Modernizing the Outer Space Treaty: Gap Analysis, Comparative State Practice, and Expert Perspectives on Reform Pathways

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Abstract

The 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space (the Outer Space Treaty, OST) remains the constitutional foundation of international space law, yet its deliberately broad Cold War-era language is increasingly strained by commercial resource extraction, satellite mega-constellations, dual-use technologies, and a multipolar field of spacefaring actors. This study combines a textual gap analysis of the OST with a comparative review of national implementation across major jurisdictions and a structured expert elicitation conducted by the Celestial Governance Initiative. Of six survey submissions received, three were identical duplicate entries and were removed, yielding four effective expert respondents. Because of this small sample, the survey is treated as a qualitative expert consultation rather than a statistically representative instrument. Respondents converged on several reform priorities, including the regulation of resource extraction, the addition of explicit debris and environmental obligations, mandatory operator insurance, an independent body for investigating space damage, a regulated registry-transfer process, and the transfer of depositary functions to a neutral United Nations body. They diverged sharply on the appropriate ambition of reform, ranging from clarifying existing language to creating new institutions. We argue that the most defensible near-term pathway codifies mature, already-practiced norms and clarifies contested terms, while building procedural mechanisms that can evolve as state practice matures. The findings are intended to inform deliberations within the Committee on the Peaceful Uses of Outer Space.

Keywords: Outer Space Treaty, space law reform, COPUOS, space resource utilization, orbital debris, non-appropriation, expert elicitation

Introduction

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, opened for signature in 1967 and continues to serve as the foundational instrument of international space law (United Nations Office for Outer Space Affairs [UNOOSA], 2017). Negotiated during a period in which space activity was the exclusive province of two competing superpowers, the treaty deliberately favored broad principles over detailed rules, reflecting both the novelty of space activity and the absence of stable state practice (Cheng, 1997; von der Dunk, 2015). That breadth was a strength: it allowed the regime to endure across decades of technological and geopolitical change without repeated renegotiation.

The same breadth, however, has become a source of strain. The contemporary environment features commercial resource prospecting, satellite mega-constellations numbering in the thousands, in-orbit servicing and rendezvous operations, and a diverse field of state and non-state actors whose interests do not always align (Jakhu et al., 2017; Kaginele, 2023). Several core provisions of the OST are now subject to competing interpretations. Article I leaves unresolved whether the obligation to conduct activities for the benefit of all countries entails distributive justice or is satisfied through shared public goods (Tronchetti, 2009; Lyall & Larsen, 2018). Article II prohibits national appropriation but is silent on the private appropriation of extracted resources, a gap that several states have filled through unilateral national legislation (Tronchetti, 2018; Hofmann & Tronchetti, 2023). Article IV bans weapons of mass destruction but does not address conventional anti-satellite systems or the proliferation of dual-use technologies (Council on Foreign Relations, 2021). Article IX requires due regard and the avoidance of harmful

contamination, yet the prevailing scholarly view is that it does not clearly encompass orbital debris (Jakhu et al., 2017).

These interpretive gaps are not merely academic. Where international law is ambiguous, states increasingly resort to unilateral legislation and to plurilateral instruments such as the Artemis Accords, raising the prospect of regime fragmentation if national practices diverge without coordination (Baker Institute, 2024; Frontiers in Space Technologies, 2025). Confidence-building measures and the codification of mature norms have both been proposed as intermediate steps toward a more durable framework (Council on Foreign Relations, 2021).

This study contributes to that debate in three ways. First, it synthesizes a textual gap analysis of the OST conducted by the Celestial Governance Initiative (CGI) Governance and Law Working Group, identifying normative and interpretive gaps on an article-by-article basis. Second, it situates that analysis within a comparative review of how major jurisdictions implement OST obligations in domestic law. Third, it reports the results of a structured expert elicitation in which CGI contributors recorded their preferences across the principal questions of treaty reform. Taken together, these strands allow us to assess not only where the treaty is deficient, but also where informed opinion converges on remedies and where it remains divided. The remainder of the paper sets out the methodology, presents the survey results alongside the documentary analysis, discusses their implications for reform, and offers concluding recommendations directed at deliberations within the Committee on the Peaceful Uses of Outer Space (COPUOS).

