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DRAWING LINES IN A BORDERLESS OUTER SPACE: LEGAL CHALLENGES TO THE ESTABLISHMENT OF SAFETY ZONES

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I. INTRODUCTION — II. LEGAL IMPLICATIONS OF CURRENT PRACTICES IN THE USE OF OPERATIONAL ZONES FOR REGULATING SAFETY IN OUTER SPACE — III. TOWARDS A NORMATIVE REGULATORY FRAMEWORK OF SAFETY ZONES ON CELESTIAL BODIES — IV. NORMATIVE INSIGHTS ON THE CONCEPT OF SAFETY ZONES IN OUTER SPACE AND ON CELESTIAL BODIES — V. CONCLUSIONS — VI. FINAL REFERENCES

ABSTRACTS: International outer space law, primarily developed in the late 1960s and 1970s, increasingly reveals its limitations in addressing the complexity and scale of contemporary space activities. As of 31 December 2024, approximately 18,070 functional space objects had been officially registered —representing nearly 89% of all launches since 1957— underscoring the intensity and acceleration of orbital operations. Concurrently, multiple missions targeting lunar exploration and utilization are actively underway. This rapid evolution has exposed significant normative gaps, particularly concerning the legal status and operationalization of safety zones. Such zones are gaining relevance as instruments to mitigate orbital congestion, prevent harmful interference, safeguard critical infrastructure and ensure the safe execution of high-risk operations, including the exploitation of celestial resources. Notably, safety zones have not been established through binding multilateral instruments, but have instead emerged from the operational practices of spacefaring actors, as well as from policy measures articulated in soft law instruments. Considering this, the main research question addressed is: To what extent are the establishment and enforcement of safety zones lawful under the current corpus of international space law? The study seeks to highlight the urgent need for coherent, equitable, and enforceable international rules capable of addressing these emerging regulatory challenges.

KEYWORDS: Non-appropriation, free access, safety zone, no harmful interference, due regard

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obligation.

TRAZANDO LÍMITES EN UN ESPACIO ULTRATERRESTRE SIN FRONTERAS: RETOS JURÍDICOS EN LA CREACIÓN DE ZONAS DE SEGURIDAD

RESUMEN: El derecho internacional del espacio ultraterrestre, desarrollado principalmente entre finales de los años sesenta y la década de 1970, revela cada vez más sus limitaciones a la hora de abordar la complejidad y la magnitud de las actividades espaciales contemporáneas. Al 31 de diciembre de 2024, aproximadamente 18.070 objetos espaciales funcionales habían sido registrados oficialmente, lo que representa cerca del 89 % de todos los lanzamientos realizados desde 1957, evidenciando así la intensidad y aceleración de las operaciones en órbita. Paralelamente, se encuentran en curso múltiples misiones orientadas a la exploración y utilización de la Luna. Esta rápida evolución ha puesto de manifiesto importantes lagunas normativas, en particular en lo que respecta al estatus jurídico y a la operacionalización de las zonas de seguridad. Estas zonas están adquiriendo una relevancia creciente como mecanismos para mitigar la congestión orbital, prevenir interferencias perjudiciales, proteger infraestructuras críticas y garantizar la ejecución segura de operaciones de alto riesgo, incluida la explotación de recursos espaciales. Cabe destacar que las zonas de seguridad no se han establecido mediante instrumentos multilaterales vinculantes, sino que han surgido a partir de las prácticas operativas de los actores espaciales, así como de las medidas políticas articuladas en instrumentos de *soft law*. En este contexto, la pregunta principal es: ¿En qué medida puede considerarse jurídicamente legítimo el establecimiento y la aplicación de zonas de seguridad, conforme al corpus vigente del derecho internacional del espacio ultraterrestre? El estudio busca subrayar la necesidad urgente de contar con normas internacionales coherentes, equitativas y exigibles, capaces de hacer frente a estos desafíos regulatorios emergentes.

PALABRAS CLAVE: (principio de) no apropiación, libre acceso, zona de seguridad, prevención de contaminación nociva, obligación de tener debidamente en cuenta los intereses de otros.

TRACER DES LIMITES DANS UN ESPACE EXTRA-ATMOSPHERIQUE SANS FRONTIERES: DEFIS JURIDIQUES DANS LA CREATION DE ZONES DE SECURITE

RÉSUMÉ: Le droit international de l'espace extra-atmosphérique, élaboré principalement entre la fin des années 1960 et la décennie 1970, révèle de plus en plus ses limites face à la complexité et à l'ampleur croissantes des activités spatiales contemporaines. Au 31 décembre 2024, environ 18 070 objets spatiaux fonctionnels avaient été officiellement enregistrés, représentant près de 89 % de l'ensemble des lancements effectués depuis 1957, ce qui témoigne de l'intensité et de l'accélération des opérations en orbite. Parallèlement, de nombreuses missions axées sur l'exploration et l'utilisation de la Lune sont en cours. Cette évolution rapide met en lumière des lacunes normatives significatives, notamment en ce qui concerne le statut juridique et l'opérationnalisation des zones de sécurité. Ces dernières revêtent une importance croissante en tant qu'instruments de gestion de la congestion orbitale, de prévention des interférences nuisibles, de protection des infrastructures critiques et de sécurisation des opérations à haut risque, y compris l'exploitation des ressources célestes. Il convient de noter que les zones de sécurité ne sont pas établies par des instruments multilatéraux contraignants, mais qu'elles ont plutôt émergé des pratiques opérationnelles des acteurs spatiaux, ainsi que des mesures politiques énoncées dans des instruments de soft law. Dans ce contexte, la question centrale qui guide cette recherche est la suivante: dans quelle mesure l'établissement et l'application de zones de sécurité sont-ils licites au regard du corpus actuel du droit spatial international? L'étude vise à souligner l'urgence d'adopter des normes internationales cohérentes, équitables et contraignantes, aptes à répondre à ces nouveaux défis réglementaires.

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MOT CLES: (principe de) non-appropriation, libre accès, zone de sécurité, prévention de la contamination nuisible, obligation de tenir dûment compte des intérêts des autres.

I. INTRODUCTION

The 1967 Outer Space Treaty (OST) represents the foundational instrument of the international regulatory frameworks governing outer space[2]. It enunciates the core principles applicable to all space-related activities conducted beyond the Earth.

At the heart of the OST lies the recognition that the exploration and the peaceful use of outer space is conducted for the benefit of all countries and is deemed to be the province of all mankind[3]. Outer space is freely accessible to all States without discrimination, on a basis of equality and in accordance with international law[4].

In any case, this freedom is not absolute. It is balanced by the principle of non-appropriation by claim of sovereignty, by means of use or occupation, or by any other means[5]. Moreover, the OST further requires that such activities be carried out with due regard for the interests of other States and mandates the prevention of harmful contamination of outer space and celestial

[2] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, adopted 27 January 1967, entered into force 10 October 1967, UN Treaty Series, No. 610, at 205. As of 23 May 2025, the OST has been ratified by 117 States, with the most recent accession being Latvia. For a recent discussion on sources of space law, see, among many others, Lyall, F. and Larsen, P.B., *Space Law: A Treatise*, Routledge, Abingdon, 2025, p. 26 ss.; Setsuko, A., "Outer Space Treaty and Fundamental Principles", in Bhat, S.B., Ukey, D., and Variath, A., (eds.), *International Space Law in the New Space Era: Principles and Challenges*, Oxford University Press, Oxford, 2024, pp. 66-85.

[3] OST, Article I (1). Furthermore, States are entitled to freedom of scientific investigation in outer space and are expected to promote and facilitate international cooperation in such activities (*Ibid*, Article I (2)). The OST also imposes a strict obligation to use outer space exclusively for peaceful purposes, expressly forbidding the placement of nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies (*Ibid*, Articles III and IV). For a recent and authoritative analysis of the main legal concepts underpinning space legislation, see Hobe, S., *Space Law*, Hart Publishing, London, 2023, p. 71 ss.

[4] Furthermore, States are entitled to freedom of scientific investigation in outer space and are expected to promote and facilitate international cooperation in such activities. *Ibid*, Article I (2,3).

[5] *Ibid*, Article II (1).

bodies as well as adverse effects on Earth's environment[6].

