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"SPACE GOVERNANCE AT RISK: RETHINKING OWNERSHIP, LIABILITY AND STATE INTERVENTION IN THE FINAL FRONTIER"

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ABSTRACT:

The rapid growth of the private activity in outer space has pushed the existing legal framework into territory it was never designed to handle in the first place. Treaties like the Outer Space Treaty 1967 and the Liability Convention 1972 were drafted for a world dominated by State agencies, but today private companies lead in satellite deployment, mega-constellations, launch services, and even early-stage plans for resource extraction. As a result, long-standing principles on non-appropriation, State responsibility, and liability are being stretched in ways that create genuine uncertainty for regulators and operators also.

This paper uses doctrinal and comparative methods to examine how international space law interacts with emerging national regimes in the United States, Luxembourg, the UAE, Japan, the UK, Australia, India, China and Russia. This analysis shows that while some States have moved towards recognising private ownership of extracted resources, others remain cautious or resistant, producing a fragmented global landscape. This research also highlights that the traditional liability system built on diplomatic claims and State-to-State responsibility struggles in an era defined by private actors, dense orbital traffic and complex supply chains.

The study argues that these tensions have consequences not only for commercial certainty but also for the long-term sustainability and equity. To address these gaps, the paper proposes a new governance approach centred on clarifying resource rights, defining narrowly tailored operational deconfliction zones, establishing stronger baselines for liability and insurance, improving transparency through some shared SSA standards, and integrating the environmental and equity considerations into mission planning.

Overall, the paper suggests that meaningful reform does not require abandoning the OST framework, but building around it in such a way that balances innovation with public responsibility. Without such reforms, the future of outer space risks becoming increasingly unstable, environmentally vulnerable and shaped by the interests of a few technologically advanced States and also corporations.

Key words: Outer space treaty, liability convention, sustainability, ownership and liability, Treaties, space mission, commercial activities

1. Introduction

1.1 Background and Rationale

Outer space is undergoing an extreme transformation. For most of the twentieth century, space activities were dominated by handful of States and largely framed in the terms of prestige, national security and scientific exploration. Today, private companies launch satellites, provide broadband internet, sell high-resolution Earth-observation data, develop space tourism services and prepare for

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the space mining ventures. The numbers themselves tell a powerful story. By May 2025, estimates suggest that there were around 11,700 active satellites orbiting the Earth[46], compared to only a few thousand less than a decade before. A significant share of these satellites belongs to mega-constellations, most prominently SpaceX's Starlink, which already accounts for a majority of the active satellites.

Scientific studies now warn that if current launch plans for mega-constellations continue, the number of satellites in the orbit could grow to hundreds of thousands in the coming decades. This raises serious concerns about critical incidents like orbital congestion, collision risk, light pollution and long-term sustainability. One study published in *Nature* suggests that satellite streaks could contaminate a large percentage of images from future space telescopes, potentially up to 96% for certain survey missions[47], thereby undermining astronomical research.

Parallel to this technological and commercial expansion, States have begun to reshape space law through the national legislation. The United States, Luxembourg[48], the United Arab Emirates (UAE)[49], Japan[50] and India[51] have each adopted laws or policies that recognise private ownership of outer space resources extracted from celestial bodies[52], while the United Kingdom and Australia have modernised their launch and licensing regimes without yet legislating explicitly on resource ownership. China and Russia, by contrast, have not adopted detailed space mining legislation[53] and often emphasise the importance of non-appropriation and collective interests in outer space.

This creates a tension: The core multilateral treaties that form the backbone of space law were drafted in the 1960s and 1970s[54], in a state-centric Cold War environment. They do not mention space mining, safety zones around lunar bases or mega-constellations. Yet it is sure that issues that determine how sustainable and fair the new space economy will be.

1.2 Research Questions

This paper is built around two broad and important questions:

1. How effective and efficient are the current international treaties in dealing with modern issues of ownership, liability and private commercial exploitation in outer space?
2. What kind of global governance system can balance out freedom for private innovation with accountability to public responsibility?

To sharpen these, the paper adopts three more specific research questions:

- RQ1 - Ownership and treaties: Can corporations own resources extracted in outer space without violating the non-appropriation principle in Article II of the Outer Space Treaty especially where national laws explicitly recognise such ownership?
- RQ2 - Liability and risk: How should liability and risk be allocated among launching States, operators, manufacturers, payload customers and insurers in an era of dense low Earth orbit, traffic and complex global supply chains?
- RQ3 - Governance model: What kind of international governance framework or reform model can realistically balance private innovation with public responsibilities such as safety, environmental protection, transparency

[46] Union of Concerned Scientists, *UCS Satellite Database* (2025) https://ucsusa.org/resources/satellite-database accessed 20 January 2025.
[47] Meredith L Rawls and others, 'The Impact of Satellite Constellations on Astronomy' (2023) *Nature Astronomy*.
[48] Luxembourg, Law of 20 July 2017 on the Exploration and Use of Space Resources.
[49] United Arab Emirates, Federal Law No 12 of 2019 on the Regulation of the Space Sector.
[50] Japan, Space Resources Act 2021.
[51] India, *Indian Space Policy 2023* (Government of India, Department of Space).
[52] Commercial Space Launch Competitiveness Act 2015, 51 USC § 51303.
[53] UN COPUOS Legal Subcommittee, Statements by China and Russia on Space Resource Activities (2019–2024).
[54] Outer Space Treaty (adopted 27 January 1967, entered into force 10 October 1967) 610 UNTS 205.

and equity, taking into account existing national regimes in the United States, Luxembourg, UAE, Japan, UK, Australia, India, China and Russia?

1.3 Methodology

The paper adopts a qualitative doctrinal and comparative approach. First this paper analysis the core treaties the Outer space treaty, the Liability Convention, the Registration Convention and the Moon Agreement and key soft-law instruments such as UNCOPUOS debris mitigation and long-term sustainability guidelines, the COSPAR planetary protection policy, and also the Artemis Accords.

Second, it even conducts a comparative examination of nine national regimes: the United States, Luxembourg, the UAE, Japan, the UK, Australia, India, China and Russia. These States were selected because they represent a mix of established and emerging space powers, different legal traditions, and contrasting attitudes toward commercialisation and resource extraction.

