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Space Commercialization and the Private Sector: Liability, Licensing, and Global Regulatory Challenges

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Abstract

The swift rise of corporate entities in outer space—from satellite mega-constellations and suborbital tourist initiatives to asteroid-mining startups—has shown an expanding disparity between the velocity of commercial innovation and the legal framework intended to regulate it. This paper analyzes three interconnected aspects of the gap: (i) the liability framework governing private space activities under both international treaty law and domestic statutory systems; (ii) the licensing structures through which states authorize and oversee non-governmental operators; and (iii) the overarching global regulatory challenges that emerge when jurisdictions with conflicting commercial interests must collaborate in an orbital commons that transcends sovereign borders. The paper contends that the existing regulatory framework is fundamentally incompatible with the New Space era, referencing the 1967 Outer Space Treaty, the 1972 Liability Convention, recent U.S. legislation such as the Commercial Space Act of 2023, and analogous regulatory advancements in the European Union, China, and other spacefaring nations. State-centric liability rules have a hard time figuring out who is to blame when missions cross state lines. Licensing moratoriums that were meant to help a new industry grow now risk making an old one even less regulated. Finally, the lack of a binding multilateral framework for debris mitigation, spectrum coordination, and in-space servicing puts the long-term health of the orbital environment at risk. The paper ends by suggesting a series of step-by-step, risk-based changes, using examples from aviation, maritime, and environmental law, that could balance the need for new business ideas with the need to keep space safe and open for everyone.

Keywords: space commercialization; liability convention; FAA licensing; Outer Space Treaty; space debris; megaconstellations; novel space activities; New Space; private sector; international space law

1. Introduction

On July 20, 1969, a person first set foot on the Moon. This was made possible by governments, with money from taxpayers, and a treaty framework that was put together quickly during the Cold War. A commercial company is now the main group that sends things into low Earth orbit, just fifty years later. There were 117 attempts to launch something into orbit in the United States in 2023. Most of these were made by commercial companies. [1] The global space industry was worth around $596 billion in 2024, and forecasts say it might be worth $944 billion by 2033.[2] In 2024, investments in space start-ups alone totaled $7.8 billion. Morgan Stanley and Deloitte experts say that the whole sector might be worth more than $800 billion by 2027 and $2 trillion by 2040. [3] In this context, the laws and rules that regulate space activities are mostly stuck in the politics of 1967. The main agreements—the Outer Space Treaty (OST), the Rescue Agreement, the Liability Convention, and the Registration Convention—were worked out when only three countries had ever put satellites into orbit and when the idea of a launch vehicle that could be used for business was still new.[4] Their rules are mostly about states: they put duties on governments, think about liability between states, and assume that any organization that works in space does so under the direct direction of a national space agency. Today, things don't look anything like that. SpaceX has a network of more than 10,000 satellites—more than all of the satellites owned by governments combined—and it does collision-avoidance maneuvers on an industrial scale. Between December 2024 and May 2025, a single company's constellation made 144,404 of these maneuvers. This is a number that even experts in orbital debris find impressive. China's new business sector is using rival

constellations with similar goals. The rules that regulate all of this behavior were never meant to handle it.

This paper continues as follows. Section 2 looks at the basic international law that applies to private space players. Section 3 looks at the domestic licensing systems, focusing mostly on the American model because it is important around the world, and its structural problems. Section 4 looks at liability: who is responsible when a commercial launch causes harm and how the current rules divide that obligation. Section 5 talks with problems with global regulation, focusing on space debris, spectrum, and how new activity in space should be run. Section 6 draws lessons from other areas of regulation that are similar. Section 7 suggests a plan for change, and Section 8 wraps things up.

