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GEOSTATIONARY ORBIT AND INTERNATIONAL LAW: EMERGING LEGAL CHALLENGES IN A GLOBALISED SPACE ENVIRONMENT

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Abstract

The geostationary orbit (GSO) remains one of the most strategically valuable and scientifically distinctive regions of outer space, providing fixed-position advantages essential for telecommunications, broadcasting, meteorology, and global navigation. Yet, as demand for GSO slots, driven by technological expansion, commercial satellite proliferation, and geopolitical rivalry, intensifies, long-standing legal and regulatory frameworks face unprecedented strain. Through doctrinal analysis, this article critically examines the adequacy of the existing international legal regime governing access to, and use of, the geostationary orbit, focusing on the Outer Space Treaty, the International Telecommunication Union's allocation mechanisms, and evolving State practice. It identifies emerging legal and policy challenges, including orbital congestion, harmful interference, spectrum scarcity, inequitable access for developing countries, and the implications of private-sector dominance that increasingly test the capacity of the current system. The analysis also considers how global political dynamics, including rising multipolar competition, commercialisation, and disputes over resource appropriation, are reshaping the interpretation of international space law. The article finds that while the current legal frameworks provide foundational guidance, they are increasingly ill-equipped to address contemporary realities, particularly regarding the equitable distribution and sustainable use of orbital resources. It concludes by proposing pathways for legal reform grounded in adaptive governance, enhanced international cooperation, and a re-evaluation of the balance between sovereign interests and collective global responsibilities.

Keywords: Geostationary Orbit; International Space Law; Orbital Allocation; Equitable Access

1. Introduction

The geostationary orbit (GSO) occupies a uniquely strategic position in the global framework of space activities. Situated approximately 35,786 kilometres above the equator, it enables satellites to match the Earth's rotational period and remain fixed relative to a specific point on the surface.1 This distinctive characteristic makes the geostationary orbit indispensable for

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telecommunications, broadcasting, meteorology, navigation, and an expanding range of commercial and governmental applications. As technological advances increase global reliance on satellite-based infrastructures, the geostationary belt has become one of the most contested and valuable segments of outer space. Yet, despite its central importance to modern connectivity and economic growth, the governance of the orbit has long been marked by legal, political, and equity-driven complexities. The foundational instruments of international space law, particularly the 1967 Outer Space Treaty, the 1971 Liability Convention, and the 1976 Registration Convention, were drafted before the contemporary surge in commercial actors, mega-constellations, and escalating demand for geostationary capacity. Consequently, they lack the legal and institutional tools necessary to address many of the challenges that now confront the geostationary orbit. Meanwhile, the 1976 Bogotá Declaration, through which equatorial States claimed sovereignty over corresponding segments of the orbit, further intensified the debate over equitable access, spatial resource allocation, and the status of outer space as the common heritage of humankind. Although the declaration lacks recognition under international law, the concerns it raised persist and have become more pronounced in an era of globalised space activities. The present global space environment, defined by commercial proliferation, strategic competition among major spacefaring States, and renewed debates over the equitable distribution of limited orbital resources, has increased pressure on the existing legal framework. Challenges related to orbital congestion, harmful interference, space debris, the growing role of private operators, and **the balance between national commercial interests and the principle of outer space as a common resource for all nations** demand renewed scrutiny.

Against this backdrop, this article critically examines the emerging legal issues surrounding the use and allocation of the GSO, assessing whether the current international legal regime can still provide fair, sustainable, and effective governance in an increasingly interconnected and competitive space environment. It foregrounds the interests of developing and emerging space-faring States in GSO governance, highlighting structural limitations that disproportionately affect less technologically advanced countries, which have received limited attention in mainstream space law scholarship. In doing so, the study advances the literature by moving beyond doctrinal critique to propose practical, equity-oriented reform measures aimed at

1M N Putri and others, 'The Difference Between Geostationary and Geosynchronous Orbit' (January 2023) <https://www.researchgate.net/publication/367127968_The_Difference_Between_Geostationary_and_Geosynchronous_Orbit> accessed 8 January 2026.

improving allocation mechanisms, enhancing regulatory coordination, and strengthening adaptive governance of orbital resources.

2. Meaning, Characteristics, and Significance of Geostationary Orbit

The Geostationary Orbit is a specific circular orbit located approximately 35,786 km (22,236 miles) above Earth's equator, where a satellite travels in the same direction and at the same speed as Earth's rotation (24 hours). Satellites in this orbit revolve around Earth above the equator from west to east, at the same rate as Earth rotates.2 This synchrony in position and angular velocity makes GSO appear stationary relative to a fixed point on the ground, and is crucial for constant communication (TV, phone) and weather monitoring.3 Consequently, telecommunications and weather satellites are commonly placed in this orbit to enable constant broadcasting services, real-time weather imaging, and atmospheric monitoring for environmental and oceanographic studies. In addition, some navigation satellites in this orbit serve as known calibration points, enhancing the accuracy and reliability of the Global Navigation Satellite System (GNSS).[4]

The Geostationary Orbit has several essential characteristics that make it a globally sought-after resource and uniquely valuable for communication, navigation, and Earth-observation applications. At the orbit, a satellite's orbital period matches the Earth's ***24-hour*** rotation**.** Because the satellite moves at the same angular velocity and in the same west-to-east direction as the Earth, it appears **fixed** relative to a point on the ground5. This positional stability enables continuous, unobstructed coverage over a large portion of the Earth's surface, typically spanning almost one-third of the globe, thereby providing persistent coverage of the same

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2 Outer Space Security Lexicon, 'Geostationary Orbit (GEO): Common Definitions' <https://spacesecuritylexicon.org/common-definition/geostationary-orbit-geo> accessed 11 December 2025.