Methodology

Research Design

This study employs a mixed-documentary and expert-elicitation design. The documentary component comprises two analytical phases conducted by the CGI Governance and Law Working Group. Phase 1 was a textual gap analysis of each operative article of the OST, assessing operational scope, applicability to non-governmental entities, and normative and interpretive gaps, supported by peer-reviewed legal scholarship and primary instruments. Phase 2 was a comparative analysis of national and regional implementation across major spacefaring jurisdictions, examining how each interprets, operationalizes, and extends treaty obligations through domestic law and policy.

The empirical component is a structured survey instrument administered to working-group contributors and affiliated experts. The instrument comprised fifteen thematic sections tracking the structure of the OST, with both closed-response items and open-text fields for written reasoning. Because participants were purposively drawn from a specialized policy working group rather than randomly sampled, the survey is properly understood as a qualitative expert consultation. It is not a statistically representative survey, and no inferential claims of significance or generalizability are made. Results are reported as counts of respondents rather than as population estimates.

Sample and Data Preparation

Six survey submissions were received. On inspection, three submissions were byte-for-byte identical in every closed and open response and were recorded within a single half-second interval, indicating a repeated submission of one respondent's questionnaire rather than three independent participants. These duplicate entries were removed during data cleaning, yielding four

effective respondents: one student, one volunteer contributor, and two members holding senior roles within the initiative. All proportions reported in this paper are computed on the deduplicated sample of four. Given this sample size, individual responses carry substantial weight, and the analysis foregrounds the direction and reasoning of expert opinion rather than precise magnitudes.

Closed responses were tabulated by item, and the leading option for each item was identified. Items on which all four respondents selected the same option are reported as points of full consensus; items with an even two-to-two split are reported as points of division. Open-text responses were reviewed thematically to surface the reasoning underlying the closed responses, with particular attention to arguments grounded in existing instruments such as the Liability Convention and the Rescue Agreement.

Analytical Approach and Limitations

Findings from the survey are interpreted in conjunction with the documentary analysis, allowing convergence between expert preference and doctrinal assessment to be identified. Several limitations follow from the design. The small expert sample limits external validity and precludes statistical inference. Participants were drawn from a single working group and may share orientations not representative of the broader space-law community. Finally, the survey captures stated preferences at one point in time and does not measure the feasibility of any given reform within the consensus-based environment of COPUOS. These limitations are mitigated, but not eliminated, by triangulating the survey against established scholarship and state practice.

Results

Respondent Profile

Table 1 summarizes the four effective respondents by role and affiliation type. All four participated as individuals rather than on behalf of an institution.

Table 1
Profile of Effective Survey Respondents (N = 4)

Respondent role	Stated affiliation	Participation type
Student	Individual contributor	Individual
Volunteer	Individual contributor	Individual
Working-group member	Academic institution	Individual
Initiative leadership	Celestial Governance Initiative	Individual

Note. Three additional submissions were identical duplicate entries from a single respondent and were excluded during data cleaning.

Orientation Toward the Artemis Accords

Respondents were divided on the role of the Artemis Accords in the future governance architecture. As shown in Figure 1, two of the four respondents endorsed the Accords fully, one endorsed only selected principles, and one preferred to pursue a United Nations-centered treaty instead. This division mirrors a broader tension in the literature between plurilateral, practice-led instruments and multilateral, treaty-based approaches centered on COPUOS (Frontiers in Space Technologies, 2025; Baker Institute, 2024).