Third, the paper uses qualitative data from few recent scientific reports, policy documents and case studies on mega-constellations, space debris, and the environmental impact of commercial activities to enjoin legal analysis with real-world developments.

The objective is not to provide the quantitative modelling but to offer a deep, conceptually clear and policy-relevant analysis of how law is adapting or failing to adapt to the changing space environment.

2. International Legal Architecture of Outer Space

2.1 Core Treaties and Foundational Principles

The **1967 Outer Space Treaty (OST)** is the milestone of international space law[55]. It establishes several foundational principles that shape any discussion of ownership, liability and commercial exploitation.

First, Article I declares that outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all the States without discrimination and on a basis of equality[56], and that such exploration shall be carried out for the benefit and in the interests of all the countries, irrespective of their level of development. Second, Article II prohibits national appropriation of outer space or celestial bodies[57] "by claim of sovereignty, by means of use or occupation, or by any other means." Third, Article VI imposes international responsibility on States for national activities in outer space[58], whether conducted by governmental or non-governmental entities, and requires that non-governmental activities be authorised and continuously supervised by the appropriate State. Fourth, Article VII establishes that States which launch or procure the launch of an object, or from whose territory or facility an object is launched, are internationally liable for damage caused by that object to another State or its natural or juridical persons. Article VIII gives the launching State jurisdiction and control over its registered space object and any personnel thereon, while Article IX imposes a duty to conduct such activities with due regard to the corresponding interests of other States and to avoid "harmful contamination" of outer space and adverse changes to the environment of Earth.

These provisions create a commons model for outer space: No State may claim territory, but all States are free to explore and use the space, subject to duties of responsibility, due regard and environmental care. The outer space treaty does not refer to "property" or "ownership" of space resources, leaving a significant interpretative gap that has become central to debates on space mining.

The **1972 Liability Convention**[59] elaborates Article VII OST. It distinguishes between (a)

[55] Outer Space Treaty (adopted 27 January 1967, entered into force 10 October 1967) 610 UNTS 205.

[56] Outer Space Treaty 1967, art 1.
[57] Outer Space Treaty 1967, art 2.
[58] Outer Space Treaty 1967, art 6.
[59] Convention on International Liability for Damage Caused by Space Objects (1972) 961 UNTS 187.

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damage caused on the surface of the Earth[60] or to aircraft, where launching States are absolutely liable, and (b) damage occurring elsewhere including in outer space, where liability is fault-based[61]. It defines the "launching State" broadly and provides for inter-State claims to be also presented through diplomatic channels, with a special Claims Commission procedure if the settlement fails. In practice, as we will see that states have rarely used these procedures.

The **1976 Registration Convention** requires States to maintain a national registry of space objects[62] and to transmit basic information such as launch date, orbital parameters and general function to the UN. This facilitates attribution of responsibility and jurisdiction.

The **1979 Moon Agreement** is more controversial. It declares that the Moon and its natural resources to be the "common heritage of mankind"[63] and calls for an international regime to govern resource exploitation when such exploitation becomes possible. However, it has been ratified by only a small number of States, none of which are major spacefaring powers like the US, Russia, China, India or Japan, nor the key commercial resource states like Luxembourg and the UAE. Its principles therefore have limited necessary strength but continue to influence the normative debates about equity and benefit-sharing.

2.2 Soft Law, Technical Regimes and Political Instruments

Beyond formal treaties several soft-law and technical regimes play an important role. The UNCOPUOS Space Debris Mitigation[64] Guidelines and Long-Term Sustainability Guidelines provide non-binding recommendations on mitigating debris creation, performing end-of-life disposal and increasing the transparency in operations.[65] The IADC debris guidelines and ISO standards, often used agencies and insurers, given by space more detailed technical criteria for simple spacecraft design and mission planning to minimise debris.

The **COSPAR planetary protection policy** sets contamination control standards for missions to bodies with potential Astro biological interest[66]. Although originally aimed at scientific missions, these standards increasingly affect commercial missions that aim to land or operate in regions such as Martian subsurface areas or icy moons.

The **International Telecommunication Union (ITU)**, through its Radio Regulations, accomplishes spectrum and orbital positions for communication satellites[67]. National regulators such as the US Federal Communications Commission or the UK's Ofcom implement these rules domestically by coordinating with other administrations to avoid harmful interference.

Finally, the **Artemis Accords** a series of the bilateral political commitments initiated by the United States and now joined by over 30 countries including Japan, the UK, Australia, the UAE and India articulate specific interpretations of OST principles[68]. They confirm that resource extraction does not inherently create national appropriation and propose practices such as notification of "safety zones" around sites of activity to avoid harmful interference. China and Russia are not signatories, highlighting political divides.

2.3 Effectiveness and Gaps

Taken together, the OST, Liability Convention, Registration Convention and soft-law instruments provide a solid but also incomplete framework[69]. They clearly prohibit sovereignty claims, anchor State responsibility for the private actors, and establish a basic liability

[60] Liability Convention 1972, art 2.
[61] Liability Convention 1972, art 3.
[62] Convention on Registration of Objects Launched into Outer Space (1975) 1023 UNTS 15.
[63] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (1979) 1363 UNTS 3, art11.
[64] UNCOPUOS, *Space Debris Mitigation Guidelines* (United Nations 2010).
[65] UNCOPUOS, *Guidelines for the Long-Term Sustainability of Outer Space Activities* (2019).
[66] COSPAR, *Planetary Protection Policy* (2021 Revision).
[67] International Telecommunication Union, *Radio Regulations* (2020).
[68] NASA, *The Artemis Accords* (2020), Principles 9–11.
[69] Henry R Hertzfeld and Frans G von der Dunk, 'Mega-Constellations and Liability Law' (2021) *Space Policy* 117.

structure. They also acknowledge the environmental concerns and require due regard to others.

However, they do not resolve the key questions now central to space governance[70]:

- Whether ownership of the extracted resources by companies is compatible with non-appropriation.
- How far can the states go in creating "safety zones" or operational areas without amounting to de facto appropriation.
- How liability should be allocated and enforced in complex chains involving multiple private actors and insurers.
- How to address the systemic environmental risks posed by mega-constellations and large-scale resource extraction.

