

Expert Conference Report

Balancing Current and Emerging Challenges in the Future Governance of Space

Space Policy Institute,
Elliot School of International Affairs
George Washington University
Washington DC

December 2-4, 2025

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EXECUTIVE SUMMARY

This Expert Conference was organized and focused on assessing approaches to space governance as nations expand and enlarge their programs to explore deep space. Deep space includes the Moon as well as destinations further away from the Earth. The conference is directly linked to the second research question of grant #62772 and follows a conference on international space cooperation in December 2024.¹

Approximately 50 experts from academia, industry and government met in Washington, D.C. from December 2nd to December 4th 2025 at the Space Policy Institute, George Washington University. The specific topics presented and discussed were:

- The role of past and present predictions for the next 50 years in space governance, science, and technology;
- Identifying and describing past and present examples of selected governance situations where two or more nations on Earth have created systems of governance over jointly owned (or unclaimed) territory. Analogies and possible solutions to various potential situations in outer space were also presented;
- The recognition and importance that national security and related policies and issues may limit or advance the various forms of future governance of deep space;
- Focusing on other challenges and specific issues that will influence future deep space governance such as:
 - Managing resources found in deep space that may have use or value, either in space or terrestrially,
 - The role of economic and commercial exploitation of deep space,
 - Crafting policies that can be clearly and consistently understood, interpreted, and implemented by space-faring nations.

These fruitful discussions challenged participants to evaluate the likely issues at the cornerstone of future space exploration. The broad and varied experience of participants stimulated conversations beyond simple governance questions to issues of language, doctrine, site selection, protection for historic and scientific reasons, and philosophy for security, deterrence, environmental preservation and exploring the “final frontier”. These engaging presentations and ensuing discussions cannot be fully summarized in this short report. However, the many recurring and overarching major results are highlighted.

A general theme was the question of whether outer space presents a fundamentally different legal and practical approach to exploration than we experienced historically on the Earth. Is deep space a variation of established Earth-based expansion, laws, norms, and standards? This question, not surprisingly, was not resolved.

¹ This study is being funded by a grant from the John Templeton Foundation (Grant #62772) to the International Space University (ISU) that includes a subgrant to the Space Policy Institute at The George Washington University. The formal title of that conference was: “*How will International Cooperation in deep space exploration and space settlements evolve with the aim of finding common values among space-faring and emerging space nations, despite the current shifts and risks induced by geopolitical tension?*” and the report on that conference’s results can be obtained from the ISU.

It did provide a controversial and appropriate fulcrum for discussing the many approaches on future governance that often get confused and mixed up when looking ahead to uncertain and challenging futures. Another major theme throughout the conference was the appropriate timeline of establishing any sort of governance model in space. There needs to be a balance between acting too soon and waiting too long before establishing new governance systems. And there is also the clear possibility that without any new formal governance system, actors will engage in controversial unilateral activities. There are multiple critical junctures that need to be identified today that can drive the impetus needed for meeting the needs of governance in deep space as a cooperative, peaceful, and implementable international action today. Presumably, such activities can and will also apply as the human presence in space expands and grows.

Other discussions also focused on more current topics such as the possibility of a significant revision to the current legal regime of space as embodied in the principles of the Outer Space Treaty. At this time, it is highly unlikely that will occur. Enforcement of existing international treaties will be a continuing contentious issue. Current trends both in the United Nations and wider geopolitics make any attempt at a new international space agreement unlikely to succeed. It may be that other approaches will be more successful such as establishing norms and standards with clear guidelines for space activities. Defining those is the immediate challenge and the body of this report will elaborate on some more specific suggestions.

In essence, the discussions have led to several concrete suggestions. **First**, identifying the most important factors in future development that will lead to identifying the optimal time to implement specific governance measures in outer space. **Second** is to identify what to govern. **Third**, to assess the different governance systems that may be required to achieve the objectives of exercising control over a specific domain or goal. **Fourth** is to look at how nations on Earth have successfully dealt with similar issues, and **fifth** look toward the very difficult problem of how to cooperatively and successfully implement any internationally agreeable and peaceful system.

Clearly, the conference and set of discussions was only a step in this process. Many others have also explored this problem and the extensive literature on this subject of future governance is very wide-ranging. We, like most other studies and conferences, offer no concrete final solutions but hope that this analysis provides an objective, useful and perhaps different approach to evaluating these issues. These issues are important, and they will likely affect future space exploration and the use of deep space for all of those involved: society, companies, nations and international organizations.

INTRODUCTION

This is the second of three events under the John Templeton Foundation grant #62772 to the International Space University and George Washington University that focuses on the fundamental questions underlying future governance choices related to deep space exploration. For the study and this report, the future is defined as roughly the next 50 years hence (to about 2075), and the term, deep space, refers to regions and bodies beyond Low Earth Orbit (LEO) and includes the Moon and other areas of interest. The main questions guiding discussion are:

- Why are we venturing into deep space? Is the motivation primarily scientific discovery, economic opportunity, national security or a combination of all these and in what proportions?
- Who will be exploring and operating in deep space? Which nations, coalitions of nations, companies or international organizations will be involved, and will their presence be through instruments, spacecraft, or human-crewed missions?
- What specific aspects of deep space activities (e.g. science, resource use, communications, etc.) could benefit from the implementation of different forms of governance or oversight?
- When and where will international governance be necessary for deep space operations? As important as these two themes are, they are not directly addressed in this report since:
 - The “where” is largely determined by the technological capabilities of space-faring nations and companies, and the potential future uses of celestial bodies and other elements in space. Predictive studies of longer-run technological changes offer valuable insights but the further out in the future predictions are offered, the more uncertain any specific projection is.
 - The “how” refers to the practical methods of exploration and utilization used. It also reflects how, as well as the capacity to “do it right” which is to apply best practices while taking into account environmental considerations and principles of long-term sustainability. These are related to economic choices and to national decisions and capabilities, both associated with governance systems but also extending beyond the scope of this study.

The conference spanned three days in Washington, D.C., welcoming approximately 50 attendees. The first day featured experts presenting keynote speeches and panel discussions introducing many of the critical topics behind the overall approaches to future space governance. Audience Q&A followed each presentation.²

Following the first day’s events, a reception was held for speakers and participants. That event also included, by invitation, graduate students in the International Science and Technology Policy program (and includes many focusing on Space Policy) at George Washington University. Many of these students were introduced to the John Templeton Foundation for the first time and were able to make connections with global experts in space affairs.

² To stimulate open and forthright discussion the conference was held under Chatham House rules. All discussions, Q&A, and comments will not be attributed to any individual or organization. Permission to publish will be obtained from speakers and panelists who prepared papers and PowerPoint slides.

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The second day's program featured spotlight talks and a panel discussion. In the afternoon of the second day, attendees broke into working groups to discuss four focused areas, the conclusions of which were presented to the whole group and followed by a general discussion. The four working groups were:

- Assessing the Limits of Humans in Space and Future Governance,
- Governance Concerns in Space Exploration and Settlement,
- Legal Issues and State Responsibility in Outer Space,
- Balancing Innovation, Commercial Activity, and Shared Governance in future Deep Space.

Members of the working groups then met on the final day of the conference and prepared summaries of their discussions. These are included in this report.

