, though this would require careful attention to **future AI and security concerns**.

Examples of existing governance models included **Space ISAC** and **Wikipedia Foundation**, with **IUPAC** cited as a model for scientific collaboration. One respondent suggested **national-level management for legal or IP-sensitive data**, with **international-level oversight for less sensitive data**, and **voluntary participation for more detailed contributions**.

In summary, while there was **no consensus**, the key priorities were **neutrality, independence, technical competence**, and **flexibility**, with varying degrees of support for **UN involvement, new institutions**, and **decentralized frameworks**.

Question 4. *Should there be one unified international database or multiple specialized databases, and how do we avoid duplication and confusion?*

Participants offered **two main perspectives**: one favoring a **unified international database**, and the other supporting a **federated or tiered system**. A **unified database** was viewed by many as **ideal for efficiency**, **reduced overhead**, and **preventing miscoordination**, especially in a context involving **multiple domain stakeholders**. Some described this vision as **utopian**, recognizing the **challenge of building a single system** but arguing that it is **easier to start with partial implementations** and scale up.

Many others advocated for a **federated architecture**, where there is **one international schema or top-level database**, with **specialized modules or linked databases** maintained by domain experts (e.g., for **propulsion, communications, surface operations**). This approach was seen as a way to **avoid duplication** while **leveraging specialized expertise**, allowing **tiered or firewalled access** depending on **regulatory or IP concerns**.

To **encourage participation**, several responses suggested the use of **incentives**—such as **restricted access for non-members** or benefits for contributors. Others mentioned the possibility of **emergency response agreements** or **legal mandates**, though it was acknowledged that **sharing commercially sensitive data** remains difficult.

Some participants questioned whether **duplication is inherently problematic**, suggesting that **consistency of data** is more important than strict unification. Others proposed **blockchain solutions** for **transparent data registration** (e.g., **astroprotocol.io**) or systems resembling **Wikipedia**, which are **centralized but collaboratively maintained**.

A few responses recommended a **common data framework and standard definitions** to integrate multiple systems and reduce confusion, emphasizing that **interoperability** could be achieved even across **tiered relational databases** if **standardized terminology** and **interfaces** are used.

In summary, while **one unified database** was broadly seen as **ideal**, many favored a **pragmatic federated or tiered model**, combining a **central access point** with **linked specialized databases**, and supported by **shared standards and incentives** to foster participation and consistency.

Question 5. *How can we ensure all stakeholders (space agencies, companies, academia, nonprofits) contribute to and agree on a single database architecture and data standards?*

Participants recognized the **difficulty, if not impossibility, of achieving full stakeholder consensus**, especially given the **diverse interests and regulatory environments** across countries, agencies, and commercial entities. Some explicitly stated that **complete participation is unlikely**, noting that **each country has its own approval processes**, and that **government and commercial missions follow different pathways**. Several suggested that **cultural differences** and the lack of a **shared value system** make it hard to foster **global harmony**, unless a **common lunar culture** can emerge, though they questioned whether that's achievable in today's world.

Despite skepticism, many participants proposed **practical mechanisms to encourage broad participation**. A common theme was the use of **incentives**, such as **gaining access to the database** only if missions **submit metadata** and **commit to harmonized standards**. There were also suggestions that the database could become a **platform to connect customers, suppliers, or partners**, adding **commercial value** and incentivizing engagement.

Several recommended **pre-mission interoperability compliance frameworks**, modeled on **launch licensing**, where participation is **regulated or mandated** by governments. **Legal and insurance frameworks** could also play a role—**accepting risk of failure and enabling legal recourse** might encourage entities to **comply voluntarily** with database standards to reduce their liability.

Technical solutions included using **modular APIs**, **public SDKs**, and **existing technical standards** to **lower the compliance burden** and foster **international buy-in**. Some suggested using **standards for database queries and information exchange**, even if a **single database architecture is unrealistic**. Others proposed **blockchain-based systems** with **smart contracts** to control access and enable **peer-to-peer file sharing** (e.g., via **Exovault.io**).

