Law Journals

Journal of
Corporate Governance &
International Business Law

ISSN: 2584-1327
Volume 9, Issue 1, 2026
January–June
DOI (Journal): 10.37591/JCGIBL

http://lawjournals.celnet.in/index.php/jcgibl/index

Research JCGIBL

Public–Private Partnerships in Space: National and International Legal Dimensions in the USA and Europe

Shikha Bhardwaj[1,*], Razia Chauhan[2]

Abstract

The increasing commercial involvement in space activities has fundamentally reshaped the dynamics between governmental and private entities engaged in space exploration and utilization. Public-Private Partnerships have become a crucial method for balancing public interests, fostering technological advancements, and attracting private investment in this developing sector. This paper, titled "Public–Private Partnerships in Space: National and International Legal Dimensions in the USA and Europe," offers a comparative examination of the legal and institutional structures that facilitate PPPs within two prominent spacefaring regions: the United States and Europe. By referencing international commitments outlined in the Outer Space Treaty, the Liability Convention, and related agreements, the study assesses how national legislation in these areas—including the U.S. Commercial Space Launch Competitiveness Act, France's Space Operations Act, the U.K. Space Industry Act, and Luxembourg's Space Resources Law—implement state accountability and oversight for private space ventures. Furthermore, it investigates how evolving international frameworks, such as the dichotomy between the U.S.-led Artemis Accords and the Chinese-Russian International Lunar Research Station initiative, influence the regulatory landscape for private actors and the overall governance of outer space (Hasin, 2022). The analysis highlights significant differences in the structuring of Public-Private Partnerships: the United States adopts a procurement-centric strategy aimed at market acceleration, drawing upon NASA's Space Act Agreements and performance-based contracts, whereas Europe favors an authorization-centric model driven by the European Space Agency and its industrial policy, emphasizing state-led development and regulatory oversight. Special attention is directed toward the allocation of liability, insurance frameworks, and the legal status of space resources, with specific case studies illustrating how legal determinations influence private sector engagement. The paper also examines how these distinct legal and policy approaches affect the competitive landscape and the pace of innovation within the commercial space sector. The results highlight crucial compromises between adaptability and supervision, fostering innovation versus managing risks, and aligning national industrial objectives with adherence to global treaties. The paper also identifies emerging issues, such as the regulation of in-orbit servicing, space resource extraction, and extensive satellite constellations, necessitating flexible PPP structures. Building upon this comparative analysis, the study proposes recommendations for developing robust legal frameworks for PPPs that are internationally responsible and promote sustainable space commercialization. By contextualizing U.S. and European practices within the broader landscape of international space law, the paper emphasizes the necessity of coherent principles that balance competitive dynamics with accountability in the global space economy. Moreover, the inherent challenges associated with space as an open-access resource, particularly

***Author for Correspondence**
Shikha Bhardwaj
E-mail: shikhabhardwajjolly@gmail.com

[1]Research Scholar, Department of Law, Sharda School of Law, Sharda University, Greater Noida, UP, India
[2]Assistant Professor, Department of Law, Sharda School of Law, Sharda University, Greater Noida, UP, India

Received Date: October 27, 2025
Accepted Date: October 31, 2025
Published Date: November 08, 2025

Citation: Shikha Bhardwaj, Razia Chauhan. Public–Private Partnerships in Space: National and International Legal Dimensions in the USA and Europe. Journal of Corporate Governance & International Business Law. 2026; 9(1): 1–27p.

concerning the potential for a "tragedy of the commons," necessitate refined governance mechanisms to prevent unregulated exploitation and ensure sustainable development (Rausser et al., 2023). This is particularly critical given the increasing number of state and private actors involved in space activities and the lack of clear international consensus on the management of space resources and activities (Korpershoek, 2023) (Wiser & Aganaba, 2022).

Keywords: Public–Private Partnerships (PPPs), Space Law, Outer Space Treaty (OST), Commercial Space Activities, Liability Convention, Comparative Legal Frameworks (USA–Europe), Space Resource Utilization

INTRODUCTION

The increasing commercialization of outer space marks a significant evolution in space exploration, transitioning from a domain historically dominated by superpowers to a complex environment characterized by public-private partnerships. In this model, states, international organizations, and private entities collaborate on the development, launch, and operation of space technologies. This shift is not merely accidental or technological; it is a direct result of the interplay between legal frameworks, policy decisions, and institutional structures that either facilitate or impede private sector participation in activities traditionally undertaken by states. (Hasin, 2022)

At the core of this trend is the inherent conflict between the obligation of states to uphold international commitments, as stipulated in treaties like the Outer Space Treaty and the Liability Convention, and the increasing need to harness private capital, technological innovation, and risk tolerance to expedite space access. This dichotomy necessitates the development of Public-Private Partnerships that can adeptly balance the stringent obligations of states under international space treaties with the evolving demands for agility and market responsiveness in private space ventures. Consequently, the optimal configuration of PPPs has emerged as a pivotal consideration within the evolving landscape of space law and policy. This balance is particularly challenging given the limited attention policy-makers and scholars have paid to the human rights and environmental implications of private sector involvement in outer space (OST, art. VI–VII) (Macchi, 2024).

The United States and Europe present distinct yet informative paradigms for comprehending the influence of legal structures on Public-Private Partnerships. The U.S. has fostered a regulatory environment conducive to procurement, underpinned by legislation such as the Commercial Space Launch Act (codified in Title 51 U.S.C. ch. 509) and the Commercial Space Launch Competitiveness Act 2015. This framework empowers federal agencies, including NASA, to employ adaptable mechanisms like Space Act Agreements and performance-based contracts. This approach has produced landmark PPPs, including the Commercial Orbital Transportation Services (COTS), Commercial Resupply Services (CRS), and the Commercial Crew Program (CCP), which fundamentally restructured access to low-Earth orbit (Stone, 2018).

Conversely, Europe has adopted a regulatory strategy centered on authorization, established through national licensing laws such as France's Space Operations Act of 2008, the UK Space Industry Act of 2018, and Luxembourg's Space Resources Act of 2017. (Korpershoek, 2023) This approach is coordinated, albeit not entirely harmonized, by the European Space Agency. European public-private partnerships are characterized by shared development expenses and a stronger emphasis on industrial strategy and risk management. These divergent legal methodologies reveal fundamental distinctions in legal application: in the U.S., law facilitates commercialization through procurement, while in Europe, it manages commercialization via licensing and state investment.

This paper undertakes a comparative examination of the design of Public-Private Partnerships in the United States and Europe, concentrating specifically on the legal frameworks that underpin these collaborations. It aims to address three interconnected inquiries: first, the extent to which international

treaties and conventions influence and shape national PPP frameworks; second, the particular statutory, contractual, and jurisprudential mechanisms utilized by U.S. and European states in structuring their PPPs; and third, the policy insights and recommendations derivable from these comparative models for the development of PPPs that are both responsible and sustainable, ensuring compliance with international obligations while simultaneously fostering innovation and commercial advancement. This analysis will highlight how disparate legal traditions, specifically common law in the U.S. and civil law in Europe, influence the contractual structures and risk allocation within space-related PPPs (Hermida, 2009). Furthermore, this paper will explore the legal implications of private property rights in space resources, a concept that has gained traction in US law but remains contentious under international frameworks like the Outer Space Treaty (Lively, 2024).

The paper employs a doctrinal legal analysis approach, examining treaties, statutes, and relevant legal decisions, complemented by a comparative assessment of institutional practices. Specific case studies, such as NASA's COTS and CCP initiatives and Europe's Ariane launcher and Galileo navigation system, are utilized to demonstrate the practical application of these legal frameworks. Additionally, the analysis will delve into the contractual nuances of risk transfer and liability allocation within these partnerships, offering a comprehensive understanding of their operational mechanics and legal implications (Iron & Davidian, 2008).

The importance of this research stems from its capacity to inform subsequent policy and legislative adjustments. As an increasing number of nations, including emergent spacefaring countries, move to establish or revise their space legislation, the comparative experiences of the United States and Europe offer valuable insights into achieving a balance between international obligations, private sector incentives, liability management, and sustainability. Ultimately, this paper posits that the trajectory of space commercialization is contingent upon the creation of composite legal structures that integrate the adaptability of the U.S. procurement model with the rigorous oversight characteristic of the European authorization model, all while adhering to the fundamental principles of international space law. Such hybrid frameworks are crucial for fostering a robust and equitable international space economy, particularly as private financing increasingly seeks avenues for engagement in ambitious endeavors like deep-space exploration and resource utilization (Taylor et al., 2008). However, the unilateral legislative actions by the United States and Luxembourg, which permit the acquisition of private property rights over celestial resources, introduce significant complexities by potentially conflicting with established international legal principles such as the Common Heritage of Mankind (Saunders, 2019) (Salter, 2016).

INTERNATIONAL LEGAL FRAMEWORK

Any discussion of public–private partnerships in outer space must situate itself within the existing body of international space law, a framework sometimes referred to as the corpus juris spatialis. This framework is primarily constituted by the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967) and the Convention on International Liability for Damage Caused by Space Objects (1972). These instruments form the backbone of international space law, setting both the parameters and constraints within which private actors and PPPs must operate (Cvetkovič, 2023) [1].

The Outer Space Treaty (1967)

The Outer Space Treaty is widely recognized as the foundational document of space law, often likened to a constitution. Although its principles were established during the Cold War, they continue to govern contemporary commercial activities and public-private partnerships [2].

Article VI lies at the heart of debates over private sector involvement. It stipulates that: *"States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities."* Moreover, *"the activities of non-governmental entities in outer space … shall require authorization and continuing supervision by the appropriate State Party [3].*

Scholarly discourse investigates whether Article VI mandates the establishment of national legislation. A contingent of academics posits that the absence of a domestic licensing framework would constitute a violation of Article VI. Conversely, others contend that the requirements for "authorization and supervision" are flexible, potentially encompassing contractual oversight or case-by-case approvals, thereby affording states considerable latitude in their approach. This divergence in interpretation highlights the ongoing tension between strict adherence to foundational international law and the adaptive pressures introduced by increasingly complex commercial space ventures (Cheney et al., 2020). This debate underscores the necessity for clearer international guidelines that can reconcile state responsibility with the burgeoning private sector's operational autonomy (Gupta & Kd, 2019) [4].

Article VII strengthens this regime by imposing international liability: *"Each State Party that launches or procures the launching of an object into outer space … and each State Party from whose territory or facility an object is launched, is internationally liable for damage …"* This ensures that even when private actors physically operate launch vehicles or satellites, the launching state remains accountable for damages [5].

Beyond these provisions, several other OST articles create structural constraints on PPPs: [6].

Article I of the Outer Space Treaty establishes the principle of freedom of exploration and use of outer space for all nations, stipulating that such activities must be conducted "for the benefit and in the interests of all countries." This provision has been interpreted to preclude commercial uses that are purely extractive or exclusionary, unless they yield broader benefits.(Jakhu, 2005) [7].