These core principles not only aim to guide a responsible behaviour of States in outer space, but have also informed the drafting and interpretation of subsequent UN space treaties, such as the Rescue Agreement[7], the Liability Convention[8], the Registration Convention[9], and the Moon Agreement (1979)[10].

However, while these instruments —largely developed during the late 1960s and 1970s— laid the foundation of international outer space law, the current legal framework increasingly reveals its structural limitations considering the rapid expansion of space activities as well as the growing involvement of both State and non-State actors[11].

By 31 December 2024, approximately 18,070 functional space objects had been officially registered, accounting for about 89% of all objects launched since 1957[12]. Concurrently, multiple missions targeting lunar exploration and utilization are actively underway[13].

[6] *Ibid*, Article IX.

[7] Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, adopted 22 April 1968, entered into force 3 December 1968, UN Treaty Series, No. 672, p. 119.

[8] Convention on International Liability for Damage Caused by Space Objects, adopted 29 March 1972, entered into force 1 September 1972, UN Treaty Series, No. 961, p. 188.

[9] Convention on Registration of Objects Launched into Outer Space, adopted 12 November 1974, entered into force 15 September 1976, UN Treaty Series, No. 1023, p. 15.

[10] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, adopted 5 December 1979, entered into force 11 July 1984, UN Treaty Series, No. 1363, p. 3.

[11] Marchisio, S., *Law of Outer Space Activities*, Edizioni Nuova Cultura, Roma, 2022, p. 19 ss.; Moltz, J.C., "The Changing Dynamics of Twenty-First-Century Space Power", *Strategic Studies Quartely,* 2019, pp. 66-94; Di Pippo, S., *The Space Economy. La nuova frontiera dello sviluppo*, Egea editore, Milano, 2022, p. 71 ss. This article will not address the dual-use nature of space activities. Moreover, the concept of safety zones will be examined from a general legal perspective, without engaging with the specific challenges arising from their potential implications in the context of military activities in outer space.

[12] COPUOS, Implementation of article XI of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, and article IV of the Convention on Registration of Objects Launched into Outer Space, 2025, UN. Doc. A /AC.105/C.2/L.338/Corr.1, para. 17.

[13] Significant attention is currently focused on NASA's Artemis program, which aims to re-establish a sustained human presence on the Moon —the first since Apollo 17 in 1972.

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The rapid evolution of space activities has revealed significant normative gaps, particularly with regard to the legal status and operational implementation of safety zones. These zones are gaining increasing relevance as mechanisms to mitigate orbital congestion, prevent harmful interference, protect critical infrastructure, and ensure the secure execution of high-risk operations[14].

Notably, safety zones have not been established through binding multilateral instruments but have instead emerged from the operational practices of spacefaring actors, as well as from policy measures articulated in *soft law* instruments.

Considering this, the main research question addressed is: to what extent are the establishment and enforcement of safety zones lawful under the current *corpus* of international space law? The study seeks to highlight the urgent need for coherent, equitable, and enforceable international rules capable

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The uncrewed Artemis I mission, launched in November 2022, marked a critical milestone, successfully testing the Orion spacecraft and Space Launch System. Future missions, including Artemis II (crewed lunar flyby, scheduled for early 2026) and Artemis III (first human lunar landing since Apollo, targeted for mid-2027), lay the groundwork for a long-term lunar base in the 2030s, supporting both scientific research and commercial exploitation of lunar resources. I-HAB, a habitation module developed with Japan Aerospace Exploration Agency (JAXA), and ESPRIT, a module dedicated to telecommunications and refuelling. These components are scheduled for launch between 2026 and 2028. ESA is also leading the Moonlight Initiative, which aims to establish a satellite-based lunar navigation and communication network to support both public and commercial missions, with initial operational services expected by 2027. At the same time, China and Russia are jointly developing a lunar base, set to begin around 2028 under the Chang'e program. The base will be built using bricks made from lunar soil and will feature a telescope with a field of view 300 times wider than Hubble's. For a recent discussion on the legal regime governing the exploration and exploitation of space resources, see: Cinelli, C., "The Evolving Regulatory Framework for Space Resource Utilization", *La Comunità Internazionale*, Vol. LXXVIII, No. 3, 2023, pp. 483-510, p. 485 ss.

[14] It is estimated that by 2029 there will be up to 100,000 satellites in orbit, with approximately 2,5 million manoeuvres conducted annually, resulting in a significantly heightened risk of collisions. See, Fasola, N., Lucarelli, S., Marrone, A., Massarin, M.A., and Moro, F.N., (eds.), *Space: Exploring NATO's Final Frontier*, NATO Allied Command Transformation, University of Bologna, Istituto di affari internazionali, 2024, p. 75. Furthermore, by 2029-2030, at least two lunar bases are expected to be under development: one led by the United States through the Artemis program, with contributions from ESA, JAXA, and others, and another jointly developed by China and Russia under the Chang'e program (note 13).

of addressing these emerging regulatory challenges.

To this overall aim, the paper proceeds by examining the legal implications of current practices related to operational zones used for regulating safety in outer space. It begins by addressing fundamental issues of definition and delimitation, specifically clarifying the boundary between outer space and airspace, as well as the establishment of operational zones within outer space.

The discussion then moves to concrete examples, such as the operational zones around the International Space Station and the designated orbital areas surrounding functional satellites, highlighting the practical and legal challenges involved.

Following this, the article explores the development of a normative regulatory framework for safety zones on celestial bodies. It assesses the contribution of The Hague Building Blocks, which provide foundational principles for the governance of space resources, and examines the implications of the Artemis Accords, a recent set of policy agreements that influence the legal landscape regarding safety zones on celestial bodies.

The analysis then turns to forward-looking considerations, offering normative insights into the conceptualization and implementation of safety zones in both outer space and on celestial bodies.

The article concludes by synthesizing its principal findings and underscoring the urgent need for coherent, inclusive, and equitable international legal instruments capable of effectively governing safety zones in the evolving context of space activities.

II. LEGAL IMPLICATIONS OF CURRENT PRACTICES IN THE USE OF OPERATIONAL ZONES FOR REGULATING SAFETY IN OUTER SPACE

1. Issues of Definition and Delimitation of Outer Space and Its Internal Zoning

Neither the OST nor subsequent UN space treaties codify the definition and delimitation of outer space[15].

[15] Despite the relevance of these issues, the definition and delimitation of outer space remain unresolved and under ongoing consideration within the Committee on the Peaceful

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The challenge of defining clear boundaries of State sovereignty is not new. One need only recall the lengthy negotiations and conflicting national positions that eventually led to the adoption of the 12-nautical-mile limit for the territorial sea (and national airspace), measured from the baseline[16].

Similarly, today we witness differing views among States regarding the delimitation of outer space from airspace: while most States have accepted the Kármán line —located at a certain altitude above sea level, generally considered the point beyond which aerodynamic control becomes ineffective— as a spatial reference point, there is no consensus on its precise height, which appears to fluctuate between 100 and 130 km[17]. Other States have refrained

Uses of Outer Space (COPUOS), especially its Legal Subcommittee (LSC). Furthermore, the matter has not yet been included in the programme of work of the International Law Commission. Among the first initiatives on the matter, see COPUOS, The Question of the Definition and/or the Delimitation of Outer Space, 1970 (updated in 1977), UN Doc. A/AC, 105/C2/7, 7; Id., Draft Basic Provisions of the General Assembly Resolution on the Delineation of Air Space and Outer Space and on the Legal Status of the Geostationary Satellites' Orbital Space, 1979, UN Doc. A/AC.105/L/112. Today, the question of defining and delimiting outer space remains under discussion: Id., Historical Summary on the Consideration of the Question on the Definition and Delimitation of Outer Space, 2020, UN Doc. A/AC.105/769/Add.1; Id., Definition and delimitation of outer space: views of States members and permanent observers of the Committee, 2025, UN Doc. A/AC.105/1112/Add.13. In doctrine, for a recent discussion, Newman, C.J., "The Never-Ending Problem of Demarcation: Addressing the Air/Space Boundary Issue in International and Domestic Law" in Bhat S.B., Ukey, D., and Variath, A., (eds.), *International Space Law in the New Space Era: Principles and Challenges*, pp. 19-37.