3R Lea, 'What is Geosynchronous Orbit?' (26 December 2022) <https://www.space.com/29222-geosynchronous-orbit.html> accessed 8 January 2026.

4Outer Space Security Lexicon (n2).

5Natural Resources Canada, 'Satellite Characteristics: Orbit and Swaths' (8 January 2025) <https://natural-resources.canada.ca/maps-tools-publications/satellite-elevation-air-photos/satellite-characteristics-orbits-swaths> accessed 11 December 2025.

geographic area.6 Geostationary Orbit is a narrow orbital belt directly above the equator, and satellites operating within it require precise station-keeping manoeuvres to maintain their assigned longitudinal slots and prevent drift or interference with neighbouring systems. While the high altitude reduces the need for complex ground-tracking antennas, it introduces a noticeable round-trip signal latency of about 0.25 seconds.7 Despite this latency, the orbit remains indispensable for **telecommunications, broadcasting, environmental observation, weather monitoring, and navigation augmentation** owing to its ability to support uninterrupted, wide-area, real-time data transmission.

Owing to these characteristics, the orbit holds immense significance in global space operations. Its unique ability to provide continuous, fixed-point coverage of specific regions on Earth, ensuring uninterrupted communication links, among other advantages, makes the orbit indispensable for television broadcasting, telephone networks, internet services, and emergency communication systems.8 The orbit's stable and constant visibility over the same geographic area also enables real-time weather monitoring, long-range storm tracking, climate observation, and environmental surveillance, all of which support disaster prediction and response.9 Moreover, it plays a crucial role in navigation systems by hosting augmentation satellites that enhance the precision, reliability, and integrity of Global Navigation Satellite Systems (GNSS). Its capacity to cover nearly one-third of Earth's surface from a single satellite makes geostationary orbit highly efficient for wide-area services, reducing the number of satellites required for global or regional coverage,10 Despite challenges such as high launch costs and signal latency, the orbit remains strategically vital for civilian, commercial, military, and scientific applications, forming the cornerstone of modern global communication, meteorology, and navigation infrastructure.

However, the limited number of available orbital slots in the geostationary orbit has created profound legal and practical challenges in its utilisation. Because only a finite number of

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6R Awati, 'Geostationary Satellite' (20 June 2023) <https://www.techtarget.com/searchmobilecomputing/definition/geostationary-satellite> accessed 11 December 2025.

7A Grillo, 'Geostationary Earth Orbit (GEO): An Overview' (22 January 2025) <https://www.deepinsecurity.com/geostationary-earth-orbit/> accessed 11 December 2025.

8Ibid.

9R Privett, 'Satellite Orbit Types' (1 August 2024) <https://satellitegroundstation.com/resources/topic-orbits/> accessed 11 December 2025.

10A Grillo, 'Geostationary Earth Orbit (GEO): An Overview' (n7).

satellites can be accommodated within the narrow geostationary belt, and because each satellite must be adequately spaced to prevent harmful radio-frequency interference, competition for orbital positions has intensified. This scarcity has resulted in struggles and conflicts among States seeking access to the same orbital slots for their satellites. Disputes over slots and frequency allocation are addressed through the *International Telecommunication Union (ITU)* under the Radio Regulations,11 which govern the coordination and assignment of these resources. A typical example is the 1976 declaration by eight equatorial States claiming sovereignty over segments of the geostationary orbits above their territories; however, this claim, commonly known as the *Bogotá Declaration*, received no international recognition.[12]

3. Legal Regimes Governing the Geostationary Orbit

The legal regime for the Geostationary Orbit (GSO) is a combination of International Space Law and International Telecommunication Law. The Outer Space Treaty affirms the free use of space but prohibits national appropriation of any segment of outer space, including the orbit. Meanwhile, the International Telecommunication Union (ITU) manages frequency and orbital slot allocation under the Radio Regulations, treating the orbit as a finite resource.13 These international legal frameworks play key roles in the entire management and utilisation of GSO, particularly in balancing the 'first-come, first-served' principle with equitable access for developing nations, preventing harmful interference, and managing space debris, all in accordance with the Outer Space Treaty's non-appropriation principle.

i. The Outer Space Treaty 1967

Although the Outer Space Treaty does not expressly mention the Geostationary Orbit, it regulates its use through general principles of international space law. The fundamental principle is that the orbit, as an integral part of outer space, cannot be subject to national

11H Yvon, 'Orbit/Spectrum Allocation Procedures Registration Mechanism under the Radio Regulation' (2009) *Space Service Department, International Telecommunication Union* <https://www.itu.int/en/ITU-R/space/workshopSingapore2010/01-SNG-2010_YH.pdf> accessed 8 January 2026.

12F. O. Agama, 'Effect of Bogota Declaration on the Legal Status of Geostationary Orbit in International Space Law' (2017) *Nnamdi Azikiwe Journal of International Law and Jurisprudence* 8(1) 26-27.