Article II of the Outer Space Treaty prohibits any nation from claiming sovereignty over outer space or celestial bodies through sovereignty claims, use, occupation, or any other method. However, the extent of this prohibition is a subject of debate. While it unequivocally bars states from asserting sovereignty, it is unclear whether it also prohibits private entities from acquiring ownership rights over extracted resources. Jurisdictions like the United States and Luxembourg interpret this prohibition as distinct from the appropriation of extracted materials, thus permitting legislation that allows for resource utilization. Conversely, other nations and legal scholars contend that such interpretations undermine the fundamental intent of Article II, effectively enabling a circumvention of the prohibition against sovereignty. This divergence highlights a critical gap in international space law, as the OST, drafted when spaceflight was solely a state endeavor, did not explicitly foresee the complexities arising from private commercial exploitation of extraterrestrial resources (Wedenig & Nelson, 2025) [8].

Article IX mandates that states conduct their space activities with due consideration for the interests of other nations and refrain from causing harmful contamination of celestial bodies, thereby imposing environmental responsibilities. Consequently, for public-private partnerships, this necessitates that states ensure private operators comply with planetary protection protocols, even when engaged in missions driven by commercial objectives (Profitiliotis & Loizidou, 2019) [9].

THE LIABILITY CONVENTION (1972)

The Convention on International Liability for Damage Caused by Space Objects elaborates on Article VII of the Outer Space Treaty, establishing a comprehensive liability framework that significantly impacts public-private partnerships [10].

Article II of the Outer Space Treaty establishes the principle of absolute liability for the launching state in cases of damage occurring on Earth or to aircraft in flight. This means that victims are not required to prove negligence, thereby creating a robust deterrent against launches that are not adequately supervised by private entities (Ryzhenko & Halahan, 2019) [11].

Article III of the Liability Convention delineates a fault-based liability regime for damages incurred in outer space, wherein responsibility is contingent upon the launching state being demonstrably "at

fault." This standard imposes significant practical evidentiary challenges, given the inherent complexity in both technological and legal aspects of establishing fault in scenarios involving orbital collisions. Furthermore, the absence of explicit international dispute resolution mechanisms within the Liability Convention exacerbates these challenges, often relegating affected parties to complex and protracted diplomatic negotiations (Cheney et al., 2020) [12].

Article V establishes joint and several liability for scenarios involving multiple states in a single launch. This is particularly pertinent to public-private partnerships where various states might contribute launch facilities, procure components, or supply technology. Consequently, a U.S. commercial entity launching from a European site could potentially render both nations liable (Pacholska, 2022) [13].

While the Liability Convention offers theoretical comprehensiveness, state practice has revealed its shortcomings. The Cosmos 954 incident, involving the crash of a Soviet nuclear-powered satellite over Canada, led to a claim under the Liability Convention. Although this claim was resolved through diplomatic means, the case highlighted the absence of compulsory dispute resolution mechanisms and the reliance on diplomatic negotiations, thereby raising questions about the adequacy of adjudication for accidents stemming from public-private partnerships. Further, the Convention primarily holds states accountable, a framework increasingly anachronistic as private entities assume greater operational roles and financial stakes in space activities, thereby straining the traditional state-centric liability paradigm (Reinert, 2020) (Ziemblicki & Oralova, 2021). This growing involvement of private actors, coupled with the Convention's ambiguity regarding "fault" in orbital incidents, necessitates a re-evaluation of its applicability and the potential for a new standard of care (Dennerley, 2018) (Wang & Li, 2021) [14].

Oversight, Authorization, and Limitations on Public-Private Partnerships

In summary, the Outer Space Treaty and the Liability Convention establish that Public-Private Partnerships do not operate independently within the international legal order. Instead, they function as extensions of their authorizing states, which have a twofold responsibility: to authorize and supervise non-governmental activities (Article VI OST), and to absorb liability for damages caused by private operations (Article II–III Liability Convention) [15].

This framework constrains PPPs by necessitating national licensing regimes before private operations can commence; placing ultimate liability on states, which often leads to mandatory insurance and indemnification clauses in national legislation (e.g., U.S. Commercial Space Launch Act; French Loi relative aux opérations spatiales ; and prohibiting private sovereignty or territorial claims in outer space (Dempsey, 2014; Kerrest, 2017)) [16].

Conversely, the treaties facilitate Public-Private Partnerships by affirming the freedom of exploration and utilization of outer space as outlined in Article I of the Outer Space Treaty, which states can leverage for commercial ventures. Furthermore, the treaties' silence on the specific issue of resource utilization is interpreted by some states as creating a regulatory vacuum that permits domestic legislation for commercial extraction. Additionally, states are permitted to contractually allocate risks with private entities, although international responsibility for treaty obligations cannot be abrogated. This arrangement, however, creates a complex interplay where states are incentivized to promote private sector innovation while simultaneously managing the inherent risks and international responsibilities associated with their activities (Kehrer, 2019) [17].

Doctrinal Tensions

The divergent perspectives on the Outer Space Treaty and the Liability Convention concerning Public-Private Partnerships continue to foster debate among nations and academics [18].

One viewpoint contends that the commercial extraction of extraterrestrial resources fundamentally contravenes the principles, both explicit and implicit, of Article II of the OST. Proponents of this view

argue that PPPs driven by profit motives undermine the concept of outer space as the "province of all mankind"" [19].

Conversely, another perspective posits that the deliberate omission of explicit prohibitions against resource extraction from these treaties constitutes a form of "constructive ambiguity." This interpretation suggests that such ambiguity intentionally allows for pragmatic commercial development. This deliberate flexibility encourages innovation and investment, particularly within public-private partnerships, by not unduly restricting potential economic ventures (Larsen, 2021) [20].

In practice, states such as the United States and Luxembourg have adopted more permissive interpretations, thereby facilitating commercial ventures. In contrast, European nations like France and Germany maintain a more cautious stance, emphasizing stringent adherence to international obligations prior to authorizing PPP exploitation [21].

Consequently, international space law establishes that public-private partnerships are fundamentally grounded in state accountability while simultaneously preserving interpretative flexibility. National legal frameworks and policies have leveraged this flexibility to promote commercial activities (Durkee, 2019; Ishkibayeva & Nurmukhankyzy, 2021) [22].

The United States: Enabling Commercial Public-Private Partnerships Through Procurement and Statutory Facilitation

Legal Framework: Authorization, Licensing, and Enabling Statutes

The legislative framework in the United States governing public-private partnerships in space is established within Title 51 of the U.S. Code, specifically concerning National and Commercial Space Programs. Central to this is Chapter 509, which focuses on Commercial Space Launch Activities. The responsibility for the licensing and safety oversight of these activities has been delegated to the Department of Transportation, with the Federal Aviation Administration's Office of Commercial Space Transportation being the designated body to execute these duties. This legislative framework, however, often intersects with broader interpretations of international space law, particularly the Outer Space Treaty, which has fueled debates regarding the classification of outer space as a "global commons" (Mei, 2024) [23].

51 U.S.C. § 50904(a): *"A license issued or transferred under this chapter, or a permit, is required to launch a launch vehicle or to operate a launch site in the United States or by a United States citizen outside the United States."* This statutory stipulation formalizes the United States' commitment under Article VI of the Outer Space Treaty to authorize and continuously oversee non-governmental space activities. This provision underscores the domestic legal mechanism through which the U.S. fulfills its international obligations regarding national activities in outer space (Dunk, 2019) [24].

51 U.S.C. § 50905(b) requires the FAA to grant a license if the launch "does not jeopardize public health and safety, safety of property, and national security and foreign policy interests of the United States." This stipulation serves as the domestic mechanism for ongoing oversight, as mandated by Article VI of the Outer Space Treaty, given that licenses can be subject to conditions and may be revoked. The U.S. commercial space sector has benefited significantly from this legal framework, with the Commercial Space Launch Act, for instance, highlighting the importance of private applications of space technology for economic growth and international competitiveness (Heracleous et al., 2019) [25].

51 U.S.C. § 50914(a) Licensees are mandated by law to secure liability insurance or provide proof of financial responsibility, with the amounts to be determined by the Secretary, to cover claims from third parties. This regulation ensures that entities involved in U.S. public-private partnerships in space assume a portion of the associated risk. This requirement aligns with international legal principles, particularly Article VI of the Outer Space Treaty, which assigns state responsibility for national space activities, including those by non-governmental entities, thereby necessitating rigorous due diligence on commercial operators (Hall et al., 2021; Soroka et al., 2023) [26].

51 U.S.C. § 50915 provides **government indemnification**: the U.S. government "shall pay successful third-party claims (to the extent not covered by insurance) resulting from licensed activities up to $1.5 billion above the insurance coverage required under § 50914, subject to appropriations." This governmental indemnity provision was designed to mitigate the risk of substantial financial loss and thereby encourage private sector involvement in launch operations, demonstrating Congress's clear policy favoring commercialization. Such indemnification mechanisms are critical in fostering a robust commercial space industry by buffering operators from catastrophic liabilities inherent in space launch activities (Harrington, 2015) [27].

The Commercial Space Launch Competitiveness Act (SPACE Act) of 2015 (Pub. L. 114-90) went further by clarifying property rights in extracted resources. 51 U.S.C. § 51303 states: *"A United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the resource obtained in accordance with applicable law, including the international obligations of the United States."[28].*

This clause generates international controversy as it engages directly with Article II of the Outer Space Treaty concerning the principle of non-appropriation. Nevertheless, it signifies the U.S. perspective that the appropriation of resources obtained through extraction does not constitute the appropriation of celestial bodies themselves.(Walker & Johnson, 2018) Legal scholars dispute this interpretation, arguing that such claims to extracted resources may violate the spirit, if not the letter, of international agreements that preclude national appropriation of outer space (O'Brien, 2021) (Chouhan, 2020) (Tjalve, 2024) [29].

Collectively, these stipulations establish a regulatory framework encompassing licensing, insurance, and liability that simultaneously adheres to the United States' treaty commitments and fosters an environment conducive to the flourishing of public-private partnerships. This framework also strategically positions the U.S. to lead in emergent sectors such as space resource utilization, despite ongoing international debates regarding the legality and ethical implications of privatizing celestial resources (Walker & Johnson, 2018) (Taylor, 2019) (Kent, 2025) [30].

NASA's PPP Playbook: COTS, CRS, Commercial Crew, and CLPS

In contrast to the regulatory oversight provided by the FAA, NASA's public-private partnerships are facilitated through procurement law and specific legislative authorities. The National Aeronautics and Space Act of 1958, currently codified in 51 U.S.C. §§ 20111–20113, grants NASA extensive powers, including the authorization to "enter into and perform such contracts, leases, cooperative agreements, or other transactions as may be necessary" (§ 20113(e)) [31].

This provision serves as the foundation for Space Act Agreements, which are flexible legal instruments employed for public-private partnerships that operate independently of the stringent Federal Acquisition Regulation framework. NASA integrates SAAs with milestone-based payment structures, conventional FAR contracts, and certification monitoring to effectively organize its commercial ventures [32].

Commercial Orbital Transportation Services (COTS): In the mid-2000s, NASA established Space Act Agreements with SpaceX and Northrop Grumman (formerly Orbital Sciences) to develop cargo resupply capabilities. This milestone-based payment structure effectively transferred technical and financial risks to the private partners while enabling NASA to maintain oversight (Stone, 2018) [33].