2. The International Legal Framework and Its Private-Sector Blind Spots

2.1 The Foundational Treaty Corpus

Four accords adopted by the United Nations between 1967 and 1975 form the basis of international space law. The 1967 Outer Space Treaty is the most important document. It says that outer space belongs to all people, that countries can't claim it for themselves, that weapons of mass destruction can't be in orbit, and—most importantly for our purposes—that states are responsible and liable.[5] Article VI of the OST says that States Parties are "internationally responsible for national activities in outer space... whether those activities are carried out by government agencies or by non-governmental organizations. "This line may appear simple, yet it has a lot of practical weight. The United States is responsible for any harm caused in orbit by a private firm that has a license from the United States. This is true even if the company is SpaceX or Blue Origin. [6] Article VII makes this even stronger by making the state that launches the rocket responsible for damage to another state or its citizens. The 1972 Liability Convention built on this framework by making people completely responsible for harm done to the Earth's surface or to planes in flight, and making people responsible for damage done in space only if they were at fault. [7]

2.2 The Private-Sector Problem

These rules were made when it was thought that states were the main players. The OST doesn't say what "non-governmental entities" are, what "authorization and continuing supervision" must include, or how to divide up accountability among several states that all worked on the same launch. The end consequence is a collection of structural uncertainties that get more important as more private actors join the mix.

Legal academics have established a minimum of three conflicting interpretations on the phrase "national activities" in Article VI, specifically in relation to determining the state responsible for a particular private operator. [8] One interpretation associates liability with the operator's nationality; another correlates it with the territory of launch; and a third connects it to the "launching state" notion later established in the Liability Convention. In practice, most states have embraced either the first or second reading in their domestic authorization legislation; nevertheless, there is no worldwide consensus, which may lead to gaps. The fact that the Moon Agreement is almost never used in business is just as important. The General Assembly passed it in 1979. It called celestial bodies the "common heritage of mankind" and suggested an international system to manage resource use. As of now, no major spacefaring country, such as the United States, Russia, China, or any European country that can launch its own rockets, has signed it. [9] The practical impact is that commercial asteroid mining and lunar resource extraction happen without any international regulations to follow. Instead, they are only subject to unclear domestic laws that may or may not apply outside of their own countries.

3. Domestic Licensing Architectures: The American Model and Beyond

3.1 The United States Framework

The United States has the most advanced and important system for licensing space activities at home. The Federal Aviation Administration (FAA) gives permission for launch and re-entry

operations; the Federal Communications Commission (FCC) gives permission for commercial satellite communications and spectrum use; and the National Oceanic and Atmospheric Administration (NOAA) gives permission for commercial remote sensing.[10] The end result is a broken system where one mission can need permission from three or more federal agencies, each with its own rules for how to do things and when to review them. The FAA's Part 450 rules, which were finalized in 2020 and replaced the old ones, were meant to make the process of getting a launch license easier and more efficient. But people have had mixed experiences with Part 450. People in the industry have criticized the FAA for regularly missing its legal 180-day review deadline. A report from the FAA's Commercial Space Transportation Advisory Committee in July 2023 said there was a "lack of sufficient expertise to assess new compliance methods," which effectively put the burden of analysis on operators. The FAA suggested that SpaceX pay $633,009 in civil penalties in 2024 for not following license rules during two launches in 2023. This shows how the enforcement system works and its limits. [12] The Commercial Space Launch Competitiveness Act of 2015 (CSLCA) was a big step forward. It gave private companies ownership rights over resources taken from space and extended the time the government would pay commercial operators for damages caused by third parties beyond their required insurance coverage. [13] Most importantly, the CSLCA put a stop to FAA rulemaking that was meant to ensure the safety of passengers on commercial human spaceflights. This moratorium, which was first set to last until 2023 and then extended, was meant to give the new business time to develop. The Commercial Space Act of 2023 suggested that this moratorium last until October 2031. [14]

Table 1: Comparative Domestic Licensing Frameworks across Major Spacefaring Jurisdictions

Country / Jurisdiction	Primary Governing Law	Licensing Authority	Key Features	Notable Gaps / Critiques
United States	Commercial Space Launch Act 1984; CSLCA 2015; Commercial Space Act 2023	FAA (launch/re-entry); FCC (spectrum); NOAA (remote sensing)	Multi-agency authorisation; government indemnification beyond MPL; resource ownership rights for operators	Fragmented oversight; FAA review delays exceed 180-day limit; moratorium on human spaceflight safety rules until 2031
United Kingdom	Space Industry Act 2018; Space Industry Regulations 2021	Civil Aviation Authority (CAA) / UK Space Agency	Single comprehensive licence for all space activities; covers launch, operations, and re-entry	Limited domestic launch sites; commercial sector still nascent; post-Brexit spectrum coordination challenges
European Union / ESA Member States	National laws (France: Loi SPACE 2008; Germany: Air Traffic Act §§48–53); EU Space Programme Regulation 2021/696	CNES (France); DLR/Federal Network Agency (Germany); ESA coordinates multi-state missions	Risk-based authorisation; strong debris mitigation requirements; emphasis on insurance adequacy	No single EU-wide licensing regime; divergence among member states; ESA has no direct regulatory authority

