Uniwersytet Wrocławski

Polish Political Science Review. Polski Przegląd Politologiczny 13 (2)/2025

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THE CONCEPT OF LONG-TERM SUSTAINABILITY OF OUTER SPACE ACTIVITIES IN THE CONTEXT OF THE ECOLOGICAL SAFETY OF SPACE

https://doi.org/10.2478/ppsr-2025-0011

► Received: 13 March 2025 ► Accepted: 4 September 2025

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Abstract
The UN COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities constitute a set of recommendations that are necessary to be pursued if states want to make space activities sustainable over the long term. The fact that this document was developed clearly confirms the threat for the safety of space activities conducted and for their continuation in the future. This scenario justifies the need to take adequate measures that comply with the recommendations stipulated in the Guidelines. It is, however, not possible without a proper space policy that takes account, among other things, of the pro-environmental context of the conceptual framework of the long-term sustainability of outer space activities. The main goal of this article is to demonstrate that implementing the concept of long-term sustainability of outer space activities is related to, and justifies the need for, states to guarantee the ecological security of outer space. Although the assumptions of the concept of ecological security were shaped in the doctrine of national law in response to the need to protect the Earth's environment from various threats, the growing problem of space pollution fully justifies the discussion on the ecological security of outer space. This conclusion is reinforced by the essence of the concept of the long-term sustainability of outer space activities.

Keywords
long-term sustainability of outer space activities, space environment, ecological safety of space

Introduction

The safe and sustainable use of outer space is under threat as a result of intensified space operations by states. The thesis that outer space is infinite may be considered true only if we adhere to a specific definition of the universe. The very activities undertaken by states

in outer space have limited scope that is determined by technological possibilities. Although technological progress is noticeable, it remains a fact that the exploration and the use of outer space is still conducted in the nearest environment of the Earth. The limit of this activity cannot be moved in the case of Earth orbits, which are by their nature a limited space resource. The real threat of their "closure" due to the high level of clutter from orbiting space objects that have ceased to function, fragments generated by them, their debris or other elements resulting from human activity in space, has prompted states to take measures to minimize such a threat.

The threat is real, as we continue to observe an ongoing increase in the volume of space debris. The relevant data is updated on an ongoing basis by the European Space Agency. This data shows that the total mass of all space objects in Earth's orbit amounts to 13,000 tonnes. Specifically, there are 40,500 pieces of space debris larger than 10 cm. The related statistics for space debris objects measuring between 1 and 10 cm yields a number of 1,100,000. Finally, the category of space debris objects encompassing items between 1 mm and 1 cm in size has reached a total of 130 million (ESA, Space debris by the numbers, 2024).

Since there is no agreement that would allow for the adoption of treaty-based solutions in the said domain, various organisational fora have been adopting guidelines that are an attempt to address the problems arising from the pollution of orbits. It is worth mentioning here: IADC Space Debris Mitigation Guidelines of 2025 (IADC Guidelines, rev. 4, 2025), Space Debris Mitigation Guidelines of the United Nations Committee on the Peaceful Uses of Outer Space of 2007 (COPUOS Guidelines, 2007), Recommendation on Environmental Protection of the Geostationary-Satellite Orbit of 2010 (ITU Recommendation, 2010), Space systems – Space debris mitigation requirements of 2023 (ISO Requirements, 2023), ESA Space Debris Mitigations Requirements (ESA Requirements, 2023).

Pollution of the space environment constitutes a threat to the continuity, stability, and safety of the space operations undertaken by various states. Thus, ensuring sustainable use of space becomes even more necessary. The concept of long-term sustainability of outer space activities was introduced to serve this purpose. It was developed by the United Nations Committee on the Peaceful Uses of Outer Space, hereinafter referred to as COPUOS. Specifically, in 2010 the Scientific and Technical Subcommittee of COPUOS established the Working Group on the Long-Term Sustainability of Outer Space Activities, hereinafter referred to as the Working Group, which was entrusted with fulfilling this task (Report of the Scientific and Technical Subcommittee, 2010, p. 26, para 181). The Subcommittee referred to above paid attention to "the importance of ensuring the safe and sustainable future use of outer space" and emphasised that the Working Group "should be established to support the preparation of a report on the long-term sustainability of outer space activities, the examination of measures that could enhance the long-term sustainability of such activities, and the preparation of a set of best-practice guidelines" (Report of the Scientific and Technical Subcommittee, 2010, p. 26, para 178). In 2016 the Working Group developed Guidelines for the Long-term Sustainability of Outer Space Activities: first set (COPUOS Guidelines, 2016). Two years later this publication was complemented by the preamble and nine guidelines, and the consolidated text was adopted at the session of COPUOS held from 12 till 21 June 2019 (COPUOS Guidelines, 2019).

