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Normative Framework For Global Coherence Of Safety Standards For Space Operation **Kaja Hopej^{a*}, Katarzyna Malinowska^b**

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Abstract

Space infrastructure has become a critical element that is gradually emerging in the government policies around the world. As a result of the identification of space as a strategic and operational domain the landscape of space activities require appropriate legal solutions to safely maintain space operations (both civilian and military) into the long-term perspective. As the space activity is intensifying in volume and types, there are several factors that have influenced the paradigm shift toward a supranational approach to ensuring the resilience of space capabilities. In order to meet this challenge, space law framework to ensure safety and minimise risk, in the form of collisions, break-ups, explosions or other hazards is gradually evolving. With the view to encourage the development of the sector and responsible behaviour, an appropriate regulatory framework should be proposed, promoting clear space legislation to maintain the security of space operations. With the increase in private, but also military, participation in space endeavours, it is becoming necessary to increase awareness and implementation of relevant practices in space within international and national legal frameworks. Therefore, according to the authors, favourable legal framework creates an environment for long-term space exploration. Furthermore law should be seen as a risk management method, which requires a certain level of unification and universalisation as well as it should take on an appropriate preventive role in order to function effectively. The authors' aim is to draw conclusions as to how the governance and regulation of the space sector affects sustainable space exploration and what would be the optimal legal solutions in this aspect. Therefore the authors pay particular attention to the evolving legal framework and normative environment focused on global coherence of technical standards and best practices to develop harmonised standards for secure space operations at supranational and national level.

Keywords: space law, standardization, dual use, sustainable development, technical standards

1. Introduction

Historically, the understanding of outer space activities were largely determined by the policies of pioneering spacefaring nations, primarily the US and the USSR. Their initial focus centered on scientific and technological advancements mostly driven by defense purposes. While early government initiatives prioritized these military and technological aspects, over time, a growing emphasis shifted towards the industrialization and commercialization of space activities. The first decade of the 21st century saw a significant increase in the activities of commercial space actors and notable development in the creation and revision of national space programs and policies. This period which witnessed the rapid expansion of the space market, encouraged many countries to prioritize the development of their own national space expertise. As an increasing number of countries broadened their space activities and capabilities, the need for structured organization and coordination became evident, necessitating a degree of formalization.[1] Consequently, numerous countries have rapidly formulated national space legislations, increasingly introducing aspects of environmental protection, risk assessment or safety of space operations in the form of references to various standards and international guidelines in this area. Consequently, despite the existence of various well-known universal standards for space operations, fragmentation and heterogeneity have increasingly grown in the application of the relevant standards leaving some doubt as to their applicability.

The current landscape of the space sector is increasingly shaped around commercial activities. For example, in 2023, the global space economy was estimated at the level of \$400 billion, with the satellite industry comprising a significant majority at \$285 billion (71% of the space sector revenues)[2]. The space economy is

estimated to have grown to between \$570 billion and \$630 billion in 2023 and is projected to reach \$1.8 trillion by 2035.[3] This growth was supported by the deployment of 2,800 commercial satellites and 223 launch attempts in 2023, of which 212 were successful.[4] This state of affairs not only indicates a paradigm shift towards increased commercialization but also suggests a growing risk of orbital congestion. Geopolitical shifts are again highlighting the military aspects and dual-use capabilities of space infrastructure. Contributing to this is the increasing development of space defense strategies at both national levels, and at the regional level with the European Space Strategy for Security and Defence implemented in 2023. [5]

A recent tendency reveals a growing danger from space debris that increasingly survives atmospheric reentry, landing on Earth and presenting a significant threat to human health and life. Within a few months, this has been observed in the territory of Kenya [6] or Poland [7] , further intensifying the international discussion on security standards in the space sector and appropriate practices for responding to such emergencies.