Following the successful demonstration of capabilities through the Commercial Orbital Transportation Services (COTS) program, NASA shifted to procurement contracts governed by the Federal Acquisition Regulation for Commercial Resupply Services (CRS). Under CRS, NASA procures cargo delivery services from commercial entities, rather than supplying the necessary hardware. This

change helped reduce the financial and technical risks of creating new launch systems, making the market more competitive for commercial space transportation (Autry, 2018) (Heracleous et al., 2019) [34].

In the Commercial Crew Program, NASA engaged both Boeing and SpaceX by utilizing a combination of Space Act Agreements, milestone-based contracts, and post-certification purchase agreements for crew transportation services. While stringent safety certification requirements provided regulatory oversight, the public-private partnership model predominantly shifted the burden of development costs to the private sector partners. This approach marked a significant departure from the traditional cost-plus contracting model, where NASA bore the full expense and assumed ownership of the technology (Heracleous et al., 2019) [35].

Commercial Lunar Payload Services (CLPS): In the CLPS program, NASA procures lunar delivery services from various commercial providers, thereby fostering a domestic lunar delivery market while maintaining strategic flexibility for mission planning [36].

(Metzger & Autry, 2022) (Sadeh et al., 2005)This approach, which leverages existing commercial capabilities and promotes competition, allows NASA to focus on scientific objectives and exploration rather than developing and maintaining a dedicated lunar transportation infrastructure (Anderson, 2013) [37].

These initiatives exemplify how NASA's statutory latitude under 51 U.S.C. § 20113(e), coupled with its adaptive procurement methodologies, has enabled the United States to embed public-private partnerships as a principal strategy for commercialization [38].

Liability, Indemnification, and Insurance in the U.S. Context

In the United States, the allocation of liability within public-private partnerships is a complex interplay of statutory indemnification provisions, the private insurance market, and contractual agreements. The statutory framework, primarily defined by 51 U.S.C. §§ 50914–50915, establishes mandatory insurance requirements for space activities and provides a limited scope of government indemnification. This dual approach aims to alleviate the potential for catastrophic financial burdens on private entities while ensuring compliance with international obligations, such as those outlined in the Liability Convention. Complementing this statutory layer, NASA's PPP contracts often incorporate indemnification clauses, obligating contractors to shield the government from damages arising from negligence or breaches of contract. For instance, under Commercial Resupply Services contracts, providers are required to secure specific insurance coverage and agree to hold the U.S. government harmless up to defined liability limits. The insurance layer is further reinforced by the common practice of U.S. launch providers obtaining third-party liability insurance that meets or exceeds FAA-mandated levels. This private insurance serves as the primary means of coverage, with the federal indemnification acting as a crucial backstop for liabilities exceeding these insured amounts. Furthermore, cross-waivers of liability between launch operators and payload owners are frequently utilized, a principle gaining wider international adoption (Larsen, 1992) [39].

Case Law and Precedent

While litigation concerning public-private partnerships in the U.S. space sector has been infrequent, the case of *Space Exploration Technologies Corp. v. U.S.*, 144 Fed. Cl. 433, provides valuable insight. In this instance, SpaceX contested NASA's decision to award Commercial Crew contracts to Boeing on a sole-source basis. Although the Court of Federal Claims ultimately dismissed certain aspects of the protest, the proceedings highlighted the interplay between procurement regulations and PPP policy, indicating that private entities are increasingly engaged in legal challenges to safeguard their involvement in NASA's PPP framework, which underscores the significant commercial interests at stake [40].

Another significant legal precedent is *Hughes Aircraft Co. v. United States*, 29 Fed. Cl. 197, which addressed issues of technology transfer and licensing. Although the case primarily concerned patent matters, it serves to illustrate the enduring impact that the specific contractual terms within federal space agreements can have on commercialization efforts. These legal precedents establish the necessity for meticulously drafted contractual frameworks that delineate intellectual property rights, data ownership, and liability, thereby mitigating future disputes and fostering a stable environment for public-private collaboration (Ruhaeni, 2019). The increasing sophistication of commercial space activities necessitates a robust legal environment capable of adapting to novel technological and operational paradigms (Weeks, 2006) [41].

Doctrinal Implications

The U.S. model illustrates how domestic statutory clarity, in conjunction with flexible procurement authority, facilitates public-private partnerships. These partnerships not only adhere to international obligations but also propel the advancement of commercialization. By harmonizing authorization and oversight responsibilities with indemnification mechanisms and market-shaping procurement strategies, the U.S. has successfully established a PPP-driven commercialization ecosystem, a model that European nations are only partially emulating. This partial emulation often stems from differing legal traditions, regulatory structures, and varying levels of risk aversion within the European Union's member states, leading to a more fragmented and cautious approach to space commercialization compared to the United States' integrated framework (Vidaurri et al., 2019) [42].

Europe: National Legal Frameworks and Public-Private Partnerships in the Context of the European Space Agency

In contrast to the United States' centralized commercialization framework, managed by NASA and the FAA, Europe employs a decentralized, multi-tiered approach. This system comprises three key elements: first, the European Space Agency law and policy, which governs major space programs across its 22 member states; second, European Union law, applicable under Article 189 of the Treaty on the Functioning of the European Union, although space is not an exclusive EU competence; and third, the national space laws of individual member states, which regulate private space activities and authorize public-private partnerships. This intricate legal landscape often leads to challenges in establishing a unified regulatory environment for space commercialization, a stark contrast to the comparatively streamlined U.S. approach (Hermida, 2009) [43].

United Kingdom

The United Kingdom stands as a leading European nation in the commercialization of space activities. Its primary legislation, the Outer Space Act of 1986, aligns with the obligations outlined in Article VI of the Outer Space Treaty [44].

Under Section 3 of the Outer Space Act 1986, individuals must obtain a license from the Secretary of State to initiate, arrange for, or manage a space object. This provision is comparable to 51 U.S.C. § 50904 in the United States, with the authority vested in the UK government [45].

Section 5 of the Outer Space Act 1986 stipulates that licensees are obligated to indemnify the UK government against any liabilities incurred under international law [46].

The Outer Space Act has been further augmented by the Space Industry Act 2018, which was introduced to establish a regulatory framework for suborbital launches, spaceplanes, and commercial spaceports within the United Kingdom. Section 11 of this Act mandates operator licensing and ensures compliance with safety regulations. Additionally, Section 36 grants the Secretary of State the authority to require licensees to obtain insurance and to provide indemnification to the government. The heading for the subsequent section is missing Liability [47].

The UK provides a framework for indemnification concerning liability under the Liability Convention, while simultaneously requiring private licensees to maintain adequate insurance coverage [48].

While direct judicial precedents are limited, licensing decisions by UK authorities offer practical illustrations of statutory powers [49].

ESA Relationship: Following its post-Brexit reaffirmation, the UK has rejoined the European Space Agency. The nation contributes financially to ESA's telecommunications and Earth observation programs, utilizing ESA procurement opportunities to promote industrial engagement. This strategic re-engagement with ESA allows the UK to leverage European collaborative research and development while fostering its domestic space industry through targeted contracts and partnerships, further solidifying its role in the global space economy. However, the UK's participation in European space initiatives, particularly regarding Galileo, has been notably recalibrated post-Brexit, leading to a shift towards bilateral agreements with EU member states for certain aspects of space cooperation (Meislová & Glencross, 2023) [50].

France

France's Loi relative aux opérations spatiales (Law No. 2008-518) is widely recognized as a comprehensive piece of national space legislation. Key provisions include Article 1, which mandates that "authorization is required for any space operation conducted on French territory or using French means." Furthermore, Article 5 requires operators to demonstrate sufficient financial capacity and possess adequate insurance coverage. Article 13 empowers the French government to cap an operator's liability, with the state assuming liability towards third parties for any amounts exceeding this cap. France's liability framework aligns with Article VI of the Outer Space Treaty and Articles II-III of the Liability Convention by necessitating insurance for commercial operators, with liability limits established by decree. In terms of public-private partnerships, Arianespace, established in 1980, stands as a pioneering example, operating launch vehicles such as Ariane, Vega, and Soyuz from French Guiana under the auspices of the Centre National d'Études Spatiales and the European Space Agency. As ESA's principal financial contributor, France exerts considerable influence over policy development and PPP procurement within the agency. This robust engagement underscores France's commitment to fostering a competitive space sector through strategic investments and collaborative ventures, positioning itself as a pivotal actor in European space commercialization (Landoni & ogilvie, 2019). [51].

Luxembourg

Luxembourg has established itself as a significant center for extraterrestrial resource extraction. The "Law of 20 July 2017 on the Exploration and Use of Space Resources" stipulates in Article 1 that "space resources are capable of being appropriated." Furthermore, Article 2 mandates that prior ministerial authorization is required for any activities involving resource exploration. This legislative framework is analogous to the U.S. SPACE Act of 2015 (51 U.S.C. § 51303), affirming the principle of private ownership over resources that have been extracted. Regarding liability, Luxembourg adheres to the Liability Convention by requiring licensed entities to provide indemnification to the state. In its relationship with the European Space Agency, Luxembourg is a key member, utilizing its legislative environment to attract private-public partnership investments.(Jakhu et al., 2017) [52].

Germany

Germany currently lacks a dedicated statutory framework for space activities, instead regulating such matters through general administrative law and existing specific legislation. Although a draft German Space Law has been considered, it has not yet been enacted. Licensing processes are presently governed by Article 20 of the Basic Law and the obligations of the Outer Space Treaty, which have been incorporated into domestic administrative acts. In terms of liability, Germany addresses this through contractual agreements and insurance mandates with operators, rather than a codified statute

comparable to France's Loi relative aux opérations spatiales. Germany holds the position of ESA's second-largest financial contributor, with its involvement concentrated on the International Space Station, the development of the Ariane launch system, and Earth sciences. While there are no landmark space-specific court rulings, German administrative courts have adjudicated disputes concerning satellite spectrum allocation under telecommunications law. This approach, while functional, introduces a degree of ambiguity for private sector entities seeking clarity on regulatory compliance and potential liabilities, thereby influencing their investment strategies in the German space sector. (ESPI et al., 2009) [53].

Italy

Italy, while establishing the Italian Space Agency in 1988, has not yet enacted a comprehensive national space law. Regulatory oversight is currently managed through Law No. 7/1988 and general administrative licensing procedures overseen by the ASI, ensuring adherence to the principles outlined in Article VI of the Outer Space Treaty [54].

Italy actively participates in ESA's Vega launcher program and consistently supports public-private partnerships within the telecommunications and Earth observation sectors. As the third-largest financial contributor to ESA, Italy holds a significant position in the development of launch systems and International Space Station modules, demonstrating its substantial influence and dedication to European space initiatives [55].

Sweden

Sweden's regulatory framework for space activities is characterized by its reliance on existing general administrative laws rather than a distinct, comprehensive space act, a characteristic shared with several other European nations. However, the "Space Activities Act" specifically governs launches, stipulating in Section 2 that any launch of a space object from Swedish territory or by a Swedish operator requires authorization from the Swedish National Space Board. Furthermore, Section 6 mandates the provision of financial guarantees and insurance. In its relationship with the European Space Agency, Sweden became a member in 1975 and has contributed to Earth observation and sounding rocket programs, notably at Esrange. This engagement highlights Sweden's pragmatic approach to space commercialization, focusing on niche areas of technological expertise and collaborative scientific endeavors rather than extensive legislative frameworks. Despite the absence of a comprehensive national space law, Sweden’s focused regulatory measures and active participation in ESA underscore its commitment to fostering specific segments of the space industry. This tailored approach allows for flexibility and responsiveness to evolving technological advancements and commercial opportunities within the New Space environment (Ciaccio et al., 2018) [56].