13J Wheeler, 'International Telecommunication Union and Access to Spectrum' (2024) *Lexology* <https://www.lexology.com/library/detail.aspx?g=d62f3e20-275e-48f2-85fa-e24a0e68b4c8> accessed January 8, 2026.

appropriation, ensuring it remains accessible to all States,14 in line with *Art. II* of the Treaty. There is a broad consensus among legal scholars and space law experts that the geostationary orbit constitutes an integral part of outer space.15 While no universally accepted legal definition of outer space currently exists, it is generally recognised that outer space begins at an altitude of approximately 100 kilometres above sea level, and that objects in Earth orbit are located within outer space.16 On this basis, the provisions of the Outer Space Treaty, particularly the non-appropriation principle, apply *mutatis mutandis* to the utilisation of the GSO.

This prevailing consensus largely explains why sovereignty claims advanced by certain equatorial States over segments of the geostationary orbit located above their territories were rejected by the international community.17 *Article I (2)* of the Outer Space Treaty provides that outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all States on a basis of equality and in accordance with international law. *Article II* further stipulates that outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means. This position rendered the sovereignty claims advanced in the *Bogota Declaration* inconsistent with established principles of international space law, leading to their prompt rejection by other space-faring States and the wider international community.

The core rationale behind this principle is to promote fairness and ensure that resources regarded as the common heritage of mankind, such as outer space, are utilised in a manner that benefits all States. Accordingly, the notions of fairness and common benefit permeate the body of international law governing outer space.18 Indeed, *Article I* of the Outer Space Treaty provides that the *exploration and use of outer space should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development.* It is questionable, however, whether this noble and egalitarian idea for the use of outer space is

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14S Hobe, 'Geostationary Orbit' (2019) *Oxford Public International Law*, <https://opil.ouplaw.com/display/10.1093/law:epil/9780199231690/law-9780199231690-e1171> accessed 15 December, 2025.

15J C Thompson, '*Space for Rent: The International Telecommunications Union, Space Law, and Orbit/Spectrum'* (1996) *62 Journal of Air Law & Com*merce 279, 303.

16S Hobe (n 15).

17F O Agama (n 12).

18M Thornburg, 'Are the Non-Appropriation Principle and the Current Regulatory regime Governing Geostationary Orbit Equitable to All of the Earth's States?' (2018) *Michigan Journal of International Law* 40

actually producing the anticipated equitable outcomes in practice, particularly with respect to access to the geostationary orbit by less-developed States. Orbital slots in geostationary orbit are both highly valuable and inherently limited, owing to their significant economic importance and physical scarcity. Moreover, the operation of the non-appropriation principle, when combined with the prevailing practice of first-come-first-served allocation of orbital slots, poses serious challenges to equitable access. This practice seemingly disadvantages less-developed States, including those with geographical proximity to the geostationary orbit, and undermines the objective of fairness embedded in the international space law regime.19

ii. International Telecommunication Law

International telecommunication law is the body of international rules and principles governing global communications, particularly the use of **radio-frequency spectrum**, **satellite orbits** (including the geostationary orbit), and cross-border telecommunication services. It seeks to ensure the ***peaceful***, ***efficient***, **and** ***equitable*** use of global communication systems, supporting services ranging from mobile phones and internet access to aviation safety and satellite broadcasting.20 The core of international telecommunication law is administered by the International Telecommunication Union **(ITU)**, a specialised agency of the United Nations,21 with the ITU Constitution, the ITU Convention, and the Radio Regulations as its binding instruments.

The Constitution of the International Telecommunication Union governs the use of radio-frequency spectrum and of the geostationary-satellite and other satellite orbits.22 It encourages Member States to limit, as much as possible, the number of frequencies and the spectrum used to the minimum essential for the satisfactory provision of services, while applying the latest technical advances as soon as practicable23. Member States are further advised to make

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19C Billing, '*There's a parking crisis in space – and you should be worried about it'* (29 September 2017) *The Conversation* <https://theconversation.com/theres-a-parking-crisis-in-space-and-you-should-be-worried-about-it-83479> accessed 12 December, 2025.

20International Telecommunication Union, *Administrative Regulation Collection* <https://www.itu.int/en/history/Pages/RegulationsCollection.aspx> accessed 19 December 2025.

21International Telecommunication, 'About ITU' (30 March 2007) <https://web.archive.org/web/20090715225630/http://www.itu.int/net/about/index.aspx> accessed 19 December, 2025.

22Constitution of the International Telecommunication Union (Geneva, 1992) Art. 1(2)(a)

23Ibid, Art. 44(1).

rational, efficient, and economical use of frequency bands for radio services, in conformity with the provisions of the Radio Regulations, recognising that frequencies and associated orbits, including the geostationary-satellite orbit, are limited natural resources.24 These resources should be used in a manner that ensures equitable access for all countries or groups of countries, taking into account the special needs of developing countries and the geographical situation of particular States. To prevent harmful interference and enable the most efficient use of orbital resources, the operation of telecommunication satellites requires effective frequency spectrum management and coordination of their orbital positions. Moreover, the adoption of the 'use it or lose it' principle is intended to prevent potential hoarding of spectrum and promote its efficient utilisation. Nevertheless, its application should take into account the practical, realistic timeframes required for operators to use spectrum, particularly where network upgrades or deployments are essential.25

3.1 Subtle Implications of *Article II* of the Outer Space Treaty

International space law in general, and in its application to geostationary orbit, places serious emphasis on principles of equity and fairness regarding access to and utilisation of finite orbital resources. This normative orientation underpins the non-appropriation principle entrenched in the Outer Space Treaty. *Article II* provides that 'Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by other means.' The **non-appropriation is thus intended to prevent both formal and *de facto* exclusion f**rom access to outer space. While this provision clearly prohibits formal *assertion* of national sovereignty, the scope and implications of the clause 'use or occupation' are somewhat intriguing and open to interpretation, particularly in light of contemporary state and commercial practice. Therefore, to avoid unfairness through permanent exclusion of less scientifically and economically developed States and those that are just plain late, further examination, interpretation, and proper application of *Article II* of the Treaty warrants reconsideration.26 A central question is whether the continuous exclusive positioning of a geostationary satellite over the same physical area in orbit constitutes a violation of the

24*Ibid*, Para. 2.