3. Ownership of Space Resources

3.1 Sovereignty vs Resource Ownership

The starting point is the basic distinction between territorial sovereignty and ownership of extracted resources. Article II OST clearly prohibits the sovereignty over outer space and celestial bodies[71]. No State may treat a part of the Moon or an asteroid as its national territory, nor can it extend its airspace or jurisdiction in a territorial sense.

However, Article II does not say anything about the status of resources taken from celestial bodies. This has led so far to two main interpretative approaches. One, followed by States that had enacted resource laws, interprets non-appropriation as a narrow prohibition on claims over territory, but not over resources. On this interpretation, just as fish caught on the high seas or minerals extracted from the deep seabed subject to specific regimes can become property without the States acquiring sovereignty over the area itself, so asteroid materials become the property of the extractor[72]. Ownership is therefore the function of national law, subject to the duty in Article VI to administer private activities.

The second stresses the shared interest in space and the danger that unregulated resource exploitation would endanger both the spirit of non-appropriation and principles of equity. Supporters of this position look for guidance in the Moon Agreement's common heritage of mankind language, upholding that celestial resources are a natural resource over which governments should use no sovereignty, but should manage under international provisions to ensure reasonable benefit-sharing, technology transfer and environmental protection. Under this approach, unilateral national recognition of private ownership, especially if it produces concentrated exploitation of rare resources is at least politically challenging and perhaps illegal.

3.2 Emerging National Practice

Practice in the nine countries studied shows a clear divergence. The United States' Commercial Space Launch Competitiveness Act (2015) provides that US citizens engaged in the commercial recovery of asteroid or space resources "shall be entitled to any asteroid resource or space resource obtained," including to possess, own, transport, use and sell such resources, while expressly denying any sovereignty claim over celestial bodies. Luxembourg's 2017 Law on the Exploration and Use of Space Resources goes further by stating that "space resources are capable of being owned" and requiring prior authorisation for exploration or use[73].

The UAE's Federal Law No. 12 of 2019, supplemented by a Space Resources Regulation, defines "Space Resources" and then authorises their use for scientific or commercial purposes under licence, effectively enabling

[70] Joanne Irene Gabrynowicz, 'The Outer Space Treaty and Emerging Issues in Space Governance' (2019) 42 *Journal of Space Law* 1.
[71] Outer Space Treaty 1967, art 2.
[72] Frans G von der Dunk, 'Mining Outer Space: International Legal Aspects' (2019) 62 *German Journal of Air and Space Law* 137.
[73] Luxembourg, Law of 20 July 2017 on the Exploration and Use of Space Resources, art 1.

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private exploitation under national supervision[74]. Japan's 2021 Space Resources Act similarly provides that the licensed operators acquire ownership of resources that they extract, again subject to compliance with international obligations and domestic regulations.[75]

India's Space Policy 2023 and its 2024 Norms, Guidelines and the Procedures declare that non-government entities may own, operate, and sell space-based assets and services and may own and sell space resources they obtain, subject to authorisation by IN-SPACe and in compliance with the international law[76]. India thus signals the alignment with the liberal resource ownership model even before a inclusive space activities statute is passed.

By contrast, the UK and Australia have not yet enacted explicit resource ownership laws, though both support commercial activities and are signatories to the Artemis Accords. Ownership of resources extracted in missions licensed by these States would likely be recognised through contract and general property law, but the absence of the explicit legislative statements leaves room for interpretation.

China and Russia have adopted a more cautious position. Neither one has passed detailed legislation granting private entities ownership rights over space resources. Their official statements in UN fora often criticise unilateral resource laws and call for multilateral arrangements[77] before large-scale exploitation occurs, emphasising non-appropriation and the interests of all States.

This divergence results in a plural legal landscape: a cluster of States explicitly protecting resource ownership; a second cluster supporting commercial development but legally ambiguous on ownership; and a third cluster resisting unilateral resource rights. For now, this pluralism co-exists, but as for the actual mining missions move from concept to practice, tensions may intensify.

3.3 Safety Zones, De Facto Control and Planetary Protection

The vision of resource extraction raises few practical questions about proximity and interference. If multiple actors seek to operate in the same lunar region, how can they avoid collisions, dust contamination or damage to equipment without asserting territorial control?

The Artemis Accords propose the concept of safety zones[78]. Signatories agree to notify the location and general nature of operations and to establish the safety zones within which they will coordinate to avoid harmful interference, framing this as an implementation of Article IX OST's due-regard and consultation obligations. In principle, safety zones are like operational tools, not only property claims.

Nevertheless, some scholars and States worry that safety zones, especially if large or indefinite, may function as de facto exclusive areas, particularly around the valuable deposits[79] such as permanently shadowed polar depressions containing water ice. The risk is that technically justified safety considerations could be used to keep others at bay, undermining both the non-appropriation principle and the equal-access spirit of Article I.

Environmental and scientific concerns deepen this tension. Extraction activities may disturb original environments alter and potentially compromise future scientific investigations COSPAR planetary protection guidelines and emerging policies like ESA's "Zero Debris by 2030" initiative emphasise minimising contamination and long-lived debris. Any credible resource regime must be therefore integrating planetary protection and debris

[74] United Arab Emirates, Federal Law No 12 of 2019 on the Regulation of the Space Sector, arts 3–5.
[75] Japan, Space Resources Act 2021.
[76] India, *Indian Space Policy 2023* (Government of India, Department of Space), §§ 3–6.
[77] UN COPUOS Legal Subcommittee, Statements by the Russian Federation and China on Space Resource Activities (2017–2024).
[78] Michelle Lall, 'Safety Zones and the Risk of De Facto Appropriation' (2022) *Proceedings of the IISL*.
[79] Fabio Tronchetti, *The Exploitation of Natural Resources of the Moon and Other Celestial Bodies* (Brill 2009) 132–140.

mitigation into its basic design, rather than treating them as afterthoughts.