[16] Despite the long process of progressive development of international law of the sea and its codification, some States continue to maintain claims that deviate from the 12-nautical-mile territorial sea limit established under international law. These divergent claims often derive from historical assertions, unresolved regional disputes, or strategic interests. A notable example is Peru, which asserts sovereignty over a maritime domain extending up to 200-nautical-miles based on national constitutional provisions, although such a claim lacks broad recognition under the current international legal framework.

[17] During the first half of the 20th century, Theodore von Kármán calculated that at an altitude of approximately 100 kilometres, the atmosphere would become so thin that its ability to provide the mathematical basis for aeronautical propulsion would no longer be sufficient. That shows a spatialist approach that considers the Kármán line as a "working border" to narrow the discussion to evaluating some concrete alternatives regarding its altitude, with a preference that seems to be emerging at present for indicating the value of 100 kilometres (COPUOS, UN Doc. A/AC.105/769/Add.1, *op. cit.*). Few States, as Australia, Denmark, and Kazakhstan, have also adopted the demarcation of the beginning of space at 100 kilometres

from adopting the Kármán line, reflecting the absence of a universally accepted standard[18].

In its most recent position, expressed in May 2025, the Legal Subcommittee of COPUOS underscores the ongoing absence of a definition and delimitation of outer space as a significant shortcoming in international law. At the same time, it adopts a positive perspective, emphasizing that through constructive dialogue, compromise, and careful drafting within the framework of the Committee, "a comprehensive multilateral regulatory framework could be established that serves the interests of all humankind"[19]. This aims

above sea level at domestic levels (COPUOS, UN Doc. A/AC.105/1112/Add.13, *op. cit.*). The International Telecommunications Union (ITU) refers to the 100 km line as being usually assumed to be the boundary between Earth's atmosphere and outer space. Otherwise, the NASA Procedural Requirements (NPR) designate 130 km as a key boundary for space operations and the safeguarding of the near-Earth space environment. See, NASA, Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments, 2017-2021, Doc. NPR 8715.6B, p. 3. The updated version is the Doc. NPR 8715.6E, titled *Orbital Debris Mitigation*, 2024-2029.

[18] The differing positions expressed by States largely revolve around the "spatialist" and "functionalist" approaches —namely, whether a flying object should be classified as an aircraft or a spacecraft based on the altitude at which it operates or the function it performs, respectively. See, Cinelli, C., *La disciplina degli spazi internazionali e le sfide poste dal progresso tecnico-scientifico*, G. Giappichelli editore, Torino, 2020, p. 101 ss.; Dempsey, P.S. and Manoli, M., "Suborbital Flights and the Delimitation of Air Space vis-à-vis Outer Space: Functionalism, Spatialism, and State Sovereignty", *Annals Air and Space*, Vol. 42, 2017, pp. 199-241. Among others, consider the following State positions: the upper limit of navigable airspace; or the limit of gravitational attraction; or the lowest feasible perigee for a satellite in sustained orbit; and a predetermined distance from the Earth's surface. Among theoretical presumptions, some authors identify the area extending from approximately 18 kilometres above sea level, which represents the practical upper limit of navigable airspace, to an altitude of 160 kilometres, corresponding to the lowest feasible perigee for a satellite in sustained orbit, as the "near space", which could be an exclusive utilization space claimed by a State above its land territory and territorial sea. See, Liu, H. and Tronchetti, F., "Regulating Near-Space Activities: Using the Precedent of the Exclusive Economic Zone as a Model", *Ocean Development and International Law,* Vol. 50, No. 2, 2019, pp. 91-116. See also, COPUOS, Near space: the quest for a new legal frontier, UN Doc. A/AC.105/1112/Add.13.

[19] The 64th Session of the Legal Subcommittee, held in Vienna from 5 to 16 May 2025, shows significant discussion of the lack of a formal definition and delimitation of outer space, as well as a positive tone toward developing a more robust multilateral regime through constructive dialogue. See Legal Subcommittee of COPUOS, Encouraging dialogue on issues concerning the definition and delimitation of outer space: towards developing a shared

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at clarifying key legal questions, minimizing the risk of inter-State conflict, and fostering the peaceful and sustainable use of both airspace and outer space[20].

Although the prospect comprehensive multilateral regulatory framework remains uncertain, continued dialogue on the definition and delimitation of outer space, including the delineation of operational space zones within it, is essential to managing space activities safely, equitably, and sustainably. In particular, the establishment of safety zones in outer space and on celestial bodies raises legal questions of fundamental importance regarding the nature and limits of State jurisdiction, and the broader implications for the international legal order governing outer space.

It is essential to differentiate between two distinct types of State space jurisdiction. The first is a type of jurisdiction which a State exercises over its space objects and the personnel aboard[21]. The second type pertains to State jurisdiction and control related to spatial zones surrounding space objects and installations beyond Earth's atmosphere. This latter form of jurisdiction, i.e. the primary focus of this paper, represents an increasingly pressing, yet currently unresolved, issue in international space law.

Indeed, State practice and evolving operational dynamics increasingly underscore the necessity of implementing functional zoning. The establishment of operational or safety zones is not, in principle, prohibited under existing international space law, even though it remains absent from binding UN space treaty provisions. Nevertheless, the concept began to acquire practical relevance during the Cold War, when informal understandings regarding the use of safety zones were developed as confidence-building measures designed to prevent escalation and conflict in the space domain[22].

stance. Working paper by the Chair of the Working Group on the Definition and Delimitation of Outer Space, 2025, UN Doc. A /AC.105/C.2/L.336, par. 12.

[20] *Ibidem*. Nevertheless, the debate remains open. See, Id., Report of the Legal Subcommittee on its sixty-fourth session, UN Doc. A/AC.105/1362, parr. 82-108 and Annex II.

[21] OST, Article VIII and Moon Agreement, Article 12. See, Ireland-Piper, D. and Freeland, S., "Star laws: criminal jurisdiction in outer space", *Journal of Space Law*, Vol. 44, No. 1, 2020, pp. 44-75.

[22] Schwetje, F.K., "Protecting Space Assets: A Legal Analysis of Keep-Out Zones", *Journal of Space Law*, Vol. 15, 1987, pp. 131-146; Stubbs, M., "The Legality of Keep-Out, Operational, and Safety Zones in Outer Space", in Steer C. and Hersch, M., *War and Peace in Outer*

These early arrangements were relatively limited in scope and rooted in the logic of strategic deterrence and the imperative to avoid confrontation between rival space powers.

More recently, we are witnessing the gradual emergence of operational zones —notably surrounding the International Space Station— as well as an increasing recognition of the need to define designated orbital areas around active satellites.

2. Operational zones around the International Space Station

Originally named "Freedom", the International Space Station (ISS) was initiated under the Washington Agreement signed on 29 September 1988, by the United States, Canada, Japan, and the member states of the European Space Agency[23]. Russian Federation later joined the program in 1993, and the collaboration was formalized through the 1998 Intergovernmental Agree-

Space, Oxford University Press, Oxford, 2021, pp. 202-228; Rapp, L. (ed.), *The Spationary. A Dictionary of Essential Space Terminology for Lawyers,* Brill, Leiden, p. 373.

[23] Agreement among the Government of the United States of America, Governments of Member States of the European Space Agency, the Government of Japan, and the Government of Canada on Cooperation in the Detailed Design, Development, Operation, and Utilization of the Permanently Manned Civil Space Station, *Journal of Space Law*, Vol. 16, 1988, p. 220. The first module was launched by Russia in 1998, followed by the contribution of modules from the other partner states, resulting in the construction of one of the most important and ambitious scientific infrastructures ever created for conducting research on a global scale. Today, the programs are managed by five partner space agencies —from Canada, Europe, Japan, Russia, and the United States. The decommissioning of the ISS is currently planned between 2028 and 2030. See, Del Valle Gálvez, J.A., "La estación espacial internacional: algunos problemas jurídicos", *Revista Española de Derecho Internacional*, Vol. 43, No. 1, 1991, pp. 7-38; Moenter, R., "The International Space Station: Legal Framework and Current Status", *Journal of Air Law and Commerce*, Vol. 64, No. 4, 1999, pp. 1033-1056; De Faramiñán Gilbert, J.M., "Spanish Law and the International Space Station" in von der Dunk, F.G. and Brus, M.M., (eds.), *The International Space Station*, Leiden, 2006, pp. 203-218; Faramiñan Gilbert, J.M. and Muñoz Rodriguez, M.C., "The commercialisation of the International Space Station", in Panella, L. and Spatafora, E., (eds.), *Studi in onore di Claudio Zanghì. Diritto dello spazio e Miscellanea*, Vol. IV, Giappichelli, Torino, 2012, pp. 37-49; Faramiñan Gilbert, J.M., "The International Space Station: Legal Reflections", in *Ordine Internazionale e Diritti Umani*, 2018, pp. 49-54; Muñoz Rodriguez, M.C., "Le futur de la coopération spatiale internationale et régionale" in Achilleas, Ph., and Hobe, S., (eds.), *Fifty Years of Space Law /Cinquante ans de droit de l'espace*, Brill, Leiden, 2020, pp. 715-784.