The Guidelines for the Long-term Sustainability of Outer Space Activities were divided into the following four parts: policy and regulatory framework for space activities (guide-

lines A.1 – A.5), safety of space operations (guidelines B.1 – B.10), international cooperation, capacity-building and awareness (guidelines C.1 – C.4), and scientific and technical research and development (guidelines D.1 – D.2). Each part relates to a specific category of activities conducted by individual states. These activities should effectively solidify the concept of the long-term sustainability of outer space activities. This paper aims to demonstrate that the implementation of the guidelines in question is related to, and justifies, the need for ensuring ecological safety in outer space.

Conceptual framework for the long-term sustainability of outer space activities

The official website of the United Nations Office for Outer Space Affairs (UNOOSA) contains the following note on the concept of the long-term sustainability of outer space activities: "Space science and space applications advance our knowledge of the universe. They also improve the daily lives of people worldwide through their contributions to, among other things, environmental monitoring, management of natural resources, meteorological forecasting, climate modelling, satellite navigation, communications, and early warning systems to help mitigate potential disasters. If the international community wishes to increase access to the benefits of current space applications, and develop innovative technologies which may offer further benefits, there is a need to preserve and protect the outer space environment for use by future generations. Space activities need to be sustainable over the long term" according *Long-term Sustainability of Outer Space Activities 2019* (Vic). The quotation provides a concise summary of the essence of the concept under analysis, as proposed by UNOOSA. The key aspect of this concept is that space activities conducted by states should be sustainable in the long term. Concern for humanity's future due to the benefits derived from space gives the concept a pro-environmental character and is closely linked to the problem of space pollution (Kuźniar, 2024, p. 727). This also justifies taking adequate diplomatic, political, and legal actions to balance the Guidelines' goals with the development of space activities. According to the first paragraph of the preamble to Guidelines for the Long-term Sustainability of Outer Space Activities, the Earth's orbital space environment constitutes a finite resource that is being used by an increasing number of states, international intergovernmental organizations, and non-governmental entities (COPUOS Guidelines, 2019, p. 50, para 1). Moreover, the proliferation of space debris, the increasing complexity of space operations, the emergence of large constellations and the increased risks of collision and interference with the operation of space objects may affect the long-term sustainability of space activities (COPUOS Guidelines, 2019, p. 50, para 1). It is emphasised that development of guidelines "is premised on the understanding that outer space should remain an operationally stable and safe environment that is maintained for peaceful purposes and open for exploration, use, and international cooperation by current and future generations, in the interest of all countries, irrespective of their degree of economic or scientific development, without discrimination of any kind and with due regard for the principle of equity". The objective here is to "mitigate the risks associated with the conduct of outer space activities so that present benefits can be sustained and future opportunities realized" (COPUOS Guidelines, 2019, p. 50, para 4). Such an approach and the objectives set in these Guidelines correspond to the principles of international space law which proclaim freedom of explo-

