

The Conceptual and Categorical Framework of International Space Law: Problems in Defining the Concepts of “Harm,” “Potentially Harmful Interference,” and “Harmful Interference” in Space Activities

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This article presents a comprehensive study of the legal nature of the concepts of “harm,” “potentially harmful interference,” and “harmful interference” in international space law. It is argued that the rapid development of space activities, increase in the number of space operators, commercialization of space, growing amount of space debris, development of technologies capable of actively influencing space systems, and intensification of geopolitical competition highlight the need to refine the conceptual framework of international space law. The evolution of the “harm” category from general theoretical legal concepts to its contemporary understanding in international space law is analyzed. The content of the concept of “potentially harmful interference” is examined as an independent legal category of a preventive nature, enshrined in Article IX of the 1967 Outer Space Treaty, as well as the origin and development of the category “harmful interference,” which emerged in international telecommunications law and was integrated into the mechanism of international legal regulation of space activities.

It is established that these categories perform different functions within the mechanism of international legal regulation: the concept of “harm” underlies the institution of international liability, whereas “potentially harmful interference” and “harmful interference” ensure the implementation of preventive mechanisms aimed at preventing the occurrence of negative consequences.

Keywords: international space law, harm, potentially harmful interference, harmful interference, space activities, international liability, preventive legal regulation, space security.

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Introduction

Nowadays, the world is witnessing unprecedented challenges to the system of international law and the international legal order. The Russian Federation’s armed aggression against Ukraine, territorial claims, and political statements by certain States regarding the possibility of revising existing borders demonstrate a crisis in the effectiveness of certain international legal mechanisms. These events highlight the need to rethink current principles, approaches, and doctrines, including in the field of international space law. Recent practice indicates that the existence of international treaties does not guarantee their proper implementation and compliance. Therefore, the effectiveness of international legal regulation depends to a large extent on the political will of States, their attitude toward international obligations, and their willingness to act in accordance with universally recognized principles of international law. It is the States themselves that determine the extent to which their national policies, legislation, and practical activities are consistent with international norms and the obligations they have undertaken.

In this context, the issue of improving international legal mechanisms to ensure the safety of space activities, the liability of States for violations of international rules, and the development of new approaches to regulating relations in outer space in the face of contemporary geopolitical challenges is of particular importance. After all, the rapid development of space activities, the commercialization of outer space, the growing number of State and private actors in space activities, and the intensifying competition for access to space resources make the issues of ensuring the safety of space activities and improving international legal mechanisms for liability for violations of established rules and standards increasingly relevant.

These issues are particularly relevant given the increasing number of space objects in orbit, the accumulation of space debris, the development of satellite systems for communications, navigation, and remote sensing of the Earth, as well as the emergence of new risks associated with the use of artificial intelligence, cyber threats, and the possibility of deliberate interference with the operation of space systems. At the same time, an analysis of the international legal instruments that form the basis of modern space law reveals the absence of a single, unified approach to defining such key concepts as “damage,” “potentially harmful interference,” and “harmful interference.” Although these categories are widely used in international treaties, United Nations documents, acts of the International Telecommunication Union, and the national legislation of individual States, their meaning, scope, and criteria for application remain insufficiently defined.

In particular, the 1972 Convention on International Liability for Damage Caused by Space Objects defines the term “harm” as “loss of life, bodily injury, or other harm to health; or the destruction of or damage to the property of States, natural or legal persons, or the property of international intergovernmental organizations” (Convention, 1972). In other words, this article primarily covers cases of actual harm to life, health, or property. At the same time, the development of modern space technologies gives rise to situations where a threat to space objects or space infrastructure exists even before any actual negative consequences occur. In such cases, the categories of “potentially harmful interference” and “harmful interference” are no less important for the regulation of space activities under international law. The first is used in Article IX of the 1967 Outer Space Treaty as a basis for conducting international consultations in the event of a possible negative impact of one State’s space activities on the activities of other States. In contrast, the term “harmful interference” is used in the instruments

of the International Telecommunication Union (ITU) to refer to interference that jeopardizes the functioning of radiocommunication services or significantly impairs their operation.