The experts in attendance are leaders in space technology, management, and policy, representing governments, industry, and academia. Thus, the discussions were at a high level and often quite knowledgeable and sophisticated. We received a number of written compliments on the proceedings. The papers and presentations at this conference are being compiled and publications are planned for later this year.

CONFERENCE SUMMARY

The John Templeton Foundation supports interdisciplinary research to foster dialogue and “create a world where people are curious about the wonders of the universe”. Space-related funding by the John Templeton Foundation spans several areas of research including the search for life, human presence in space (both people and instruments/technologies), and philosophy. The grant funding of this conference enables the cross-disciplinary dialogue. The program was built to facilitate these dialogues, inside and outside the conference room.

This conference consisted of 2 keynotes, 3 spotlight talks, 5 panels and a breakout session of 4 working groups.

The program was organized as follows:

Day 1

- Introductory remarks to the conference and the John Templeton Foundation
- Keynote 1: G. Ryan Faith “Fortunate Problems: The Paradox of Space Governance”
- Keynote 2: Scott Pace “International Relations and Governance”
- Panel 1: Past and Present Predictions of Future Deep Space Activities; Overall Predictions and Priorities and Science and Technical Projections
 - Henry Hertzfeld, Space Policy Institute, GWU
 - Doh Kim, Graduate Student, SPI/GWU
 - Nicolas Hedman, COSPAR
- Spotlight Talk 1: Stephen S. Buono “The Moon Agreement”
- Spotlight Talk 2: Richard DalBello “Reflections on Space Governance”
- Panel 2: Legal and other terrestrial analogies to Deep Space Governance (past and current)
 - James Green, Retired, Former NASA Chief Scientist
 - Bhavya Lal, Former NASA Associate Administrator for Policy
- Spotlight Talk 3: Patrick Besha “Institutional Mapping of Space Actors”
- Panel 3: Terrestrial Examples of Shared Governance and the Artemis Accords
 - Tanya Masson-Zweig, Leiden University
 - Ulpia Botezatu, Romanian Space Agency
 - J.P. Blount, Durham University
 - Michelle Hanlon, University of Mississippi

Day 2

- Spotlight Talk Panel/Session: Jordan Foley, John Klein, and Jamie Morin “The Interplay Between National Space Security and Cislunar Space”
- Panel 4: Balancing Today’s and Tomorrow’s Challenges in Space Governance
 - Michael Gold, Redwire
 - Giovanni Zanalda, Duke University

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- Daniel Capper, Metropolitan State University of Denver
- Michael Castle Miller, Lunar Development Cooperative
- Break Out Session for Working Groups:
 - Group 1: The Limits of Humans in Space and Future Governance
 - Group 2: Governance Concerns in Space Exploration and Settlement
 - Group 3: The Legal Environment and State Responsibility in Space
 - Group 4: Balancing Innovation, Commercial Activity, and Shared Governance in Future Deep Space

Day 3

- Summarizing and evaluating the Working Group results

KEYNOTE SPEAKER SUMMARIES:

4.1. Keynote 1: “Fortunate Problems: The Paradox of Space Governance”

This keynote, delivered by G. Ryan Faith, is directly tied to his research of the Fortunate Problems framework. Space issues are inherently different and difficult to resolve. Theoretically every vision proposed could work because none have been actually stress-tested. Space governance faces a fortunate problem: at this moment in time, all governance solutions are valid which makes it difficult to narrow options down to what might work best. In the early 1960s when the Outer Space Treaty (OST) was negotiated and drafted, many future space issues being negotiated had not arrived. The document was a performative measure that outlined principles based on terrestrial precedence. The established governing document is primarily theoretical, addressing issues that were current in the Cold War Era and it is now also being applied to technologic and political changes that are different. Moving forward with space governance must prioritize a learning process over a prescribing process to establish actual practice and evolving conditions.

There are many difficulties with defining space governance. First, the problem of “unknown unknowns,” in new situations and new kinds of practice and organization, make all attempts at legislation expectations rather than concrete issues. These range from economic exploitation and mining in outer space to possible future changes in the world power structure with the potential for changing geopolitical landscapes. Second, the problems with the timing of implementing new governance practices and early lock-in pressures on institutions can lead to possibly missing the optimal timing window to make good, responsive governance. Finally, the precautionary principle prescribes that inaction becomes destructive action because space is inherently hostile. This can place an imperative on current actors to operate “responsibly” to near-term issues without adequately evaluating the ultimate outcomes.

The transition between exploration and operation in space activities is the critical zone in which rules must be established. The Fortunate Problems framework builds on the following 5 points to predict if, when and how rules should come about without issues due to deferred or anticipatory actions.

- 1) Agency & Affordances, 2) Actual and verifiable realities, 3) Future Values, 4) Legibility (documentation), 5) Future Options

This structure is not post-catastrophe. All the while governance is being established, space has to remain usable because real practice builds reliable knowledge instead of speculative rules which may result in systemic risk-taking. This can serve as a guardrail to avoid early lock-in while establishing norms and best practices in informal ways.

From the Q&A portion, it was discussed that the involvement of more states and stakeholders in space relative to the two superpowers is essential. Regarding site preservation (either those of historic or scientific merit), this framework covers that issue and looks to the overall system level to guide actor interactions. Regarding current action, the time now is for data collection and measurements to inform rules of the future.

4.2. Keynote 2: “International Relations and Governance”

This keynote focused on the theoretical International Relations models and tools that are important and relevant as space governance emerges. The first of these was Analytical Eclecticism, which emphasizes the use of the right tool for the right time instead of trying to build an all-encompassing theoretical perspective. The Republican Deterrence perspective, built from French naval theory, pivots on the result that a space hegemony is dangerous, and should be avoided. The final perspective is that of Constructivism, foundationally compelling those who have a vision for the future to build it, relying on shared ideas and norms in a cooperative arrangement. The United States should promote deterrence and compliance as two sides of the same coin. To get others to follow rules and norms, enforcement may not be as necessary if first the rules and norms we seek to set are followed. The material conditions to compel

and increase dominance don't yet exist. Rules and norms are made by those who show up, furthering emphasis on coalitions for space faring. States have a say in the roles of non-state actors, and combinations of parties will likely be more important as space increases in usage. To develop a frontier mindset is not necessarily bad, as it encourages innovation. Further research on the topic will revolve around strategic stability, avoiding making rules until we are ready, encouraging a multi-cultural space, understanding space as a conditional good, and looking at the applicability of emerging technologies like AI with a long-term view.

4.3. Spotlight Talk 1: "The Moon Agreement"

The Moon Agreement draws significantly from the OST, but the memory of this failed agreement stereotypes the actors involved in its creation and negotiation. The central debate that prompted the Moon Agreement was whether the Moon would reflect the United States capitalist structure, or the USSR communist structure stereotype. The Moon agreement was originally drafted and generated by Aldo Armando Cocca, a lawyer from Argentina who advocated that law must precede mankind into space.³ This was ignored initially. When the USSR delegation took notice of the treaty draft, the rest of the international community began to take notice. This pushed the United States into engaging with the treaty. The Moon Agreement faced several obstacles, including differences regarding scope, advanced reporting, and natural resources, all obstacles likely to again be debated when new space law is developed. Historically, the 3rd-World's quest for a New International Economic Order eclipsed the Moon Agreement on the world stage.