ration and use of outer space, including the Moon and other celestial bodies, use of outer space for peaceful purposes, and cooperation of states in the exploration and use of outer space. They constitute the foundation of the concept of long-term sustainability of outer space activities, and they treat outer space and celestial bodies as a global common good. As provided by the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies of 27 January 1967 (610 UNTS, p. 205), the exploration and use of outer space and celestial bodies "shall be carried out for the benefit and in the interests of all countries [...] and shall be the province of all mankind" (article I). Outer space and celestial bodies may not be subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means (article II). This means that this area is considered *res communis* rather than *res nullius*. Therefore, it is the responsibility of all states to care for the outer space environment and for the continuity of its exploration and use, being equally entitled to draw benefits from the operations in outer space. However, the fact remains that the increasing volume of activities undertaken by states in outer space and its commercialisation have led to a rise in the amount of space debris, threatening the safety of space operations and their future. On the other hand, it is noted that the risks associated with space operations justify consideration of the general environmental issues associated with them (Karski & Myszona-Kostrzewa, 2020, p. 64). Furthermore, taking into account that the dependency of humans on outer space will only grow in the future, space activities should be preserved not only in the short-term perspective, but also on a long-term basis (Popova & Schaus, 2018, p. 4).

The notion of the long-term sustainability of outer space activities is defined in the guidelines as "the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations" (COPUOS Guidelines, 2019, p. 50, para 5). This quotation also verbalises the objectives set out in the document and pursued by individual states. The provisions stipulated in the guidelines refine the conceptual framework of the long-term sustainability of outer space activities. Specifically, the focus is, among other things, on the international responsibility of states for the space activities of non-governmental entities. Thus, states should "adopt, revise, or amend regulatory frameworks to ensure the effective application of relevant, generally accepted international norms, standards and practices for the safe conduct of outer space activities" (guideline A.1.2). It is pointed out that when developing, revising, or amending regulatory measures applicable to the long-term sustainability of outer space activities, states should implement space debris mitigation measures, such as the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, and the guidance contained in the Safety Framework for Nuclear Power Source Applications in Outer Space, and they should also satisfy the intent of the Principles Relevant to the Use of Nuclear Power Sources in Outer Space (guidelines A.2.1 and A.2.2, p. 2 (b), (e)). It is important that states encourage each entity conducting space activities: (i) to establish and maintain all the necessary technical competencies required to conduct the outer space activities in a safe and responsible manner, (ii) to develop specific requirements and procedures to address the safety and reliability of outer space activities, (iii) to assess all risks to the long-term sustainability of outer space activities associated with space activ-

ities and (iv) to take steps to mitigate such risks to the extent feasible (guideline A.3.2). The issue of developing effective and comprehensive registration practices is also brought to the fore. Specifically, it is emphasised that proper registration of space objects is a key factor for the safety and the long-term sustainability of space activities, while inadequate registration practices may have negative implications for ensuring the safety of space operations (guideline A.5.1).

Furthermore, the COPUOUS Guidelines extensively problematise the issue of pollution of the space environment. It is a key issue for maintaining the long-term sustainability of outer space activities, but at the same time it is related to the problem of safety of space operations. Hence, apart from the implementation of the space debris mitigation measures, as referred to above, it is recommended, among other things: (i) that states mutually exchange information on space objects and on actual or potential situations in near-Earth space (guideline B.1.3), (ii) that – in order to achieve harmonized and standardized record-keeping on space objects and events in outer space – states implement a dedicated consultative process, preferably under the auspices of the Committee on the Peaceful Uses of Outer Space, taking into account the work of relevant technical bodies (guideline B.1.4), (iii) that the development and use of techniques and methods should be promoted to improve the accuracy of orbital data for spaceflight safety (guideline B.2.1), (iv) that conjunction assessments during all orbital phases of controlled flight for their current and planned spacecraft trajectories are conducted (guideline B.4.1), (v) that space objects are designed in such a way that limits the production of space debris (guideline B.8.2). Moreover, states should also investigate the necessity and feasibility of possible new measures, including technological solutions, and they should also consider implementation of these measures in order to address the evolution of the space debris population in the long term and its management (guideline D 2.1).

Summing up, the recommendations included in the Guidelines under discussion relate to the concept of the long-term sustainability of outer space activities in the context of space sustainability sensu largo, where outer space is perceived as an environment that ensures safe conduct of outer space activities without interference, in a way that ensures continuity of the benefits (Martinez, 2021, p. 99).