2. Binding laws versus recognized international standards

The space law ecosystem is made up of five international treaties as a foundation¹ customs and practice of countries, UN General Assembly Resolutions² , international agreements (bilateral and multilateral)³ , UE law (i.e. communication directives) as well as national laws. Regulation of the space environment at international level contains gaps in its comprehensive protection and in addressing critical issues such as space debris. From the level of international space law, the existing provisions are scarce and in fact only several articles point to environmental protection (article IX⁴ of the Outer Space Treaty), including one directly (article 7⁵ of the Moon Agreement).

National regulations are more comprehensive, which often refer in their laws to internationally recognised standards. As defined by NOAA, US Department of Commerce, *‘space standards are guidelines, best practices, and recommendations that describe the specifications, dimensions, and requirements for designing and operating equipment, and systems in space. These help ensure the safety, reliability, and compatibility of space missions and activities within and across organizations, as well as facilitate international cooperation and coordination.* [8]In space sector, due to its inherent global nature, we need not just standards, but supranationally recognized standards, which can provide a reference framework and a common language, facilitating trade and technology transfer, prioritizing the description of performance requirements and interfaces, and offering a means of verification. [9] They should be well-suited for contractual mechanisms and ensure shared technical knowledge and computability. Furthermore, they should provide a basis for health, safety, and environmental legislation. By following standards, space professionals can ensure the safety, reliability, and compatibility of space systems in a safe and sustainable manner.[10]In this context, the technical standards, as in any other field, should be set by national regulations in order to be fully enforceable. However, in the case of technical safety, it may simply be based on the universal, unbounded state of the art and is central to the considerations here. Its enforceability can be based on an originally national law, but also on a ratified international law - if it is addressed to all stakeholders, including private entities (as is the case, for example, in the Chicago Convention, where both governments and airlines are bound by

¹ The "Outer Space Treaty" Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies entered into force on 10 October 1967 The "Rescue Agreement" Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space entered into force on 3 December 1968 The "Liability Convention" Convention on International Liability for Damage Caused by Space Objects entered into force on 1 September 1972 The "Registration Convention" Convention on Registration of Objects Launched into Outer Space entered into force on 15 September 1976 The "Moon Agreement" Agreement Governing the Activities of States on the Moon and Other Celestial Bodies entered into force on 11 July 1984.

² RES 1721 (XVI), A/RES/55/122, A/RES/59/115, A/RES/62/101, A/RES/68/74, A/RES/72/78.

³ Such as International Telecommunication Union, International Space Station Agreement (or Memorandum of Understanding).

⁴ "[...] States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose[...]"

⁵ "1. In exploring and using the moon, States Parties shall take measures to prevent the disruption of the existing balance of its environment, whether by introducing adverse changes in that environment, by its harmful contamination through the introduction of extra-environmental matter or otherwise. States Parties shall also take measures to avoid harmfully affecting the environment of the earth through the introduction of extraterrestrial matter or otherwise.[...]"

respective obligations). [11] In the first case, there is a greater risk that it will differ from country to country, which is not a desirable solution when it comes to space operations. [12] To date, neither of these solutions has emerged, and the space sector lacks a consistent approach to safety standards. [13] There are no international regulations, but only a few national ones, which are often scattered among different government agencies and organisations, or are not applied in a uniform manner. [14]