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ment (IGA)[24]. The IGA provided for the launch of the ISS, conceived as an orbiting scientific laboratory to be built progressively through the assembly of various components —space modules— directly in orbit.

From a legal point of view, the ISS is generally classified under the broad concept of a "space object"[25]. The 1974 Registration Convention merely states that the term "space object" includes its component parts, as well as the launch vehicle and its stages. Additionally, the Convention provides the criteria for identifying a space object through a national registry, the establishment of which must be reported to the UN Secretary-General. The UN, in turn, maintains a Register of Objects Launched into Outer Space, using the information submitted by member states in accordance with the Convention[26].

Regarding jurisdiction and control over the ISS, the general rule is that each partner agency retains jurisdiction and control over the modules it registers, in accordance with the applicable legal framework governing their relationships with entities directly involved in program operations[27].

[24] Agreement Among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station, done at Washington, 29 January 1998.

[25] Its physical structure consists of multiple modules, which are also considered "space objects" assembled in geostationary orbit. However, international space law does not explicitly address the creation or placement of scientific infrastructures in orbit, nor does it offer a precise legal definition of a "space object". Such a definition depends on a preliminary issue already discussed: the definition and delimitation of outer space. Indeed, this delimitation is a prerequisite for qualifying an object placed there as a "space object" and for determining the jurisdiction and control exercised over it. See, Registration Convention. Article I; Registration Convention, Article I; and Liability Convention, Article I(d).

[26] Registration Convention, Article II. The information to be reported to the Secretary-General of the United Nations primarily concerns the launching State(s), the date and location of the launch, the appropriate identifying mark or registration number of the space object, and the main orbital parameters (nodal period, inclination, apogee, and perigee). See also, *Ibid*, Articles III and IV.

[27] In accordance with IGA, Article 5, the foundational principle is that "each Partner shall retain jurisdiction and control over the elements it registers and over personnel in or on the Space Station who are its nationals". Scientific activities aboard the ISS are carried out in line with the legal regime established by the 1998 IGA and supplemented by four Memoranda of Understanding between the NASA and each co-operating Space Agency: ESA, Canadian Space Agency (CSA), Russian Federal Space Agency (Roscosmos), and JAXA; as well as numerous bilateral and multilateral implementing agreements among the various actors

More specifically, article 16 IGA, "Cross-Waiver of Liability", establishes a comprehensive regime of mutual waiver of claims among the five Partner States, their respective related entities (including contractors, users, and other participants), and their personnel. This provision applies to damage arising out of activities carried out in the performance of the ISS Program and aims to minimize inter-party litigation by ensuring that each participant assumes responsibility for damage to its own property or personnel, irrespective of fault[28].

The waiver extends to all ISS-related activities conducted both within the ISS and in its adjacent operational area in outer space or during transit between Earth and outer space, provided they fall within the scope of the ISS related activities[29].

Although Article 16 IGA does not expressly refer to the concept of safety zones, its implementation may nonetheless support the establishment of such zones around the ISS as a matter of operational safety, consistent with current practice. In fact, commercial providers of orbital transportation services to the ISS —such as those operating under NASA's Commercial Resupply Services program[30]— are required to comply with specific operational and safety protocols, which effectively entail the delineation and respect of such zones.

Among these requirements are two key spatial safety zones designed to regulate approach procedures to the ISS: the approach ellipsoid and the keep-out sphere[31].

(partner agencies and others, including private entities and additional states) to implement the Memoranda of Understandings. These agreements cover specific areas depending on the type of program being implemented.

[28] IGA, Article 16(1).

[29] Indeed, it is important to note that Article 16 applies to damage occurring during what the IGA defines as "Protected Space Operations" —a term encompassing a broad, yet specifically delineated set of activities related to the development and utilization of the ISS, including "all launch vehicle activities, Space Station activities, and payload activities on Earth, in outer space, or m transit between Earth and outer space in implementation of this Agreement, the MOIJs, and implementing arrangements" (*Ibid*, par. 2(f)).

[30] Under the NASA's Commercial Resupply Services program, NASA, for example, awarded commercial resupply services contracts to Orbital ATK and SpaceX, each tasked with delivering a minimum of 20 metric tons of cargo to the orbiting laboratory.

[31] Koons, D.S., Schreiber, C., Acevedo, F. and Sechris, M., *Risk mitigation approach to commer-*

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The approach ellipsoid is a three-dimensional zone centered on the ISS center of mass, with dimensions aligned to the orbital reference frame[32]. Within this ellipsoid, visiting vehicles must adhere to strict navigation and coordination protocols to ensure collision avoidance and operational safety[33]. More restrictive is the keep-out sphere, defined as a sphere with a radius of 200 meters, also centered on the ISS's center of mass. Entry into this latter zone is prohibited without prior explicit authorization from NASA, if the vehicle is under its operational coordination[34].

Indeed, the key difference between the approach ellipsoid and the keep-out sphere lies in the degree of access restriction. The approach ellipsoid is a larger safety zone where spacecraft may enter without prior authorization, provided they comply with strict navigation protocols and remain under continuous coordination with NASA. In contrast, the keep-out zone is a highly restricted area —entry is prohibited unless NASA grants explicit authorization. This distinction reflects a rising level of operational risk as proximity to the ISS increases and serves to protect the station and its crew.

In any case, any of these requirements do not constitute general legal obligations under international space law but are instead specific agreements conditions imposed on commercial service providers.

In practice, NASA and its partners have formalized these zones through

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cial resupply to the International Space Station, NASA, 2010; ISS Safety Requirements Document, International Space Station Program Baseline, Doc. SSP 51721, 2019.

[32] The approach ellipsoid "is defined as the 4 x 2 x 2 km ellipsoid, centered at the ISS center of mass, with the long axis aligned with the V-Bar. The approach initiation is the first maneuver which will bring the orbital vehicle into the AE". See, Koons, D.S., Schreiber, C., Acevedo, F. and Sechris, M., *Risk mitigation approach to commercial resupply to the International Space Station*, *op. cit.*, par. 2.1.

[33] The Keep Out Sphere "is defined as a 200m radius, centered at the ISS center of mass". *Ibidem*.

[34] This measure constitutes a certification requirement applicable exclusively to commercial spacecraft seeking to dock with the ISS, rather than a general normative standard binding upon all space actors. As for the NASA Crew Transportation System (CTS), certification is the documented authorization granted by the NASA that allows the use of the CTS within its prescribed parameters for its defined reference missions. CTS certification is obtained prior to the first crewed flight (for flight elements) or operational use (for other systems). See, Crew Transportation and Services Requirements Document, 2015, Doc. no. CCT-REQ-1130, p. 182.

mission protocols and proximity operation standards for the ISS, which mandate that any visiting spacecraft coordinate approach plans and demonstrate safe abort capabilities prior to entering the designated zone[35].

Nonetheless, they represent a concrete and operationally effective model of spatial safety management and may serve as a precedent —or, at least, point of reference— , in the development of future international norms or regulatory frameworks for space traffic management and the protection of critical space infrastructure.

3. Operational zones surrounding functional satellites

In the segment of outer space deemed most operationally significant — namely, Earth orbits— international cooperation has primarily manifested through technical coordination mechanisms. This development has been driven by the growing density and complexity of satellite constellations[36].