Protection of outer space as a natural and human environment

The discussion needs to focus on the notion of the space environment and its protection in order to adequately problematise the issue verbalised in the title and in order to address the phenomenon of the long-term sustainability of outer space activities in the context of the ecological safety of space. It is worth noting that one of the most important goals of protecting the environment of outer space and celestial bodies is to ensure the safe conduct of exploration and exploitation activities by states and other entities (Kuźniar, 2025, p. 35).

It needs to be noted that the semantics of the notion of the space environment is discussed here in the context of the natural environment and the human environment. Generally, pursuant to the provisions of the Guidelines, states and international intergovernmental organizations should support the idea of minimizing the impacts of human activities on the Earth as well as on the outer space environment. This comparative account of the impact that the activities conducted by the individual states have on the Earth and

on outer space is of particular significance in view of the profits earned from this environment by people. Satellite technologies significantly affect the living standards on the Earh and they ensure life safety. Furthermore, in future years it may become quite feasible to extract natural resources from celestial objects. These arguments are undoubtedly sufficient to justify the need for protection of the space environment.

The use of outer space by various states necessitates protecting its environment, although – as some academics claim – the care for the space environment may result from ethical concerns (Lahcen, 2012, p. 3; Williamson, 2003, pp. 47–48). Some arguments for space environment protection may be identified in the very definition of the notion of environment. This term is defined as "a totality of physical (climate), chemical (e.g., soil), and biological factors (e.g., competition) that make the habitat for living organisms" (Bryła, 2002, p. 245). It emerges from this definition that it is both the abiotic (non-living) and biotic (living) components of the environment that are to be under protection. It needs to be emphasised that for some scholars the concept of the environment also covers the universe without the products of human labour (Ciechanowicz-McLean, 2009, p. 322) or celestial bodies (Bryła, 2002, p. 201). It is claimed in the subject literature that environmental protection covers the whole natural environment that surrounds a human being, concerning not only biotopes, which are biotic environments except for human beings (Bartkowski, 1991, p. 22). The goal is to protect the values of the natural environment in their spatial dimension because they are rare and in danger of extinction (Radecki, 2016, p. 44). We still know little about the space environment and therefore cannot say with certainty whether life exists in the celestial environment. However, the findings of the research that has been conducted so far positively verify the thesis that it is possible. Protection of outer space as a natural environment has significant impact on the planetary protection. The aim is to protect celestial bodies against biological contamination that results from the operation of human beings in space. Further, we need to ensure that space research is conducted with scientific precision. Transfer of germs and organic material from the Earth may nullify the current and future research and it may disturb the planetary environment or potential endogenic (foreign) ecosystem (Conley & Rummel, 2008, pp. 1025–1026).

Treating outer space as a source of resources for various states leads to more pragmatic arguments in favour of protecting the outer space environment. These arguments refer to the concept of the long-term sustainability of outer space activities. The need for such activities to be undertaken is justified by states on the ground of outer space being an environment that determines the quality of human life. The fact remains that states have long-term plans with regard to the exploration and use of outer space, including the Moon and other celestial bodies. In search of arguments to support the rationale for legal protection of the space environment we may quote the words of M. Grzegorczyk, who claimed that the conquest of the space environment caused it to become a component of our environment (Grzegorczyk, 1973, p. 59). In turn, K. Wolfke noted that the concept of the environment needing protection is expanding due to correlations between various phenomena and the complexity of the elementary needs of a human being. These cover not only air, water, and soil, but also accommodation standards, protection against noise, or the cultural environment, to mention just a few. The author conceives the human environment as an entirety of conditions that are indispensable for an individual or for a society to live normal life (Wolfke, 1979, p. 6). To some extent , this approach is reflected in the Stockholm Declaration and Action Plan for the Human Environment, adopted at