25Digital Regulation Platform, 'Spectrum Management: Key Applications and Regulatory Considerations Driving Future Use of Spectrum' (25 April 2025) <https://digitalregulation.org/spectrum-management-key-applications-and-regulatory-considerations-driving-the-future-use-of-spectrum-2/> accessed 19 December, 2025.

26J C Thompson (n16).

ban on national appropriation by use or occupation, under *Article II*.27 The argument is that, where a satellite in geostationary orbit maintains its exact position and occupies the same orbital slot over a period of time, it may amount to appropriation in violation of the objectives of the Treaty.28

These concerns centre on the exclusionary effects of prolonged occupation on late-arriving and less technologically developed States. Given that the average operational lifespan of a geostationary satellite ranges from 15 to 20 years,29 the occupation of a single orbital slot effectively precludes access by other States for a prolonged period. A timeframe of this nature arguably reaches the very type of 'use or occupation" the Treaty seeks to foreclose, as it may result in unequal access to the use of space, and has the potential to entrench the economic interests of certain States and private entities. As it stands presently, practices under the International Telecommunication Union may be understood as **operationalising *de facto* appropriation**, even though they remain formally compliant with *Article II*. The issue is further compounded by the practice under the ITU, whereby satellite operators are permitted to refile and replace ageing satellites, thereby retaining control over the same orbital slot indefinitely.30 This practice raises crucial questions about the compatibility of existing regulatory mechanisms with the non-appropriation principle and the broader objectives of equitable access and shared benefit enshrined in international space law.

4. Emerging Legal Challenges in a Globalised Space Environment

In light of the Outer Space Treaty, a legal instrument fundamentally oriented towards fair and equitable access to and use of outer space, the indefinite occupation of orbital slots has increasingly been viewed as a breach of the non-national appropriation principle. This practice, together with the system of so-called 'priority access,' is inconsistent with the recognition in international space law of equal access, shared benefits and the obligation to promote and

27S Gorove, '*Major Legal Issues Arising from the use of the Geostationary Orbit'*, (1984) *Michigan Journal of International Law* 1, 5.

28Ibid.

29Intelsat, '*Intelsat to Extend Life of Additional Satellites with Mission Extension Vehicles'* (May 2024) <https://www.businesswire.com/news/home/20240523619448/en/Intelsat-to-Extend-Life-of-Additional-Satellites-with-Mission-Extension-Vehicles> accessed 22 December 2025.

30Space in Africa, 'Spectrum and Orbital Slotting – A Case for African Countries' (2020). <https://spaceinafrica.com/2020/12/03/spectrum-orbital-slotting-a-case-for-african-countries/> accessed 19 December 2025.

provide technical assistance to developing countries, particularly in the field of telecommunications.31 Perceived inequities and lack of fair access in the allocation of geostationary orbital resources have generated discontent among certain States, especially those with limited access to space technology. This dissatisfaction is largely directed at the '***first-come, first-served' (FCFS)*** principle, which apparently favours developed countries with existing space capabilities. This sense of injustice culminated in several responses, most notably the *Bogotá Declaration*,32 which was drafted as a protest against the prevailing interpretation and application of the non-appropriation principle in relation to the geostationary orbit. This was an attempt by eight equatorial States to assert national sovereignty over segments of the geostationary orbit directly above their borders, which they interpreted as constituting an integral part of the land over which they exercised complete and exclusive sovereignty. Accordingly, each State claimed that its sovereignty had been breached by the continued occupation of these orbital segments by foreign satellites. Although this proclamation failed to garner considerable international support,33 it nonetheless reflects the broader sentiments of many developing countries and indicates how the prevailing legal framework and practice governing the use of geostationary orbit are perceived.

In addition to ongoing debates over the adequacy of the outer space legal regime to cater to the interests of all States, new legal and regulatory challenges are emerging regarding the effective governance of an increasingly globalised space environment, which is replete with advanced commercial operations.

i. Orbital Congestion and Frequency Spectrum Scarcity (due to 5G/6G and broadband expansion)

The expansion of 5G and 6G networks, which integrate with vast Low Earth Orbit (LEO) mega-constellations for global broadband, is creating new legal challenges in the present space environment in the form of *orbital congestion and frequency spectrum scarcity*. Existing international space law, grounded in mid-20th century treaties, is struggling to manage and address these evolving space issues effectively due to broad language and a lack of specific,

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31S Khabazian, 'International Regulation of Access to the Geostationary Orbit: Mission Impossible?' (2007) 26(2) *Communication Law Bulletin.*

32Declaration of the First Meeting of Equatorial Countries (3 December 1976).