Consequently, the lack of unified approaches to understanding and applying these concepts creates significant difficulties both for legal practice and for the development of international cooperation in the space sector. In particular, this complicates the establishment of violations of international obligations, the determination of the grounds for States' liability under international law, the assessment of risks associated with space activities, and the development of effective mechanisms to prevent emergencies in outer space.

In addition, the study of the categories of “damage,” “potentially harmful interference,” and “harmful interference” takes on particular significance in the context of ensuring space security. It is precisely these concepts that underpin mechanisms for risk assessment, the adoption of preventive measures, the development of international standards for safe conduct in space, and the determination of the limits of liability of States and private operators for the consequences of their activities. Establishing clear and uniform definitions of the categories under study is a necessary prerequisite for the further development of international space law and the improvement of national legislation in the field of space activities.

Theoretical and Legal Foundations of the Concept of Damage in Space Law

The Concept of Harm in General Legal Theory

The category of harm is one of the fundamental concepts of legal science and is a key prerequisite for the emergence of legal liability. It is precisely through this category that the law defines the limits of permissible conduct, justifies the need for State intervention, and establishes mechanisms for the protection of individuals' rights and legitimate interests.

The philosophical foundation of the modern understanding of harm is largely linked to the «harm principle», formulated by the English philosopher John Stuart Mill in his work “On Liberty” (Mill, 1859). According to this principle, an individual's freedom may be restricted only when his/her actions cause harm to others.

At the same time, the question of defining the nature of harm remains a matter of debate. In legal doctrine, harm is traditionally understood as adverse consequences arising from unlawful conduct and leading to a violation of rights, legitimate or legally protected interests (Von Bar, 2020; Simonović, 2020; Alle, 2020). Depending on the nature of such consequences, a distinction is made between property damage, moral harm, physical harm, environmental harm, reputational harm, and other types of harm.

At the same time, the meaning of this concept is not fixed and varies depending on historical conditions, social values, and the nature of the relationships within which it is applied.

The issue of defining harm takes on particular relevance in the sphere of international relations, where the consequences of individual States' actions can extend far beyond their national borders and affect the security of the entire global community. It is no coincidence that the researchers of international conflicts point out that human history has, to a significant extent, been marked by wars and violence.

In particular, Joseph de Maistre noted that “Unhappily, history proves that war is, in a certain sense, the habitual state of mankind, which is to say that human blood must flow without interruption somewhere or other on the globe, and that for every nation, peace is only

a respite" (de Maistre, 1974: 51). This approach demonstrates that the concept of harm has traditionally been associated primarily with physical losses, destruction, and human casualties. At the same time, this thesis also reflects the well-known principle of political and military thought – "Si vis pacem, para bellum" – which is based on the idea that ensuring security often requires a preemptive response to potential threats. However, advances in science and technology have given rise to new spheres of activity where harm may manifest not only in the form of direct material losses or physical impact, but also through the creation of threats, risks, and obstacles to the safe operation of complex technical systems. One such sphere is space activities, in which the issue of defining harm takes on particular legal significance.

Characteristics of harm as a legal category in space activities

Space activities have a number of characteristics that determine the specific legal understanding of harm. Firstly, the consequences of one entity's activities can simultaneously affect a large number of States, organizations, and private operators. Secondly, harm can occur both in outer space and on the Earth's surface. Thirdly, establishing a causal link between a specific activity and negative consequences is often difficult due to the technological complexity of space systems and the multi-party nature of space relations.

Unlike traditional areas of legal regulation, in space activities, harm is not always limited to the actual destruction or damage to property. It can be manifested in the form of disruptions to the functioning of space systems, threats to flight safety, loss of access to critical communication or navigation services, as well as the emergence of long-term risks to the use of outer space by future generations.