The discussion following this spotlight talk surrounded specific language chosen for the Moon Agreement, including the issue that if the term, common heritage of mankind, implied ownership and if a new authority was meant to create a new organization. The discussion did not reach a consensus on either point.

4.4. Spotlight Talk 2: "Reflections on Space Governance"

This spotlight talk posited that the Moon Agreement is now a backward step, and in many ways drafting a revised or new Outer Space Treaty is not achievable now and probably will not be anytime soon. Issues abound, including space debris, orbital congestion and the rise of dual-use technologies that blur civil-military lines, proliferate counterspace technologies, and put environmental issues under stress. Policy and norms currently lag actions and technical capabilities. A key to moving forward is SSA (Space Situational Awareness) sharing. In the future. Space sustainability also will take many forms, including new normative coalitions. Present day COPUOS and the ITU are limited and unable to handle the future adequately. Industry needs formal rules as they become a larger share of actors in space.

The discussions following this talk revolved around the debris issue and concluded that users will clean up only when it becomes convenient to do so. Also, publicly funding of the removal of upper stage debris will be necessary and that the first step to cleaning up space is now emerging with upcoming launch operations being more efficient and less polluting. The other focus of discussion was on the current state of discussing a new or revised Outer Space Treaty. As also mentioned above, this is unlikely to happen.

4.5. Spotlight Talk 3: "Institutional Mapping of Space Actors"

Institutional mapping is done to better understand supply chains and linkages between industry actors and government. NASA does this by sending a survey to map tech taxonomy and who their suppliers work with. This survey gives information regarding geography and financing. In US supply chains, many critical minerals come from overseas, exposing these supply chains to vulnerabilities. The survey is also able to show overlaps in suppliers with other government agencies, spotlight regional clusters and map US industrial bases. The US has traditionally partnered with close allies like the 5 Eyes, Europe, Russia and Japan who all have high levels of skilled workers and robust budgets. In the 2010s, the US made a

³Stephen S. Buono, *Governing the Moon: A History*. [Buono, Stephen S. \(2025\)](#).

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bigger push to India and the UAE. China on the other hand largely partners with Russia and Brazil, with their “go out” policy forging partnerships with other Asiatic neighbors, then expanding to Europe, South America, and Africa with the type and degree of cooperation varying greatly by partnership. Most recently, there have been broad-base cooperation agreements with 130+ countries involved and more participation in the UN regarding space. Using the data from the surveys in addition to public data regarding agreements and budgets from national and regional space agencies, NASA developed a tool with approximately 40-50 variables that places countries relative to one another. This tool assists actors with understanding the relationships between suppliers and space agencies, underlining vulnerabilities, and providing a roadmap for increasing resiliency.

PANELS

5.1. Panel 1: Past and Present Predictions of Future Deep Space Activities

5.1.1. Part 1: Overall Predictions and Priorities

Long-Term Futures Analysis and Implications for Space Governance

The panel examined how long-term futures studies looking approximately 50 years ahead can inform contemporary debates on space governance. It reviewed two major government-supported foresight studies conducted several decades apart—one from the mid-1970s and another produced recently in Europe—highlighting that both were intended as general and independent outlooks rather than extensions of specific agency planning documents.

A panelist emphasized that long-term forecasting is inherently uncertain. The primary value of such exercises is not to predict the future accurately, but rather to use projected conditions and trajectories to structure thinking about how governance and governance frameworks should be prepared. While both studies assumed rapid technological adaptation and diffusion, the panel noted that actual space activities have historically progressed more slowly due to funding constraints, technological challenges, and the slow development of markets.

The 1975 study anticipated dramatic reductions in launch costs and universal access to space by the early 2000s, as well as the emergence of single-stage-to-orbit systems. In practice, technological and financial barriers have delayed these outcomes. Recent data suggest that some commercial launch providers operate at significantly lower cost levels than others, but definitional issues—such as total production cost versus the actual price charged—mean that the true extent and impact of cost reductions remains open to interpretation.

The panelist also observed that many futures studies predict growing commercial investment and the rise of specific emerging space nations, but such national trajectories are often misidentified in hindsight. Some forecasts further suggest that large-scale human settlement in space and deep solar system human exploration will be unlikely within the next 50 years, potentially creating tension with national exploration strategies that prioritize human missions.

Overall, the panel concluded that the core structure of international space law is unlikely to change fundamentally. Rather than pursuing comprehensive treaty reform, future governance should focus on incremental adaptation in areas not covered by existing agreements. Strengthened regulatory and licensing frameworks, along with governance arrangements capable of supporting financial and insurance markets, were identified as critical. Long-term forecasting was characterized as most useful for shaping planning and strategic thinking, while governance itself should evolve incrementally and in response to specific problems rather than through the creation of a new overarching international regime.

The Evolution of Global Space Governance through UN Platforms

The panel reviewed the historical evolution of global space governance as developed within UN intergovernmental platforms. It outlined a progression of governance phases, each lasting roughly two decades: an initial treaty-making phase, followed by a period focused on principles due to declining consensus for binding law, and the current phase characterized by soft law instruments, guidelines, and resolutions aimed at implementing existing treaty obligations.

Political will and geopolitical context were identified as the primary drivers of these transitions. The Cold War environment enabled the establishment of the foundational treaty regime, whereas declining geopolitical consensus subsequently limited the scope for new binding agreements. As a result, no major new treaties have emerged since the late 1970s.

Major UN conferences have historically reinforced global governance efforts, with capacity building for developing countries forming a consistent common denominator. Over time, more operational

mechanisms—such as planetary defense coordination and satellite navigation cooperation—have emerged under UN platforms. The recent inclusion of space affairs in the UN’s broader global political agenda was highlighted as a significant milestone linking space governance to post-2030 global development priorities.

The panel noted that the current agenda of intergovernmental space governance bodies has become increasingly complex and multi-layered, encompassing sustainable development, climate change, disaster management, space debris, near-Earth objects, and long-standing unresolved legal issues. Membership has expanded to more than 100 states, reflecting global diversity but also making consensus-building more difficult. This diversity constrains the ability of major spacefaring nations to advance priorities without addressing the interests of emerging and developing space actors.

Looking ahead, the panel anticipated that geopolitics continue to shape global space governance, while the complexity of safety, security, and sustainability challenges will increase. It argued that governance design should proceed from political needs to operational requirements and then to institutional models, rather than attempting to force new operational realities into legacy institutional frameworks that may no longer be optimal.

Assessment of Deep Space Governance and Critical Junctures

The panel presented an analysis of approximately 90 academic and policy publications from the past decade to assess how different stakeholder communities prioritize space governance issues and whether it is premature to engage in comprehensive deep space governance discussions.

Using bibliometric methods, the literature was categorized by safety, environmental, economic, and national security themes. The analysis revealed that academic research has focused primarily on environmental and economic issues; non-governmental organizations on safety and environmental concerns; intergovernmental organizations on environmental issues; private sector actors on a broader range of topics beyond economics and security; and governments primarily on environmental and national security matters. These divergent priorities suggest that space governance is unlikely to converge on a single unified model.