33G Thomas, 'Who Owns the Geostationary Orbit?' (2006) *Annals of Air and Space Law,* 31.

enforceable modern regulations.34 Concerning orbital congestion, the major challenge arises from the sheer volume of satellites being deployed. The rapid development and deployment of mega-constellations, comprising a large number of small satellites operating at various orbital altitudes, such as Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Orbit (GSO), have significantly transformed the landscape of space activities.35 A study conducted by the United Nations Office for Outer Space Affairs (UNOOSA) revealed that in 2018, approximately 2075 satellites were launched into orbit. By the end of 2023, however, this figure had increased dramatically to over 11,000 satellites.36 Private companies such as *SpaceX*, *OneWeb*, *Amazon*, and *Telesat* are at the forefront of this trend, with some showing readiness to further expand their constellations in the near future.37 This surge in satellite deployment is largely driven by the need to provide global broadband internet coverage and other communication services, and is facilitated by the advantages of smaller, more cost-effective satellites compared to traditional, larger spacecraft.38 This development invariably intensifies competition for spectrum, which is a finite resource.

Unfortunately, the existing outer space legal regimes were drafted in the 1960s–1970s, at a time when only a limited number of large, individual satellites were being launched into orbit39. Consequently, the current legal framework did not envisage the present reality in which mega-constellations consisting of thousands of satellites operate simultaneously in orbit, thereby leaving notable regulatory gaps and interpretative ambiguities. For instance, mechanisms established under the existing regime to prevent harmful interference have proven grossly inadequate with the growing number of satellites in orbit. This inadequacy is illustrated by the space debris mitigation guidelines issued in 2010 by the *United Nations Office for Outer Space Affairs,* which remain purely voluntary and without enforcement mechanisms40. Moreover, there have been growing concerns regarding the potential violation of

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34M Sanchez, *Advancements in Space Law: Satellite Communications Industry Regulations and Obligations for Orbital Debris Mitigation* (Cambridge University Press, 2025).

35K Yang and S Amongin, 'Assessing the Principle of Equitable Access versus Non-Appropriation in the Era of Mega-Constellations' (2024) *Aerospace 11*(10) 842 <https://doi.org/10.3390/aerospace11100842

36Andy, 'How many Satellites are orbiting the Earth in 2923?' (5 July 2023) *Pixalytics* < https://www.pixalytics.com/satellites-orbiting-earth-2023/> accessed 22 December 2025.

37A C Boley and M Byers, 'Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth' (2021) *Scientific Reports* 11 10642.

38K Yang and S Amongin (n37).

39*Ibid.*

40United Nations Committee on the Peaceful Uses of Outer Space, 'Space Debris Mitigation and Remediation: Policy and Legal Challenges' (May 2025) <https://www.unoosa.org/res/oosadoc/data/documents/2025/aac_105c_22025crp/aac_105c_22025crp_24_0_html/AC105_C2_2025_CRP24E.pdf> accessed 22 December 2025.

environmental sustainability principles in outer space activities. At present, there are no stringent international rules governing how operators manage satellite constellations in orbit, despite the rapid expansion of mega-constellations.41

ii. Astronomical Interference and Space Debris

The emergence of satellite mega-constellations has seriously exacerbated astronomical interference and the proliferation of space debris. Measures within the existing space legal framework to address these problems have proven inadequate, as evidenced by increasing incidents of interference with astronomical observation, on-orbit collisions, and accumulation of space debris.42 The growing density of satellites in earth orbit heightens the risk of both direct and knock-on collisions, thereby threatening existing and future space operations.43 These trends complicate establishing liability and causation for collision damage, especially in cases involving cascading debris events, given the absence of clear international standards on satellite design and operational conduct to determine negligence44. Moreover, the legal status of mega-constellations remains uncertain and contentious under the current international space law framework.45 Space debris thus presents a serious challenge to space activities and to the effectiveness of the existing legal regime, especially in light of the rapid deployment of large numbers of satellites into low Earth orbit by private actors. Although the *Liability Convention*46 sought to address aspects of debris problems by defining a 'space object' to include parts and launch vehicles, this approach has proven insufficient, leaving substantial gaps in application. Notably, the Convention does not explicitly encompass non-functional debris within its definition, leading to ambiguity regarding the responsibility and accountability for such debris.47

iii. Environmental Sustainability and Space Pollution

41*Ibid.*
42K Yang and S Amongin (n 40).
43C D Johnson, 'Legal status of Mega LEO Constellations and Concerns About Appropriation of Large Swaths of Earth Orbit. In *Handbook of Small Satellites*, (Springer International Publishing, 2020) 1-22.
44K Yang and S Amongin (n 44).
45A S Martin and S R Freeland, 'From One to Many: "Mega" (Constellation) Challenges to the Legal Framework for Outer Space'. (2021) *Annals of Air Space Law* 46 131–176.
46Convention on International Liability for Damage Caused by Space Objects (29 March 1972).
47K Yang and S Amongin (n 46).

Article III of the *Outer Space Treaty* provides that space activities should be conducted in accordance with international law, which encompasses environmental sustainability48. However, the rapid deployment of mega-constellations often disregards the need to prevent unnecessary pollution and ensure environmental sustainability. In line with the Treaty's principle of "due regard" for the interests of other States,49environmental impact assessments may be required before approving mega-constellations, although the Treaty has no explicit provisions to that effect. The *Rio Declaration on Environment and Development (1992)* further highlights the importance of sustainable development and the protection of global environmental integrity.50 Despite these principles and the Declaration's emphasis on sustainable development, the space industry presently lacks rigorous environmental regulations to govern the increasing number of space activities, leading to potential long-term ecological impacts. This proliferation of advanced space activities warrants the urgent need for comprehensive environmental standards specific to space operations.[51]

The proliferation of space activities, particularly the deployment of mega-constellations, increases the likelihood of environmental pollution. While the *Liability Convention* addresses the physical damage caused by space objects, it does not account for the environmental impacts of space debris. Space debris, as a form of pollution, threatens the space environment and contributes to contamination through combustion by-products that accumulate in orbit, potentially altering the chemical composition of the near-Earth atmosphere.52 The multifaceted impacts of space launches and debris on the space environment necessitate a more comprehensive approach that explicitly includes environmental damage within the space legal regime. Scholars have argued that if these impacts are not carefully addressed, they could undermine the principles of the Outer Space Treaty by creating inequalities among nations, particularly by widening the gap between technologically advanced space-faring nations and upcoming space actors.[53]

48L I Hoe, R Umar and M K A Kamarudin, 'Article III of the 1967 Outer Space Treaty: A Critical Analysis' (2018) *International Journal of Academic Research in Business and Social Sciences* 8 326–338.