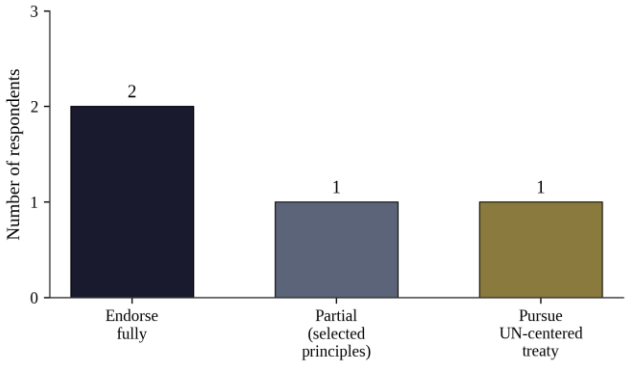

Figure 1. Respondent orientation toward the Artemis Accords (N = 4).

Ambition of Reform

Respondents disagreed on how ambitious treaty reform should be. As Figure 2 indicates, two respondents favored a high-ambition approach centered on creating new institutions for licensing, dispute resolution, and benefit-sharing, while one favored moderate binding standards and one favored minimal clarification of existing language. The written responses revealed that this divergence reflects differing judgments about political feasibility rather than differing assessments of the underlying gaps. One respondent cautioned that proposing binding provisions or new institutions risks being disregarded at COPUOS, whereas another argued that essential new institutions are necessary to give the regime effect.

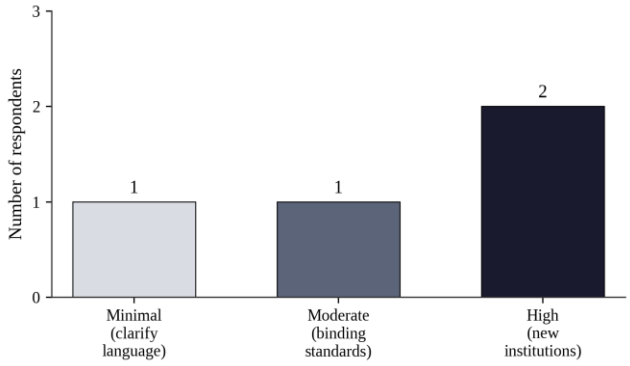

Figure 2. Preferred ambition of OST reform (N = 4).

Reform Priorities

When asked to identify reform priorities, respondents most frequently cited the regulation of resource extraction and the addition of explicit debris and environmental obligations, each named by three of the four respondents. A second tier of priorities, each named by two respondents, included creating a liability tribunal, defining continuing supervision, extending rescue obligations, clarifying peaceful purposes, and banning destructive anti-satellite testing. Figure 3 presents the nine most frequently cited priorities. The prominence of resource and environmental

concerns is consistent with the documentary analysis, which identified Articles II and IX as among the most contested provisions of the treaty.

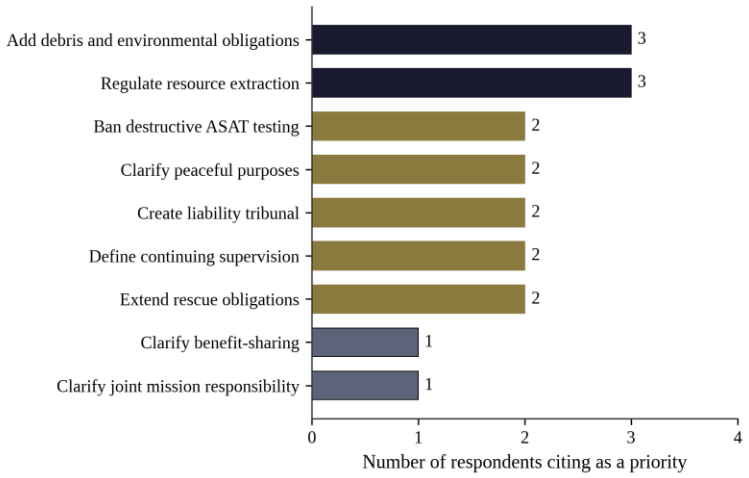

Figure 3. Most frequently cited reform priorities (N = 4). Items cited by three respondents are shown in the darkest shade.