While publication volumes indicate a strong academic emphasis on environmental issues, the panel stressed that in actual governance debates these concerns represent only one dimension among many. Security and economic issues, although less visible in academic output, remain central in policy discussions.

The Moon was presented as a practical stepping-stone for assessing the stage of deep space governance. To date, lunar activities have largely consisted of short-duration, experimental, and technology-demonstration missions, indicating that the sector remains in an R&D phase rather than an operational one. Even national plans for the next decade are dominated by technology demonstrations, suggesting that full-scale operations are unlikely before the 2030s.

Three critical juncture scenarios were identified as triggers for more comprehensive deep space governance:

1. Surface Congestion and Site Competition – When high-value lunar locations become congested and infrastructure begins to interfere, safety zones may evolve into de facto exclusion zones and overlapping installations could escalate into territorial disputes.
2. Economic Validation of Resource Extraction – When in-situ resource utilization yields net economic benefits or Earth-return costs fall sufficiently, first-mover monopolization, equity concerns, scientific interference, and claims over extracted materials will become unavoidable governance challenges.

3. Orbital Congestion Around the Moon – As lunar orbital activity increases, collision risks, communications interference, and the lack of natural orbital decay will make disposal and traffic management a central governance issue.

The panel concluded that governance priorities will continue to evolve as technologies and operational realities change, just as space debris has risen from a marginal issue to a core sustainability concern over the past two decades. However, the current period—before intense competition emerges—represents a valuable opportunity to map potential conflict points and design coordination mechanisms in advance. Rather than constructing a comprehensive governance regime all at once, the panel recommended developing targeted cooperative mechanisms aligned with each anticipated critical juncture.

5.1.2. Part 2: Science and Technical Projections

Predictions of Scientific Breakthroughs

The panel deliberately framed the future of space over the next fifty years at the opposite extreme of conservative projections, presenting a highly ambitious and transformative vision. This framing reflects the expectation that humanity will ultimately imagine—and pursue—far more expansive space activities, encompassing life detection, permanent habitation, industrial development, and new forms of mobility. In this view, space development will move beyond the realm of scientific exploration and enter a phase that fundamentally reshapes human civilization itself. The discussion opened with a foundational question: “Are we alone in the universe?” The panel answered this unequivocally in the negative, emphasizing that such a discovery would represent not merely a scientific breakthrough, but a profound transformation of humanity’s worldview. Four major lines of evidence and exploration trajectories were cited in support of this assessment.

First, Mars exploration. The Curiosity and Perseverance rovers have significantly strengthened the case for ancient life on Mars through environmental and mineralogical evidence. In particular, Perseverance is operating in an ancient river delta, conducting biosignature investigations and collecting samples for eventual return to Earth. The panel noted that Mars exploration has now reached Level 4 on the life-detection “confidence scale,” indicating strong environmental and mineralogical indicators of past microbial activity, and that sample return could push this confidence to a much higher level. On this basis, the panel judged it increasingly likely that Mars once hosted microbial life.

Second, exoplanet exploration. In the era following the James Webb Space Telescope (JWST), astronomy is expected to move beyond identifying merely “Earth-sized” planets to distinguishing truly “Earth-like” worlds based on atmospheric composition. The detection of oxygen, ozone, and potentially even artificial compounds such as CFCs through atmospheric spectroscopy would allow systematic searches for biosignatures and technosignatures, bringing the study of extraterrestrial life and civilization into a mature scientific domain.

Third, exploration of icy moons. Bodies such as Europa possess subsurface oceans, abundant internal energy, and the full suite of life-essential elements (carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur). These environments could support not only simple life forms but potentially complex life. The panel noted that submarine-style probes capable of penetrating the ice shell and accessing these oceans have been under development for many years.

Fourth, exploration of Titan. Titan’s liquid hydrocarbon environment opens the possibility of life based on entirely different biochemical processes from those found on Earth, potentially redefining the very concept of life itself.

The panel argued that these discoveries will intensify international scientific competition and place strategic value on being the first to detect extraterrestrial life, making life discovery a major source of geopolitical leverage.

Looking ahead to 2075, the panel outlined a detailed vision for both the Moon and Mars. The far side of the Moon, shielded from terrestrial radio interference, offers an unparalleled radio-quiet environment for interferometric radio telescope arrays capable of probing the “Dark Ages” of the universe—the epoch following the Big Bang before the formation of stars and galaxies. The panel envisioned a future in which the United States, Europe, and China engage in both cooperation and competition to develop this scientific infrastructure.

On the lunar surface, long-term habitation is expected to emerge through the use of regolith-based agriculture and local resource utilization, alongside the growth of mining, manufacturing, and fuel production. The lunar far side, with its greater exposure to the solar wind, may contain significantly higher concentrations of helium-3, while platinum-group metals essential for modern electronics may also be abundant, particularly in the south polar region. Permanently shadowed regions could contain water, hydroxyl, and even Earth-origin volatiles deposited through past magnetic field interactions between Earth and the Moon. The panel further suggested that volcanic outgassing during the era of mare formation may once have sustained a lunar atmosphere of roughly 12 millibars, making exploration of these regions a potential “game changer” for lunar science.

For Mars, the panel anticipated that human settlers would ultimately access subsurface aquifers to secure water resources and, in doing so, might encounter extant life. The possibility of coexistence between humans and Martian life was left open. A future Mars settlement would likely involve outpost construction, agriculture, AI- and robotics-enabled operations, and in situ manufacturing. Looking further ahead, the panel described a speculative vision of deploying multiple dipole current systems in Mars-synchronous orbit to generate an artificial magnetosphere and initiate long-term terraforming efforts—an outlook referred to as “Mars 2500.”

Finally, the panel emphasized that the deep-space future will be shaped decisively by developments in low Earth orbit. Commercial space stations are expected to host pharmaceutical production, life-science research, space hospitals, and space hotels. Microgravity environments may enable medical technologies impossible on Earth, such as the growth of artificial organs from stem cells. As launch costs decline dramatically, orbital transportation systems could eventually supplement or replace long-haul aviation, enabling travel from Washington, D.C. to the opposite side of the planet in roughly ninety minutes via orbital trajectories.

Predictions of Technology Breakthrough

The panel's core message is that the challenge is not to predict specific hardware choices fifty years from now—such as which launch vehicle or reactor design will prevail—but rather to understand the structural technological trajectories that will shape deep space, and the bottlenecks and stress points those trajectories will create. Deep space will become a crowded, multi-coalition environment involving governments, agencies, and commercial actors, and therefore systems must be designed to function under both optimistic and conservative scenarios. Technological forecasting is not neutral: each actor emphasizes futures that favor its own capabilities. The real task is not to “predict the future,” but to decide which future we are willing to prepare for.

Accordingly, instead of focusing on specific vehicles or systems, the panel identifies five major technological trajectories that will define the deep-space environment over the next 20 to 50 years and generate operational and strategic friction points.

The first trajectory is access and transportation. Launch and transport capabilities are evolving in a manner analogous to aviation in the 1950s: early systems exhibit high failure rates that decline over time, followed by increasing reliability and the eventual introduction of high-energy propulsion. The contrast

between traditional partially reusable systems such as SLS Block 1 and fully reusable, fully refueled orbital architectures such as Starship illustrates this shift. The potential addition of nuclear propulsion systems (NEP and NTP) would enable high-delta-V missions. However, greater access does not imply frictionless expansion. Instead, it concentrates traffic into specific bottlenecks, such as lunar south-polar approach corridors, limited surface landing zones, and high-energy trajectories that only a small number of providers can service. These become strategic vulnerabilities rather than purely technical constraints.