3.4 Interim Assessment

In relation to RQ1, the picture is mixed. The existing treaties are neither clearly prohibit nor clearly authorise private ownership of extracted resources. National practice is moving strongly in a permissive direction among some States, but significant actors remain sceptical. The legal debate is therefore not settled, and the risk of regulating fragmentation is real. In practical terms, however, companies are licensed under the laws of States like the US, Luxembourg, UAE, Japan and India can plan for ownership of resources, while recognising that some States may contest the legitimacy of such ownership at the international level.

4. Liability and Risk Allocation

4.1 Structure of the Liability Convention

The Liability Convention was designed to allocate the risk between States in an era of state-run space programmes. It introduces three key concepts those are: the "launching State," the distinction between absolute and fault-based liability, and procedural rules for claims[80]. A launching State is any State that launches or procures the launch of a space object, or from whose territory or facility it is launched.[81]

For damage on the surface of the Earth or to aircraft, launching States are also absolutely liable.[82] Victims need not prove fault; they must only show that the damage resulted from a space object. For damage away than on the surface of the Earth essentially, in outer space liability is fault-based: a launching State is liable only if the damage is due to its fault or the fault of persons for whom it is responsible. The Convention provides that claims must be presented by States on behalf of themselves or their nationals, and sets out time limits and procedures for negotiations[83]. A Claims Commission may be established if negotiations fail, with decisions in principle binding if agreed by the parties.

4.2 Practice and Limitations

In practice, the Convention has been formally invoked only once: Canada's claim against the Soviet Union after the Cosmos 954 nuclear-powered satellite re-entered over Canadian territory in 1978, spreading radioactive debris. Canada sought approximately 6 million Canadian dollars in costs; after negotiation, the USSR paid 3 million CAD without going to a Claims Commission.[84]

Recent incidents highlight the Convention's limitations. The 2009 collision between the active Iridium-33 satellite and the defunct Russian Cosmos-2251 satellite produced thousands of debris fragments and is often cited as a turning point for congestion risk[85]. Yet no claim was brought under the Liability Convention. Losses were addressed through commercial insurance and private arrangements, while States declined to sue fault.

Today's constellation environment with thousands of satellites, multiple operators, and complex supply chains makes fault determination in space extremely challenging. Establishing whether a particular State, operator or manufacturer was "at fault" in a collision requires detailed SSA data, telemetry and knowledge of avoidance decisions, much of which may be proprietary or classified. The Convention's focus on State parties and its diplomatic claim process is poorly suited to a world where private actors are the primary victims and participants.

4.3 National Law, Insurance and Private Contracts

Because of these limitations, national law and insurance markets play a central role in

[80] Convention on International Liability for Damage Caused by Space Objects (adopted 29 March 1972, entered into force 1 September 1972) 961 UNTS 187.
[81] Liability Convention 1972, art I(c).
[82] Liability Convention 1972, art II.
[83] Liability Convention 1972, arts VIII–X.
[84] 'Claim for Damage Caused by Soviet Cosmos 954' (1979) 18 ILM 899.
[85] Brian Weeden, '2009 Iridium–Cosmos Collision' (Secure World Foundation, 2010).

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practical risk allocation. In the United States, the FAA requires launch operators to obtain insurance up to a calculated "maximum probable loss," with the government offering indemnification above that amount up to a statutory cap. Waivers of claims between the operator, the government and payload customers are common.

The UK's Space Industry Act 2018 and Australia's Space Launches and Returns Act 2018 similarly order insurance and allow the government to cap an operator's liability[86], with the State effectively acting as an insurer of last resort for catastrophic claims. The UAE's Federal Law No. 12 of 2019 also requires operators to carry insurance and indemnify the State for international claims arising from their activities[87]. Japan's and India's evolving frameworks also contemplate insurance and explicit allocation of liability among operators and the State in their regulatory designs.

On-orbit insurance provides a coverage for satellite loss or damage due to technical failure or collision, often for periods up to 15 years. Premiums and exclusions are adjusted in response to perceived risk. Industry reports suggest that insurers are increasingly suspicious of debris and conjunction risks[88] associated with mega-constellations, and may treat certain orbits as high-risk or even uninsurable if debris levels continue to rise.

Contracts between operators, manufacturers, launch providers and customers contain detailed clauses allocating risk, including force majeure provisions, limitation of liability and dispute resolution clauses, often referring disputes to arbitration rather than national courts. Thus, while the Liability Convention remains formally in place, the real functioning of the liability and risk allocation has also migrated into national regulatory systems and private law, leaving systemic environmental harms under-addressed.

4.4 Evaluation in Light of Mega-Constellations

In light of mega-constellations and increased debris concerns, the Liability Convention appears ill-equipped to act as a primary deterrent or compensation mechanism. Absolute liability remains useful for surface damage, but such events are relatively rare. Fault-based liability in space is seldom invoked, and fault is hard to prove. There is no vigorous mechanism to deal with cumulative environmental harm[89] or the loss of orbital capacity that affects the international community as a whole.

For RQ2, therefore, the answer at this stage is that liability is fragmented and under-incentivising. Private insurance and national regulations partially fill the gap, but they are not designed to reflect the broader public interest values and such as preservation of the orbital environment and fairness among States.

5. Regulating Commercial Space Activities and Private Actors

5.1 Types of Commercial Activities

Commercial space activities now cover a wide and rapidly expanding spectrum[90]. They include launch services provided by companies such as SpaceX or ISRO's commercial arm, satellite communications and broadband services offered by mega-constellations, Earth-observation services used in agriculture, urban planning and security; satellite navigation augmentation, in-orbit servicing such as refuelling or debris removal, space tourism and human spaceflight, and prospective activities such as lunar or asteroid mining[91] and space-based manufacturing.

These activities generate enormous economic potential but also raise complex regulatory questions[92]. They use limited resources like orbital slots and spectrum, cause debris

[86] Space Industry Act 2018 (UK), ss 12–15.
[87] United Arab Emirates, Federal Law No 12 of 2019, arts 32–37.
[88] Swiss Re, *Space Insurance Report* (2022).
[89] European Space Agency, *ESA Space Debris Environment Report* (2023).
[90] OECD, *The Space Economy in Figures* (2022) https://oecd.org accessed 20 January 2025.
[91] Federal Aviation Administration, *Commercial Space Transportation Forecasts* (2023).
[92] European Space Agency, *Space Debris Environment Report* (2023).