Belgium

Belgium's legal framework for space activities is delineated by the Law of 17 September 2005. This legislation mandates prior authorization for any space-related activities undertaken within Belgian territory or by Belgian entities. Furthermore, Article 6 stipulates the requirement for operators to furnish proof of insurance and establishes their liability to the Belgian state. Belgium is recognized as a founding member of the European Space Agency, with notable contributions to satellite technology and scientific missions. This foundational involvement within ESA underscores Belgium's long-standing commitment to multilateral space endeavors, facilitating its integration into the broader European space commercialization landscape (Adriaensen et al., 2015) (Adams, 2019). This comprehensive regulatory approach, coupled with its active participation in international collaborations, positions Belgium as a key player in shaping the European approach to commercial space activities, particularly in the realm of satellite technology and scientific missions [57].

COMPARATIVE OBSERVATIONS

Authorization and Supervision

The UK's Outer Space Act 1986 and Space Industry Act 2018, alongside France's LOPS 2008, Luxembourg's 2017 law, Sweden's 1982 Act, and Belgium's 2005 law, all establish licensing

frameworks to fulfill obligations under Article VI of the Outer Space Treaty. Whereas Germany and Italy currently rely on administrative practices for regulation but are considering codifying their space laws [58].

Liability Allocation

In contrast to France, the United Kingdom, Luxembourg, and Sweden, which enforce mandatory insurance and indemnification with the state ultimately assuming liability under the Liability Convention, Germany and Italy presently lack codified liability statutes and manage liability through established practices. This divergence highlights a critical regulatory gap in these latter nations, potentially impacting the financial exposure and operational calculus for private space actors (Zhao, 2004) [59].

Property Rights

Regarding the ownership of resources extracted from space, Luxembourg and the United States align in permitting private claims, whereas France, the United Kingdom, and Germany interpret Article II of the Outer Space Treaty conservatively, refraining from unilaterally acknowledging property rights. This disparity in legal interpretation creates a complex international landscape, requiring careful navigation for commercial entities interested in space resource utilization (Xu & Su, 2020) [60].

ESA's Coordinating Role

The European Space Agency functions as a European counterpart to NASA, albeit without supranational authority. Through a system of industrial return, where contracts are allocated proportionally to member state contributions, ESA develops and procures major launchers and satellites. Public-private partnerships, such as Arianespace, operate within this framework. Nevertheless, the ultimate responsibility for authorizing and overseeing private space ventures resides with national governments, in accordance with the Outer Space Treaty. This decentralized regulatory approach, despite ESA's coordinating efforts, underscores the fragmentation within the European space commercialization landscape, contrasting with the more unified federal oversight typically observed in the United States (Harrington, 2015) (Dunk, 2019). This structural difference often leads to varied approaches in managing legal obligations, such as those pertaining to space debris mitigation, where European states have distinct standards compared to the United States (Zaefen, 2020) [61].

A comparative Examination of the Design Choices and Legal Trade-offs Inherent in Public-Private Partnership Models within the Space Sector [62]

All national public-private partnerships in space activities are bound by the foundational principles of the Outer Space Treaty and the Liability Convention. Specifically, Article VI of the OST establishes state responsibility for national space activities, mandating "authorization and continuing supervision." Concurrently, Articles II and III of the Liability Convention stipulate absolute liability for damages occurring on Earth's surface or in the atmosphere, and fault-based liability for damage caused elsewhere. These treaty obligations necessitate the design of domestic legal frameworks that encompass licensing, insurance, and indemnity provisions. This imperative informs the various approaches observed across European nations, where states balance the promotion of commercial innovation with their international legal responsibilities. However, this often creates a conflict between the agility sought by New Space enterprises and the bureaucratic structures inherent in stringent safety protocols and complex procurement contracts, particularly within organizations like the European Space Agency (Clegg et al., 2023). Furthermore, the intricate web of intergovernmental cooperation within ESA, while fostering technological development, can lead to extended project timelines and resource allocation disputes among member states vying for industrial returns (Rouyre et al., 2023). These structural and operational differences contribute to a fragmented regulatory environment that poses unique challenges for harmonizing private sector involvement across Europe. [63]

Procurement vs. Authorization-first Models

United States

Procurement-friendly (market creation through demand).

The United States employs a procurement-centric strategy, leveraging NASA's broad statutory authority to engage in Space Act Agreements and other flexible instruments outside the Federal Acquisition Regulation regime. This approach facilitates milestone payments, staged financing, and outcome-based contracting, thereby integrating procurement directly into industrial policy by enabling NASA to utilize its contracting and transactional powers. This methodology contrasts with a 'licensing-first' model, where safety and third-party risk are overseen by agencies like the FAA's Office of Commercial Space Transportation under specific statutory provisions, while procurement serves as the primary driver for generating guaranteed market demand. The practical effect of this procurement-led approach is the conversion of government demand into predictable revenue streams that attract private investment, simultaneously shifting early-stage technical and schedule risks to industry through mechanisms such as milestone payments and fixed-price contracts. Legally, this approach involves a trade-off between speed and innovation on one hand, and the potential for market distortion on the other; while procurement accelerates capability development by creating guaranteed markets, it can also entrench incumbent firms or skew competition. Furthermore, substantial government procurement raises concerns regarding state aid and potential unfair competitive advantages.[64]

Licensing Separate from Procurement

The Federal Aviation Administration's Office of Commercial Space Transportation (FAA/AST) oversees safety and third-party risk under 51 U.S.C. ch. 509, but the primary mechanism for generating guaranteed market demand is through procurement. This approach effectively translates government demand into predictable revenue streams that attract private investment, while simultaneously transferring early-stage technical and schedule risks to industry via milestone payments and fixed-price contracts. The legal trade-offs involve balancing the acceleration of capability development through guaranteed markets against the potential for market distortion, such as entrenching incumbent firms or skewing competition, and concerns about state aid and unfair competitive advantages arising from substantial government procurement. This procurement strategy, exemplified by the Commercial Orbital Transportation Services program, allowed NASA to cede significant control over the development process to contractors through fixed-price contracts and advance market commitments, thereby fostering innovation and cost efficiency (Sankaran, 2024). This model, often cited as the COTS model, demonstrated significant success in cultivating new commercial capabilities for space transportation, proving that fixed-price contracts and milestone-based payments can effectively de-risk private investment and incentivize the rapid development of innovative solutions (Autry, 2018) (Sankaran, 2024). [65]

Speed & Innovation vs market Distortion

By creating guaranteed markets, procurement accelerates capability development but may entrench incumbents or skew competition. Furthermore, this strategy permits NASA to redirect its focus towards ambitious deep-space exploration by relying on private sector capabilities for Low-Earth Orbit operations (Lambright, 2015).[66]

State Aid and Subsidy Concerns

Substantial government procurement can lead to concerns regarding unfair competitive advantage. This is particularly relevant in the context of EU State aid law, which scrutinizes public support to private undertakings to prevent market distortion and ensure a level playing field (Petersen, 2018). [67]

Europe: authorization-first public development (State Co-Funding + ESA)

European Space Agency and National co-funding

The European Space Agency functions as an intergovernmental entity for procurement and funding, with Member States providing co-financing for development projects. Concurrently, national legislation, such as France's "Loi n°2008-518," the UK's "Outer Space Act 1986" and "Space Industry Act 2018," and Luxembourg's 2017 law concerning resources, prioritizes licensing and pre-authorization procedures. (Sagath et al., 2017)[68]

Upfront Public Investment

In European models, national governments or the European Space Agency often provide substantial funding for research and development, as well as initial capital investments—exemplified by the development of the Ariane rockets. The private sector then leverages this upfront public investment to undertake the commercialization of production and ongoing operations.[69]

Public investment

Cultivates capabilities that may not be initially funded by private markets; licensing mechanisms ensure more stringent oversight prior to market entry.[70]

Industrial Policy & Fairness

The principle of geographic return employed by ESA aids in maintaining the health of the industrial base, although it may potentially diminish price-based competition and impede the development of a mature private market.[71]

Regulatory Friction

Strong pre-authorization may delay commercialization and raise compliance costs for SMEs.[72]

Comparative Summary (Procurement v. Authorization)

The United States model prioritizes rapid market development through demand-driven approaches and risk transference to the private sector, with less emphasis on pre-market regulatory scrutiny. Conversely, Europe's approach is characterized by a development-led strategy, featuring robust gatekeeping mechanisms via licensing and public research and development, which results in a more deliberate, though potentially more protective, development of its industrial base and adherence to treaty obligations. [73]Ultimately, the choice between these models hinges on normative policy objectives: whether to foster immediate market creation or to pursue a more cautious path of industrial development and regulatory oversight. This divergence reflects differing philosophies on the role of government in fostering innovation and managing risk within nascent high-technology sectors (Lin et al., 2024). Further analysis reveals that the European Union's current space policy endeavors to maintain its position among global space leaders by emphasizing autonomy in access and use of outer space, fostering symbiotic cooperation between public institutions and private companies, and addressing the challenges and opportunities presented by the dynamic growth of the private space sector (Kolczyński, 2019). [74]

Both Systems are Subject to Treaty Constraints

States are obligated by the Outer Space Treaty to authorize and regulate space activities, with liability for damage on Earth or in the atmosphere assigned under the Liability Convention, and fault-based liability for damage occurring in outer space. Consequently, nations must establish domestic regulatory frameworks to manage downstream risks, as they cannot delegate their treaty-based responsibilities to other sovereign entities. This inherent non-delegability underscores the critical need for national regulatory bodies to develop comprehensive, yet adaptive, frameworks that can accommodate the burgeoning private sector while upholding international legal obligations and ensuring safety and sustainability in space activities (Chatzipanagiotis & Kyriakopoulos, 2019). [75]

United States Approach

The United States framework incorporates a layered statutory approach, including Federal Aviation Administration licensing under 51 U.S.C. § 50904, mandatory insurance and financial responsibility requirements as stipulated in § 50914, and a limited federal indemnification provision under § 50915. This indemnification is applicable when third-party claims surpass the coverage provided by private insurance and is contingent upon available appropriations.[76]

In terms of practical risk allocation, private entities typically assume routine operational risks, often through insurance. The government, however, provides a safety net for catastrophic events, thereby

capping the maximum potential exposure for commercial operators and fostering greater market entry.[77]

In NASA's Public-Private Partnership agreements, contractual provisions for indemnification and risk allocation are incorporated, wherein the selected partners assume substantial technical risks. This arrangement incentivizes private innovation by mitigating certain high-magnitude, low-probability risks that might otherwise deter investment in complex space endeavors (Rausser et al., 2023). [78]