The second trajectory is power and infrastructure, which represents the largest programmatic shift. Future surface operations will move toward tens to hundreds of kilowatts—and eventually megawatts—of power generation, through large photovoltaic arrays, advanced surface power systems, and potentially beamed power. This represents a fundamental departure from the short-duration Apollo and early Artemis mission model. Once power is established in a location, all other activities reorganize around it: mobility networks, science stations, ISRU sites, communications, and navigation. In this sense, future deep-space development can be described as “power first, everything else second,” with links and logistics forming the additional pillars. Most deep-space architectures ultimately collapse to the challenge of scaling power, connectivity, and transport.

The third trajectory is robotics, autonomy, and operational complexity. Autonomy is advancing along the steepest curve, building on capabilities already demonstrated by Mars Exploration Rover and Curiosity, such as terrain-relative navigation, cooperative navigation, hazard detection, and autonomous sampling. Over the next fifty years, this is projected to evolve into construction robots assembling large structures, excavators operating under time-delay supervision, servicing missions using largely autonomous rendezvous, and distributed robotic swarms performing science and local mapping. The key stress point in this domain is attribution: when autonomous systems interfere or fail, high-fidelity telemetry, persistent signaling, and onboard data recording will be required to reconstruct events and assign responsibility.

The fourth trajectory is in-situ resource utilization (ISRU) and early industry. From an engineering standpoint, the most realistic near-term ISRU applications are water and oxygen extraction, water harvesting, and regolith-based structural systems. Early demonstrations such as MOXIE on Mars and pilot ISRU concepts within Artemis illustrate this direction. The primary stress point here is competition for location. Illumination corridors near Shackleton crater are narrow, and water-ice distributions are patchy. As multiple actors establish operations at the same sites, safety perimeters effectively become de facto territorial boundaries—not as a legal construct, but as an operational reality.

The fifth trajectory is human and life sciences. The greatest surprises are expected to emerge from human physiology, including partial-gravity effects, long-duration radiation exposure, closed-loop life-support performance, and biological experiments that cannot be conducted on Earth. With Mars architectures, and commercial stations, human missions are moving toward multi-month and multi-year durations. The stress points here involve duty of care, medical evacuation, emergency response, baseline health standards, and crew selection frameworks—issues that are as technical as they are political.

The panel emphasizes that none of these trajectories require exotic assumptions; all are extensions of work already underway at NASA and its partners. Transformative change does not come from a single breakthrough, but from combinations of capabilities. Just as cheap launch, miniaturization, and digital communications together produced the explosion of Earth-orbit services, deep space will be reshaped by the convergence of cheap access, autonomy, ISRU, and high-reliability power in the same geographic regions—particularly lunar polar regions. Illustrative scenarios include high-density operations with multiple landers, rovers, and fission power systems operating within a few kilometers; high-power reactors operating near sensitive scientific sites such as permanently shadowed craters used for volatile studies; and mixed human-robot-commercial operations with overlapping operators and communication windows. These are not hypothetical futures, but the natural outcome of current NASA roadmaps combined with increasing commercial cadence and expanding international participation.

The panel concludes with two principles for using such projections. First, deep space will be a multi-coalition environment in which NASA operates alongside ESA, JAXA, ISRO, emerging agencies, commercial stations, ISRU pilots, and security missions from multiple states. Systems must therefore function under both optimistic and conservative scenarios. Second, technical forecasts are not neutral: heavy-lift providers emphasize infrastructure, science missions emphasize radio-quiet zones and planetary protection, and commercial firms emphasize cadence, cost of capital, and flexibility. Using projections is therefore not merely forecasting but choosing which future we are willing to plan for. The productive question is not what the year 2075 will look like, but what technical architecture and operational frameworks are required to support a deep-space environment that is scientifically rich, operationally stable, commercially viable, and broadly legitimate.

5.2. Panel 2: Analogies to Deep Space Governance (Past and Current Examples)

a. Past Examples

The panel emphasized that any discussion of space governance must begin by clarifying what exactly is being regulated. The early norms of space governance were not primarily about outer space as a physical place, but rather about controlling and managing technologies such as nuclear delivery systems. From this perspective, contemporary space governance is still closer to a regime for regulating technology than one for governing a territory. This distinction also determines which comparative models are most appropriate: if space is understood as a shared area, then analogies such as the Antarctic Treaty System or the law of the sea appear natural; if it is understood as a domain of technological activity, then regimes governing nuclear technologies or cyberspace provide more relevant points of comparison.

In the same vein, the phrase “province of all mankind” in Article I of the Outer Space Treaty can be read not as referring to outer space itself, but to the use and exploration of outer space. In practice, regulation has therefore tended to focus less on prohibiting activities in a particular place and more on restricting specific technologies—for example, by limiting certain types of launch systems. The panel further invoked the internet governance principle of “rough consensus and running code” to illustrate the core dilemma of space governance today: how to balance innovation with the need to avoid inaction, while navigating between state-centric consensus models and the universal idea that space belongs to everyone. The conclusion was that relying on treaties alone reflects a “hammer-and-nail” mindset, and that a more realistic approach lies in technical and multi-layered governance combining law with technical standards, engineering practices, market incentives, and social norms to steer actors toward desired outcomes.

b. Current Examples

ATLAC (Action Team on Lunar Activities Consultation)

ATLAC is a consultation mechanism under the UN Committee on the Peaceful Uses of Outer Space (COPUOS) that serves as an expert-level platform for improving international coordination on lunar activities. The team examines a range of institutional options, including whether a dedicated international consultation mechanism is needed. It invites member states to present their lunar activities and share key challenges, with major issues to date including lunar dust, landing site selection, and lunar mission planning. The panelist also highlighted the challenge of integrating non-state actors into the international consultation framework. While acknowledging that consensus-based UN decision-making is inherently slow, it was emphasized that ATLAC is working to move as quickly as possible through monthly meetings and continuous intersessional discussions. Overall, ATLAC is engaged in building international consensus on lunar governance through a transparent and inclusive multilateral process.

In response to a question from the audience, the ATLAC representatives explained that ATLAC does not take a position for or against the Artemis Accords. Rather than debating specific legal frameworks or wording, ATLAC’s purpose is to provide a dialogue platform focused on identifying common ground by

discussing the broader concepts and challenges surrounding lunar activities. It was emphasized that, at the global level, there are many participants beyond the Artemis signatories, and therefore the discussions are not tied to any single framework but instead focus on shared challenges such as interoperability.

In response to another audience question regarding ATLAC's mandate, the panel explained that ATLAC's mandate is to assess whether the international community needs an organized consultation mechanism on lunar activities in the first place. They noted that a collective conclusion on this question has not yet been reached.

The panel also acknowledged that the UN's consensus-based decision-making process is inherently slow, while commercial actors are already moving at a much faster pace in terms of investment and operations, placing institutional discussions in a constant "catch-up mode." Nevertheless, ATLAC is seeking to develop an appropriate consultation mechanism for emerging lunar activities, using the Outer Space Treaty as an anchor and guiding framework during this transitional period.