Therefore, if we generalize the existing approaches to understanding the concept of "harm," the following can be stated in the context of space activities:

- 1) harm exists only when there is a violation of a right, a legitimate interest, or another legally protected interest. In the context of space law, this means that harm can consist not only of the destruction of a satellite but also of a violation of a State's or operator's right to the safe use of outer space and compliance with the principle of «due regard»;
- 2) the content of the damage is not once and for all determined. Its limits depend on what interests society recognizes as requiring legal protection. For space activities, this allows the rationale for extending the traditional notion of damage to: damage to the space environment; damage to orbital safety; damage from space debris; damage to information and communication infrastructure; damage to navigation systems;
- 3) harm encompasses not only direct material losses but also intangible losses, including loss of opportunities, disruption of system operations, or restrictions on the exercise of rights. For example, loss of a satellite communication signal; temporary disruption of RNSS/GNSS systems; blocking of access to satellite services; loss of Earth remote sensing data (ITU, 2022). In such cases, the satellite may not be physically damaged, but harm is nevertheless caused;
- 4) harm must be legally relevant, as not every negative consequence is recognized as harm. To establish this, the following must be demonstrated: the existence of a protected interest; the fact of its violation; and a causal link between the action and the consequence. If the launch of a satellite by one State results in the loss of a commercial advantage for another operator, this in itself does not constitute harm.

- However, intentional disruption of a competitor’s satellite’s normal operation may be considered a legally significant act that can be classified as causing harm;
- 5 one of the key conclusions of contemporary doctrine is a shift in emphasis from harm already inflicted to the prevention of potential harm. This approach is particularly important for space law. For example: dangerous satellite encounters; the formation of space debris clouds; testing of anti-satellite weapons; the risk of a Kessler syndrome cascade effect. In such cases, no actual damage has yet occurred, but there is a high probability that it will occur.

Thus, an analysis of contemporary doctrinal approaches to understanding the concept of «harm» indicates a gradual shift away from its narrow interpretation as exclusively actual material or physical losses. In modern law, harm is increasingly viewed as a violation of legally protected rights, interests, or benefits, which can manifest itself in both material and non-material forms. This approach is of particular importance for space activities, where negative consequences may arise not only as a result of physical damage to space objects, but also through the creation of risks to the safe use of outer space, interference with the functioning of space systems, generation of space debris, or restrictions on access to space services. In this regard, the traditional understanding of harm requires further development, taking into account the specific nature of space activities and contemporary challenges to space security.

“Potentially harmful interference” as a distinct category of space law

Unlike most branches of international law, where legal consequences are primarily linked to the fact of harm already caused, international space law established mechanisms to respond to the possibility of negative consequences even at the stage of its formation. This is due to the specific nature of space activities, the consequences of which can be transboundary in nature, affect an indeterminate group of entities, and pose threats to the entire space environment.

One of the first international legal instruments to use the term «potentially harmful interference» was the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty). Of particular importance is Article IX of the Treaty, under which a State Party is obligated to conduct international consultations if it has reason to believe that its planned space activity or experiment may cause “potentially harmful interference” (Treaty, 1967) to the activities of other States in the peaceful exploration and use of outer space.

Thus, international space law links the emergence of certain legal obligations not to the actual occurrence of harm, but to the existence of a reasonable probability of its occurrence. The very use of the term “potentially harmful interference” indicates that, as early as 1967, States recognized the need to prevent risks before negative consequences arise.

At the same time, the Outer Space Treaty does not define the concept of “potentially harmful interference,” which has been the subject matter of numerous scholarly debates. According to Sergio Marchisio (Marchisio, 2009), the provisions of Article IX must be viewed as an expression of the principles of due regard for the interests of other States and international cooperation, which impose on States the obligation to assess the possible negative consequences of their activities even before they begin.

The concept of “potentially harmful interference” was further developed in the work of United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). In particular, documents on the long-term sustainability of space activities and the guidelines for reducing space debris emphasize the need to assess risks, prevent collisions between space objects,

and minimize potential adverse effects on the space environment before they occur. However, it should be noted that the COPUOS LTS Guidelines (Long-term, 2026) are advisory and voluntary in nature and do not have contractual force.