[35] The NASA Procedural Requirements (NPR) establish the responsibilities and requirements to ensure that NASA, along with its partners, providers, and contractors, take necessary measures to preserve the near-Earth space environment. This is in alignment with the National Space Policy and the U.S. Government Orbital Debris Mitigation Standard Practices, aiming to reduce risks to human life and space missions caused by orbital debris and meteoroids. Regarding the ISS, the NPR specifically applies to NASA payloads and components expected to be released, jettisoned, or deployed from the Station. Consequently, these requirements are directly relevant to activities within the zone surrounding the ISS, including the management of debris and operational safety within that space. See, *NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments*, *op. cit.*, p. 4; and the updated version, Doc. NPR 8715.6E, *op. cit.*

[36] Between January and April 2025, over 1,200 satellites were launched worldwide, marking a significant increase from approximately 800 during the same period in 2024. This surge reflects intensified global space exploration efforts and a substantial rise in commercial satellite deployments. SpaceX has been a major contributor to this surge, launching 573 Starlink satellites in the first quarter of 2025 alone. This is a notable increase from the 472 satellites launched during the same period in 2024. Other significant contributors include Amazon and Chinese enterprises. Amazon's Project Kuiper initiated its operational phase in April 2025, launching its first set of 27 internet satellites to compete with SpaceX's Starlink. Meanwhile, China has been actively expanding its satellite capabilities, launching multiple satellites for its Guowang low Earth orbit megaconstellation. See, Gover, M., "Record-Breaking 1,200+ Satellites Launched in 2025", *Orbital Today*, 16 June 2025. The exponential increase in the number of satellites orbiting Earth is generating growing risks related to space debris, as highlighted in the recent ESA Report 2024, which describes increasingly crowded or-

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Nevertheless, such cooperation remains predominantly procedural and technical and has not yet evolved into a comprehensive regulatory framework capable of systematically addressing current challenges such as orbital congestion, environmental degradation, or the equitable distribution of orbital resources[37].

Within this context, the International Telecommunication Union (ITU) continues to play a central role[38]. It is responsible for the registration of orbital slots and the assignment of frequency bands notified by States for their national satellite operators. Although the ITU's mandate remains largely technical, it performs a critical function in preventing interference and overlapping operations in adjacent orbital positions and frequency allocations[39].

This regulatory function effectively promotes physical and spectral separation among space objects, leading in practice to the delineation of operational zones around satellites —zones that serve to preserve both functionality and the integrity of space-based systems.

More specifically, Articles 9 and 11 of the ITU Radio Regulations contribute to the emergence of operational zones for regulating safety in outer space, particularly in the geostationary orbit.

Indeed, Article 9 ITU Radio Regulations governs coordination procedures obliging States to notify the ITU of their proposed use of orbital resources and to engage in consultations with potentially affected administrations in order to mitigate the risk of harmful interference[40]. On the other hand,

bits filled with fast-moving, hazardous fragments from defunct satellites and rocket bodies. *ESA's Annual Space environment report 2024*, 2025.

[37] Cinelli, C., *La disciplina degli spazi internazionali e le sfide poste dal progresso tecnico-scientifico*, *op. cit.*, p. 109 ss.

[38] Codding, G.A., *The International Telecommunication Union: An Experiment in International Cooperation*, Arno press, New York, 1952.

[39] Brobst, J.A., "Role of the International Telecommunication Union in Regulating Space Activities", in Bhat S.B., Ukey D. and Variath, A., (eds.), *International Space Law in the New Space Era: Principles and Challenges*, pp. 204-229.

[40] Article 9 sets out the procedural framework through which administrations coordinate or seek agreement regarding frequency assignments for satellite networks and systems. Prior to initiating any formal action under Article 11, an administration —or a group acting on its behalf— must submit a general description of the satellite network or system to the ITU Radiocommunication Bureau for advance publication in the International Frequency Information Circular (BR IFIC). This submission should ideally occur no earlier than seven years

Article 11 ITU Radio Regulations complements this by establishing the framework for the formal notification and recording of frequency assignments and orbital positions in the Master International Frequency Register (MIFR), thereby conferring international recognition and protection upon such assignments[41].

Together, Articles 9 and 11 of the ITU Radio Regulations establish indeed a structured and technical framework crucial for safeguarding orbital zones by promoting transparent use of spectrum resources and preventing harmful interference. The dispute between Eutelsat and the Russian Satellite Communications Company (RSCC) offers a practical illustration of the critical importance of these mechanisms. Although primarily arising from financial obligations, the disputed involved claims about unauthorized use and the need to preserve operational integrity and frequency rights. This underscores the complexity and necessity of maintaining clear and enforceable operational agreements within orbital regions.

The resolution of this dispute restored a cooperative relationship, highli-

and no later than two years before the satellite network is expected to enter service. Once the complete information is received, the Bureau publishes it within a two-month timeframe, unless otherwise unable to meet this deadline, in which case it must notify all relevant administrations accordingly. The Bureau plays a crucial role in this process by informing all administrations of those that have submitted comments and providing summaries of these concerns, thus promoting transparency and facilitating cooperative problem-solving. Ultimately, the procedures set forth in Article 9 serve not only to coordinate the technical use of space radiocommunications but also to keep administrations informed of ongoing developments and foster harmonious use of the satellite spectrum and orbital resources. See, specifically, ITU, Article 9 (Section I and II).

[41] Article 11 establishes the procedures for the notification and recording of frequency assignments to transmitting and receiving stations. The term "frequency assignment" encompasses both new assignments and changes to existing ones already recorded in the Master International Frequency Register (*Ibid*, Section I). Administrations are required to notify the ITU Radiocommunication Bureau of any frequency assignment that could cause harmful interference to other administrations, is intended for international radiocommunication, falls under a regional or global allotment plan without its own notification process, is subject to coordination under Article 9, or when international recognition is sought. The notification obligation also applies to associated receiving stations under certain conditions, and administrations may notify frequency assignments used by radio astronomy stations if they wish the data to be recorded. This process ensures the accurate recording of frequency assignments in the MIFR, facilitating international coordination and reducing interference risks (*Ibid*, Section II).

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ghting the importance of legal certainty alongside technical coordination in protecting designated orbital zones. This case exemplifies how technical and regulatory mechanisms established by the ITU must be complemented by robust legal frameworks to ensure the effective management and protection of orbital resources.

At this stage of the analysis, it is important to underline that Articles 9 and 11 of the ITU Radio Regulations establish the technical coordination and notification mechanisms for those activities typically governed by Earth-orbit-specific frameworks, including those discussed within UNCOPUOS in relation to the Guidelines on the long-term sustainability of outer space activities (LTS Guidelines)[42].

The LTS Guidelines considers that the long-term sustainability of outer space activities reflects a need to identify the general context of, and modalities for, continuous improvements in the way that space actors remain committed to the use of outer space for peaceful purposes, so as to ensure an equitable access and utilization of celestial resources and that the outer space environment is preserved for current and future generations [43].

Both frameworks —the ITU Radio Regulations and the LTS Guidelines— advocate for information sharing, operational separation, and transparent management of orbital and spectral resources, with the overarching goal of preventing physical and radiofrequency interference.

Indeed, the idea of an operational perimeter surrounding active satellites is implicitly affirmed in both instruments: the ITU rules formally prescribe spatial and spectral constraints through mandatory notification and coordination procedures, while the LTS Guidelines, as a form of soft law, encourage responsible conduct and cooperative norms to preserve space sustainability.

At the domestic level, competent authorities increasingly align their regu-

[42] Report of the Committee on the Peaceful Uses of Outer Space, UN Doc. A/74/20, Annex II (UN Doc. A/AC.105/2018/CRP.20), Guidelines for the long-term sustainability of outer space activities, 12-21 June 2019. In order to underscore the significance of the milestone achieved, the President of the 62nd session of COPUOS, Andre Rypl —during which the aforementioned guidelines were adopted— remarked: "[w]e started this session talking about how we at COPUOS make the impossible possible. We have done just that. The guidelines on the long-term sustainability of outer space activities and, more importantly, the decision to move forward and advance the concept of sustainability in space, is probably the most significant achievement of COPUOS in a decade". UN Doc. UNIS/OS/518, 2019.

[43] UN Doc. A/AC.105/2018/CRP.20, *op. cit.*, par. 6.

latory frameworks with internationally recognized best practices. A notable example is the recent decision by the U.S. Federal Communications Commission (FCC), which granted partial authorization to SpaceX for its second-generation Starlink system (Starlink Gen2)[44]. This constellation envisions the deployment of nearly 30,000 non-geostationary satellites distributed across multiple orbital shells at altitudes ranging from approximately 340 to 614 kilometres[45].