49This principle is found in *Article IX* of the Treaty, which constitutes a core legal obligation requiring spacefaring States to conduct all activities with consideration for other states' interests, preventing harmful interference and ensuring space remains for peaceful exploration for all humankind.

50Rio Declaration on Environment and Development (Rio de Janeiro, 1992) Preamble.

51J N Pelton and S Madry, 'Retrofitting and Redesigning of Conventional Launch Systems for Small Satellites' in *Handbook of Small Satellites: Technology, Design, Manufacture, Applications, Economics and Regulation* (Springer International Publishing: Cham, Switzerland, 2020) 403 - 422.

52K Yang and S Amongin (n 49).

53*Ibid.*

iv. Transfer of Satellite Ownership in Orbit

The transfer of satellite ownership in orbit has become increasingly common, unlike the early days of space exploration when it was not considered essential.54 The low incidence of ownership transfer in the past was likely due to the fact that only a few countries could carry out space activities, resulting in limited interest. The rise of in-orbit ownership transfer has been driven, in part, by changes in public procurement schemes that have led to public–private partnerships (PPP),55 essentially involving privatisation. International space law currently provides no explicit provisions on the concept of the transfer of ownership. While the Outer Space Treaty addresses ownership under *Article 6*, it is silent on the concept of transfer, neither expressly allowing nor restricting it. Restrictions on the launching State's role as a State of registry further complicate the application of ownership rules.56 The ITU Treaty instruments,57 which regulate radio frequency interference, are also silent on ownership or its transfer. The UNDROIT Space Assets Protocol58 is the only international treaty addressing satellite ownership from a private law perspective, but it is not yet in force, having only four signatories: Burkina Faso, Germany, Saudi Arabia, and Zimbabwe.59 Consequently, satellite ownership and transfer remain shrouded in legal uncertainty, highlighting the need for broader discussions and adoption of the Protocol to resolve these issues.

Although some of these challenges existed earlier, the rapid evolution of space activities, particularly the emergence of mega-constellations, has exacerbated the situation. The emerging challenges of orbital congestion, spectrum scarcity, and mega-constellation deployment have particularly significant distributive implications for developing and emerging space-faring States, including African countries, revealing structural asymmetries within the current international allocation regime.60 Although the Outer Space Treaty affirms equal access to outer space and the ITU framework is f neutral, the first-come-first-served system, combined

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54F. von der Dunk, 'Transfer of ownership in orbit: From fiction to problem' in *Ownership of Satellites* (Nomos Verlagsgesellschaft mbH & Co. KG, Baden-Baden, 2017) 27–44.

55G Rausser, E Choi, and A Bayen, 'Public–private partnerships in fostering outer space innovations' (2023) *Proceedings of the National Academy of Sciences of the United States of America* 120.

56K Yang and S Amongin (n 54).

57Constitution of the International Telecommunication Union (Geneva, 1992) and Radio Regulations of the International Telecommunication Union.

58Protocol to the Convention on International Interests in Mobile Equipment in Matters Specific to Space Assets (Berlin, 9 March 2012).

59K Yang and S Amongin (n 58).

60Sheer Abbas, 'Challenges to Space Activities in the Context of Mega Satellite Constellations: A Focus on Environmental Impacts' (2025) *Journal of Astronomy and Space Sciences*, 42(1) 1-13 < https://www.janss.kr/archive/view_article?pid=jass-42-1-1&utm_source=ts2.tech> accessed 30 June 2026.

with the technical and financial demands of orbital filing and coordination, tends to favour established space actors.61 Moreover, the absence of a clear governance policy for mega-constellations, especially regarding legally binding, unambiguous definitions and the regulation of private space actors, has created significant gaps. While some non-binding guidelines are in place, current space activities urgently require the development of new international regulations and norms to address the challenges posed by mega-constellations and to ensure the sustainable and equitable use of outer space envisioned by the space regime.

5. Reassessing Equitable Access and the Non-Appropriation Principle in Contemporary Outer Space Operations

The principles of equitable access and non-appropriation, enshrined in the Outer Space Treaty, are foundational to international space law. Their primary objective is to strike a balance among divergent State interests in the use of outer space resources.62 Although there have been debates regarding how effectively these principles serve the interests of various States, they were largely adequate in the past when space activities were confined to a few technologically advanced nations and satellite deployments remained relatively limited. However, in the modern, globalised space environment, characterised by the rapid emergence of satellite mega-constellations comprising hundreds or even thousands of satellites, as well as the advancement of digital twin technologies across the space sector,63 the application of these principles has become not only increasingly challenging but, in many respects, ineffective.

i. Large-scale occupation of orbital slots by private space actors, especially private companies from technologically advanced nations, amounts to *de facto* appropriation (or space monopolisation), effectively bypassing the non-appropriation principle and undermining the notion of fair access for all states, particularly developing and emerging space-faring nations.

ii. Paper satellites, enabled by the 'first-come, first-served' system, are a practice in which powerful nations and private companies reserve orbital slots through registration, effectively denying future access to others. Because of the high value and scarcity of these slots, the geostationary orbit is becoming increasingly saturated, even though many States have not yet placed a single satellite into orbit due to technological or economic constraints. This

61Y M Putro, 'Geostationary Orbit Slot Reconceptualization In Accommodating the Souththe South' (2022) *Indonesian Journal of International Law* 19(3)

62This is recognised in the Preamble of the Outer Space Treaty.