There were calls for **standardization of common fields**, especially those **intrinsic to lunar operations** (like position or trajectory), and for **government regulations** that **enforce database participation**—at least within specific jurisdictions. Some suggested that while **technical standards may not require universal agreement**, **open standards would yield efficiencies** that could motivate stakeholders to adopt them voluntarily.

Workshops and community engagement were seen as essential for **building consensus and recognizing shared value**. **Recognized standards**, **coordination on data collection**, and a **clear return of value to the community** were also cited as necessary for broad participation.

In conclusion, while **universal agreement may not be realistic**, a combination of **legal frameworks**, **technical ease-of-use**, **incentives**, and **community-driven value** could encourage wide, if not complete, participation.

Question 6. *How should data be validated or verified (e.g., open input vs. official confirmation), and who should be responsible for overseeing data accuracy?*

Participants proposed a variety of approaches for **data validation and oversight**, with many suggesting a **tiered or structured model**. One widely supported idea was a **three-tier validation system**, where **Tier 1** is **self-reported mission data**, **Tier 2** involves **peer confirmation**, and **Tier 3** requires **ground-truth verification** (such as imagery from landers or orbiters). Oversight in this system could **rotate among contributors** or be assigned to a **neutral third-party review panel**.

Another common proposal was the use of a **moderator or curator**, responsible for **reviewing data submissions** and possibly **interviewing data providers** before the information is posted. Some participants stressed that **operators should be responsible for their own data entry**, with **periodic checks** by database overseers to ensure ongoing accuracy.

There was also a suggestion that **commercial industry** could support validation activities, but that **accreditation by an oversight body** might be necessary, especially for **compliance verification**. In line with this, participants noted that **standard compliance assessment** is already common globally and typically handled by **third parties**. In such cases, **only verified compliance data is made public**.

Some contributors raised **concerns about intentional misreporting**, while others suggested that allowing for **low precision or uncertainty levels** could be a practical solution in early exploratory phases, especially when dealing with **proprietary results**. This ties into the recommendation to include **uncertainty quantification** in the **data structure** itself.

Technical solutions included **blockchain-based registries** (e.g., **cislunar.id**) to provide **tamper-resistant data timestamps** and **transparency of updates**. Others emphasized **timeliness of data entry** and the need for **data baselines**, possibly in the form of a **design reference entry**, to help contextualize open data.

The idea of **fusing multiple datasets** for **cross-validation** was proposed, reinforcing a **"trust but verify"** model. One suggestion was to **validate data against known standards or reference datasets**, ensuring that data is **verified against something tangible**.

In conclusion, while **self-reporting and openness are valued**, most participants favored **moderation, third-party oversight, and tiered validation**, supported by **standards compliance checks**, **timestamping**, and possibly **blockchain registries** to ensure **data integrity and trustworthiness**.

Question 7. *What existing policies, norms, or technical standards can we build upon to streamline data collection, sharing, and interoperability?*

Participants identified a broad array of **existing frameworks, standards, and policies** that can serve as **foundations for space data sharing and interoperability**. A key recommendation was to leverage **CCSDS protocols** (Consultative Committee for Space Data Systems) for **communications**, along with **COSPAR Planetary Protection policies** and **NASA's SP-8000 documentation**. These were seen as **robust but needing updates** to account for **simultaneous surface operations**, not just orbital activities. Similarly, **ITU spectrum coordination rules** were highlighted as critical to avoid communication interference.

Several contributors mentioned **ISO standards**, particularly **ISO TC20/SC13** (Space Data and Information Transfer) and **ISO TC20/SC14** (Space Systems and Operations), both of which include participation from **over thirty countries** and remain **open to new members**. These subcommittees are part of **ISO's role as the UN's preferred standards forum** (chartered in 1947), though **other standards development organizations** were also acknowledged as important contributors.

Legal and policy frameworks were also emphasized, including **OST Article XI** (Outer Space Treaty), which focuses on **sharing information to avoid harmful interference**, and the **Artemis Accords**, which offer a **construct for cooperation and transparency**. Some mentioned **COSPAR's PPP-PEDAS** guidelines and **LunaNet**, a NASA initiative to establish **network standards for lunar communications**.