In its order, the FCC assigns defined altitudes and orbital inclinations to specific segments of the constellation, thereby facilitating orbital traffic management and reducing the risk of radiofrequency and physical interference among operators[46]. Through these measures, the FCC effectively operationalizes the concept of "operational zones" by establishing clear spatial and technical boundaries within which satellite operations must be conducted[47].

This regulatory approach demonstrates how national authorities can give practical effect to international standards and soft-law instruments by integrating them into binding domestic law.

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[44] Federal Communications Commission, FCC 22-91, 29 November 2022, pp. 1-3.

[45] *Ibid*, p. 6.

[46] *Ibid*, p. 39 ss.

[47] The Federal Communications Commission (FCC) assigns specific altitudes and orbital inclinations to designated segments of satellite constellations. This approach facilitates orbital traffic management and mitigates the risk of both radiofrequency interference and physical collisions among operators. Through such measures, the FCC effectively delineates spatial and technical parameters within which satellite operations must be carried out.
In recent years, an increasing number of States have adopted national space legislation to regulate space activities within their jurisdiction. For instance, on 12 June 2025, Italy enacted its first Space Economy Law, establishing a regulatory framework applicable to private entities conducting space operations under Italian jurisdiction. Neither this law nor the majority of comparable national legislations explicitly refers to safety zones. Instead, they generally require operators to adopt "appropriate measures" to ensure the safety and sustainability of their activities. With regard to the United Arab Emirates, the Cabinet Resolution No. (19) of 2023, which sets forth the Space Resources Regulations, refers in Article 8 to the implementation of "safety measures in the area associated with authorised Space Resources Activities". However, this provision remains broadly framed and will require further specification and operational implementation through subsequent regulatory instruments.

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III. TOWARDS A NORMATIVE REGULATORY FRAMEWORK OF SAFETY ZONES ON CELESTIAL BODIES

The increasing complexity and scale of planned activities on celestial bodies, in particular lunar missions[48], necessitate the development of clear normative frameworks to establish and manage safety zones that protect both operations and scientific interests. Safety zones have been introduced in recent years through non-binding instruments, most notably The Hague Building Blocks for the Development of an International Framework on Space Resource Activities (the Hague Building Blocks)[49] and the Artemis Accords[50]. Together, the Hague Building Blocks and the Artemis Accords, form a critical foundation for the progressive establishment of a normative regulatory framework governing safety zones on celestial bodies.

1. The contribution of the Hague Building Blocks to establish a safety zone, or other area-based safety measure

The Hague Building Blocks provide a set of non-binding normative provisions aimed at guiding the development of international regulatory framework for space resource utilization. They propose that safety zones may serve as a cooperation mechanism to prevent harmful interference with ongoing operations.

More specifically, the Building Block 11, titled "Technical Standards for, Prior Review of, and Safety Zones Around Space Resource Activities", ad-

[48] Potter, N., "The Many Planned Moon Landings of 2025 (and Beyond). NASA, China, and others are in a new, and patient, space race", *Spectrum.ieee.org*, 25 February 2025.

[49] Hague International Space Resources Governance Working Group, Building Blocks for the Development of an International Framework for the Governance of Space Resource Activities, 2020. For a commenatry, Bittencourt Neto, O., de O., Hofmann, M., Masson-Zwaan, T., and Stefoudi, D., (eds.), *Building Blocks for the Development of an International Framework for the Governance of Space Resource Activities: A Commentary*, Eleven International Publishing, 2020; Fengna Xu, J.S., "New Elements in the Hague Space Resources Governance Working Group's Building Blocks", *Space Policy*, 2020.

[50] Artemis Accords: *Principles For Cooperation in The Civil Exploration And Use Of The Moon, Mars, Comets, And Asteroids For Peaceful Purposes, 13 October 2020. For a commentary,* Deplano, R., "The Artemis Accords: Evolution or Revolution in International Space Law?", *International and Comparative Law Quarterly*, 2021, pp. 799-819.

dresses the need to ensure that space resource activities are conducted safely and without causing harmful impacts[51].

This suggests that States may establish temporary safety zones around areas of space resource activity to avoid harmful interference. In any case, these zones must not violate the principle of non-appropriation and should not block free access by other operators according to OST[52].

Restrictions should be time-limited and based on prior public notice[53]. In cases where safety zones overlap or cause disputes over access, the framework should provide for international consultations to resolve conflicts[54].

First and foremost, it is essential to underline that the scope of Building Block 11 specifically relates to "safety zones around space resource activities". Accordingly, it is important to clarify what is meant by space resource activity. Consistent with the definitions outlined in the same Building Blocks, this refers to "an activity conducted in outer space for the purpose of searching for space resources, the recovery of those resources and the extraction of raw mineral or volatile materials therefrom, including the construction and operation of associated extraction, recovery, processing and transportation systems"[55].

Accordingly, the building block adopt a functional rather than strictly geographic scope, indeed focusing on "space resource activities". Furthermore, the term space resources is defined as "an extractable and/or recoverable abiotic resource in situ in outer space[56]. According to the understanding adopted by the Working Group, this includes mineral and volatile materials, including water, but explicitly excludes: (a) satellite orbits; (b) radio frequency spectrum; (c) energy from the sun, except when collected from unique and scarce locations[57].

Therefore, the concept of safety zones as addressed in this Building

[51] The Hague Building Blocks, 11(1, 2).

[52] *Ibid*, 11(3).

[53] *Ibidem*. A Technical Panel has proposed five guiding principles: safety zones must protect operations, comply with the OST, be clearly justified, be transparent where possible, and support the safe and efficient use of space resources.

[54] *Ibid*, 11(4).

[55] The Building Block, 2(3).

[56] *Ibid*, 2(1).

[57] *Ibidem*.

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Block applies to a specific operational context—namely, activities associated with space resource utilization—and thus differs in scope and legal characterization from other categories of operational zones, such as those intended for regulating the safety of satellite operations or the ISS programme.

The Commentary on the Building Blocks emphasizes that the legal basis for the establishment of safety zones and associated technical standards is closely grounded in OST, especially, articles I, II, VI and IX[58].

Pursuant to Articles I and II, any decision to establish a safety zone should carefully balance the imperative of ensuring operational safety with the principle of non-appropriation and the freedom of access to all areas of celestial bodies. The language employed in the Building Blocks is deliberately guarded to avoid any suggestion of territorial control or the conferment of exclusive rights

Article VI OST provides that States bear international responsibility for all national space activities, whether undertaken by governmental bodies or by private entities. The concept of safety zones can thus be viewed as a practical mechanism through which a State fulfils its due diligence obligations under Article VI[59].

Furthermore, Article IX OST complements this framework by addressing situations where space activities may give rise to potentially harmful effects, such as interference resulting from the extraction or use of space resources. It obliges States to carry out all space activities with due regard to the corresponding interests of other States Parties, to avoid harmful contamination or adverse changes to the space environment, and to engage in international consultations where planned activities are likely to cause harmful interference.

These obligations reinforce the necessity of preventive technical and legal measures—such as the delineation of safety zones—as part of responsible conduct in outer space.

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[58] Bittencourt Neto, O.O., Hofmann, M., Masson-Zwaan, T. and Stefoudi, D., (eds.), *Building Blocks for the Development of an International Framework for the Governance of Space Resource Activities: A Commentary*, Eleven International Publishing, The Hague, 2020, p. 67 ss.

[59] Morozova E., "Safety Zones as a Means to Ensure a Balanced Liability Regime in Space", in Blount, P.J., Masson-Zwaan, T., Moro-Aguilar, R., and Schrogl, K-U., (eds.), *Proceedings of International Institute of Space Law*, Eleven International Publishing, The Hague, 2019, pp. 359-374.

2. The Artemis Accords to the definition and determination of safety zones and harmful interference

At international level, one of most recent advancements, is that related to the implementation of the Artemis Lunar Program, i.e. the adoption of the Artemis Accords in 2020. They are adopted by the United States plus 54 States as of May 2025, and "represent a political commitment"[60] in accordance, at least in theory, with principles and norms set up by OST.

The overall purpose and scope of these Accords is to establish, including by adopting and implementing 'accords' between States signatories, a common vision to enhance the governance of the civil exploration and use of the Moon and other celestial bodies, with the intention to advance the Artemis Lunar programme[61].