Points of Consensus and Division

Despite disagreement on overall ambition, respondents converged fully on several specific reforms. As shown in Figure 4, all four respondents agreed that resource extraction should be permitted subject to international licensing and benefit-sharing; that an independent forensic body should investigate space damage; that operators should be required to carry insurance; that registry transfers after launch should proceed through a regulated international process; that any national-security exception to transparency should be narrow and accompanied by confidential UN notification; and that depositary responsibilities should be transferred from the original three governments to a neutral UN body. Two further items attracted three-of-four support: permitting dual-use systems subject to transparency, and banning debris-generating anti-satellite testing.

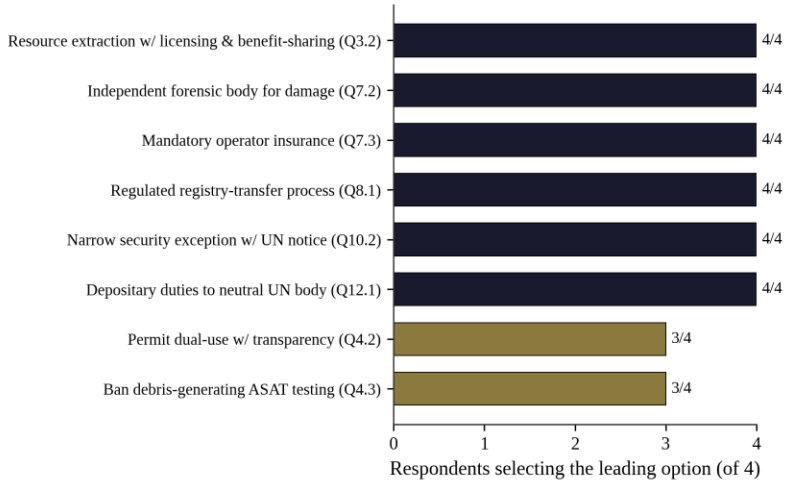

Figure 4. Items of full and near-full consensus (N = 4). Bars reaching four of four indicate unanimous agreement on the leading option.

Table 2 contrasts these points of consensus with the items on which respondents were evenly divided. The pattern is instructive: consensus clustered on procedural and institutional mechanisms that extend existing instruments, whereas division clustered on questions of principle and degree, such as how to define the benefit of all countries, how ambitious reform should be, and whether consultation before potentially harmful activities should be binding.

Table 2
Points of Full Consensus Versus Points of Even Division (N = 4)

Full consensus (4 of 4)	**Evenly divided (2 of 4)**
Resource extraction permitted with international licensing and benefit-sharing	How to define the “benefit of all countries”
Independent forensic body for space-damage investigations	Overall ambition of treaty reform
Mandatory insurance for operators	Whether to create a binding space-claims tribunal
Regulated registry transfer after launch	Whether orbital debris should be a separate obligation
Narrow security exception with confidential UN notification	Whether pre-activity consultation should be binding
Transfer of depositary duties to a neutral UN body	Whether inspection should apply to all installations

Note. Question identifiers correspond to the survey instrument. Consensus items are those for which all four respondents selected the same leading option.

Discussion

The convergence of expert preference and documentary analysis points toward a coherent reform strategy, even though respondents disagreed on its ambition. The most striking feature of the survey is that consensus formed around mechanisms that extend or operationalize existing instruments, rather than around contested matters of principle. All four respondents supported mandatory operator insurance, an independent investigatory body, regulated registry transfers, and the transfer of depositary functions to a neutral UN body. Each of these builds on machinery that already exists in the broader corpus of space law, and each was independently identified as a gap in the textual analysis.

This pattern supports an incremental, codification-first approach. As the Phase 1 analysis observed, many once-flexible principles of the OST have matured through repeated practice and institutional reinforcement, particularly in debris mitigation, registration, and the national authorization and supervision of private actors under Article VI (Jakhu et al., 2017; UNOOSA, 2010). Governance scholarship consistently finds that codifying established practice reduces legal uncertainty while minimizing political resistance (von der Dunk, 2015). The survey reinforces this: the reforms that commanded unanimous support are precisely those that formalize behavior states already exhibit, whereas the reforms that divided respondents would require states to resolve genuinely contested questions of principle.