the United Nations Conference in Stockholm in 1972. Point 1 proclaims that: "Man is both creature and moulder of his environment, which gives him physical sustenance and affords him the opportunity for intellectual, moral, social, and spiritual growth. [...] Both aspects of man's environment, the natural and the man-made, are essential to his well-being and to the enjoyment of basic human rights-even the right to life itself". Hence, the concept of environment covers not only the conditions that allow us to protect ecosystems and the life of human beings, but all these things that can contribute to reaching a specific life quality, which is conditioned by many elements of our environment, these being for example numerous finance-related aspects that help us to satisfy our economic, intellectual, and aesthetic needs (Łustacz, 1979, pp. 10–11, 13). Although the Stockholm Declaration concerns the Earth's environment, the contemporary approach holding the space environment as an element of the human environment is fully justified in view of the wide range of possibilities provided by the space environment, contributing to increasing standard of living on the Earth and ensuring its protection. This argument legitimises the need to take account of the technical conditions resulting from the use of outer space by a human being, and treat them as a new element of the human environment, which consequently brings us to the point where the space environment and celestial bodies are distinguished as those under protection (Kuźniar, 2019, p. 37). In fact, this process has already begun. The adoption of space debris mitigation measures or the guidelines for the long-term sustainability of outer space activities are to evidence this trend.

Space as the nature-related element of environment is endangered by degradation consequences. It is worth emphasising that space is not capable of undergoing self-cleaning processes (Hobe, 1992, p. 42). It has long been a well-known fact that space operations contribute to pollution of the space environment. It is a common problem that was triggered by the entities running space activities, and the results may be experienced by everybody (Viikari, 2008, p. 260). Thus, in view of the ever-expanding plans for outer space activities, it becomes vital to strengthen efforts aimed at the protection of the outer space environment, understood as an area that is distinct in terms of its nature, that remains under the influence of states and ensures specific living standards on the Earth. In other words, it remains the duty of states to protect space as a natural environment and as a human environment. Such a position would justify the appropriate transposition of the principles and concepts of international environmental law to the issues of environmental protection of outer space and celestial bodies. It is worth noting that in environmental protection policy, the justification for pro-ecological actions results largely from the non-renewability of environmental elements and the protection of human interests (Lisowska, 2006, p. 223).

Ecological safety of space and the need to have it guaranteed

The legitimacy of the "pro-ecological" treatment of space arises out of the provisions of international space law requiring that the exploration and use of outer space and celestial bodies shall be conducted for the benefit, and in the interests, of all countries and as the province of all mankind. The Outer Space Treaty also stipulates that states parties "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" (article IX). This regulation does not, however, introduce the principle of protection of extra-terrestrial space and, in its light, no specific activity is prohibited on the ground of the need to protect

environment. The only disposition is to avoid harmful contamination (Kenig-Witkowska, 2017, p. 145).

The Guidelines for the Long-term Sustainability of Outer Space Activities may be interpreted more extensively, since the recommendations included therein attempt to balance the possibility to draw benefits form the exploration and exploitation of space with the need to protect its environment for future generations. As noted above, the Guidelines point to the need to implement the provisions provided for in the relevant international treaties and take space debris mitigation measures. In spite of the fact that states did not produce any legally binding laws regulating the protection of the space environment, this process may be successfully completed by the implementation of soft law. In light of a clear reluctance of states to create hard law regulations in international space law, this is undoubtedly a reasonable alternative (Kuźniar-Kwiatek, 2017, p. 409). It seems that the adoption of appropriate regulation is inevitable if states want to maintain the possibility of the exploration and use of outer space in the future. Paradoxically, an increasing threat of losing access to the resources of outer space may contribute to the acceleration of this process. The progressive degradation of the space environment also makes it justifiable to postulate the ecological safety of outer space.

The notion of ecological safety in outer space may seem to be an abstract construct. The semantics of the term "ecological safety" may vary, depending on the specific domain to which it is being applied. It also needs to be borne in mind that this notion has been subject to some semantic shifts. Namely, it was employed in the sense of temporary neutralisation of the effects brought about by negative events or in the context of long-term thinking that propagated the need to take some measures aimed at preserving the adequate condition of the nature and environment that human beings live in. Moreover, the notion of ecological safety became part of international safety, and states are held responsible for protecting their citizens against ecological threats (Żuber, 2014, p. 11). As noted by G. Grabowska the term "ecological safety" is to be understood as "elimination or minimization of all threats to human life and health arising from the surrounding environment" [author's translation] (Grabowska, 1996, p. 28). In turn, M. Pietraś claims that ecological safety is "a condition of social relations [...] that not only limits and eliminates ecological threats but it also promotes positive activities that enable the pursuit of values essential for the existence and development of nations and states" [my translation] (Pietraś, 2000, p. 85). An essential element of the concept is maintaining the continuity and stability of human existence. As B. Rakoczy states ecological safety is defined as "reaching a condition of environment which allows human beings for safe habitation in this environment and makes it possible for them to use it in a way that ensures their development" [author's translation]. The author notes that environment protection constitutes one of the elements of ecological safety (Rakoczy, 2014, p. 19). Its guarantee serves to ensure the quality of life (Papuziński, 2005, p. 51).