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hazards, and are usually dual-use technology with security considerations. Simultaneously, they have the potential to provide strong public good, including bridging the digital gap, enhancing climate surveillance and aiding in disaster response.

5.2 Article VI OST and the National Supervision Model

Under Article VI OST, States remain responsible for national activities in outer space and must authorise and continuously supervise non-governmental entities. This provision has become the legal foundation for national commercial licensing regimes.

The most developed is the example of the United States. Launching and re-entry are licensed by the FAA and are concerned with the compliance with the national interests of the security of the populace and the environmental regulations; satellite communications are licensed by the FCC and are subject to the regulations of adherence to the ITU assignments and the rules of the interference; commercial remote-sensing is licensed by NOAA and subject to the regulations of the national security and privacy. The Department of Commerce has been tasked with developing civil space [93]situational awareness and traffic management, tying safety and commercial efficiency together.

Luxembourg, the UAE and Japan have all introduced national licensing and oversight mechanisms specifically tailored to space activities. Luxembourg requires authorisation for exploration and use of space resources, checking financial and technical capacity[94]. The UAE's Space Agency grants permit under the 2019 law,[95] assessing safety, insurance, environmental and security aspects. Japan's Space Activities Act and Space Resources Act set out detailed requirements for mission plans[96], risk management and compliance with international law.

India's Space Policy 2023 and its 2024 norms give IN-SPACe a central role in authorising and supervising non-government entities across the entire value chain from satellite operation to launches and resource utilisation mirroring Article VI's logic. The UK's and Australia's frameworks similarly revolve around national regulators granting licences and ensuring compliance with safety and environmental conditions.

China and Russia exert control over commercial actors through state-centred governance[97]; many "private" companies in China are closely linked to state-owned enterprises, and Russia's commercial sector remains comparatively small and tied to Roscosmos.

In all nine States, therefore, the basic model is the same: commercial freedom exists, but only within the framework of State authorisation and supervision, fulfilling Article VI.

5.3 Regulatory Competition and Forum Shopping

The existence of multiple national regimes inevitably raises the possibility of regulatory competition. Companies may choose to incorporate or register their missions in jurisdictions that offer favourable conditions, such as lower insurance requirements, faster licensing or more generous recognition of property rights. This is visible in Luxembourg's strategy of presenting itself as a space resources hub, and in the UAE's positioning as a regional centre for space services.[98]

Such competition is not inherently negative. It can encourage innovation and improvements in regulatory quality. However, unconstrained competition risks creating a "race to the bottom," where some States relax safety or

[93] US Department of Commerce, *Space Policy Directive–3: National Space Traffic Management Policy* (2018).
[94] Luxembourg, Law of 20 July 2017 on the Exploration and Use of Space Resources, arts 1–4.
[95] UAE Federal Law No 12 of 2019 on the Regulation of the Space Sector.
[96] Japan, Space Activities Act (Act No. 76 of 2016) and Space Resources Act 2021.
[97] Kevin Pollpeter and others, *China's Commercial Space Sector* (RAND Corporation 2020);
[98] Tanja Masson-Zwaan and Matteo Tugnoli, 'National Space Legislation and the Problem of Forum Shopping'
(2020) *Journal of Space Law* 44.

environmental standards to attract business, thereby undermining global public interests. Given that debris and light pollution affect all States, the actions of one regulator can impose costs on others. This is particularly worrying for mega-constellations, where decisions about end-of-life disposal and collision avoidance have system-wide consequences.

5.4 Balancing Innovation and Public Responsibility

For RQ2 and RQ3, the regulation of commercial activities is the arena where the tension between private innovation and public responsibility is most visible[99]. States must design rules that are strict enough to ensure safety, environmental protection and fairness, but flexible enough to attract and support private investment.

The nine States studied show different balances. The United States, Luxembourg, UAE, Japan and India lean towards a liberal commercial model with clear recognition of private rights and detailed licensing[100]. The UK and Australia adopt a cautious commercial model, enabling private activity but moving more slowly on resource rights[101]. China and Russia adopt a state-centric model, prioritising strategic control and multilateral principles over explicit private mining laws.

A future global governance system will need to recognise these differences while setting common minimum standards[102] for authorisation, supervision, safety and environmental performance, so that commercial freedom does not come at the cost of a degraded or unfairly allocated space environment.

6. Comparative National Regimes

6.1 United States

The United States is the leading commercial space power and a key norm-setter[103]. Its legal framework includes the Commercial Space Launch Act, the Commercial Space Launch Competitiveness Act, the Communications Act, the National and Commercial Space Programs Act and related regulations. These laws collectively regulate launch licences, re-entries, remote-sensing, satellite communications and, crucially, resource ownership.

The US explicitly recognises private ownership of extracted resources, imposes insurance and safety obligations on operators, and uses agencies such as the FAA, FCC and NOAA to supervise private activities under Article VI OST. It also leads the Artemis Accords[104], shaping interpretations of OST provisions on resource extraction and safety zones.

6.2 Luxembourg

Luxembourg has positioned itself as a specialised hub for space resources[105]. Its 2017 law declares that space resources are capable of being owned and sets up a mission authorisation regime, under which the government evaluates technical and financial capacity.

The law has attracted both praise for providing certainty to investors and criticism, for moving ahead of multilateral consensus and potentially conflicting with equitable access concerns. Nevertheless, it has clearly influenced other States such as the UAE and Japan[106].