In addition, **technical and operational standards** such as the **Planetary Data System (PDS)** and **European ECSS standards** were cited. Participants also referenced **ISAM/CLD standards development efforts** in in-space servicing and manufacturing, and even drew analogies to the **International Building Code**, noting that standards often evolve **in response to failures**, with many being "written in blood."

Cultural and ethical considerations were also brought forward, including the **CARE Principles for Indigenous Data Governance**, emphasizing **ethical data use and inclusivity**.

There were philosophical reflections as well, with some questioning the **role of standards in codifying existing behavior versus imposing new requirements**. A practical suggestion was to **incorporate participation in data systems into launch licensing**, ensuring compliance through regulatory means.

In summary, participants agreed that **numerous standards and norms already exist** that can be **adapted or expanded** to serve the needs of lunar and deep space interoperability, but they must be **updated**, **harmonized**, and possibly **enforced via licensing or other policy tools** to remain effective in the evolving space environment.

Question 8. *What funding mechanisms (e.g., subscriptions, grants, government funding) would sustain the database long-term, and how can we incentivize participation?*

Participants proposed a range of **funding models** to support the **long-term sustainability** of a space interoperability database. A popular suggestion was a **hybrid approach**, combining **tiered subscriptions** (based on **mission complexity** or **commercial benefit**), **agency-backed grants**, and **public-private partnerships**, especially for **tool and API development**. Participation could be incentivized with **early-access privileges** or **database-integrated services**, such as **hazard modeling** tools.

Several respondents proposed **direct government funding**, with **sovereign space agencies** including the database as a **budget line item**. Others saw potential in **non-profit models**, referencing the **Wikipedia model** of **donations**, or funding via **high-net-worth individuals** or a **dedicated foundation**.

A number of ideas focused on **incentivizing participation through access benefits** and **disincentives for non-participation**. For example, **free access for contributors**, possibly with an **initiation fee** and **per-query usage fees**, was one suggested model. Another recommended a **membership-based system**, where **countries or organizations pay fees**, although there was skepticism about asking companies to contribute both **data and membership fees**.

Commercial subscription models were also explored. One idea mirrored **open-source licensing**, allowing **free data viewing**, but requiring **payment for commercial use**. This would ensure that those **profiting from the data help fund the database**.

Other suggestions included **user fees**, **tiered membership incentives**, and leveraging the **intrinsic value of participation** once the system is well-established. Participants noted that **access to valuable data and services** could be a powerful **natural incentive**, especially when **denial of access** is used as a **disincentive** for non-participants.

Lastly, one response compared the funding model to **open-source software development**, where **parties self-fund their involvement** when they see the **benefit of contributing** to and maintaining a **central registry**.

In summary, participants advocated for **flexible, multi-source funding**, including **subscriptions, grants, and public-private mechanisms**, while encouraging participation through **access incentives**, **commercial use fees**, and **natural benefits derived from engagement**.

Question 9. *Beyond the database, what governance or coordination system do we need to ensure alignment, prevent conflicts, and foster ongoing collaboration?*

Participants stressed the need for a **formal governance framework** that extends beyond data management to address **conflict prevention, coordination, and collaboration** in lunar and space operations. One proposal was the creation of a **Lunar Operations Conflict Prevention Framework (LOCPF)** - an **ongoing forum** featuring **technical working groups**, **dispute resolution mechanisms**, and **shared impact forecasting tools**. Such a framework should be **consensus-driven**, but also **backed by enforceable consequences** to ensure compliance.

Several responses pointed to **existing international agreements** that can serve as **foundations for broader coordination**, including the **Outer Space Treaty (OST)**, the **Artemis Accords**, and

the **China-Russia International Lunar Research Station (ILRS) agreement**. These were seen as **starting points for alignment**, though additional **community processes** would be needed to **refine norms and behaviors**. **ATLAC**, a UN-affiliated group, was mentioned as a possible mechanism for facilitating such efforts.

Participants also highlighted the value of **digital frameworks** for identifying **partnership opportunities**, potentially enabling more dynamic and accessible collaboration. Constructs like **AIAA/Lunaverse** were suggested as models for structuring such digital or community-based systems.