Turning attention to some of the leading national space legislation and example of the United Kingdom can be given. The Outer Space Act [15], prior to the changes introduced by the Space Industry Act [16], did not regulate environmental issues. In 2018, through the SIA, a requirement was added (under terms of license) to the Act⁶ to carry out activities in such a way as to prevent outer space contamination or adverse changes to the Earth's environment. The SIA contains broader provisions governing environmental aspects in Section 11, where the requirement for an assessment of environmental effects⁷ is indicated. According to Section 11(1) this condition applies only to a spaceport licence and an operator licence authorizing launches of spacecraft or carrier aircraft, who are required to apply for such assessment before obtaining a licence (spaceport licence or vehicle operator one).⁸ Belgium's national space law (adopted in 2005 and amended in 2013, with executive regulations updated in 2022) calls for the concrete implementation of such guidelines. Recent changes include incorporating environmental impact assessments (both terrestrial and space, now covering resource utilization), ensuring the registration of objects launched by non-governmental entities (with new criteria based on design and development in Belgium and operation by Belgian entities), and establishing a new alert procedure for failures of Belgian-registered space objects.[17] In France a two-tier approach based on the French Space Operation Act [18] and the Technical Regulations [19] is visible. These Regulations are composed of launch systems and orbital system regulations. Space safety requirements and procedural rules are derived from an analysis of best practice and experience gained nationally and globally[20]. In response to the development of the NewSpace sector, the French Space Operations Act of 2008 was amended in August 2023. With regard to launchers, the new regulations focus on Centre National d'Études Spatiales (CNES's) assurance of safety both in flight and on the ground, in particular during the return of rocket stages or orbital modules to the European spaceport in French Guiana. In addition, the Technical Regulations Update, which became effective on 1 July 2024, introduced other regulatory measures, including an opening to autonomous flight safety systems[21] The U.S. legal framework is characterized by its consistency and accessibility. Key documents include NASA Procedural Requirements (NPR 8715.6B) and NASA standards (NASA-STD-8719.14B) for limiting orbital debris, as well as the Commercial Space Launch Act (CSLA).[22]

Widely used standards for space operations include European Cooperation for Space Standardization (ECSS), ISO (International Organization for Standardization), the Inter-Agency Space Debris Coordination Committee (IADAC), and the broader framework of LTS Guidelines concerning sustainable development⁹. The ECSS serves as an example of standards developed to unify those governing European space activities. These standards were established to address the harmonization requirements of the European space industry, encompassing diverse domains such as project management, engineering, and product assurance. Furthermore, they ensure the application of safety considerations throughout the space system lifecycle, from the initial design and manufacturing phases to launch operations, mission control, ground activities, and the terminal disposal of space systems [23]. ISO standards represent an example of technical and procedural standardization at the international level. They cover a wide range of aspects related to space debris, from specific requirements for the design and operation of satellites (ISO 24113) to risk assessment methods (ISO/TR 16158) and data exchange formats (ISO 26900, ISO 13526). ISO 14200 is an example of guidelines concerning the use of space environment models for a better understanding and management of risks associated with meteoroids and debris. These ISO

⁶ Section 5(2)(e)(i) OSA

⁷ „(3) In this section “assessment of environmental effects”— (a) in relation to a spaceport licence, means an assessment of the effects that launches of spacecraft or carrier aircraft from the spaceport in question, or launches of spacecraft from carrier aircraft launched from the spaceport, are expected to have on the environment; (b) in relation to an operator licence authorising launches of spacecraft or carrier aircraft, means an assessment of the effects that those launches are expected to have on the environment.”

⁸ Section 11 SIA 11 Grant of licences: assessments of environmental effect

⁹ United Nations Office For Outer Space Affairs *Guidelines For The Long-Term Sustainability Of Outer Space Activities Of The Committee On The Peaceful Uses Of Outer Space*

standards aim to ensure consistency and interoperability in the approach to the space debris problem globally. [24] An example of International Telecommunication Union (ITU) Regulations is ITU-R S.1003.2, the Guidelines for geostationary satellite orbits (GSO), which represent a regulation specific to a particular orbit. Finally the IADAC guidelines, through its four key principles, provides an example of fundamental guidelines of an international nature that are widely recognized by space agencies worldwide.[25] These principles form the basis for many national and international regulations concerning space debris, emphasizing the importance of a proactive approach to minimizing its creation and the risks associated with its presence.