[99] Frans G von der Dunk, *International Space Law* (Edward Elgar 2020) ch 7.
[100] Tronchetti, Fabio, *The Exploitation of Natural Resources on the Moon and Other Celestial Bodies* (Brill 2009) 210–230.
[101] Australia, Space (Launches and Returns) Act 2018.
[102] UNCOPUOS, *Long-Term Sustainability of Outer Space Activities Guidelines* (2019).
[103] US Commercial Space Launch Act 1984 (as amended 2015); Commercial Space Launch Competitiveness Act 2015, 51 USC § 51303; Communications Act of 1934, 47 USC; National and Commercial Space Programs Act, 51 USC.
[104] US Commercial Space Launch Act 1984 (as amended 2015); Commercial Space Launch Competitiveness Act 2015, 51 USC § 51303; Communications Act of 1934, 47 USC; National and Commercial Space Programs Act, 51 USC.
[105] Luxembourg Law of 20 July 2017 on the Exploration and Use of Space Resources.
[106] Tanja Masson-Zwaan and Mahulena Hofmann (eds), *The Luxembourg Approach to Space Resources* (LUP 2020).

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6.3 United Arab Emirates

The UAE's Federal Law No. 12 of 2019 on the Regulation of the Space Sector[107], along with its Space Resources Regulation, creates a comprehensive licensing regime for space activities, including exploration and use of space resources. Operators must obtain permits, carry insurance and accept obligations related to safety, environmental protection and international law.

The UAE's strategy illustrates how a relatively new space power can leverage regulation[108] and investment policy to become a regional leader and partner in international missions, such as the Hope Mars Mission and potential future lunar projects.

6.4 Japan

Japan's Space Activities Act and Space Resources Act illustrate a cautious but firm commitment to commercial utilisation. The Resources Act defines space resources, creates an authorisation process for exploration and development[109], and grants ownership of extracted resources to authorised operators, while emphasising compliance with Japan's international obligations.

Japan participates in the Artemis programme[110] and views commercial activities as integral to its long-term space strategy, but maintains close state oversight and alignment with international law.

6.5 United Kingdom

The UK's Outer Space Act 1986 and Space Industry Act 2018[111] regulate satellite operations and launches, respectively. Licences require insurance, safety measures and sometimes environmental assessments, and the government can cap operator liability.

The UK has not yet adopted a dedicated space resources law, but as an Artemis signatory it has politically endorsed the concept that resource extraction, in itself, does not violate Article II OST.

6.6 Australia

Australia's Space Launches and Returns Act 2018 provide a modern framework[112] for launching and returning space objects and operating facilities. It imposes licensing, insurance and environmental obligations.

Like the UK, Australia has not yet legislated on space resource ownership but participates in allied initiatives and may move in that direction as commercial opportunities develop.

6.7 India

India's Space Policy 2023 and the 2024 Norms, Guidelines and Procedures[113] mark a major shift from a purely state-driven model towards a mixed ecosystem. Private entities may design, operate and own satellites, provide space-based services, and own and sell space resources they obtain, subject to authorisation by IN-SPACe and compliance with international law.

India's future Space Activities Bill is expected to address liability, insurance and detailed licensing. India also faces growing debris and SSA challenges[114], prompting investments in tracking systems such as NETRA and IS4OM.

6.8 China

China's space sector is dominated by state-owned enterprises and a national strategy that emphasises sovereignty, development and security. While private companies have emerged, they operate within a tightly controlled framework. Chinese policy papers stress respect for OST principles and caution against "privatisation" of space resources[115].

China has not adopted detailed private resource ownership laws, and is likely to favour

[107] United Arab Emirates, Federal Law No 12 of 2019 on the Regulation of the Space Sector.
[108] UAE Space Agency, *Emirates Mars Mission: Hope Probe Overview* (2020).
[109] Japan, Space Resources Act 2021.
[110] NASA, *Artemis Program: International Partnerships* (2022).
[111] Space Industry Act 2018 (UK).
[112] Australia, Space (Launches and Returns) Act 2018.
[113] IN-SPACe, *Norms, Guidelines and Procedures 2024*.
[114] ISRO, *Project NETRA Overview* (2020);
[115] China National Space Administration, *China's Space Activities White Paper* (2021).

state-led or multilateral arrangements for any future exploitation.

6.9 Russia

Russia, as the successor to the Soviet space programme, remains a significant actor, though its commercial sector has faced challenges. Russian space legislation predates the modern commercial boom[116] and concentrates on state activities. Official statements at the UN often oppose unilateral space resource laws[117] and emphasise the need for collective arrangements consistent with the Moon Agreement's spirit.

6.10 Synthesis: Three Models

Across these nine States, three models emerge[118]:

1. Liberal commercial model: United States, Luxembourg, UAE, Japan, India – strong support for private activities, explicit recognition of resource ownership, detailed licensing and insurance regimes.
2. Cautious commercial model: United Kingdom, Australia supports commercial activities and participate in Artemis but have not yet adopted resource ownership laws.
3. State-centric model: China, Russia emphasise sovereign control, strategic interests and multilateral principles, with no explicit resource ownership laws and critical views of unilateral commercial appropriation.

This fragmentation is central to the risk that space governance may become unstable just as commercial exploitation accelerates.[119]

7. Regulatory Touchpoints Beyond Space Law

7.1 Spectrum and Orbital Slot Management

The ITU Radio Regulations and national telecommunications laws shape who can operate satellites and where. [120]Orbital positions and frequencies, especially in geostationary orbit and popular LEO shells, are limited resources[121]. Early filers and large operators can potentially dominate certain orbits, raising concerns about equitable access for latecomers and smaller States.

For mega-constellations, coordination of frequencies and avoidance of interference are critical. Regulators like the FCC have already tightened rules on orbital debris and end-of-life disposal for LEO satellites, linking spectrum rights to sustainability obligations[122].

7.2 Export Controls and Sanctions

Space hardware and software often qualify as dual-use items[123]. Export control regimes such as the US International Traffic in Arms Regulations and Export Administration Regulations restrict transfers of sensitive technologies. Sanctions can also affect spacecraft supply chains and international partnerships, as seen in recent restrictions affecting Russia's access to Western launch and satellite technologies[124].

These regimes can limit which countries and companies may participate in space mining or in-orbit servicing projects[125]. Any global governance model must be compatible with security concerns embedded in export control law.