Country / Jurisdiction	Primary Governing Law	Licensing Authority	Key Features	Notable Gaps / Critiques
China	Interim Measures on Commercial Launch 2024; Military-Civil Fusion policy	CASC / SASTIND; National Space Administration (CNSA)	Centralised approval; listed commercial space as "new growth engine" in 2024; Qianfan & Guowang constellation approvals	Opaque decision-making; dual-use civilian-military ambiguity; international transparency concerns
Luxembourg	Law of 20 July 2017 on Space Resource Activities	Ministry of the Economy	First EU state to grant legal ownership of extracted space resources; light-touch regulatory philosophy	Small domestic enforcement capacity; risk of regulatory arbitrage by foreign companies incorporationg locally

Note. Data compiled from national legislation, ESA regulatory reports, and UNOOSA country profiles (2024–2025). CSLCA = Commercial Space Launch Competitiveness Act; SASTIND = State Administration for Science, Technology, and Industry for National Defence; MPL = Maximum Probable Loss.

3.2 Regulatory Fragmentation and the Novel Activities Gap

In addition to launch and communications, there is an increasing number of actions that are not clearly covered by any domestic or international rules. In-space servicing, assembly and manufacturing (ISAM), commercial space stations, orbital debris cleanup, and lunar surface operations are all examples of these "novel space activities." The White House Executive Order on Enabling Competition in the Commercial Space Industry, which came out in August 2025, clearly recognized this loophole and told the Secretary of Commerce to change the way these activities are approved. [15] There is a regulatory system in place for launch (FAA), communications (FCC), and remote sensing (NOAA). This structure was developed for certain, well-defined types of missions. A satellite that takes pictures, sends data, and then moves to service another satellite fits into at least three of these groups at the same time. Without a "one-stop" authorization process for complex, multi-function missions, operators don't know if they are following the rules, and governments can't fulfill their Article VI commitments.

3.3 Comparative Licensing Frameworks

Different spacefaring countries have dealt with the same problem in different ways. The Space Industry Act 2018 and accompanying rules in the UK set up a full licensing system that covers all space activities, not just certain sorts of missions like in the US. In 2017, Luxembourg passed a law that set out a framework for how to use resources. This law drew a lot of interest from businesses. China has set up a centralized authorization system run by the State Administration for Science, Technology, and Industry for National Defense (SASTIND). This is because the country's commercial space sector grew so quickly that the government called it a "new growth engine" in 2024. [17] None of these frameworks can fully work with the others. This is a big problem because operators can avoid regulations by adding entities or registering satellites in jurisdictions that are more lenient. The state where the satellites are actually located still has residual Article VI responsibility. It is still unclear which state is responsible for supervision in these cases and whether any state is actually doing it.

4. Liability in the New Space Era: Who Pays When Things Go Wrong?

4.1 The International Liability Convention in Practice

The 1972 Convention on International Liability for Damage Caused by Space Objects is still the only international agreement that talks about paying for damage caused by space operations. The law makes a distinction between absolute liability, which applies when a space object damages something on Earth or an aircraft in flight, and fault-based liability, which applies when damage happens in space. [7] The Liability Convention has only been used once in its history: when the Soviet Kosmos 954 satellite crashed in 1978 and sent radioactive debris all over northern Canada. In the end, the Soviet Union paid Canada CAD 3 million in damages, which had little to do with the real expenditures. There are a number of problems with how the Convention applies to harm in the private sector. First, it only works between states. A private corporation can't file a claim under the Convention, and a state doesn't have to support a claim on behalf of a private company. Second, the Convention doesn't say what level of fault should be used in the case of damage in space, therefore it's up to interpretation and discussion. Third, in a mission that involves more than one jurisdiction, like a satellite made in the US and launched from a Kazakh facility by a company based in Luxembourg, it is hard to figure out which state or states are the "launching state" for liability purposes. The Convention does not give any tools to do this.