To summarise, the definitions referred to above indicate that ecological safety refers to a process connected with environmental protection aiming at mitigating the threats to the development of all mankind. The concept combines minimizing the effects of environmentally harmful factors with minimizing their impact on the quality and standard of human life. The use of space technologies to meet our own needs and create living standards, the inextricable connection and dependence of humans on the benefits of space,

which standardize the standard of living on Earth, further justify the need to care for our environment (Kuźniar, 2019, p. 198). As states have intensified their space activities and the benefits drawn from these operations, space has become part of the human environment, making essential its protection through preventive and corrective measures. The social, economic, and scientific progress achieved by states through satellite technology development clearly justifies efforts to ensure the ecological safety of space. Although it might seem that the concept itself can only be considered in the context of protecting the Earth's environment, the threats posed by the expansive space activities of states to the space environment, to maintaining its accessibility and stability, so important for the development of life on Earth, make the discussion on the ecological safety of space fully justified. At the same time, the threats for the long-term sustainability of outer space activities, as diagnosed in the Guidelines constitute a threat for the ecological safety of space. This is why, in order to have the latter guaranteed, the COPUOS recommendations need to be implemented. This is important for the continued exploration and exploitation of space and celestial bodies now and in the future in the face of ever-increasing threats, the consequence of which may be, as mentioned earlier, the loss of such an opportunity. The success of this process largely depends on the attitudes that states adopt towards the status of outer space and celestial bodies. Observing the principles introduced in the treaties adopted in the area under discussion is another factor conditioning successful implementation of the recommendations. The lack of a unified approach to these issues makes it difficult to effectively negate the expansionist activities in space conducted by states, and it acts as an inhibiting factor to provide a guarantee for ecological safety of space (Kuźniar, 2020, p. 33). Due to the lack of interest of states in adopting binding regulations on the protection of the environment of outer space and celestial bodies that would specify and expand the content of Article IX of the 1967 Treaty, the implementation of an appropriate policy on the protection of the space environment, with the COPUOS Guidelines as its basis, seems not only justified but also necessary.

Conclusions

In the light of the above considerations, it seems correct to say that the concept of ecological security of outer space crystallizes on the basis of soft law within the concept of long-term sustainability of outer space activities. The relevant guidelines adopted in this respect are a result and – to some degree – a summative account of the harmful activities of states in outer space. The findings are concerning. Space operations conducted by various states have resulted in the world facing the real threat of losing the ability to use outer space according to current principles and to the currently possible extent. The process is not irreversible. The individual states' policy must be compliant with the provisions of the Outer Space Treaty. States should not forget about their responsibility for their operations in space and for the results of their activities. With the increasing commercialisation of space, it should be borne in mind that space operations conducted by non-governmental institutions and legal entities need to be legitimised by the authorisation and permanent supervision of states. Such operations are treated on a par with the operations conducted by governmental institutions, where it is the state that holds responsibility. Broader cooperation between states and international intergovernmental organizations is also needed to avoid harm to the space environment. A key element of this should be the promotion

and implementation of the recommendations developed at the COPUOS forum. All these actions should be guided by the assumption that space pollution threatens our present and future in space, as well as our present and future on Earth. It contains a compelling argument justifying appropriate actions to protect the outer space environment. This goal is one element of the concept of the long-term sustainability of outer space activities and justifies the discussion on the ecological safety of outer space, the assumptions of which are conceptually linked to the assumptions of the COPUOS Guidelines. Sustainable and stable exploration and exploitation of space requires taking measures to minimize its negative impacts on the space environment.

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