Regarding governance authority, some noted that **supervision or oversight** could be tied to the **Authorizing State**, in line with current **space governance practices**. On a technical level, one suggestion involved establishing **common docking or handling interfaces** to facilitate **shared use of tools, data, power, and fuel**, thus promoting **practical interoperability and collaboration**.

Finally, the importance of **ongoing dialogue** through **international conferences** was emphasized, providing platforms for **multilateral discussion, consensus-building, and norm development**.

In summary, participants advocated for a **multi-layered coordination system** that combines **existing treaties and accords**, **new technical and legal frameworks**, **digital collaboration platforms**, and **regular community engagement**, all aimed at **preventing conflicts** and fostering **long-term collaboration** in space.

Question 10. *What concrete steps or actions would you recommend to build an international community dedicated to interoperability, and how can we sustain momentum post-event?*

Participants emphasized the need for **immediate, practical steps** to build and sustain an **international community focused on space interoperability**. A commonly suggested action was to **launch a working group** dedicated to **lunar interoperability use cases**, with a **clear 12-month timeline** to **draft a shared data schema**, supported by **quarterly review meetings** hosted by **rotating institutions**. To facilitate adoption, participants recommended the publication of **open-source toolkits for data contribution** and the creation of a **recognition or compliance badge system** to reward **early adopters**.

Several responses advocated **building on existing efforts**, such as promoting and publishing the **Open Lunar database**, and **combining it with UN database parameters**. Some stressed the importance of **starting immediately**, without waiting for **universal participation**, and focusing on making **coordination mechanisms easy, open, and evolvable**. This would enable **natural alignment on community issues and interoperability opportunities**.

A recurring theme was the importance of **transparency**, especially when requesting **subscriptions or funding**. Participants stressed the need to **show tangible value** and **clear actions** at every step to maintain trust and engagement.

Concrete actions also included **establishing a flexible, evolvable forum** that equips the community with **coordination tools**. Participants supported **iterative planning**, urging that pursuit of the "**gold standard solution**" should not delay **incremental progress**. There was a call to **coordinate existing resources**, by initiating **conversations on operationalizing small funding pools** from different organizations.

Stakeholder mapping was identified as a key step to understand **roles and responsibilities**, and to **connect related efforts**. Suggestions included forming an **"association of associations"** to bridge initiatives, and using gatherings like the **International Astronautical Congress (IAC)** to create **connective tissue between efforts**.

There were also calls to **set standards around data collection and reporting** early in the process. One community, **Nexus Aurora**, was cited as an example of an **international group** already **funding projects, maintaining databases, and solving problems collaboratively**.

Lastly, participants noted that **existing standards subcommittees SC13 and SC14** (under ISO) are **already active**, working together on a **young reference architecture for space**, with **lunar activities among their interests**. These long-standing committees consist of **national space agencies (SC13)** and **national standards bodies with industry involvement (SC14)**.

In summary, participants called for **immediate, actionable steps**, **leveraging existing structures**, and fostering **inclusive, transparent, and iterative collaboration** to build and sustain an international community for **space interoperability**.

Comments.

Participants expressed support for **collaborative engagement** and **interoperability between existing initiatives**. One recommendation was that **all participants should document their activities in the Open Lunar Ledger**, a platform aimed at improving transparency and coordination in lunar operations.

OffWorld, a participating organization, stated that it would **discuss participation in the Open Lunar Registry**, with the intent to **join the effort pending agreement**.

Additionally, participants suggested establishing a **dialogue among related platforms**, including the **Open Lunar Ledger**, **Cislunar.io**, the **Open Lunar Registry**, and **For All Mankind**. The goal would be to explore **practical collaboration** or, at a minimum, to ensure **mutual visibility through cross-linking each other's websites**. This approach would promote **greater integration and accessibility** across the ecosystem of lunar data and coordination efforts.

Bonus question. *Your favorite sci-fi movie / tv series!*

We asked our participants to mention what are their favorite sci-fi movie / tv series. Here is the list: Expanse, For All Mankind, Interstellar, Star Trek The Next Generation, Enders games, Black Mirror, Star Wars, Galaxy Quest, Space Balls, Firefly, Orville, Star Trek: Deep Space Nine.