Table 2: The International Space Treaty Liability Regime: Architecture and Limitations

Treaty / Instrument	Year in Force	Liability Standard	Liable Party	Key Limitation for Private Sector	Ratifications (2025)
Outer Space Treaty (OST)	1967	State responsibility (Art. VI); State liability (Art. VII)	Launching State	Private entities not directly bound; no private right of action	115
Liability Convention	1972	Absolute liability (surface damage); Fault-based liability (outer space collisions)	Launching State(s) jointly & severally	State-to-state claims only; no binding adjudication; multi-operator fault allocation unresolved	98
Registration Convention	1976	No liability provision; establishes object registry	Launching State	Incomplete registry; debris objects not systematically registered; mega-constellations strain database capacity	72
Moon Agreement	1984	Common heritage of mankind; resource exploitation regime pending	State Parties (but no major spacefaring state has ratified)	Effectively inapplicable to commercial resource extraction; no enforcement body	18 (zero major spacefaring states)
Artemis Accords (non-binding)	2020 (bilateral)	No liability provision; voluntary principles only	Signatory States; no private operator obligations	Excludes Russia & China; no enforcement mechanism; outside COPUOS framework	50+ signatories (2025)

Note. Ratification figures as of January 2025 per UNOOSA treaty database. OST = Outer Space Treaty; COPUOS = Committee on the Peaceful Uses of Outer Space. The Artemis Accords are a bilateral/plurilateral executive agreement, not a formal treaty under international law.

4.2 Domestic Indemnification and the Insurance Architecture

Operators must get third-party liability insurance up to a "maximum probable loss" (MPL) set by the FAA as part of the United States' launch license system. The government pays for damages above that amount via a fund set up by Congress. This system is meant to make sure that accident victims are paid without making insurance too expensive for commercial launches. [11] The Government Accountability Office found that the FAA's process for figuring out MPL levels wasn't clear enough and didn't properly take into account how much it would cost the industry. A SpARC advisory committee made suggestions for changes as recently as March 2024. [12]

The indemnity system also brings up a bigger moral question: how much should public money help private businesses take risks? As the industry grows up, the justification for continuous government support becomes difficult to argue on equity grounds, even though the hazards of mega-constellation operations get larger. For example, SpaceX alone will be worth over $400 billion by 2025.

4.3 Liability for Orbital Debris Damage

Orbital debris may be the biggest liability issue in the New Space era. In 2024, the global market for monitoring and removing space debris was worth $1.17 billion. This shows how big the problem is. [18] The operational statistics are even more telling: SpaceX's Starlink constellation did 144,404 collision avoidance maneuvers between December 2024 and May 2025. Hugh Lewis, a space debris expert at the University of Birmingham, says this number shows that the constellation is only one-fifth the size it is expected to be. [19] When debris from a broken commercial satellite hits and destroys an active satellite owned by another state or firm, it's not clear who is responsible. The Liability Convention's blame standard applies to collisions in space, although it's very hard to prove who is at fault. It may be possible to figure out what caused the debris, but the state that launched it may disagree with its part of the blame if a series of collisions (cascade events) is involved. There is no international forum with mandatory jurisdiction to resolve these disputes, and the sole formal claims process under the Liability Convention necessitates state-to-state discussion or, ultimately, a Claims Commission whose rulings are non-binding.

5. Global Regulatory Challenges: Debris, Spectrum, and the Sustainability of Orbit

5.1 Space Debris and the Kessler Syndrome Risk

In 2025, the Starlink constellation has more than 8,600 operating satellites. SpaceX plans to add 42,000 more. China's Qianfan constellation has already sent up 90 satellites and expects to send up 15,000 more. The Guowang network wants to send up 13,000. [20] The number of items in low Earth orbit is expanding at an unprecedented rate, thanks to Amazon's Project Kuiper, OneWeb, and other companies. A research from 2024 indicated that a typical 250-kilogram spacecraft releases about 30 kilos of aluminum oxide particles when it re-enters the atmosphere. These particles may stay in the upper atmosphere for decades, and we don't know how they affect the ozone layer over time. [21] The management of debris mitigation highlights the structural deficiencies of the existing international framework. In 2019, the UN COPUOS set rules for the long-term sustainability of activity in space. You don't have to follow these rules. States can choose to include them or not in their own licensing rules. The United States requires debris mitigation plans as a requirement of FAA launch licenses. The FCC has also shortened the time frame for disposing of low Earth orbit satellites after their missions from 25 years to 5 years. But these are national laws that don't have to be followed by other countries, and governments that host operators with weaker domestic criteria can undercut them.