European Approach

National legislation in European countries mandates insurance and authorization for space activities. While national governments generally assume responsibility for treaty-related liability, the extent and mechanisms of governmental indemnification vary across jurisdictions. For instance, the Liability Convention of 1972 stipulates joint and several liability for launching States, pushing them to implement robust national legislation and risk mitigation strategies without limiting liability (Graham et al., 2024).[79]

France's Law on Space Operations and Luxembourg's 2017 legislation establish more explicit and stringent requirements for pre-authorization and financial solvency. Notably, Luxembourg's law also indicates a supportive posture towards resource utilization, incorporating licensing frameworks designed to manage state accountability. However, despite these national variations, a common thread across European approaches is the emphasis on comprehensive regulatory frameworks that explicitly address liability, insurance, and authorization to align with international treaty obligations and promote responsible space activities (Aoki, 2019) (Ruhaeni, 2019) (Larsen, 2019). [80]

When the European Space Agency engages in procurement and co-funding, it involves multiple Member States, necessitating a coordinated approach to risk apportionment among them. This often entails complex intergovernmental agreements and robust legal instruments to delineate responsibilities and financial contributions, ensuring adherence to international liability conventions and safeguarding national interests (Wang & Li, 2021) (Hearsey, 2008). [81]

COMPARATIVE TRADEOFFS

The U.S. system of indemnification serves as a market stimulant but raises concerns about moral hazard, whereas Europe's more rigorous licensing framework mitigates exposure but can increase the costs of market entry.[82]

Both regulatory approaches grapple with imperfect insurance markets due to challenges in evidence gathering and attribution, consequently relying on state capacity to absorb residual catastrophic risks. This reliance is further complicated by the inherent limitations of international space law, particularly the Outer Space Treaty and the Liability Convention, in fully attributing liability for damages caused by increasingly autonomous space objects (Bratu et al., 2021). [83]

Incentives for Commercialisation: Special Regimes and Market Signals

U.S. incentives

Firstly, the SPACE Act, specifically 51 U.S.C. § 51303, establishes an explicit entitlement to resources extracted from celestial bodies such as asteroids. This provision serves as a market-clearing signal for potential investors by defining property rights for space-derived resources.Further, NASA's procurement capacity functions as a catalyst for nascent markets, stimulating demand for services within low Earth orbit and lunar payload delivery.[84]

European Incentives

Luxembourg's legal framework explicitly encourages resource exploration companies by affirming their rights to extracted materials and issuing national authorizations, thereby providing a robust market incentive.[85]

Conversely, France, the UK, and Italy leverage infrastructure support, public procurement, and co-funding through the ESA to foster the growth of industrial clusters.

The European Space Agency co-funds telecommunication and satellite services through initiatives like ARTES and Partnership Projects, thereby fostering the development of specialized market segments. This direct investment strategy aims to de-risk technological advancements and provide a stable demand signal for commercial entities operating within the European space ecosystem (Kolczyński, 2019) [86]

Comparative Trade-offs

Legal Certainty

The United States and Luxembourg offer clearer property rights signals, which diminishes investor uncertainty but creates interpretive challenges regarding Article II of the Outer Space Treaty.[87]

While procurement strategies foster immediate client bases, legislative frameworks establishing property rights are more effective in cultivating sustained investment for resource extraction and subsequent industrial development. This divergence highlights a fundamental tension between regulatory pragmatism and the aspirational principles of international space law, particularly concerning the common heritage of mankind ("Management of Outer Space Economic Resources – Legal and Political Challenges," 2021) (Lin et al., 2024). This is particularly relevant given the "gold rush enthusiasm" for space resource utilization, which risks creating a regulatory vacuum that could lead to significant environmental and ethical challenges (Frieden, 2025). [88]

Speed vs. Oversight: Regulatory Agility and Safety

Speed (U.S.)

Regulatory agility is enhanced through Space Act Agreements and procurement processes, while the FAA streamlines licensing to facilitate the pace of commercial space activities.

The accelerated pace of commercial space activities may compromise safety standards and international consensus, while the reliance on indemnities presupposes effective domestic supervision. The complexity of these arrangements is further exacerbated by the increasing involvement of private actors, whose motivations may not always align with broader international objectives, thereby complicating efforts to establish a unified and enforceable regulatory regime (Moranta & Donati, 2020). [89]

Oversight (Europe)

In terms of pre-authorization rigor, both France and the UK impose stringent conditions prior to issuing licenses.

Enhanced oversight mechanisms can mitigate external risks and reduce exposure to international treaty violations; however, such rigorous supervision may impede the pace of innovation. This balance between fostering innovation and ensuring robust oversight is a critical challenge, as lax regulatory frameworks could precipitate a "tragedy of the commons" in the orbital environment (Tjalve, 2024).

Comparative Trade-offs

In the short term, the United States demonstrates superior agility in commercial space endeavours, evidenced by rapid market growth and visible successes.

In the long term, Europe's more conservative regulatory posture may offer greater protection for the public interest, its industrial base, and its international treaty reputation; however, this approach may concurrently impede the growth and scaling of the private sector (Table 1). These differing philosophies underscore a fundamental tension between fostering a dynamic commercial space industry and adhering to principles of sustainability and equitable access (Tjalve, 2024).

Table 1. Pros & cons matrix (compact).

Dimension	United States (procurement)	Europe (ESA + authorization)
Market formation speed	High (milestone procurement)	Moderate–Low (upfront development cycles)
Regulatory certainty for operators	High for procurement winners; moderate otherwise	High: clear licensing but can be prescriptive
State liability exposure	Backstop indemnity (limited) promotes entry	State retains primary exposure; often no broad indemnity
Investor signals for property rights	Strong (SPACE Act)	Mixed strong in Luxembourg; cautious in France/UK
Industrial policy & fairness	Risk of incumbency, competition disputes	ESA return rules protect industrial base but may distort market
Safety & environmental oversight	Lighter pre-launch gating; post-certification models	Strong pre-authorization and environmental safeguards

Actionable Recommendations for the Design of Balanced Public–private Partnerships

Adopt Hybrid Models

Integrate demand-side procurement mechanisms with pre-authorization licensing protocols, along with establishing minimum safety and insurance requirements. Furthermore, a robust framework for environmental impact assessment, encompassing orbital debris mitigation and spectrum management, should be integrated into all licensing procedures to ensure long-term sustainability of space operations (Hall et al., 2021).

Transparent Indemnity Triggers

It is essential to establish legislative clarity regarding the specific conditions under which state indemnity applies, including caps, duration, appropriations, and clawback provisions, in order to mitigate moral hazard. Such clarity would not only protect taxpayer interests but also incentivize private entities to internalize risk management, promoting safer operational practices (Vistisen & Jensen, 2020).

Regulatory Sandboxes & Phased Certification

Regulatory sandboxes and phased certification models facilitate experimental operations through graduated oversight, moving from conditional licenses to full certification. This iterative approach allows for the development of new technologies and operational procedures in a controlled environment, gradually integrating them into the broader regulatory framework as their safety and reliability are demonstrated (Vidaurri et al., 2019).

Harmonize Key Standards at EU/ESA Level

It is essential to standardize aspects such as minimum insurance requirements, planetary protection protocols, and dispute resolution mechanisms to mitigate cross-jurisdictional conflicts. This harmonization is crucial for fostering a predictable and equitable operational environment, especially given the diverse legal and economic landscapes of member states (Gokhan et al., 2020).

International Dialogue on Resource Rights

It is essential to coordinate the permissive stances adopted by the United States and Luxembourg with more cautious states to foster multilateral norms. This approach aims to mitigate conflict and reduce investment uncertainty in the context of space resource utilization. Moreover, developing a United Nations-based information-sharing mechanism for objects and events in space could facilitate transparency and trust, forming a basis for global space traffic management (Lema et al., 2021).

Short Legal Takeaways

The U.S. procurement framework effectively leverages governmental purchasing power to stimulate market development, underpinned by statutory indemnities and robust signals regarding property rights [51 U.S.C. §§ 20113-e; 50914–50915; 51 U.S.C. § 51303].

European Models

European models integrate co-funding from the European Space Agency with national licensing frameworks, such as France's LOPS, the UK's Outer Space Act/Space Industry Act, and Luxembourg's 2017 law. These frameworks prioritize pre-market regulation and industrial policy. Furthermore, ESA's multi-country procurement processes introduce additional complexity through requirements for industrial return and considerations of joint liability. These disparate approaches necessitate a comprehensive comparative analysis to identify best practices for fostering innovation while ensuring responsible and sustainable space utilization in the evolving global space economy (Soroka et al., 2023) (Palmroth et al., 2021).

Both Approaches

Must reconcile their treaty obligations, specifically those under Article VI of the Outer Space Treaty and Articles II–III of the Liability Convention, with national policy goals. The optimal design for public-private partnerships will likely integrate hybrid models, utilizing procurement to foster market growth while simultaneously maintaining stringent authorization, insurance, and liability frameworks to safeguard public interests. Moreover, addressing the "tragedy of the commons" dilemma necessitates establishing a robust international legal framework that extends beyond the current principles of non-appropriation, especially as private entities increasingly engage in resource extraction and in-space manufacturing (Ma & Liu, 2021) (Rausser et al., 2023) (Delgado-López, 2014).

Cases and Operational Examples

NASA–SpaceX (Commercial Crew & CRS)

NASA's strategic use of procurement and Space Act Agreements has successfully facilitated SpaceX's provision of regular cargo and crew transport services to the International Space Station. This outcome highlights the efficacy of employing milestone payments, stringent certification requirements, and purchase contracts to cultivate a thriving commercial service market. The successful deployment of the Crew Dragon further exemplifies the effectiveness of the U.S. public–private partnership model in the space sector. This collaborative approach not only mitigates financial risks for private ventures but also accelerates technological development and operational capabilities, demonstrating a scalable paradigm for future space endeavors (Lissandrello et al., 2022).

ESA–Arianespace (Ariane Family)

The European Space Agency funded the development of launchers, subsequently transferring their commercial operation and marketing to Arianespace, a private entity established specifically for the commercialization of these launchers. This framework, integrating public research and development with private commercialization, positioned Europe as a prominent provider of commercial launch services for several decades.

Luxembourg Space Resources Authorisations

Luxembourg's 2017 legislation, coupled with its subsequent authorization register, indicated a national commitment to hosting and regulating ventures related to resource extraction. This initiative successfully attracted companies and investments, thereby stimulating downstream economic activity within the space sector. However, the long-term viability and broader international acceptance of such unilateral approaches to space resource governance remain subject to ongoing debate and require multilateral consensus for sustained stability (Korpershoek, 2023) (Wiser & Aganaba, 2022).

POLICY LESSONS AND STRATEGIC RECOMMENDATIONS FOR DESIGNING RESPONSIBLE PUBLIC–PRIVATE PARTNERSHIPS IN OUTER SPACE

Building a Balanced Governance Architecture

Policymakers face the complex task of reconciling international legal obligations with national economic imperatives. Article VI of the Outer Space Treaty stipulates that states bear international responsibility for all space activities undertaken by both governmental and non-governmental entities.