On resource extraction, the documentary analysis and the survey align closely. All four respondents agreed that extraction should be permitted subject to international licensing and benefit-sharing, and the comparative analysis shows that this position is already reflected in the national legislation of several jurisdictions, including the United States and Japan, which authorize private recovery and ownership of space resources while maintaining that such activity does not

constitute national appropriation (Tronchetti, 2018; Hofmann & Tronchetti, 2023). The unresolved questions concern the design of the licensing and benefit-sharing mechanism, not its existence. Here the literature points consistently toward the deep-seabed regime under the United Nations Convention on the Law of the Sea as an analogue that reconciles exclusive extraction with a common-heritage principle through benefit-sharing administered by an international authority (Jaeckel, 2017; Lodge et al., 2014). The recurring scholarly caution is that benefit-sharing obligations set too high will simply be ignored, undermining the development of a sharing custom (Tronchetti, 2009).

On the environment, the prominence of debris and environmental obligations among respondent priorities tracks a well-documented deficiency. Although the OST does not explicitly prohibit debris creation, the UN-endorsed mitigation guidelines reflect a shared understanding that such conduct is inconsistent with sustainable use, and the majority scholarly view is that Article IX does not clearly reach orbital debris (UNOOSA, 2010; Jakhu et al., 2017). Making debris obligations explicit would convert a soft expectation into an enforceable standard, mirroring the path several states have already taken in domestic law.

The division over the Artemis Accords and over the ambition of reform reflects the central strategic dilemma of contemporary space governance. Plurilateral instruments such as the Accords advance practice quickly but risk fragmenting the regime and marginalizing states outside the arrangement, a concern voiced especially from Global South perspectives (Frontiers in Space Technologies, 2025). A UN-centered approach preserves universality but moves at the pace of consensus. The survey suggests that this is not a binary choice: respondents who differed on the Accords nevertheless agreed on numerous concrete reforms that could be pursued through COPUOS regardless of the Accords' ultimate role. Confidence-building measures may bridge the

two approaches by establishing agreed norms that later harden into binding commitments (Council on Foreign Relations, 2021).

Finally, the comparative analysis cautions against assuming that gaps in the OST imply an absence of governance. Several jurisdictions have filled treaty silences with detailed domestic regimes covering licensing, compulsory insurance, environmental prohibitions, and extended jurisdiction. The risk is not lawlessness but divergence: as national interpretations multiply, the prospect of incompatible legal regimes grows. This strengthens the case for codifying a common baseline at the international level before national practices crystallize into conflicting customs.

Conclusion

The Outer Space Treaty endures because it was written to be durable, but durability is not the same as sufficiency. This study has combined a textual gap analysis, a comparative review of national implementation, and a structured expert elicitation to assess where the treaty falls short and where informed opinion converges on remedies. Although the expert sample is small and the findings should be read as a qualitative consultation rather than a representative survey, the convergence between expert preference and documentary analysis is notable.

Three conclusions follow. First, the most promising near-term reforms are those that codify mature, already-practiced norms and clarify contested terms, rather than those that attempt to resolve deep questions of principle by fiat. Respondents agreed unanimously on procedural and institutional mechanisms, including mandatory insurance, an independent investigatory body, regulated registry transfers, and a neutral depositary, each of which extends existing machinery. Second, resource extraction and environmental protection are the substantive priorities most urgently in need of explicit treatment, and both admit of designs drawn from existing analogues such as the law of the sea and the UN debris-mitigation guidelines. Third, the division over

plurilateral versus multilateral pathways need not paralyze reform, because a substantial agenda of concrete improvements commands agreement across that divide.

We therefore recommend that deliberations within COPUOS prioritize the codification of agreed baselines, the explicit incorporation of debris and environmental obligations, the design of an internationally coordinated licensing and benefit-sharing mechanism for resource activities, and the modernization of depositary and amendment procedures. These steps would strengthen accountability and legal certainty without destabilizing the foundational architecture that has governed outer space for more than half a century. Future work should expand the expert base substantially, incorporate the perspectives of states currently underrepresented in space governance, and test the political feasibility of each proposed reform within the consensus environment of COPUOS.

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