The practice of space activities also demonstrates a gradual shift from responding to damage that has already been caused to managing the risks of its occurrence. Cases involving the creation of space debris are particularly illustrative. For example, the collision between the Iridium-33 and Cosmos-2251 satellites in 2009 (Johnson, 2009) was one of the first instances, in which actual damage to individual space objects transformed into a long-term potential threat to a large number of other space users. As a result, 1,800 pieces of debris measuring approximately 10 cm or larger were created (Johnson, 2009), which still pose a risk to space operations.

The tests of anti-satellite weapons (ASAT) (Anti-Satellite, 2026; Hoffmann, 2021) conducted by certain States in the 21st century, are even more revealing. Even if the immediate damage is limited to the destruction of a single spacecraft, the resulting debris can pose a threat to the operation of other space systems for decades. In such cases, the underlying problem is not so much the damage already caused as the scale of potential damage to the international space community.

The concept of "potentially harmful interference" in scientific doctrine encompasses both intentional and unintentional disruption of space services, including navigation, communication, and other critical services. Moreover, the mere threat of interference can pose a danger even before actual damage occurs.

When discussing the significance of "potentially harmful interference" for preventive legal regulation, it is important to note that, in the context of space activities, it serves as a legal risk indicator triggering the preventive mechanisms of international law even before actual damage occurs. It is precisely the existence of the risk of «potentially harmful interference» that justifies the need for international consultations, risk assessments, information exchange, space situational awareness, and the implementation of measures to ensure space security.

In fact, the category of "potentially harmful interference" serves as the legal basis for implementing the precautionary principle in space activities. Its significance is particularly growing amid the rapid increase in the number of space objects, development of satellite constellations, space commercialization, and emergence of new dual-use technologies.

Thus, "potentially harmful interference" is not merely a theoretical category but also an important instrument of modern international space law. Its use helps ensure a balance between freedom of space exploration and the need to protect the interests of other states, contributes to strengthening international space security, and creates the basis for the formation of an effective system of preventive legal regulation of space activities.

Harmful Interference: Concept and Significance

The category of "harmful interference" is one of the key concepts of modern space law, although its origin is linked not so much to space activities as to the international legal regulation of telecommunications. The development of this concept arose from the need to ensure the orderly use of limited natural resources, primarily the radio frequency spectrum, which is used by both terrestrial and space-based communication systems.

The first regulatory foundations for the category of "harmful interference" were laid by the International Telecommunication Union (ITU), which has been coordinating the use of radio frequencies since the early 20th century (Events, 2024). In ITU documents, the concept of

harmful interference is viewed as a threat to the effective functioning of radio communication systems and the safety of users of such services (Harmful, 2026a).

According to the findings of historical and legal research by Peter A. Tenhula and Carl R. Frank, the term “harmful interference” began to be used in international radio regulation documents after World War II. Prior to that, international conventions had used only the term “interference” without the adjective “harmful” (Tenhula & Carl, 2022).

The Atlantic City Radio Regulations (International Radio Conference, Atlantic City, 1947) are considered the first international document to establish the category of “harmful interference” (Tenhula & Carl, 2025). It was at the International Radio Conference in Atlantic City (1947) that the modern concept of “harmful interference” was first formulated, although its definition had not yet been definitively established. Subsequently, the concept underwent editorial refinements in the ITU Radio Regulations, and following the 1992 reform of the International Telecommunication Union, it was enshrined in the ITU Constitution and the Radio Regulations, where it is still used today.

For example, harmful interference is defined in No. 1.169 of the Radio Regulations (RR) and in No. 1003 of the ITU Constitution as “interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with the Radio Regulations.” Harmful interference (including blocking, jamming, or degradation of service) can occur for a wide range of reasons, which may be either accidental or intentional. Both commercial services and critical safety-of-life applications may be degraded and affected (Radio, 2025).