This foundational principle was reaffirmed in the Bogotá Declaration, where equatorial states emphasized the duty of states to exert control over activities within their jurisdiction to prevent the unilateral exploitation of outer space. Consequently, the design of legal frameworks should incorporate dual mechanisms: one facilitating market acceleration through procurement, and another embedding robust licensing and authorization procedures. For instance, the U.S. National Aeronautics and Space Act of 1958 enabled flexible procurement via Space Act Agreements, whereas European national statutes, such as the French Space Operations Act, institutionalized pre-launch authorization and continuous oversight. Both examples demonstrate the potential for procurement and licensing to coexist within a balanced governance architecture, suggesting that policy should aim for such hybridization. Furthermore, the success of the U.S. commercialization efforts, particularly through entities like CASIS managing the ISS U.S. National Laboratory, highlights the critical role of supportive policy environments and sustained governmental investment in fostering private sector engagement and innovation in space (Wu et al., 2024).

Recalibrating Liability and Insurance Regimes

The 1972 Liability Convention established that launching states bear absolute liability for damage on Earth and fault-based liability in outer space. This provision has led states to be cautious about potential unlimited financial claims. For example, France's Space Operations Act mandates that operators secure insurance and sets a cap on indemnification, with the French state only assuming liability beyond this threshold. Similarly, in the U.S., 51 U.S.C. §§ 50915–50916 outlines a three-tiered liability system: operator insurance, governmental indemnification up to a statutory limit, and Congressional re-engagement for losses exceeding this limit. This structure aims to prevent moral hazard while ensuring compliance with treaty obligations. The 1996 Ariane 5 failure underscores the critical importance of carefully calibrated insurance: the loss of billions of dollars worth of payloads would have resulted in immense liability had states not established statutory safeguards. Therefore, future public-private partnership frameworks should legally mandate tiered liability regimes, including explicit indemnification caps, compulsory insurance requirements, and a residual state guarantee reserved solely for catastrophic events. This approach minimizes state exposure while ensuring that commercial actors bear primary responsibility, thus aligning financial incentives with robust risk management and safety protocols (Vidaurri et al., 2019).

Encouraging Innovation through Phased Licensing and Regulatory Sandboxes

Historically, stringent licensing frameworks have impeded market entry. The U.S. Federal Aviation Administration, through the Commercial Space Launch Amendments Act of 2004, pioneered the implementation of experimental permits for reusable suborbital rockets. This facilitated technology testing for entities like Blue Origin and Virgin Galactic under a less burdensome regulatory scheme, prior to their full launch licensure. Conversely, such phased regulatory models have seen limited adoption in Europe. National statutes, including the UK Outer Space Act of 1986, typically necessitate complete authorization upfront, thereby imposing elevated compliance burdens. The policy implication is that regulatory sandboxes, analogous to those in financial services law, could enable companies to undertake proof-of-concept missions without immediately incurring the full costs associated with comprehensive regulatory compliance. Drawing inspiration from terrestrial examples, such as the U.K. Financial Conduct Authority’s sandbox regime, space law can develop a graduated compliance approach, thereby fostering innovation among startups while preserving governmental oversight. Such an approach would facilitate the iterative development of new space technologies and services, allowing for controlled experimentation within a clearly defined regulatory perimeter before broader deployment (Vidaurri et al., 2019).

Harmonization and Regional Coordination

Fragmented regulations across different legal systems incentivize entities to seek out the most permissive jurisdictions. For instance, prior to the enactment of the UK Space Industry Act in 2018, some operators established their companies in locations such as the Isle of Man to benefit from less

stringent oversight. Similarly, Luxembourg's 2017 Space Resources Act demonstrated how attractive legal frameworks could draw companies that might otherwise be based elsewhere.

Policymakers should therefore recognize the critical need for regional harmonization mechanisms. Within Europe, the European Space Agency Convention facilitates cooperation for resource pooling and aligning national industrial policies, although licensing remains a national responsibility. Furthermore, the European Union's Copernicus program exemplifies how shared funding and technical standards can unify diverse national regulatory systems.

A forward-looking strategy would involve integrating compatibility clauses into national legislation—similar to Article 2 of the German Draft Space Law—mandating regulators to align authorization processes with international sustainability and safety benchmarks. This approach would mitigate fragmentation, enhance predictability, and resolve the issue of jurisdiction shopping.

Legal Certainty in Resource Utilization and Property Rights

Recent legislative developments have centered on the legality of private ownership of extracted space resources. The U.S. Commercial Space Launch Competitiveness Act of 2015 explicitly affirmed private rights to such resources while disclaiming national sovereignty, a precedent subsequently adopted by Luxembourg in 2017, attracting companies like Deep Space Industries and Planetary Resources. Despite the absence of international tribunal rulings on these statutes, ongoing discussions within the UNCOPUOS Legal Subcommittee indicate persistent concerns regarding their consistency with the non-appropriation principle articulated in Article II of the Outer Space Treaty. To mitigate legal ambiguity, states should enact conditional entitlements that grant rights over extracted materials, contingent upon adherence to sustainability obligations, environmental due diligence, and equitable benefit-sharing. This approach aligns with terrestrial models, such as the United Nations Convention on the Law of the Sea, which conditions deep seabed mining on benefit-sharing through the International Seabed Authority. Consequently, legal certainty can be achieved without contravening existing treaty frameworks, provided that resource rights are precisely defined as usufruct rights—linked to responsibilities—rather than as absolute ownership. This structured approach ensures that the commercial exploitation of space resources proceeds within a recognized legal framework, safeguarding both state interests and private investments while upholding the spirit of international agreements (Freeland, 2023) (Vajiram et al., 2023).

Embedding Transparency and Accountability Mechanisms

To foster legitimacy in Public-Private Partnerships, transparency is paramount. The European Court of Auditors' 2014 assessment of the Galileo program underscored the perils of inadequate oversight, citing inefficiencies and procurement opaqueness. Similarly, the contentious awarding of NASA's Human Landing System contract in 2021 in the U.S., marked by Blue Origin's legal challenge at the U.S. Court of Federal Claims, illustrated the litigation risks inherent in unclear procurement processes. Therefore, policy frameworks should mandate transparent procurement regulations, public dissemination of licensing decisions, and the establishment of independent review mechanisms. Incorporating dispute resolution clauses that refer to arbitration under the Permanent Court of Arbitration Optional Rules for Outer Space Activities would offer private entities credible avenues for redress while preserving state authority. Integrating these provisions into national legislation would ensure predictability, mitigate litigation exposure, and align with international best practices in PPP governance. Moreover, establishing robust accountability frameworks that delineate responsibilities between public agencies and private operators is crucial, particularly in areas like planetary protection, where non-compliance carries significant risks (Vidaurri et al., 2019).

Integrating Sustainability and Ethical Obligations

The proliferation of space debris presents a formidable obstacle to sustainable commercial endeavors in outer space. The 2009 collision between Iridium and Cosmos satellites vividly illustrated the

catastrophic risks that arise from inadequate debris mitigation strategies among satellite operators. Although the UNCOPUOS Long-Term Sustainability Guidelines of 2019 offer non-binding international norms, their integration into domestic legal frameworks remains inconsistent. Consequently, national legislation should mandate adherence to debris mitigation guidelines, including post-mission disposal obligations, as a prerequisite for licensing. Existing precedents include the French Space Operations Act, which explicitly requires environmental risk assessments before authorizing space activities, and the U.S. Orbital Debris Mitigation Standard Practices, which link licensing to responsible disposal measures. Furthermore, sustainability provisions should be coupled with financial contributions; operators benefiting from resource extraction or extensive satellite constellations could be required to contribute to a dedicated space sustainability fund. This model draws parallels with terrestrial regimes, such as oil spill compensation funds, ensuring that commercial expansion does not compromise the principle of intergenerational equity, a concept increasingly relevant in international law, as evidenced by advisory opinions from the International Tribunal for the Law of the Sea concerning environmental responsibilities. Such a fund would incentivize responsible behavior and internalize the external costs associated with unchecked orbital proliferation and resource exploitation (Cheney et al., 2020) (Vistisen & Jensen, 2020).

CONCLUSION

The commercialization of space is inextricably linked to the legal and institutional frameworks governing public–private partnerships. Internationally, the Outer Space Treaty and the Liability Convention continue to delineate the scope of permissible activities, establishing states as ultimately responsible and liable for both governmental and non-governmental space endeavors. These foundational instruments impose ongoing obligations for authorization, supervision, and liability management, which inherently shape the structure of PPPs across different jurisdictions. Far from merely imposing restrictions, these treaties offer a normative basis upon which national regimes can construct balanced systems that reconcile innovation with accountability.

A comparative examination of the United States and Europe reveals that legal design choices are not uniform but are deeply rooted in distinct policy traditions. The United States has historically favored a procurement-driven model, bolstered by statutory provisions such as the Commercial Space Launch Act (Title 51 U.S.C. ch. 509) and the Commercial Space Launch Competitiveness Act of 2015. NASA, in this context, leverages Space Act Agreements and milestone-based contracting to accelerate commercial capabilities. Case studies, including the Commercial Orbital Transportation Services and Commercial Crew Program, demonstrate how governmental demand can be transformed into stable private-sector revenue streams, with technical and financial risks allocated through meticulously crafted contracts. The liability framework, specifically 51 U.S.C. § 50914–50916, further balances commercial viability with state indemnification responsibilities, ensuring compliance with treaty obligations.

Conversely, Europe has embraced an authorization-first strategy, evident in both European Space Agency-led initiatives and national legislation, such as France's Space Operations Act, the UK's Space Industry Act, and Luxembourg's Space Resources Act. This approach involves a more proactive state role in co-funding, industrial policy formulation, and stringent upfront regulatory assessments. European Public-Private Partnerships typically prioritize substantial public investment in infrastructure, mandatory licensing procedures, and rigorous insurance requirements to insulate the state from undue liability exposure. These measures underscore Europe's stronger inclination towards precautionary principles and state control, even if this orientation occasionally impedes market entry compared to the more adaptable U.S. model. Both methodologies present inherent trade-offs: while the U.S. system's celerity and adaptability have spurred rapid private sector innovation, they have also ignited concerns regarding procurement equity and market concentration. In contrast, the European system’s focus on authorization and state-driven development mitigates risks and advances industrial sovereignty but can temper entrepreneurial vigor. The dynamic between ESA and its member states further complicates this landscape, as ESA orchestrates technical and funding priorities, yet ultimate licensing authority remains

firmly national, thereby creating both opportunities for collaborative action and potential risks of fragmentation.

Against this backdrop, the policy lessons and recommendations elucidated in this study offer a blueprint for the forthcoming era of space governance. States developing PPP frameworks must incorporate tiered liability structures, regulatory sandboxes, and harmonized authorization standards to reconcile international treaty obligations with the exigencies of commercialization. Statutes governing resource utilization must achieve a delicate equilibrium: providing legal certainty and market signals to attract investment while linking property entitlements to sustainability, transparency, and benefit-sharing obligations. Instituting accountability mechanisms, such as procurement transparency and dispute resolution under the PCA Optional Rules for Outer Space Activities, will be crucial for maintaining legitimacy as commercialization expands. Finally, integrating environmental and sustainability mandates—including debris mitigation requirements and potential sustainability funds—will ensure that commercialization does not jeopardize the long-term viability of outer space as a shared domain.