TOWN HALL DISCUSSION

The workshop transitioned into an **open town-hall discussion**, with participants invited to share **feedback**, **next steps**, and **ideas for building a lasting community around interoperability**.

A participant shared preliminary notes from the Miro boards, highlighting recurring themes: the concept of a **multi-tier database**, **skepticism about the UN leading database efforts**, the **importance of funding considerations**, and a clear need to **build a community that values interoperability and communication**. They noted the **absence of a consensus leader** and

proposed discussing whether there should be an **organization to act as connective tissue among various entities**.

One of the moderators, Tim, added that **discussions are already happening across many forums**, and rather than being prescriptive about who can participate, the community should focus on **creating value that naturally draws in stakeholders**. Progress and meaningful collaboration on lunar projects would serve as the **"juice worth the squeeze"** that attracts more engagement.

One participants suggested starting with **recommendations from Questions 7 and 10**, including forming a **working committee**. Ekaterina confirmed a **report will be shared** summarizing views from the workshop and breakout rooms, and the team would consider how to gather further **community input**.

The potential for **AI tools** to aid in **data management and facilitation** was discussed. In breakout room 1, AI was suggested as a tool for **management, facilitation**, and possibly **data collection**. However, concerns around **intellectual property** and comfort with AI handling sensitive data were noted. One idea was to use **AI agents to scrape data from open sources or forums** and summarize it, helping **consolidate fragmented conversations** across groups. This was seen as **promising**, given the difficulty for humans to track **multiple discussions** occurring in **different spaces**.

In closing, the **importance of community dialogue** was emphasized, noting the presence of many organizations (e.g., **Open Lunar, GEGSLA, LOGIC, LSIC**) with overlapping interests in **interoperability and cooperation**. She suggested creating a **forum for dialogue and common ground**.

It was agreed that the **Miro board content will be compiled into a report**, and participants will be invited to provide feedback. Suggestions on **community-building strategies** were welcomed, and **active participation and recommendations** from attendees were encouraged.

A participant recommended involving **UN and related agencies**, including **ICG**, **IAG**, **FIG**, and **IGS**, which work on **compatibility and operability of lunar PNT systems**. These organizations could offer **synergistic contributions and existing databases**.

NEXT STEPS

1. **Establish immediate, practical measures to foster community building**
   Participants emphasized the need for taking concrete actions to cultivate and sustain an international community dedicated to space interoperability. The focus should be on initiatives that provide both near-term value and a foundation for long-term collaboration.

2. **Launch a dedicated working group on lunar interoperability**
   A common recommendation was to create a specialized working group tasked with addressing lunar interoperability use cases. This group would operate on a defined 12-month timeline with the specific goal of drafting a shared data schema that can serve as a baseline standard.

3. **Build upon and align with existing resources**
   Participants emphasized the importance of leveraging ongoing efforts, particularly by advancing the Open Lunar database and combining it with United Nations database parameters.

4. **Create a flexible and evolvable coordination forum**
   There was broad agreement on the need for an adaptable forum that can provide the community with the necessary tools for coordination, knowledge exchange, and collective problem-solving. This forum should be designed to evolve alongside the needs of the community.

5. **Initiate collaboration discussions**
   GEGSLA will explore opportunities for collaboration and alignment with the Open Lunar Foundation (Lunar Ledger). In addition, follow-up discussions will be held with LSIC and LOGIC to incorporate their perspectives and ensure their input in shaping the next phase of activities. This report with the participants feedback will be placed at the core of these discussions.

6. **Explore formation of a formal consortium**
   Recognizing the need for a more structured approach, GEGSLA is considering the potential establishment of a "Consortium for Interoperability on Lunar Activities (CILA)" as a long-term tool for coordination, standards development, and stakeholder engagement.

7. **Target the GEGSLA Operational Meeting (December 2025) for advancing proposals**
   The Operational Meeting in December will serve as a key milestone where concrete proposals for a path forward will be formally presented and discussed.