Thus it seems important to discuss the standards as an element of the space legislation. According to the authors international coherent standards are essential to achieve sustainable goals of the space exploration and form inherent part of all the three areas: Space Traffic Management (STM), Space Situation Awareness (SSE) and Space Environmental Management (SEM) – as main domains where the assurance and safety are dominating drivers. In all these areas, and particularly in the field of STM, we are living in an era of inefficient methods that are no longer suited to the congested space environment. [26] This applies to both the legal and governance aspects of space exploration. The current approach of differentiated and only generally defined safety standards [27] therefore needs to be redesigned and adapted. The space law in national and European dimension should be based on fundamental principles, such as those contained in the Outer Space Treaties, and then enforced by precise and coherent technical measures. Changing the rules need not affect the principles, such as those derived from the Outer Space Treaty. [28]

3. Dual-Use Space Capabilities: The Need for Standardized Practices and Governance

A fundamental challenge is that space law mainly regulates civilian programmes. As a result, concerns arise in the application of space law to space defence endeavours, particularly with regard to security, technical standards and sustainability issues such as space debris prevention and mitigation. The main difficulty is to take into account the military dimension and to determine the extent to which it may be subject to space law principles. In addition, questions arise regarding the governance of dual-use space systems and the jurisdiction of space authorities. This leads to the need to examine whether space agencies have the authority to supervise and regulate governmental military missions that involve or are conducted by private entities. It is essential to analyze how the dualism in the governance and regulation of the space sector influences sustainable space exploration. Specifically, there is a need to consider how the increase in space defense activities affects governance and regulation, with a focus on the approach taken in by the way of example - Europe.

Currently the number of national space agencies has increased significantly. In 2019 there were around 72 national space agencies and over 70 nations were operating space programs. [29] Another noticeable trend, alongside the revision and implementation of a new space strategies, is the emergence of defence strategies dedicated strictly to the space sector. The threats that have emerged over the past few years have increased the focus of the international community on security and defence matters, with the result that space assets are gradually being recognised as critical elements of defence strategies around the world. While a decade earlier there was also a focus on the military aspect, currently government spending on defence exceeds investment in the civilian programmes.[30] The emergence of space defence strategies are visible in the case of Luxembourg (Luxembourg's Defence Space Strategy 2022) France (The French Space Defence Strategy 2019) and the United Kingdom (UK Space Defence Strategy 2022).

An examination of EU strategies, national policies, and space laws across international, regional, and national levels reveals an ongoing trend of developing dedicated strategic documents specifically for the space domain. This entails the institutionalization of activities and the separation of competencies between bodies responsible for space, especially between military issues and commercial space activities. However, the precise role of space agencies, generally subordinated to the civilian government administration is not clear with respect to the application of space legal provisions. While we are also dealing with the development of legal regulations for the use of space, this is essentially taking place at the national level and only for civilian applications, where the role of space agencies is quite clear. It is not the case when military missions are at stake. Regulations concerning space law that could be relevant to military matters remain in the regulatory grey area, not subject to

licensing, and consequently also questionably subject to technical standards if only for the prevention of space debris, or in general, for ensuring the sustainability of space exploration. The powers vested in the space agencies are dubious as regards the certification of space activities.

Conclusions

The lack of cohesive global governance can negatively influence the safety and security of both the space environment and all space activities. Consequently, individual countries often refer to their own regulatory approaches for environmental concerns. The implementation of recommendations and guidelines related to space activities frequently occurs through national legal instruments such as executive orders, decrees, or regulations. While analyzing national space legislation, a common practice involves referencing internationally recognized standards and guidelines, particularly concerning state authorization and supervision of non-governmental space activities. However, the selective application of these "internationally recognized standards" can vary significantly, leading to legal uncertainty and divergent requirements for space activities.



Appropriate regulations and standards can serve as a method of managing the risks associated with space activities, following the unification and universalisation of safety norms and regulations. By creating a common set of rules and guidelines, the law can play a preventive role, seeking to minimise potential hazards and mitigate risks before the damage may be caused. The ultimate goal of this approach is to ensure the long-term sustainability and security of both military and civilian space operations, understood and implemented also by private companies.

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