7.3 Environmental Law and Planetary Protection

Launches and re-entries can have environmental impacts on Earth, leading to

[116] Russian Federation, Federal Law on Space Activities No 5663-1 (1993).
[117] UNCOPUOS Legal Subcommittee, *Statement of the Russian Federation* (2018–2023).
[118] Frans von der Dunk and Fabio Tronchetti (eds), *Handbook of Space Law* (Edward Elgar 2015).
[119] UN COPUOS, *Report of the Working Group on Long-Term Sustainability of Outer Space Activities* (2019).
[120] International Telecommunication Union, *Radio Regulations* (Edition 2020).
[121] International Telecommunication Union, *Handbook on Satellite Communications* (2018) ch 4.
[122] Federal Communications Commission, *Mitigation of Orbital Debris in the New Space Age*, Report and Order (2020).
[123] International Traffic in Arms Regulations (ITAR), 22 CFR pts 120–130.
[124] US Department of Treasury, *Sanctions Related to the Russian Federation* (2022–2024).
[125] Aaron Boley and Michael Byers, 'Commercial Space Mining and International Security' (2021) *Nature Astronomy* 5.

application of national environmental assessment procedures such as NEPA[126] in the US and similar frameworks in Australia and Europe.

In space, debris and light pollution are central environmental concerns[127]. ESA's Zero Debris initiative commits the agency to design missions that do not leave long-lived debris in key orbits by 2030[128], and the associated Charter has been signed by numerous organisations. Scientific studies warn that the cumulative impact of mega-constellations on astronomy could be profound if unregulated.

These developments suggest that environmental principles such as prevention of transboundary harm, due diligence and environmental impact assessment increasingly relevant in interpreting OST Article IX and in shaping future governance.

8. Dispute Resolution

8.1 Inter-State Claims

The OST and Liability Convention provide mechanisms for inter-State claims[129], but in reality, States have rarely used them. Cosmos 954 remains the only widely cited case where the Liability Convention was formally invoked and compensation paid[130].

The absence of published Claims Commission decisions means that key concepts such as "fault" and "due regard" have not been refined through jurisprudence[131]. Most disputes are instead handled diplomatically or left unaddressed, especially when politically sensitive actors such as major powers or defence satellites are involved.[132]

8.2 Arbitration and Commercial Disputes

[133]In the commercial domain, arbitration is the dominant mechanism. Contracts frequently specify arbitration under institutions such as the ICC, LCIA or the Permanent Court of Arbitration. The PCA's Optional Rules for Arbitration of Disputes Relating to Outer Space Activities (2011) provide a tailored framework, allowing States, international organisations and private entities to bring disputes to a tribunal with specialised expertise[134].

Although most awards remain confidential, practitioners report a growing number of cases involving satellite procurement, launch failures, insurance disputes and service interruptions[135]. Arbitration offers flexibility, confidentiality and expert decision-makers, making it attractive for both companies and States.

8.3 Evidence, SSA and Attribution

A distinctive problem in space disputes is evidence. Attribution of debris, determination of collision responsibility, or assessment of interference often depends on SSA data, telemetry and sensitive technical information[136]. States may be reluctant to share military-grade tracking data, and companies may protect proprietary information[137].

Without robust and shared SSA, it is difficult to prove fault under the Liability Convention or even to reconstruct events accurately for arbitration. Scholars have therefore proposed mechanisms such as mandatory logging of key operational data[138] and improved international SSA data-sharing arrangements.

For RQ2, this evidentiary weakness further undermines the effectiveness of the current liability and governance framework.

[126] National Environmental Policy Act 1969 (US), 42 USC § 4321.
[127] Australian Government, *Environmental Protection and Biodiversity Conservation Act 1999*;
[128] European Space Agency, *Zero Debris Charter* (2023).
[129] Convention on International Liability for Damage Caused by Space Objects 1972, arts VIII–X.
[130] 'Claim for Damage Caused by Soviet Cosmos 954' (1979) 18 ILM 899.
[131] Gerhard Reintanz, 'Liability Convention Practice and the Absence of Claims Commission Decisions' (2016) *Journal of Space Law* 40.
[132] Bin Cheng, *Studies in International Space Law* (Clarendon Press 1997) 420–432.
[133] Matthew Schaefer, 'Arbitration in Commercial Space Activities' (2019) *Nebraska Law Review* 98.
[134] Permanent Court of Arbitration, *Optional Rules for Arbitration of Disputes Relating to Outer Space Activities* (2011).
[135] A Lloyd's Market Association, *Space Insurance Claims and Arbitration Trends* (2020).
[136] Henry R Hertzfeld and Brian Weeden, 'Space Situational Awareness and Legal Attribution' (2016) *Space Policy* 82.
[137] Secure World Foundation, *Global Counterspace Capabilities Report* (2023).
[138] Christopher Johnson and others, *Towards an International Framework for Space Traffic Management* (Secure World Foundation 2020).

9. Case Studies

9.1 Lunar Water-Ice Mining Mission

Consider a joint venture involving companies from the United States, Luxembourg and India, using Japanese technology and UAE financing, to extract water-ice from a permanently shadowed crater near the lunar south pole.

Under current law, each participating State would authorise and supervise its own nationals according to Article VI OST. The US, Luxembourg and Japan would apply their resource laws and licensing procedures, recognising ownership of extracted resources and requiring insurance and debris mitigation[139]. India would authorise its participants through IN-SPACe under the Space Policy and NGPE, recognising ownership and ensuring compliance with international obligations[140]. The UAE would regulate its financial and technical contributions under its 2019 law.

The mission would secure launch licences, register spacecraft with the UN[141], coordinate spectrum through the ITU and comply with debris mitigation guidelines. Upon landing, the consortium might declare a safety zone around its operations, following Artemis practice, and notify this to other States.

From a liberal interpretation, this mission is lawful: no State claims sovereignty, resource ownership is recognised under domestic law, and safety zones are used to implement due-regard obligations. From a more sceptical perspective, the same mission could be viewed as problematic: a small group of States and companies effectively control a high-value site, enjoy exclusive access to resources and scientific opportunities there, and do so without any international benefit-sharing.

This case highlights how the same legal framework can produce very different perceptions of legitimacy depending on one's view of non-appropriation and equity.