63G Dedre, 'Toward an equitable governance of space resources: A policy-oriented framework for sustainability and resilience' (2025) *Journal of Aviation and Space Studies 5*(2).

situation has led to the emergence of the term 'over-filing', which describes the registration of unneeded orbital resources by a space actor, thereby foreclosing others with near-term needs from achieving access or conflict-free registrations.[64]

iii. Mega-constellations create new congestion in orbital pathways, increasing the risk of interference and collisions65. The deployment of large LEO and MEO constellations exacerbates these risks, affecting the sustainability of geostationary orbit (GSO) and altering the current space order,66 thereby raising concerns about the potential *de facto* appropriation of vast orbital areas. These developments leave developing nations frustrated, echoing concerns previously raised in the *Bogota Declaration*. Equitable access assumes that all States, irrespective of their space-faring capabilities, should have equal access to outer space and be able to operate satellites safely without undue risk arising from orbital congestion.67 The current outer space legal regime lacks explicit, binding guidance on managing these risks in the context of mega-constellations, leaving serious gaps in enforcement and accountability.

Due to the parochial and uneven application of the non-appropriation principle, resulting in one-sided beneficial effect, less developed nations have sought alternative strategies to benefit from orbital resources. Examples include sovereignty claims by Equatorial States and spectrum leasing by Tonga,68 both of which provoked international criticism. The response to the *Tonga incident* made it clear that States are not permitted to trade orbital slots allocated to them as pseudo-commodities.69 By contrast, private communication companies are allowed to sell stable streams of satellite transmissions to consumers, thereby generating monetary income from which their home States also benefit.70 Similarly, the lukewarm reaction to the *Bogotá Declaration* indicates the international community's unwillingness to recognise claims to

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64I D Galeriu, 'Paper Satellites and the Free Use of Outer Space' (2015) *Global Legal Information Network* <https://www.nyulawglobal.org/globalex/Paper_satellites_free_use_outer_space.html> accessed 31 December, 2025.

65A C Boley and M Byers, 'Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth' (2021) *Scientific Reports* <https://pmc.ncbi.nlm.nih.gov/articles/PMC8137964/> accessed 5 January 2026.

66China Xi'an Satellite Control Centre, 'LEO Mega-Constellations is Deeply Influencing Space Activities of the World' (2022) <https://www.unoosa.org/documents/pdf/copuos/2022/1._China_LEO_Mega-Constellation_is_Deeply_Changing_Space_Activities_of_the_World.pdf> accessed 5 January 2026.

67B A Gur and J Kulezsa, 'Equitable Access to Satellite Broadband Services: Challenges and Opportunities for Developing Countries' (March 2024) *Telecommunications Policy 48*(3) https://doi.org/10.1016/j.telpol.2024.102731

68J C Thompson, '*Space for Rent: The International Telecommunications Union, Space Law and Orbit/Spectrum Leasing' (1996)* ***Journal of Air Law and Commerce*** **62**.

69S Chaturvedi, 'Right in Orbital Slots: Analysis of Tonga Incident' (2021) *International Journal of Humanities* 10(1) 4-5

70M Thornburg (n 18)

orbital slots based on a nation's sovereign rights over the space above its territory. The international rejection of the *Bogota Declaration* was premised on the view that it violated the non-appropriation principle, which has long attained the status of customary international law.

6. Towards a More Adaptive and Equitable Framework for GSO Governance

The persistent challenges facing the realisation of fair and equitable principles, together with unsuccessful attempts to circumvent the much-feared phenomenon of '*de facto appropriation,*' and the increasing complexity of modern space operations, have disproportionately sidelined certain nations, particularly less technologically advanced States, from a fair share of orbital resources within the global commons of outer space.71 These developments have created an urgent need for a more adaptive and equitable governance framework for the geostationary orbit, as the existing regime, largely guided by the Outer Space Treaty and the International Telecommunication Union allocation mechanisms, has become increasingly outdated and lacks the necessary wherewithal to address the evolving legal and regulatory challenges associated with equitable and sustainable access.[72]

A more adaptive and equitable governance framework for the geostationary orbit (GSO) can be achieved through carefully calibrated reforms focusing on three interconnected dimensions. First, **enhanced regulatory mechanisms** are required to manage orbital congestion and prevent the over-filing of orbital slots. These may include binding limits on registrations, the prioritisation of active satellite operations, and periodic review and reallocation of underutilised slots. A framework that prioritises satellite licensing based on social, environmental, and economic benefits could help curb the proliferation of 'paper satellites.' Also, the introduction of orbital-use fees or taxes once a State or commercial operator exceeds a specified launch threshold may be adopted to incentivise more efficient use of limited orbital resources, reduce congestion and collision risks, and help fund debris-mitigation and remediation efforts.[73]

Second, **equitable-access policies** should explicitly integrate the needs of developing States, allowing for technical assistance, coordinated leasing arrangements, or temporary usage rights,

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71S Palit, T S Dias and S Hazra, 'Rebalancing Space Governance: A Global South Perspective on Outer Space as a Global Common' (2025) *Frontiers in Space Technologies* 6 <https://doi.org/10.3389/frspt.2025.1594352> accessed 6 January 2026.