Lunar Policy Platform

The Lunar Policy Platform (LPP) was presented as a global network designed to facilitate international policy dialogue on lunar exploration and governance. According to the panel, LPP's core activities include policy development, policy implementation, and policy education, and it has developed policy documents and guidelines for lunar governance through a range of international consultation processes. LPP also seeks to integrate a broad range of values and stakeholders into policy discussions, including science and ethics, the interaction between regional policies and international space governance, and dialogue with Indigenous communities, with the aim of building a more inclusive and responsible framework for lunar exploration.

Planet Stewards

Planet Stewards was introduced as an international research project funded by the European Research Council (ERC) and grounded in an Earth-Space systems paradigm that treats Earth and outer space as an integrated system. The panel explained that the project focuses on environmental integrity and "more-than-human justice" on a multi-planetary scale and argues that a transformative change is needed in the way space activities are conducted and governed. By integrating diverse values and perspectives, Planet Stewards is developing a new science-policy agenda and convening multi-stakeholder forums and platforms to advance a governance framework centered on Earth-Space sustainability.

Open Lunar Foundation

The Open Lunar Foundation was described as a non-profit organization dedicated to enabling a peaceful, cooperative, and sustainable human presence on the Moon. According to the panel, the foundation focuses on building infrastructure, norms, and governance frameworks that foster collaboration among lunar actors and prevent conflict. Its activities include developing open data-sharing platforms, technical standards, and policy tools as public goods for the lunar ecosystem. In particular, the recently launched LUMER Ledger—an open-access database for registering lunar missions and activities—aims to enhance transparency and reduce site conflict. The foundation also participates directly in international governance discussions as a permanent observer to the UN Committee on the Peaceful Uses of Outer Space (COPUOS).

5.3. Panel 3: Terrestrial Examples of Shared Governance and the Artemis Accords

The third panel at this conference sought to cover terrestrial examples of shared governance and the Artemis Accords. This started with an update from the week prior's Ministerial Council 2025 for ESA. At the ministerial conference, the discussion of the budget for ESA for the next 3 years was fundamentally different from previous budgeting discussions. There are two reasons for this: space is rapidly changing,

and Europe is in crisis in connection with the ongoing war in Ukraine which is causing more states to prioritize investment in defense programs over space. The negotiated budget is up €22 billion from three years ago and funds projects across the continent, showing promising signs for the Artemis Accords and program.

The Artemis Accords were an important step in stabilizing US space expenditures and priorities administration-to-administration and as a tool to encourage norms and behaviors for a peaceful and prosperous space future. The Accords also helped establish precedence in space. The Accords are just the beginning of the conversation, with clarification needed to avoid the dangers of ambiguity and to better establish safety zones and heritage sites. On the topic of heritage sites, the point was raised of using Environmental Impacts Assessments (EIAs) on the lunar surface specifically for preservation efforts as well as raising the value of responsible commerce, balancing scientific and commercial ventures, and avoiding expensive cleanups.

Rules are hard to establish because with the speed of technological change in space they become obsolete relatively quickly. The soon-to-be-signed rules on cyber security will have serious implications for space. Technology is changing fast and the geopolitical context in which space rules are made has also changed rapidly and drastically. There needs to be more flexibility in rulemaking and actors involved. The Lunar Development Cooperative is attempting, in special jurisdictions around the world, to understand how to finance expensive infrastructure and how to create institutional frameworks to promote economic activity to one day set up an economy on the Moon. The cooperative could make legally binding contracts and pilot sustainable development and investment and the use of a site registry. These legally binding agreements could have teeth to protect investments without conferring ownership, as is made illegal by the OST.

Following the panel, there were two student presentations, both focusing on terrestrial examples of shared governance that display similar characteristics to space. Examples involved two or more nations having an agreement on issues involving overlapping sovereign territory with critical issues involving environmental protection, resource use or commercial interests.

The first presentation covered the following examples: the Oregon Territory between 1818-1846, the nation of Andorra from 1278-Present, and Lake Constance. The Oregon Territory, a failed example of shared governance, was a jointly occupied territory by the US and the British Empire between 1818 and 1846, was later used as a bargaining chip in other disputes between the countries because both parties continuously put-off establishing any institutions or governance that could have maintained a shared-governance structure. The nation of Andorra maintained a formal shared governance structure since the 1200s between leaders in France, Spain and the Catholic Church (at one point the Holy Roman Empire) until 1993, when a new constitution set Andorra as an independent nation with head-of-state roles filled by the President of France and the Bishop of Urgell. As a successful example, Andorra shows interesting methods to develop and sustain institutions isolated from the drastically evolving outside world. Lake Constance, a current example of sharing resources, managing economic exploitation, and environmental sustainability efforts, shows the effectiveness of issue-specific governance.

The second presentation covered Svalbard and Tangier as examples. Svalbard shows in-practice policies around equal-access, tax restrictions and demilitarization, as well as enforcement mechanisms including police and specific court jurisdiction. Tangier (under international control 1923-1956) modeled similar issues to other examples, including rule by committee, mixed courts, and special status as a tax-free zone, but unlike Andorra was unable to withstand outside political turmoil at the start of World War II. Both presentations, and all the examples therein, look to likely issues with space governance as actors clash over physical space, resources and economic exploitation and as states attempt to enforce treaties and adjudicate issues between actors.

5.4. Panel 4: Balancing Today's and Tomorrow's Challenges in Space Governance

This panel was meant to examine how advances in space science and technology call for adaptive governance approaches. The panel focused on regulatory, institutional, and cultural frameworks that can support effective decision-making, ethical responsibility, and long-term sustainability in space exploration within a diverse, multi-stakeholder environment. The panel was structured around five guiding questions.

Question 1: Which laws and regulations should be established to avoid a Moon Wild West?

The panel spoke on how the west was not lawless, as just like in space, the existing laws applied. However, there were issues with how the laws were applied and how they were enforced. In space, GNSS has already been talking about coordination, but more work needs to be done in national regimes. With the current state of space and communication and surveillance network it is difficult to miss space happenings, making it more difficult for any action to take place unnoticed. Humans already influenced the evolution of Earth, and there needs to be a shift in philosophy in line with an Indigenous proverb that instead of inheriting the land from ancestors the current generation is instead borrowing from their descendants. Actors need to avoid the tragedy of the commons. LEO shows a clear need for more coordination and regulations to define landscape, explore societal impacts, and promote collaborative solutions.

Question 2: Should COPUOS play a more important role?

The panel felt that COPUOS already has a strong role because it brings stakeholders together. COPUOS and the UN currently do not occupy an enforcer role in space. Industries can adopt their own rules and norms instead of the burden being on COPUOS or national space agencies. Conversations about space in expert circles show much slower movement than conversations about space in public are showing.

Question 3: Do we still need space agencies?

While the US has dramatically weakened NASA in the past 10 months, the panel discussed that space agencies are still incredibly important. With the need to create and enforce space laws, space agencies still have a place in the ecosystem. There is also a confidence gap in terms of investments that space agencies help legitimize.

Question 4: Do regional space agencies have a specific future role?