Ultimately, the comparative experiences of the United States and Europe highlight that no single "ideal" PPP model exists; rather, there is a continuum of design choices reflecting varying balances of innovation, risk, and state responsibility. For global policymakers, the strategic imperative is to devise hybrid frameworks that integrate the flexibility characteristic of U.S. procurement with the accountability inherent in European authorization systems, always anchored in the binding tenets of international space law. Such judiciously calibrated approaches will not only foster economic growth and private-sector engagement but also safeguard the integrity of outer space as the "province of all humankind," ensuring that commercialization serves collective interests rather than narrow gains. The emergence of new space actors, particularly private entities, necessitates a re-evaluation of established norms and the development of responsible behavior guidelines to prevent fragmentation of international space law (Delgado-López, 2014) (Cvetkovič, 2023).

REFERENCES

1. Adams, B. (2019). Cooperation in space: An international comparison for the benefit of emerging space agencies. *Acta Astronautica*, *162*, 409. https://doi.org/10.1016/j.actaastro.2019.06.011
2. Adriaensen, M., Giannopapa, C., Sagath, D., & Papastefanou, A. (2015). Priorities in national space strategies and governance of the member states of the European Space Agency. *Acta Astronautica*, *117*, 356. https://doi.org/10.1016/j.actaastro.2015.07.033
3. Anderson, C. (2013). Rethinking public–private space travel. *Space Policy*, *29*(4), 266. https://doi.org/10.1016/j.spacepol.2013.08.002
4. Aoki, S. (2019). Domestic Legal Conditions for Space Activities in Asia. *AJIL Unbound*, *113*, 103. https://doi.org/10.1017/aju.2019.14
5. Autry, G. (2018). Commercial Orbital Transportation Services: A Case Study for National Industrial Policy. *New Space*, *6*(3), 191. https://doi.org/10.1089/space.2017.0043
6. Bratu, I., Lodder, A. R., & Linden, M. van der. (2021). Autonomous Space Objects and International Space Law: Navigating the Liability Gap. *Indonesian Journal of International Law*, *18*(3). https://doi.org/10.17304/ijil.vol18.3.818
7. Chatzipanagiotis, M., & Kyriakopoulos, G. D. (2019). 'One-stop shop' space safety regulation: Should we do it and how? *Journal of Space Safety Engineering*, *6*(3), 212. https://doi.org/10.1016/j.jsse.2019.09.002
8. Cheney, T., Newman, C. J., Olsson-Francis, K., Steele, S. R., Pearson, V. K., & Lee, S. (2020). Planetary Protection in the New Space Era: Science and Governance. *Frontiers in Astronomy and Space Sciences*, *7*. https://doi.org/10.3389/fspas.2020.589817
9. Chouhan, K. S. (2020). Privatization of Outer-Space and Ownership: ISA as a Model of Regulation for Resource Exploitation. *SSRN Electronic Journal*. https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID3870701_code3986644.pdf?abstractid=3832673&mirid=1

10. Ciaccio, S. D., Cramarossa, A., & Fatica, M. (2018). New Space: A Glance at Italy. *New Space*, *6*(4), 254. https://doi.org/10.1089/space.2018.0021
11. Clegg, S., Cunha, M. P. e, López, A., Sirage, E., & Rego, A. (2023). Tackling sustainable development goals through new space. *Project Leadership and Society*, *5*, 100107. https://doi.org/10.1016/j.plas.2023.100107
12. Cvetkovič, I. R. (2023). Two sides of the same coin? Examining the interrelation between the proposed new human right and the law governing outer space. *Digital War*, *5*, 59. https://doi.org/10.1057/s42984-023-00066-9
13. Delgado-López, L. (2014). Beyond the Moon Agreement: Norms of responsible behavior for private sector activities on the Moon and celestial bodies. *Space Policy*, *33*, 1. https://doi.org/10.1016/j.spacepol.2014.08.006
14. Dempsey, P. S. (2014). National Legislation Governing Commercial Space Activities. *Journal of Space Safety Engineering*, *1*(2), 44. https://doi.org/10.1016/s2468-8967(16)30082-9
15. Dennerley, J. A. (2018). State Liability for Space Object Collisions: The Proper Interpretation of 'Fault' for the Purposes of International Space Law. *European Journal of International Law*, *29*(1), 281. https://doi.org/10.1093/ejil/chy003
16. Dunk, F. G. von der. (2019). Scoping National Space Law: The True Meaning of 'National Activities in Outer Space' of Article VI of the Outer Space Treaty. *International Institute of Space Law*, *62*(3), 227. https://doi.org/10.5553/iisl/2019062003002
17. Durkee, M. J. (2019). *Interstitial Space Law*.
18. ESPI, FRS, IFRI, & SWP. (2009). The need for a new Franco-German partnership in space: A joint policy memorandum. *Space Policy*, *25*(3), 152. https://doi.org/10.1016/j.spacepol.2009.05.005
19. Freeland, S. (2023). The peaceful use of outer space: protecting life on Earth. *Digital War*, *5*, 46. https://doi.org/10.1057/s42984-023-00065-w
20. Frieden, R. (2025). Dangers from Regulatory Vacuums in Outer, Inner, and Near Space. *Journal of Air Law and Commerce*, *90*(1), 3. https://doi.org/10.25172/jalc.90.1.2
21. Gokhan, I., Bilge, K., & Andy, I. (2020). A Mixed Public-Private Partnership Approach for Cyber Resilience of Space Technologies. In *NATO science for peace and security series. D, Information and communication security*. IOS Press. https://doi.org/10.3233/nicsp200013
22. Graham, T. P., Thangavel, K., & Martin, A.-S. (2024). Navigating AI-lien Terrain: Legal liability for artificial intelligence in outer space. *Acta Astronautica*, *217*, 197. https://doi.org/10.1016/j.actaastro.2024.01.039
23. Gupta, B., & Kd, R. (2019). Understanding International Space Law and the Liability Mechanism for Commercial Outer Space Activities—Unravelling the Sources. *India Quarterly A Journal of International Affairs*, *75*(4), 555. https://doi.org/10.1177/0974928419874553
24. Hall, J. C., Walker, C. E., Rawls, M. L., McDowell, J., Seaman, R., Venkatesan, A., Lowenthal, J. D., Green, R. F., Krafton, K., & Parriott, J. (2021). SATCON2: Executive Summary. *Bulletin of the American Astronomical Society*. https://doi.org/10.3847/25c2cfeb.4554c01f
25. Harrington, A. J. (2015). Legal Considerations for Commercial Space: An Overview. *New Space*, *3*(2), 82. https://doi.org/10.1089/space.2015.0003
26. Hasin, G. (2022). From 'Space Law' to 'Space Governance': A Policy-Oriented Perspective on International Law and Outer Space Activities. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4179934
27. Hearsey, C. M. (2008). *A Review Of Challenges To Corporate Expansion Into Outer Space* [Review of *A Review Of Challenges To Corporate Expansion Into Outer Space*]. https://doi.org/10.2514/6.2008-7816
28. Heracleous, L., Terrier, D., & González, S. (2019). NASA's Capability Evolution Toward Commercial Space. *Space Policy*, *50*, 101330. https://doi.org/10.1016/j.spacepol.2019.07.004
29. Hermida, J. (2009a). Convergence of Civil Law and Common Law Contracts in the Space Field. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1429664
30. Hermida, J. (2009b). Law Reform and National Space Law: A Participatory Approach to Space Law Making in Developing Countries. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1424283

31. Iron, D., & Davidian, K. (2008). *Applying the UK's PPP Lessons to NASA's Commercial Development Policy*. https://doi.org/10.2514/6.2008-7938
32. Ishkibayeva, G., & Nurmukhankyzy, D. (2021). LEGAL EXPERIENCE OF THE UNITED STATES OF AMERICA IN THE ISSUE OF SPACE COMMERCIALIZATION. *Journal of Actual Problems of Jurisprudence*, *98*(2). https://doi.org/10.26577/japj.2021.v98.i2.10
33. Jakhu, R. S. (2005). *Legal Issues Relating to the Global Public Interest in Outer Space*.
34. Jakhu, R. S., Jasani, B., & McDowell, J. (2017). Critical issues related to registration of space objects and transparency of space activities. *Acta Astronautica*, *143*, 406. https://doi.org/10.1016/j.actaastro.2017.11.042
35. Kehrer, T. (2019). Closing the Liability Loophole: The Liability Convention and the Future of Conflict in Space. *Chicago Journal of International Law*, *20*(1), 5. https://chicagounbound.uchicago.edu/cgi/viewcontent.cgi?article=1756&context=cjil
36. Kent, J. (2025). Space Resource Development and Property - Clarifying Usufruct. *Journal of Air Law and Commerce*, *90*(1), 41. https://doi.org/10.25172/jalc.90.1.3
37. Kerrest, A. (2017). The concept of the 'launching State' in commercial launch ventures. In *Edward Elgar Publishing eBooks*. Edward Elgar Publishing. https://doi.org/10.4337/9781785361074.00007
38. Kolczyński, P. (2019). The new European Union space policy in order to maintain Europe's position among space leaders. *Исследования Космоса*, *2*, 20. https://doi.org/10.7256/2453-8817.2019.2.32162
39. Korpershoek, K. (2023). Accessibility to Space Infrastructures and Outer Space: Anthropological Insights from Europe's Spaceport. *International Journal of the Commons*, *17*(1), 481. https://doi.org/10.5334/ijc.1284
40. Lambright, W. H. (2015). Launching commercial space: NASA, cargo, and policy innovation. *Space Policy*, *34*, 23. https://doi.org/10.1016/j.spacepol.2015.05.005
41. Landoni, M., & ogilvie, dt. (2019). Convergence of innovation policies in the European aerospace industry (1960–2000). *Technological Forecasting and Social Change*, *147*, 174. https://doi.org/10.1016/j.techfore.2019.07.007
42. Larsen, P. B. (1992). Cross-Waivers of Liability. *SSRN Electronic Journal*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3787165
43. Larsen, P. B. (2019). Commercial Operator Liability in the New Space Era. *AJIL Unbound*, *113*, 109. https://doi.org/10.1017/aju.2019.18
44. Larsen, P. B. (2021). Is There a Legal Path to Commercial Mining on the Moon? *University of Pittsburgh Law Review*, *83*(1). https://doi.org/10.5195/lawreview.2021.821
45. Lema, R., Fu, X., & Rabellotti, R. (2021). Latecomer Development in the Global Green Economy. *Research Portal Denmark*, 86. https://local.forskningsportal.dk/local/dki-cgi/ws/cris-link?src=aau&id=aau-a3cdee04-5c8c-441d-a50f-e4ee36ca160c&ti=Latecomer%20Development%20in%20the%20Global%20Green%20Economy
46. Lin, K., Matthews, W. J., & Olsen, S. (2024). Middle spacepowers' integration with the global supply chain for the space industry: Taiwan and Thailand. *Business and Politics*, 1. https://doi.org/10.1017/bap.2024.18
47. Lin, P., Abney, K., DeBruhl, B., Abercromby, K. J., Danielson, H., & Jenkins, R. (2024). Outer Space Cyberattacks: Generating Novel Scenarios to Avoid Surprise. *arXiv (Cornell University)*. https://doi.org/10.48550/arxiv.2406.12041
48. Lissandrello, E., Steffansen, R. N., & Nørgaard, L. S. (2022). Knowledge Co-production on Air Quality – The Role of Planning Research in Participatory, Healthy, and People-Centered Cities. *Research Portal Denmark*, 385. https://local.forskningsportal.dk/local/dki-cgi/ws/cris-link?src=aau&id=aau-8b5b3093-6e1e-44f4-80ab-720f56a309e9&ti=Knowledge%20Co-production%20on%20Air%20Quality%20%2013%20The%20Role%20of%20Planning%20Research%20in%20Participatory%2C%20Healthy%2C%20and%20People-Centered%20Cities
49. Lively, M. (2024). Corporate Attributed Lawmaking under the Outer Space Treaty of 1967. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.5000725
50. Ma, B., & Liu, J. (2021). Realistic Dilemma and Legal Countermeasures against the "Non-Appropriation" Principle in Outer Space Treaty. *Advanced Space Law*, *7*. https://doi.org/10.29202/asl/7/5