9.2 Mega-Constellation Collision and Debris Cascade

Imagine a scenario in which a large broadband constellation, licensed in one State, suffers a collision with a derelict satellite belonging to another State. The collision produces thousands of debris fragments, some of which damage satellites operated by third States and companies and significantly increase debris density in a popular orbital shell.

Under the Liability Convention, launching States of the colliding satellites may be liable for damage caused to others, but only on a fault basis for in-space damage[142]. Establishing fault would require detailed SSA data and analysis of avoidance manoeuvre decisions. In reality, States might be reluctant to share this information or to accuse each other publicly[143]. As in the Iridium Cosmos case[144], losses might be handled through insurance rather than international claims.[145]

The most serious harm is long-term degradation of the orbital environment and increased collision risk for everyone is barely addressed by current law. There is no requirement for the responsible operators to fund debris removal or compensate for lost orbital capacity. Yet scientific and agency reports show that such cascades are a real risk as satellite numbers increase.

This scenario illustrates the systemic weaknesses of the existing liability and governance framework in dealing with high-impact but diffuse environmental harm.[146]

[139] US Commercial Space Launch Competitiveness Act 2015, 51 USC § 51303.
[140] IN-SPACe, *Norms, Guidelines and Procedures 2024*.
[141] Convention on Registration of Objects Launched into Outer Space (1975), arts II–IV.
[142] Liability Convention 1972, art III.
[143] Hertzfeld and Weeden, 'Space Situational Awareness and Legal Attribution' (2016) *Space Policy* 82.
[144] Brian Weeden, '2009 Iridium–Cosmos Collision' (Secure World Foundation 2010).
[145] Secure World Foundation, *Global Counterspace Capabilities Report* (2023).
[146] UNCOPUOS, *Report of the Working Group on Long-Term Sustainability of Outer Space Activities* (2019).

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10. Reform Proposals and Conclusion

10.1 A Space Resources Governance Compact

To address RQ1 and RQ3, this paper suggests developing a Space Resources Governance Compact, ideally adopted under UN auspices. The Compact would not replace the OST but clarify how resource extraction can occur consistently with its principles.

Key elements could include:

- Acceptance that States may recognise ownership of extracted resources[147] under national law, provided operations comply with agreed standards on transparency, environmental protection and non-interference.
- Creation of an International Resource Registry where States must notify the location, nature and duration of resource projects, facilitating deconfliction and inspection.
- Establishment of a modest Space Equity Fund, financed by small levies on commercial resource activities[148], to support capacity-building, space science and SSA infrastructure in developing States.

This approach would acknowledge existing national resource laws while embedding them in a broader framework of fairness and sustainability.

10.2 Operational Deconfliction Areas

Safety zones should be reframed as Operational Deconfliction Areas: narrowly tailored, time-limited and justified by specific operational risks. States could agree on maximum default sizes and durations for ODAs, notification procedures, and consultation mechanisms. Disputes over ODAs could be referred to arbitration. By grounding ODAs explicitly in Article IX's due-regard and harmful-interference language[149], States could reduce suspicion that they are asserting disguised territorial claims.

10.3 Liability and Insurance Baselines

To strengthen RQ2-related governance, States could adopt minimum international standards for third-party liability insurance[150] for high-risk operations such as large constellations and resource extraction missions. A global space risk pool, funded by small levies on launch and operation licences[151], could provide supplemental compensation and environmental restoration funding in the event of catastrophic debris events.

Such measures would not alter the Liability Convention's formal rules but would make it more likely that victims receive compensation and that operators internalise environmental risks.

10.4 Specialised Space Arbitration and SSA Transparency

Building on the PCA's Optional Rules, a specialised space arbitration and claims facility could be created, with a standing panel of arbitrators and technical experts. States might also agree on minimum standards for SSA data sharing[152], particularly in collision investigations and deconfliction, to support both arbitration and the application of fault-based liability.

Improved transparency would not only aid dispute resolution but also enhance safety and trust among operators.

10.5 Space Environmental Impact Assessments and Equity

Finally, States could commit to conducting space-specific environmental impact assessments for major missions, including mega-constellations and resource projects[153]. These EIAs would examine debris generation, light pollution, planetary protection and

[147] Artemis Accords (2020) Principles 10–12.
[148] UN Committee on the Peaceful Uses of Outer Space, *Space2030 Agenda* (2021).
[149] Outer Space Treaty 1967, art IX.
[150] UK Space Industry Act 2018, ss 11–16;
[151] Henry R Hertzfeld and Frans von der Dunk, 'Allocating Liability and Financial Responsibility in Satellite Collisions' (2020) *Space Policy* 113.
[152] Secure World Foundation, *Global Space Traffic Management Report* (2022).
[153] COSPAR, *Planetary Protection Policy* (2021).

potential impacts on scientific activities. Results could be reviewed by independent experts, perhaps under COSPAR auspices[154].

Equity measures such as the Space Equity Fund and targeted capacity-building programmes[155] would help ensure that benefits of space activities are not confined to a small group of technologically advanced States and corporations.

10.6 Conclusion:

Going back to the two key research questions, it is found that the existing international treaties are still imperative yet not complete. They effectively ban the ability to claim sovereignty and create responsibility and liability at a fundamental level, yet fail to provide a clear answer to questions regarding the ownership of resources, commercial safety zones, or systemic environmental damages. Commercial practices and national laws have advanced particularly in the United States, Luxembourg, UAE, Japan and India, to provide a liberal form of commercial practice, which is co-existing with a more conservative and state-oriented approach in the UK, Australia, China and Russia. Regarding governance, the paper avers that the answer to the question of resource rights clarification via a concise, ceremonial operational deconfliction; establishing a liability and insurance floor, enhancing arbitration and the transparency of SSA and incorporating environmental assessment and equity into the activities of the space is not to write the OST anew but to work around it. Should these reforms be sought, outer space can be left a place where individual innovation and social obligations support but not contradict each other. Otherwise, there is an actual threat that the last frontier will be another overcrowded, unequal and polluted arena, dominated not by common values of law but by the strength of first movers.

[154] Committee on Space Research (COSPAR), *Scientific Guidelines for Space Activities* (2020).
[155] UN COPUOS, *Space2030 Agenda: Space as a Driver of Sustainable Development* (2021).