In contrast to the Hague Building Blocks —which adopt a functional approach based on the nature of space resource exploration and utilization activities irrespective of their location— the Artemis Accords embrace a spatially defined framework. Their scope is limited to specific celestial environments beyond Earth orbit, namely the Moon, Mars, asteroids, and comets, reflecting the operational priorities and strategic objectives of NASA's civil space exploration agenda[62].

In the context of activities conducted under the Artemis Accords, a set of cooperative procedures is established to ensure the deconfliction of space operations, meaning the prevention and mitigation of potential interference between concurrent missions by different actors[63]. These procedures are primarily grounded in the overarching obligation under Article IX OST to exercise "due regard" for the activities of others and to avoid "harmful in-

[60] Artemis Accords, Section 1.

[61] *Ibid*, Section I(1).

[62] *Ibid*, Section I(2) establish that space activities "may take place on the Moon, Mars, comets, and asteroids, including their surfaces and subsurfaces, as well as in orbit of the Moon or Mars, in the Lagrangian points for the Earth-Moon system, and in transit between these celestial bodies and locations".

[63] Artemis Accords, Section 11.

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terference"[64].

To operationalize these principles, the Signatories of the Accords commit to conducting their activities in accordance with the Guidelines LTS, adapting them as necessary for environments beyond low Earth orbit. This includes the proactive exchange of information concerning the location, scope, and timing of planned operations, particularly where there is a foreseeable risk of interference or hazard[65].

A key component of this cooperative framework is the definition and demarcation of safety zones[66]. Safety zones are the areas around space activities where notification and coordination with relevant actors are required in order to prevent harmful interference. These zones encompass the region in which the normal operation of a mission —or any potential anomaly— could reasonably be expected to interfere with other activities[67].

The Artemis Accords seem to establish fundamental principles guiding the creation and management of safety zones, generally emphasizing proportionality, reasonableness, temporariness and adaptability, as well as transparency.

Proportionality requires that the size and scope of a safety zone, along with the extent of notification and coordination, be commensurate with the nature of the activity and the specific characteristics of the environment in which it occurs[68].

Reasonableness further demands that the boundaries of safety zones be determined objectively and logically, based on widely accepted scientific and engineering standards[69].

The principles of temporariness and adaptability recognize that safety zo-

[64] *Ibid*, 11(1,3). See, Harrington, A.J., "Due Regard as the Prime Directive for Responsible Behavior in Space", *Loyola University Chicago International Law Review*, Vol. 20, 2023, pp. 57-86, p. 82 ss.; Mallowan, L., Rapp, L. and Topka, M., "Reinventing treaty compliant "safety zones" in the context of space sustainability", *Journal of Space Safety Engineering*, Vol. 8, 2021, pp. 156-166; Xiaodao, L. and Jie, L., "Developing safety-zone rules: Based on an institutional choice framework", *Space Policy*, Vol. 71, 2025, pp. 1-13, p. 2 ss.

[65] *Ibid*, 11(2,5).

[66] *Ibid*, 11(6).

[67] *Ibid*, 11(7).

[68] *Ibid*, 11(7a).

[69] *Ibid*, 11 7b).

nes are inherently temporary and must evolve in size and scope in response to changes in the operational status, ultimately ceasing to exist once the relevant activity concludes[70].

Finally, transparency obliges Signatories to promptly notify other parties and the Secretary-General of the United Nations about the establishment, modification, or termination of any safety zone in strict compliance with the notification requirements set forth in Article XI OST[71].

Indeed, safety zones, as envisioned in the Artemis Accords, represent a voluntary mechanism adopted by a coalition of like-minded States —primarily strategic partners of the United States— aimed at ensuring the protection of space activities on celestial bodies. Their success will depend not only on technical soundness but also on adherence to international legal norms and constructive dialogue with all spacefaring actors, including non-signatories to the Artemis Accords[72].

[70] *Ibid*, 11(7c).

[71] *Ibid*, 11(7d).

[72] It has also been suggested from a technical and policy standpoint, that safety zones should be mission-specific and based on an assessment of potential hazards. These may include, but are not limited to regolith displacement, radiation (ionizing and non-ionizing), mechanical failures (e.g., pressure vessel ruptures), hazardous chemical releases, interference with sensitive instruments, or terrain-induced risks such as shadowing or dust contamination. Rather than imposing rigid parameters (such as a fixed two kilometers radius), the design of safety zones should be context-sensitive and derived from scientific and engineering analysis, as well as geographic considerations of the operational environment. See, Swiney, S. and Hernandez, A., *Lunar Landing and Operations Policy Analysis*, Report ID 20220015973, NASA Office of Technology, Policy, and Strategy, 2022, pp. 29-35. Other authors note that the current position of States regarding the Artemis Accords is far from unanimous: some delegations view the Accords as potential starting point for future regulatory developments concerning space resources, while others criticize them for being implemented outside the framework of international organizations. See, Gutiérrez Espada, J.M., "Section 10 of the Artemis Accords (on the natural resources of space, the moon and other celestial bodies)", *Cuadernos de Derecho Transnacional*, Vol. 16, No. 2, 2024, pp. 859-873.

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IV. NORMATIVE INSIGHTS ON THE CONCEPT OF SAFETY ZONES IN OUTER SPACE AND ON CELESTIAL BODIES

As in other domains, international law outlines several types of "safety zones", depending on the specific legal regime involved, adopting both functionalist and spatial approaches. For instance, according with a functionalist approach, international humanitarian law allows for the establishment of different types of protected or safe areas, all aimed at safeguarding civilians and persons not taking part in hostilities from the effects of armed conflict[73]. Such zones are established within the territory of a belligerent State. Their creation typically occurs through explicit agreement between the Parties to the conflict, often facilitated by the International Committee of the Red Cross (ICRC) as a neutral intermediary[74]. In certain circumstances, their establishment may also be endorsed by the United Nations Security Council, particularly in situations involving threats to international peace and security[75].

According to more spatial approach, the UN Convention of the law of the sea (UNCLOS)[76] —which is now widely regarded as reflecting customary law— allows coastal States to establish safety zones up to 500 meters around artificial islands or structures in their exclusive economic zones and continen-

[73] The Geneva Conventions (GC) and their Additional Protocols I and II (API and APII) draw a systematic distinction between various categories of protected zones, including non-defended localities (API Art. 59), hospital and safety zones and localities (CGIV, Article 14 and Annex I), neutralized zones (GCIV Art. 15), and demilitarized zones (API, Art. 60). See, Gillard, E., "Safe Areas. The international legal framework", *International review of the red cross*, Vol. 99, No. 906, 2017, pp. 1075- 1101.

[74] The IV Geneve Convention underscores the role of the protecting powers and the ICRC, who are expressly invited to offer their good offices with a view to supporting and facilitating the establishment and formal recognition of hospital and safety zones and localities (GCIV, Art. 14).

[75] Among other examples, in Bosnia, the Security Council established "safe areas" (e.g., Srebrenica, Sarajevo) via Resolutions 819, 824, and 836 (1993), mandating UNPROFOR to deter attacks and ensure humanitarian aid. In Rwanda, the Security Council expanded UNAMIR's mandate via Resolution 918 (1994) to create "secure humanitarian areas".

[76] The UN Convention on the Law of the Sea (UNCLOS) regulates the maritime spatial distribution of State sovereignty, sovereignty rights and jurisdiction by dividing the oceans and seas into multiple jurisdictional zones. Coastal States exercise specific powers and control in their nearest (sub)marine areas, which gradually decrease by moving away from the coast.

tal shelves to ensure the exercise of States' sovereign rights and jurisdiction[77]. It is well-established that third States must respect such zones once they have been duly established.

By contrast, international air law contains no explicit treaty provisions authorizing the establishment of "air defense identification zones" (ADIZs). However, the 1944 Convention on International Civil Aviation (ICAO) sets conditions and procedures governing access to State national airspace. This includes the airspace above their land territory, territorial sea and, for archipelagic States, the waters enclosed by archipelagic baselines[78].