51. Macchi, C. (2024). *Business, Human Rights and International Space Law: Filling the Gaps of Corporate Accountability in the "New Space."* https://doi.org/10.2139/ssrn.4849961
52. Management of outer space economic resources – legal and political challenges. (2021). *Conferencii*. https://doi.org/10.51586/bmess2021-2
53. Mei, D. (2024). Integrating outer space as a global commons with private property rights to outer space resources. *Frontiers in Space Technologies*, *5*. https://doi.org/10.3389/frspt.2024.1351850
54. Meislová, M. B., & Glencross, A. (2023). From multilateralism to bilateralism: Making sense of the UK's security cooperation with EU member states after 2016. *The British Journal of Politics and International Relations*, *26*(4), 1322. https://doi.org/10.1177/13691481231208146
55. Metzger, P. T., & Autry, G. (2022). The Cost of Lunar Landing Pads with a Trade Study of Construction Methods. *New Space*, *11*(2), 94. https://doi.org/10.1089/space.2022.0015
56. Moranta, S., & Donati, A. (2020). Space Ventures Europe 2018—Entrepreneurship and Private Investment in the European Space Sector. *New Space*, *8*(1), 7. https://doi.org/10.1089/space.2019.0020
57. O'Brien, N. W. (2021). Who Owns Space? *UF Journal of Undergraduate Research*, *23*. https://doi.org/10.32473/ufjur.v23i.128713
58. Pacholska, M. (2022). Military Artificial Intelligence and the Principle of Distinction: A State Responsibility Perspective. *Israel Law Review*, *56*(1), 3. https://doi.org/10.1017/s0021223722000188
59. Palmroth, M., Tapio, J., Soucek, A., Perrels, A., Jah, M., Lönnqvist, M., Nikulainen, M., Piaulokaite, V., Seppälä, T., & Virtanen, J. (2021). Toward Sustainable Use of Space: Economic, Technological, and Legal Perspectives. *Space Policy*, *57*, 101428. https://doi.org/10.1016/j.spacepol.2021.101428
60. Petersen, C. F. (2018). Award of Public Contracts as a Means to Conferring State Aid : A Legal Analysis of the Interface Between Public Procurement Law and State Aid Law. *Research Portal Denmark*, 285. https://local.forskningsportal.dk/local/dki-cgi/ws/cris-link?src=cbs&id=cbs-982990e6-6f1b-4933-823e-ee0ff7967107&ti=Award%20of%20Public%20Contracts%20as%20a%20Means%20to%20Conferring%20State%20Aid%20%3A%20A%20Legal%20Analysis%20of%20the%20Interface%20Between%20Public%20Procurement%20Law%20and%20State%20Aid%20Law
61. Profitiliotis, G., & Loizidou, M. (2019). Planetary Protection Issues of Private Endeavors in Research, Exploration, and Human Access to Space: An Environmental Economics Approach to Backward Contamination. *Space Policy*, *50*, 101332. https://doi.org/10.1016/j.spacepol.2019.08.002
62. Rausser, G. C., Choi, E., & Bayen, A. M. (2023). Public–private partnerships in fostering outer space innovations. *Proceedings of the National Academy of Sciences*, *120*(43). https://doi.org/10.1073/pnas.2222013120
63. Reinert, A. P. (2020). Updating the Liability Regime in Outer Space: Why Spacefaring Companies Should Be Internationally Liable For Their Space Objects. *William and Mary Law Review*, *62*(1), 325. https://scholarship.law.wm.edu/cgi/viewcontent.cgi?article=3875&context=wmlr
64. Rouyre, A., Fernandez, A., & Vaquero, I. E. (2023). Co-evolution of governance mechanisms and coopetition in public-private projects. *Journal of Operations Management*, *70*(1), 50. https://doi.org/10.1002/joom.1281
65. Ruhaeni, N. (2019). The Concept of Allocation of Certain Risk and its Construction in the Formulation of National Legislation on Liability in Outer Space Activities. *Proceedings of the Social and Humaniora Research Symposium (SoRes 2018)*. https://doi.org/10.2991/sores-18.2019.79
66. Ryzhenko, I., & Halahan, O. (2019). Types of Liability for Illegal Space Activities. *Advanced Space Law*, *3*. https://doi.org/10.29202/asl/2019/3/8
67. Sadeh, E., Livingston, D., Matula, T. J., & Benaroya, H. (2005). Public–private models for lunar development and commerce. *Space Policy*, *21*(4), 267. https://doi.org/10.1016/j.spacepol.2005.08.004

68. Sagath, D., Papadimitriou, A., Adriaensen, M., & Giannopapa, C. (2017). Space strategy and governance of ESA small member states. *Acta Astronautica*, *142*, 112. https://doi.org/10.1016/j.actaastro.2017.09.029
69. Salter, A. W. (2016). Ordering the Cosmos: Private Law and Celestial Property Rights. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2840856
70. Sankaran, K. (2024). The body politic has private parts: market creation as a policymaking tool. *Economics and Philosophy*, 1. https://doi.org/10.1017/s0266267124000282
71. Saunders, M. K. (2019). Mining on Celestial Bodies: The Equitable Distribution of Benefits Doctrine and Distributive Justice. *The Australian Year Book of International Law Online*, *36*(1), 195. https://doi.org/10.1163/26660229_03601010
72. Soroka, L., Danylenko, A., & Sokiran, M. (2023). Public Administration of Space Activities of Individual Countries of the World at the Present Stage. *Advanced Space Law*, *11*. https://doi.org/10.29202/asl/11/8
73. Stone, D. (2018). A New Era in Space Flight: The COTS Model of Commercial Partnerships at NASA. In *Springer eBooks* (p. 117). Springer Nature. https://doi.org/10.1007/978-3-319-32817-1_12
74. Taylor, K. (2019). Fictions of the Final Frontier: Why the United States SPACE Act of 2015 Is Illegal. *Emory International Law Review*, *33*(4), 653. https://scholarlycommons.law.emory.edu/cgi/viewcontent.cgi?article=1218&context=eilr
75. Taylor, T. C., Kistler, W., & Citron, B. (2008, May 12). Innovating Public Private Partnership Technology for Commercial Financing. *2018 SpaceOps Conference*. https://doi.org/10.2514/6.2008-3436
76. Tjalve, V. S. (2024). Corporate cosmos : How commercial American space imagines our future and shapes our present. In *Research Portal Denmark* (Issue 10, p. 50). Technical University of Denmark. https://local.forskningsportal.dk/local/dki-cgi/ws/cris-link?src=diis&id=diis-1895e2c0-b70e-40f2-8708-6cd991ccdd54&ti=Corporate%20cosmos%20%3A%20How%20commercial%20American%20space%20imagines%20our%20future%20and%20shapes%20our%20present
77. Vajiram, J., Maurya, U., & Senthil, N. (2023). India's Progress in Space Exploration and International Legal Challenges in Meeting Goals within International Space Boundaries: A Review [Review of *India's Progress in Space Exploration and International Legal Challenges in Meeting Goals within International Space Boundaries: A Review*]. *arXiv (Cornell University)*. Cornell University. https://doi.org/10.48550/arxiv.2309.06560
78. Vidaurri, M., Wofford, A., Brande, J., Black-Planas, G., Domagal-Goldman, S., & Haqq-Misra, J. (2019). Absolute Prioritization of Planetary Protection, Safety, and Avoiding Imperialism in All Future Science Missions: A Policy Perspective. *Space Policy*, *51*, 101345. https://doi.org/10.1016/j.spacepol.2019.101345
79. Vistisen, P., & Jensen, T. (2020). The Selfish Vision : Addressing the problematic lack of explicit discourse and ethical contract in corporate design fictions. *Research Portal Denmark*, *1*, 385. https://local.forskningsportal.dk/local/dki-cgi/ws/cris-link?src=aau&id=aau-4340eb18-12e6-4a68-ae3e-12ff11e00657&ti=The%20Selfish%20Vision%20%3A%20Addressing%20the%20problematic%20lack%20of%20explicit%20discourse%20and%20ethical%20contract%20in%20corporate%20design%20fictions
80. Walker, J., & Johnson, M. (2018). On mineral sovereignty: Towards a political theory of geological power. *Energy Research & Social Science*, *45*, 56. https://doi.org/10.1016/j.erss.2018.07.005
81. Wang, G., & Li, C. (2021). Applicability of the Liability Convention for Private Spaceflight. *Space Science & Technology*, *2021*. https://doi.org/10.34133/2021/9860584
82. Wedenig, S.-M., & Nelson, J. W. (2025). *Artificial Intelligence in Outer Space: The Responsibility of the State of the Software Developer under Article VI of the Outer Space Treaty*. https://doi.org/10.2139/ssrn.5084614

83. Weeks, E. E. (2006). Politics of Space Law in a Post Cold War Era: Understanding Regime Change. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2458127
84. Wiser, L., & Aganaba, T. (2022). An evolving space governance system: Balancing interests in five policy debates. *Acta Astronautica*, *203*, 537. https://doi.org/10.1016/j.actaastro.2022.11.023
85. Wu, A. X., Han, Y., & Yang, F. (2024). Analyzing CASIS Policy Data with AI: Sentiment Trends and Topic Modeling. *Research Square (Research Square)*. https://doi.org/10.21203/rs.3.rs-5271894/v1
86. Xu, F., & Su, J. (2020). New Elements in the Hague Space Resources Governance Working Group's Building Blocks. *Space Policy*, *53*, 101386. https://doi.org/10.1016/j.spacepol.2020.101386
87. Zaefen, C. M. (2020). Handling "Space Debris" under the International Space Treaties Regime: Case Studies Analysis. *Environmental Claims Journal*, *33*(3), 194. https://doi.org/10.1080/10406026.2020.1843291
88. Zhao, Y. (2004). The 1972 Liability Convention: time for revision? *Space Policy*, *20*(2), 117. https://doi.org/10.1016/j.spacepol.2004.02.008
89. Ziemblicki, B., & Oralova, Y. (2021). Private Entities in Outer Space Activities: Liability Regime Reconsidered. *Space Policy*, *56*, 101427. https://doi.org/10.1016/j.spacepol.2021.101427