The panel spoke to the need of allies as space, with its inherent hostility and great difficulty, cannot be done by one nation alone. There is a participation problem in space, with gaps not only in funding commitments but also in engagement. The burdens cannot be borne by any one nation individually.

Question 5: Should ethical concerns be considered?

The panel again spoke to definitions and word choice, as "Humanity's Presence" can possibly encompass more than direct human presence. The transmission of experience changes things. Transmission is now human-made robots and their journeys and observation. The broaching of this non-concrete human presence to world cultures today must be handled with caution. Discussions should continue to determine the appropriate level of human involvement in robotic exploration.

These answers were given with a lunar scenario in mind including international coordination for rescue, aid and assistance, human presence on the lunar surface in 5-10 years, and active scientific experiments such as low-frequency detection on the dark side of the Moon. These aspects of a lunar scenario are incredibly dependent on government ambition, heavy and reusable rockets and payloads to be viable.

5.5. Spotlight Session: The Interplay Between National Space Security and Cislunar Space

This session centered around the doctrine under which space activities are conceptualized, financed, and executed. With the Artemis missions, the US has shown a distinct change in funding characterized by renewed US ambition in space. This new ambition has multiple objectives. It requires sustained funding beyond science and technology and must include national security. The US's Space Force emphasizes "doctrine" over governance. It includes offensive and defensive components. This doctrine, as with space doctrines prior, draws significantly from maritime strategy. This includes brown water and blue water analogies that incorporate space technologies to support ground operations and ground operations to support space security. Additionally, the narrative warfare in space mirrors Earth's grey-zone. In space, lines of communication are shared, complicating activities and national security. The Golden Dome is another example of increasing investment by the U.S. Government that indicates new priorities and an emphasis on the role of commercial partners.

Space Security is difficult to define because it is not absolute, instead barriered by time and scope. Once again, the debate encountered the question if space is fundamentally special or if it has the same governance challenge encountered throughout human history but with a new iteration of applications.

This issue of doctrine has become pressing as China has increased space activities. The imminent strategic objective of the US is to dominate space and counter China. With more spacefaring nations, especially those not directly allied, space becomes additionally complicated. Space is a strategic battleground for influence. Operational language and measurement systems are both soft power indicators that must be made uniform to be able to operate in space without causing avoidable harm. Both must be standardized because ambiguity, as seen throughout treaties governing space, can be used as a weapon. Rules and laws hold no meaning when various actors interpret them divergently. This is an issue again of language and definition, including vital components like institutional capture, space security, obligation, and authority, which have different interpretations by different actors.

Space suffers from a presentism bias. In planning missions, making laws, and drafting treaties, there is an inherent assumption that tomorrow will look like today. This can be in terms of scientific and technologic capacity and ability and in terms of geopolitics. This assumption is dangerous and real.

The discussion following this panel revisited the themes of doctrine and interpretation and issues of resource and site management. These overarching themes were recontextualized with a specific security mindset, with talks centering around current defense doctrines.

There is a say-do gap in space doctrines, especially in China. The United States publicly publishes its doctrine, which is often parroted in Chinese documents, but this is seen as an attempt to deter attention from actual actions. There are different interpretations of action under the current ecosystems of treaties governing space, to the US what is seen as cheating the rules is viewed as competing by Chinese actors. There are also disparate views of what is escalatory, The Chinese prefer actions to compel in contrast to the United States emphasis on self-defense. Following this, deterrence can be difficult. The US should mirror-image and fully communicate the futility of actions that threaten other nations' sovereignty.

Space, in many ways, is conceptualized as an infinite resource, with ever-expanding boundaries and a suspension of time. However, especially for near-Earth bodies and orbits, this is largely untrue. LEO is crowded with satellites and communication lines must be shared. Sites on the Moon are finite, including 0°,0° for a space elevator, the dark side of the Moon for scientific experiments without the interference of Earth's chatter, places of historical significance and ideal places for operation. These sites, at some point, will become scarce. This panel however felt that site selection on the Moon would not become an issue within the prescribed time period, as this conference was specifically intended to look at the next 50 years (2025-2075). In some areas though, a first mover advantage might come to fruition through a denial of benefits.

WORKING GROUP SUMMARY DOCUMENTS

The summaries below were produced by representatives from each of the working groups and are presented here without any editing or alterations.

6.1. Working Group 1: The Limits of Humans in Space and Future Governance (2075 Horizon)

The basic question is whether there will be a significant human presence in space, and if so, what its scale will be. In terms of governance, will humans remain scarce—limited to brief visits—or will we see the development of permanent settlements and colonies? Over the next 50 years, human expansion into space will test both biological and societal limits. Physically, humans face challenges such as radiation exposure, muscle and bone deterioration, and the psychological strain of isolation and distance from Earth. Technological and medical advances may mitigate some issues, but fundamental human biology will remain a constraint.

We have engaged in the 4 generic images of the futures – GROW, COLLAPSE, DISCIPLINE, TRANSFORMATION

Grow scenario: NOOSPACE 2075

Inspired by the concept of the noosphere (see Pierre Teilhard de Chardin and Édouard Le Roy 1927), this scenario posits that the singularity predicted by transhumanist prophets (see Ray Kurzweil, Hans Moravec) has occurred. The control and governance of individuals and societies have been entrusted to AI. Social organization is modeled on trading posts: powerful corporations manage territories, resources, and entire societies. Humanity is becoming transhuman, not only through the modification of their bodies, but also through changes in their lifestyles and organizations. Humanity's expansion into space is a necessity linked to the increasing lifespan of human beings (even immortality) and the limits of Earth's resources (territories, energy, etc.). However, in 2075, the human presence in space remains limited. There are no humans beyond the Moon, only robots on Mars and a few moons of Saturn and Jupiter. On the Moon, AI imposes strict resource management, barely capable of sustaining limited human settlements, much like Antarctic stations on Earth. However, asteroid mining has begun, albeit modestly. But the forecasts are encouraging...

Collapse Scenario: China Alone

China is the sole remaining space power. Deep space exploration is limited to robots and a few astronauts on the Moon and Mars. There are no settlements. China continues to dominate in rare earth materials due to asteroid mining, in AI, robotics, automatic cars, drugs, and manufacturing. Mega-constellations have collapsed as commercial ventures and only government subsidized constellations remain. The Chinese Communist Party has consolidated its dominance through pervasive surveillance technologies, while Russia has devolved into a quasi-vassal state whose once-proud space program survives largely as a historical memory. Europe continues to undergo profound demographic and cultural erosion. Meanwhile, the United States faces a more subtle but equally consequential crisis: a failure of national will embedded within a broader economic and cultural deterioration. AI has eroded literacy and ambition worldwide. Space is just not exciting.

Disciplined Scenario: Deployment to a Space Oil-Rig

Space is a frontier for two-to-three-year deployments for repairmen and machinists while robots do most of the labor. There is no domestication, and no real economic sector develops. Deployment is like working in Antarctica in the 20th century or on an oil rig. Space tourism is small and unable to scale because of high-spender exhaustion, continued high cost, and space lacking prestige. Governance reaches only as far as commercial sites. Culture is entirely Earth-focused. Space is trivial.