Furthermore, the ICAO affirms that aircraft, regardless of their location —including when flying over the high seas— are subject to the rules relating the flight and maneuver established by the Convention[79]. In practice, individual States have implemented unilateral measures that significantly affect such flights over the high seas, notably through the temporary imposition of restrictions in designated danger areas. This practice has gone unchallenged, suggesting that the right to establish an ADIZ might be now widely accepted as a legitimate exercise of State under international law[80].

As for regulatory frameworks, like the Antarctic legal system, protected areas are primarily regulated under the Madrid Protocol of 1991, which supplements the Antarctic Treaty with specific provisions for environmental protection[81].

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[77] UNCLOS, Article 60 and 80. Furthermore, UNCLOS Part XIII specifies that the deployment of scientific research installations or equipment shall not constitute an obstacle to established international shipping routes (*Ibid*, article 261). Such installations and equipment bear identification markings indicating the State of registry or the international organization to which they belong, and have adequate internationally agreed warning signals to ensure safety at sea and the safety of air navigation (*Ibid*, article 262).

[78] ICAO, Article 2.

[79] *Ibid*, Articles 11 and 12.

[80] Roach, A., "Air Defence Identification Zones", *Max Planck Encyclopedias of International Law*, 2017, par. C (6).

[81] The Protocol establishes several categories of protected areas aimed at preserving the unique environmental, scientific, historic, and aesthetic values of the continent. Among these are Antarctic Specially Protected Areas (ASPAs), which are designated to safeguard significant natural or scientific features, and where access is strictly controlled and requires special permits. In addition, there are Antarctic Specially Managed Areas (ASMAs), which are intended to coordinate multiple activities, prevent conflicts, and minimize environmental

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Furthermore, practice shows that safety zones are established around national scientific stations, according to national guidelines and coordinated multilaterally among States to prevent interference and ensure environmental stewardship[82].

Despite variations in terminology, legal character, and operational purpose, international law regulates safety zones that serve to define spatial boundaries for the exercise of certain State rights, as well as to enhance situational control and mitigate risks. It is therefore essential that each type of safety zone complies not only with the general principles of international law, but also with the specific principles underlying the legal regime under which it is established —be it international humanitarian law, the law of the sea, airspace law or Antarctic legal system.

It is therefore not incorrect to emphasize that, within the framework of the principles governing the international legal regime applicable to outer space, safety zones are not, in principle, unlawful. They represent the extension of jurisdiction exercised over space objects and/or (future) space stations; an extension which is necessary for the effective implementation of the provisions of the United Nations space treaties.

The outstanding issue concerns the extent to which jurisdiction may be exercised. It is essential to articulate a range of relevant factors, including, at a minimum: the actor conducting the activity, the location in which the activity is carried out, and the nature or object of the activity itself.

With regard to the actor, it is pertinent to determine whether the State establishing the operational zone is the one exercising jurisdiction and control over the space object concerned. Additionally, the involvement of third States must be considered, particularly whether their participation is governed by a specific agreement among the States involved.

Furthermore, the location in which the activity is carried out, i.e. in outer

impacts without fully restricting access. Furthermore, Historic Sites and Monuments (HSMs) are protected due to their cultural or historical importance, often related to early Antarctic expeditions. The legal framework for the designation and management of these areas is set out in Annex V of the Madrid Protocol, which outlines the procedures for their protection and oversight.

[82] See for example, United States Antarctic Program, *Management Plan for Antarctic Specially Managed Area No. 5: The Amundsen-Scott South Pole Station*, par. 6ii(a), titled, "Operational Zone", available at: https://www.usap.gov.

space (such as, in orbit) and on celestial bodies, may be relevant. Although the OST applies both to outer space and to celestial bodies, certain principles acquire different meanings depending on the operational context[83].

In orbital space, the environment is characterized as a dynamic three-dimensional volume occupied by high-velocity objects. In this context, operational zones are inherently temporary and fluid, typically defined by technical and safety-related considerations, including collision avoidance protocols, debris mitigation measures and close approach warnings.

Conversely, activities conducted on the surface of celestial bodies are often more static and enduring in nature —for example, the establishment of scientific installations or the conduct of resource utilization operations. In such cases, the creation of an operational zone may entail a sustained presence, thereby raising legal concerns regarding potential *de facto* appropriation, which is expressly prohibited under Article II OST.

Finally, depending on the nature and objective of the activity conducted in outer space or on celestial bodies, a complex balancing of competing interests arises between involved States.

This balance might justify the adoption of differentiated restrictive measures vis-à-vis third States. Such measures may range from the mere notification of access procedures to the establishment of temporary exclusive zones, aimed at ensuring the safety of operations, protecting space assets, or safeguarding natural resources being extracted or exploited. The specific nature of the activity —particularly when related to sensitive operations such as infrastructure deployment or resource utilization— thus might legitimize the adoption of such restrictive measures within cooperation frameworks.

These factors seem to be indispensable for the development of a coherent legal framework capable of addressing the increasing complexity of space-related activities, particularly considering the principles of free access, non-appropriation, due regard obligation and the obligation of avoid harm-

[83] The 1979 Moon Agreement, however, appears to introduce normative boundaries within the international space regulatory framework: a freedom-of-use regime governing the geostationary orbit and the deep space and a common heritage of mankind regime applicable to celestial bodies and their natural resources. Despite this conceptual division, the dual structure remains uneven in practice, revealing significant gaps and inconsistencies in its implementation. Status of Moon Agreement ratification on 1 January 2025: 17 States. V. McKeown, B., Dempster, A.G., and Saydam, S., "Artemis Accords: Are Safety Zones Practical for Long Term Commercial Lunar Resource Utilization?", *Space policy*, 2022.

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ful interference.

V. CONCLUSIONS

This study has demonstrated that, within the current framework of international space law, the establishment and enforcement of safety zones are characterized by significant ambiguity and a lack of explicit, binding normative instruments. Nevertheless, this does not imply that safety zones are inherently unlawful. Under certain conditions and subject to specific criteria, their implementation may be necessary to balance the principle of free access to outer space —enshrined in Article I OST— with the obligations of due regard and non-harmful interference under Article IX OST. Such measures should, however, strictly adhere to the fundamental tenets of international law, including the non-appropriation principle and the requirement that outer space activities be conducted for the benefit and in the interest of all countries, irrespective of their degree of development.

In any event, the status of international outer space law evidences a lack of clearly defined criteria that would comprehensively take into account critical parameters such as: "who" conducts the activity; "where" the activity takes place; and "what" the activity entails in terms of its nature and purpose.

This regulatory gap continues to present challenges for the consistent and equitable application of the relevant legal principles in relation to the establishment of safety zones in outer space and on celestial bodies.

Perhaps the issue lies at a more fundamental level: international outer space law remains too embryonic and underdeveloped to fully address the complexities of current space activities. Consequently, before such safety zones can be effectively established and enforced, it is essential to address the definition and delimitation of outer space in relation to airspace, along with its internal subdivision into distinct spatial zones.

This approach mirrors historical developments in other areas of international law, such as the law of the sea, international air law, and the Antarctic Treaty System, which all emerged in response to evolving maritime, aerial, and scientific activities, respectively. Importantly, this does not imply a national territorialization of outer space; rather, similar to Antarctica legal regi-

me[84], these zones can remain beyond national jurisdiction, while being regulated through international agreements that define and govern specific areas.

Adopting such a zonal framework would not only clarify the spatial scope and legal status of safety zones, but also facilitate their use as concrete regulatory instruments to advance safety, sustainability, and peaceful use in outer space.

In this context, the OST can be understood as a "living instrument", capable of evolving to incorporate emerging principles such as sustainability in outer space. Accordingly, COPUOS should assume a central role in guiding multilateral negotiations toward the development and adoption of clear guidelines or protocols that embed safety zones within broader sustainability frameworks. This process must be inclusive and universally representative, setting itself apart from initiatives like the Artemis Accords, which, although important, reflect only a segment of the international community.

It is therefore imperative that the establishment and enforcement of safety zones be pursued through multilateral, legally binding instruments adopted under the auspices of universally representative for a, such as COPUOS, in order to ensure legal certainty, prevent unilateral appropriation or fragmentation, and uphold the foundational principles of international law.

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[84] One should also consider the recent United Nations Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ Agreement), adopted on 19 June 2023 by the Intergovernmental Conference on Marine Biodiversity of Areas Beyond National Jurisdiction, UN Doc. A/CONF.232/2023/4.

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