72B Batoki-Gonczy and M Ganczer, 'Space Sustainability: Current Challenges' (2024) *Hungarian Journal of Legal Studies* 65(2).

73M Sanchez, *Advancements in Space Law: Satellite Communications Industry Regulations and Obligations for Orbital Debris Mitigation*' (Cambridge University Press, 2025).

thereby operationalising the Outer Space Treaty's principle of fairness in a tangible practical manner.[74]

Third, the adoption of **adaptive governance** as a dynamic and technology-responsive approach is essential to accommodate emerging innovations such as artificial intelligence, digital twins, and space situational awareness systems.75 This method requires a regular update to regulatory provisions and frameworks governing the application of these tools to monitor orbital use in real time, improve collision-avoidance capabilities, and support data-driven allocation decisions.[76]

Moreover, due to the global nature of the outer space environment, there is a need for ***enhanced international cooperation and transparency*** in the use of the Geostationary Satellite Orbit. This includes establishing robust mechanisms for dispute resolution and knowledge sharing to ensure equitable outcomes and build trust among States.[77] By combining regulatory modernisation, equity-focused allocation, and adaptive technological integration, the international community can ensure that the geostationary orbit remains both sustainable and accessible, reflecting the spirit of the Outer Space Treaty while effectively addressing contemporary challenges.

7. Conclusion

The existing governance framework, largely guided by the Outer Space Treaty and the allocation mechanisms of the International Telecommunication Union, is increasingly confronted with significant challenges in ensuring equitable and sustainable access to orbital resources. The historical reliance on the 'first-come, first-served' principle has allowed technologically advanced nations and private actors to occupy large portions of the geostationary orbit, often through the use of 'paper satellites' practices, thereby limiting or effectively foreclosing opportunities for developing and emerging space-faring States. This

74J Li and J Su, 'Activating the principle of 'taking into account the special needs of the developing countries in the distribution of low Earth orbit frequency/orbit resources' (2026) *Telecommunications Policy* 5(1).

75M F Harris and R Linares, 'Developing Adaptive Space Governance Based on Terrestrial Examples' (2024) paper presented at the 37th IAA Symposium on Space Policy, Regulations and Economics, 75th International Astronautical Congress (IAC 2024) 8.

76D L Oltrogge and I A Chsistensen, 'Space Governance in the New Era' (2020) *Journal of Space Safety Engineering*,7(3).

77B Singh, 'Resurgence of Territorial and Maritime Disputes: Strategic Pursuit of Political-Legal Mechanisms of Resolution Lensing International Arbitration in a Globalized World' (2024) *Journal of Territorial and Maritime Studies* <https://www.journalofterritorialandmaritimestudies.net/post/resurgence-of-territorial-and-maritime-disputes-strategic-pursuit-of-political-legal-mechanisms-of> accessed 6 January 2026.

situation is further compounded by the deployment of large-scale LEO and MEO mega-constellations, which exacerbate orbital congestion and raise critical questions regarding fairness, sustainability, and long-term operational safety values the outer space regime purports to uphold.

Against this backdrop, mechanisms for equitable allocation of orbital slots must move beyond historical access alone and take into account technological and financial capabilities and the developmental needs of States. Equally, the non-appropriation principle must be interpreted and applied in a manner that prevents the *de facto* monopolisation of orbital 'space' through excessive satellite deployment. It is therefore imperative for the international community to reassess the effects of the existing treaty norms and the broader legal regime on the equitable use of outer space. As the economic potential of outer space continues to expand, the contemporary relevance and functional adequacy of the non-appropriation principle warrant critical re-evaluation. Without meaningful legal, policy, and procedural innovation, the current approach to geostationary orbital allocation risks perpetuating structural inequities and excluding less developed States from equitable participation in, and benefits derived from, outer space activities. Achieving fair and equitable access to the geostationary orbit in contemporary space operations, therefore, requires a recalibrated governance framework capable of reconciling commercial expansion with the foundational principles of equity and sustainability.

This paper recommends a comprehensive and timely review of the existing space legal regime, including the Outer Space Treaty and the regulatory mechanisms of the International Telecommunications Union, to amend relevant provisions to ensure the effective governance of increasingly complex modern space operations in a manner that adequately serves the interests of all States. In addition, it is proposed that the *Tonga initiative* be reconsidered and adopted as a possible mechanism for enhancing the inclusion of less-developed States in the use and benefits of orbital resources, particularly where such States have demonstrated sustained interest and commitment.

Under the current framework, private communications companies and, indirectly, their home States, are allowed to benefit financially by selling stable streams of satellite transmission services to consumers. If the non-appropriation principle permits such private financial gain, it should not, in principle, preclude States from profiting in any way they deem fit from the allocation of orbital slots, provided that such arrangements do not amount to sovereignty claims or permanent appropriation. The leasing or controlled commercial utilisation of orbital slots,

when carefully regulated and internationally coordinated, need not contravene the non-appropriation principle.

Only through such carefully monitored and cooperative approaches can the international community effectively operationalise fair and equitable access to orbital resources, in accordance with the core objectives of the Outer Space Treaty and its commitment to protecting the interests of all nations, even in the contemporary space environment.