5.2 Spectrum and Orbital Slot Coordination

The International Telecommunication Union (ITU) coordinates radio spectrum and orbital slots, although it does not give them out. The ITU's first-come, first-served method for

frequency coordination gives operators strong reasons to submit for spectrum before they have real plans to use it, and states to file on behalf of operators who are based in their territories as a way to get ahead of the competition. [22] Amazon has already asked the U.S. Federal Communications Commission to look more closely at SpaceX's long-term constellation plans. They say that proposed deployments of near-unlimited scale are not possible with current launch capabilities and would take up all of the orbital and spectral resources. [23] SpaceX has to deal with a lot of different rules on international spectrum coordination, national spectrum licenses, and data sovereignty in every country where Starlink works. Data sovereignty laws, like the EU's General Data Protection Regulation and similar laws in other countries, make compliance much harder, especially as Starlink services move into areas with tight data localization rules. The Boston Consulting Group has said that government regulation is the biggest obstacle to getting the most out of LEO satellite technology.

5.3 The Artemis Accords and Bilateral Norm-Setting

The United States has used the Artemis Accords, a set of rules for the peaceful exploration and use of the Moon, Mars, and other celestial bodies, to set norms between two or more countries. By early 2025, more than 50 countries had signed on to the accords. The Accords talk about safety zones around ongoing operations, as well as transparency, interoperability, space debris reduction, and the protection of heritage locations. [24] People have criticized the Accords for being negotiated outside of the established UN COPUOS framework, not having any ways to enforce them, and mostly serving American business interests. Russia and China, two big spacefaring countries with their own big business sectors, have both said no. A governance framework lacking the participation of two of the foremost space-faring nations cannot establish the universal standards necessary for the orbital commons.

6. Lessons from Analogous Regulatory Domains

Scholars of space law have long compared it to the law of the sea and, more recently, to international aviation law. These areas of law have had to deal with comparable conflicts between national interests, private business, and the necessity to manage a shared global commons. These comparisons give reformers both hope and warning.

6.1 International Aviation Law

The Chicago Convention of 1944 set up the International Civil Aviation Organization (ICAO), which has been a very long-lasting model for creating technical standards amongst several countries. ICAO creates Standards and Recommended Practices (SARPs) that member states use to make their own laws. An annex structure lets technical standards be changed without having to renegotiate the treaty that they are based on. The Universal Safety Oversight Audit Programme is a way for ICAO to keep an eye on compliance. [6] The connection to aviation is not ideal because the physics of flight create a consistent operational environment that orbital mechanics does not. However, the institutional model is useful. An comparable organization for space activities may fill up the most important gaps in governance without having to renegotiate the basic treaties. This organization would have the power to create binding technical standards for avoiding collisions, reducing debris, and coordinating spectrum use.

6.2 Maritime Law and the Problem of Flags of Convenience

The maritime practice of flags of convenience—where shipowners register their ships in jurisdictions that are more lenient in order to avoid stiffer rules at home—serves as a warning for space law. The International Maritime Organization (IMO) came up with the idea of port state control as a way to fight back. Ships can be checked and held in any port, no matter what flag they fly, and states that certify subpar ships suffer legal and reputational consequences. A comparable mechanism—potentially termed "launch state control" or "data state control"—could incentivize licensing nations to uphold sufficient supervisory criteria, even within a competitive, open framework.

6.3 Environmental Law and the Precautionary Principle

Environmental law provides a third example, especially pertinent to the issue of debris. The precautionary principle, which is found in Principle 15 of the Rio Declaration and many other multilateral environmental agreements, says that if activities could cause serious or permanent harm, not being completely sure of the science behind them should not be used as an excuse to put off cost-effective preventive measures.[5] If this principle were applied to space debris, it would support the idea that all commercial launch licenses should come with mandatory, binding mitigation requirements. This would include operational responsibility for removing active debris, even if it can't be proven that a specific collision caused it.