An illustrative example of practical application of the “harmful interference” category is the mass jamming of Global Navigation Satellite System (GNSS) signals recorded by the International Telecommunication Union in 2021–2022. According to the ITU, 329 official reports of harmful interference were received in just one year, posing a threat to the operation of radio navigation services and flight safety (ITU, 2022).

Thus, in international telecommunications law, “harmful interference” was initially viewed as a technical problem related to the use of the radio frequency spectrum. At the same time, the development of space activities and the growing dependence of States on satellite technologies have gradually given this concept a broader legal meaning.

It should be noted that, in modern space law doctrine, the category of “harmful interference” is interpreted much more broadly than merely radio frequency interference. For example, in the reference work “A Lexicon for Outer Space Security,” this category is defined as “... external blocking or reduction of services provided by space systems, which may be accidental or intentional, and include interference with any space services, ranging from commercial services to critical safety-of-life programs” (Harmful, 2026b).

Thus, while ITU documents were primarily focused on eliminating existing interference in the field of radio communications, Article IX of the Outer Space Treaty aims to prevent potential negative consequences even before the relevant activities begin.

However, despite the fact that Article IX of the Outer Space Treaty provides for international consultations in the event of potentially harmful interference, the consultation procedure under Article IX has never been formally implemented. This is acknowledged by leading experts in space law, including Sergio Marchisio, Ram S. Jakhu, and Frans von der Dunk. Instead, issues of harmful interference have been resolved through diplomatic channels, ITU mechanisms, or political consultations.

Thus, the category of “harmful interference” has evolved from a narrow technical concept in international telecommunications law into a comprehensive legal category in international space law. Its significance lies not only in protecting the operation of space systems but also in ensuring space security, implementing the principle of “due regard” for the interests of other States, and establishing mechanisms for the preventive regulation of space activities under international law. Although the concept of “harmful interference” has been successfully used in international telecommunications law for over 75 years and is actively applied by the International Telecommunication Union in resolving disputes regarding radio frequency interference, the mechanism for international consultations on “potentially harmful interference,” as provided for in Article IX of the Outer Space Treaty, has never been formally implemented. This indicates a gap between the normative establishment of the preventive mechanism and its practical application, highlighting the need to clarify the meaning of the term «potentially harmful interference» and the procedures for its implementation in international space law.

Conclusions

The present study allows us to draw the following conclusions.

Firstly, it has been established that the concept of “harm” is one of the fundamental categories of international law, traditionally associated with the occurrence of negative consequences and the emergence of international legal liability. In the field of space activities, this category takes on a specific meaning, as it encompasses not only physical damage to space objects or property on Earth, but also functional, environmental, informational, and other negative consequences that may affect the safe and peaceful use of outer space.

Secondly, it has been argued that “potentially harmful interference” can be regarded as a doctrinal category that characterizes not the actual occurrence of negative consequences, but the existence of a reasonable probability of their occurrence. It is precisely this category that underlies the preventive mechanism enshrined in Article IX of the 1967 Outer Space Treaty, pursuant to which States are obligated to assess the potential risks of their space activities and conduct international consultations in the event of a possibility of causing “potentially harmful interference.”

Thirdly, it has been established that the category of “harmful interference” historically developed within international telecommunications law and was subsequently integrated into international space law as one of the key instruments for ensuring space security. Unlike the concept of “harm,” “harmful interference” characterizes a specific negative impact on the functioning of space systems, which does not always result in actual damage but is capable of creating conditions for such damage to occur.

To close the existing gap between the provisions of Article IX of the Outer Space Treaty and its practical application, it is advisable to develop an international procedural mechanism for conducting consultations on “potentially harmful interference.” Such a mechanism could take the form of COPUOS Guidelines on the Application of Article IX of the Outer Space Treaty and provide for uniform criteria for identifying potentially harmful interference, a procedure for conducting a preliminary risk assessment (Space Harm Assessment), a procedure for notifying interested States, timeframes for consultations, and recommendations for preventing harm. This would transform the current declaratory mechanism for international consultations into an effective instrument of preventive international legal regulation of space activities.

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