Transformative Scenario: Space Utopia 2075

In the year 2075, a coalition led by G7 nations based on PPP has been able to make great progress in space exploration. The human presence in LEO and on the Moon is robust and in its infancy on Mars. There are multiple commercial LEO destinations focused on: space tourism, medical and pharmaceutical research including 3D organ-printing, and zero-G manufacturing. The permanent lunar settlement has 1000 permanent inhabitants and 250 rotating researchers and tourists. There are several stations on the Moon including administration and communication, medical research, mining and ISRU, an asteroid exploitation launch site and a deep space science research facility on the far side of the Moon. There is a nascent presence on Mars with rotation of humans staying on Mars less than 45 days at a time. Permanent off-Earth inhabitants withstand radiation, physiological decline, and immune weakening through advanced shielding, storm shelters, regolith-based habitats, plasma barriers, radioprotective medicine, and synthetic-biology systems for life support and health. Over five decades, intensive research and early adaptations—gravity-enhanced zones, centrifuge pods, and daily artificial-gravity exposure—have enabled long-term survival beyond LEO. We eventually anticipate hybrid off-world federalism characterized by chartered self-governance, autonomous local councils, and treaty-linked ties to Earth.

6.2. Working Group 2: Governance Concerns in Space Exploration and Settlement

Governance should prioritize coordination over rigid rules/strict multilateralism. Existing frameworks like OST Article IX suffice initially; bilateral agreements will emerge from necessity, focusing on mitigation and conflict avoidance rather than new regulations that could slowly progress. Flexible cooperation works better than centralized agencies > no need for a new international space agency due to timeline/cost/political issues, favor bilateral/multilateral models like ISS for speed and realism. Reframe priorities beyond "being first" > emphasize conflict avoidance, human survival needs (vs. commercial resources), and adaptive frameworks that prepare for all scenarios, including non-human operations.

Final Statements:

- Statement 1: More research is needed on the role that COPUOS and other multilateral arrangements can play in future governance.
- Statement 2: It's not too early to work to identify potential frameworks for conflict avoidance and mitigation, even in advance of human landings.
- Statement 3: The "flag and footprint" paradigm is not the most fruitful for developing space governance frameworks.

6.3. Working Group 3: The Legal Environment and State Responsibility in Space

Space law should adjust to developments as we progress in uses of LEO to evolving use and exploration of deeper space including the Moon. Increasingly space activities will require consideration of not only space law but the growing merging of situations parallel and interacting with those of other terrestrial legal regimes such as the Law of the Sea.

Governing deep space activities is not a separate legal issue from managing activities in LEO, MEO, and GEO because all are involved in transport and use of the space environment. In all associated activities transparency, best practices, agreements, etc. are important things to consider.

Recommendations in terms of governance:

Need concurrent buy-in from all aspects of management and governance: IGOs, NGOs, governments, civil society, and other involved and interested parties. The leadership, importance (weight) and views of any one actor may vary depending on specific needs. The balance of effectively dealing with these specific issues, listed below, is essential to realize effective and inclusive governance.

- Recognize in the law the interconnectivity of space with existing (and future) terrestrial regimes.
- Strengthening regulatory capacity through technical expertise.
- Industry-developed technical standards backed by national mechanisms for enforcement
- Reciprocity of equivalent authorization standards.
- Encourage development of alternative methods of compliance with agreed standards of responsible behavior among nations.
- No single model will suffice; a mixed system of incentives, oversight, and international coordination is likely required.
- Future governance models, shared standards, and sustained international dialogue will be essential to ensuring that the lunar surface develops in a peaceful, sustainable, and scientifically valuable manner.

6.4. Working Group 4: Balancing Innovation, Commercial Activity, and Shared Governance in Future Deep Space

The working group examined the scope of space regulations, from international treaties to national laws, and examined critical issues such as space traffic, space debris, and space resource utilization. The working group discussed how space governance can adapt to a rapidly evolving landscape shaped by technological innovation, commercial activity, and shifting geopolitical dynamics. The working group explored how to balance conflicts of interests, such as can surround invasive physical activity and scientific potential, such as mining and preservation of scientific sites, or places of high cultural and intangible value.

To address broader challenges related to mission authorization and lack of international regulatory authority. As a tangible, educational example, the group borrowed the analogue from the international status of the ICG (International Committee on Global Navigation Satellite Systems).

Focusing narrowly on technical challenges enables the conversation to center concrete needs for near term advancement. From this point, policies can be developed incrementally that enable innovation and overcome obstacles encountered by stakeholders, as well as establish best practices, from empiric experience. The working group also proposed a “policy readiness level” akin to the “technical readiness level” used for example by NASA, to gauge the maturity of an issue area. The issue area can be made more specific through research and stakeholder engagement until it reaches a level that is narrowed enough for policy action or proposals. The narrower technical structure also provides clarity as to *who* should sit at the table and be involved in decision making. Here, discussions surrounding safety; risk, technical advancement, technical standards, and financial investment can occur.

Adding to the ICG model, the group discussed the success of the COSPAR Panel on Planetary Protection (PPP), standards for planetary protection and planetary protection policy; these standards are adopted by NASA, Russia, China, India, ESA, and therefore, all missions that are contracted through them. As a result, COSPAR PPP guidelines provide flexibility: as they are updated with new scientific knowledge, changes propagate through domestic agencies. In a future that involves increasingly private space missions independent of these funding sources, the PPP guidelines still exist as a body of best practices to benefit from the research and historic knowledge.

Put together, a body that sits in the international stage similarly to ICG, narrow in focus, built to develop mechanisms like the COSPAR PPP, would be one ideal manner to approach planetary protection outside of the origins of life. The working group further concluded that implementation of such a similar idea would be an interpretation of fulfilling existing treaty obligations of the OST.

The working group identified that the coordination mechanism enables multi-stakeholder engagement and encourages commercial stakeholder participation to balance the governance mechanism.

Summary and Take-Away

1. It's important to ensure we have open communication among different communities – scientists, commercial entities, policymakers, diplomats, etc.
 - 1.1. Look at example of *Dark and Quiet Skies* as an example how these groups work together to address issues that balance their concerns
2. National regulation, and guidelines associated with government contracting are important – arguably the most effective types of governance right now
3. Moving to the international level, possibility of implementing an ICG-type organization (gaps in mechanisms for coordination)
 - 3.1. Beneficial that this has technical working groups to focus on technical challenges - could work on things like understanding dust mitigation/ dust plumes
 - 3.2. Does it matter that lunar activity may have much broader membership?
 - 3.3. Is Lunar activity so political and with high global visibility, so it wouldn't work?
 - 3.4. COSPAR PPP could also be an interesting model
4. Any regulation needs to be balanced, flexible – needs to accept that we will change the lunar environment in some ways, just as we have on the Earth.
5. Need to protect some specifics, irreversible things
 - 5.1. Example – the visible face of the Moon (and specifically the “Man in the Moon”)
 - 5.2. Difficult to determine how to draw normative limits – who decides?

Final Thoughts/Summary

Governance of deep space exploration is an extremely complex and highly controversial topic, subject to deep emotional interpretations and meanings. Approaches to future governance may be best considered through solving specific operational, safety, and practical issues under the oversight of involved governments with detailed solutions through agreements among relevant experts. Over time this can lead to a structured system of international governance focused on broad goals of international cooperation. History has illustrated this approach as a possible workable and long-term formula for success.