7. A Reform Agenda: Graduated, Risk-Proportionate Regulation

The study above backs up a plan for reforms that would happen at the same time on the international, regional, and national levels. The following suggestions are graded, meaning they are based on the size and risk level of distinct business operations. They are also risk-proportionate, meaning they need higher protections where the risk of permanent injury is highest.

7.1 International Reform: A Convention of the Parties

Scholars have suggested organizing a Conference of the Parties to the current space treaties, similar to the methods employed in environmental treaty frameworks, to formulate binding resolutions regarding liability distribution in multi-jurisdictional missions, establish minimum standards for debris mitigation, and define the procedures for a compensation fund for damage caused by debris.[15] This kind of system would keep the basic treaty structure in place while letting it change to meet the needs of business. This is better than either completely renegotiating the treaty (which is not politically possible) or continuing to rely on voluntary guidelines (which are not enough in practice).

7.2 Domestic Reform: Consolidation and Risk-Proportionality

The United States should combine its broken multi-agency authorization system into a single interagency pathway for complicated, multi-function missions at home. This is what the Commercial Space Act of 2023 planned to do, but it hasn't happened yet. The FAA's personnel problems, which have made it hard to hire people for human spaceflight jobs, should be fixed by making more money available for hiring and allowing more technical experts to be hired from the private sector with proper protections against conflicts of interest.[24] The embargo on human spaceflight safety regulation, which has been extended many times since 2004, should not be prolonged beyond 2031 unless there is clear evidence that more time is needed to protect innovation. The GAO's judgment that the FAA has not properly looked into the costs and risks of its financial responsibility framework supports a full study instead of another moratorium.

7.3 Liability Reform: Operator-Level Responsibility and Mandatory Insurance

The most important structural change would be to set up a second level of culpability that goes directly between private operators instead of only through state channels. For this to happen, major spacefaring countries would need to pass laws that hold licensed operators directly liable for any damage their operations create. These laws would also need to require insurance or bonding that is based on the mission's risk profile. States would keep their worldwide liability under the Liability Convention, but they would also get the power to go after domestic operators. This is something that some national laws already provide for, although it is not always followed.

7.4 Debris Governance: From Voluntary to Binding

The UN COPUOS Long-Term Sustainability Guidelines ought to be transformed into obligatory international commitments via a protocol to the Outer Space Treaty or a separate debris mitigation agreement. Such an instrument should: require operators to show plans for disposing of their equipment at the end of its life as a condition of getting a license; set

minimum acceptable disposal timelines (the FCC's five-year rule is a good example); make a list of defunct objects with the states that are responsible for them; and set up a way—possibly based on the International Oil Pollution Compensation Funds—to pay for damage caused by debris.

8. Conclusion

The commercialization of space has brought about incredible benefits. It has made satellite services available to everyone, lowered the cost of getting into orbit, and made communications, navigation, and Earth-observation capabilities possible that were once only available to a few superpower governments. It has also caused a regulatory problem that most people in the policy debate still don't know about.

The laws that govern this burst of activity were established for a world that no longer exists. When only states launched satellites, its state-centrism made sense. But now that a single private corporation runs more satellites than all government organizations put together, it is a big concern. When there were only a few launches a year, the liability rules were good enough. But when Starlink satellites alone do more than 140,000 collision-avoidance maneuvers in six months, they aren't strong enough. To move forward, we need to take action on many fronts at once. This includes making domestic licensing and enforcement stronger, changing liability laws to hold operators directly responsible, turning voluntary debris guidelines into binding international rules, and creating multilateral institutions that can set and enforce technical standards for a shared orbital environment. None of these changes are easy, and they all involve making hard choices between safety and new ideas, between the interests of the country and the interests of the whole group.

It's evident that doing nothing will cost you money. The orbital environment is limited, and if it is badly damaged by debris cascade events, it may be impossible for any operator, whether commercial or government, to access it for generations. The law has always had to keep up with technology, but in space, the failure mode is irreversible. Reformers who want to avoid that consequence will have to move faster than they have been.

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