

Navigating Damages in Space Activities: Comprehensive Understanding of Damage in Space Activities

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How to cite this paper: Sayed, M. M., & Li, S. P. (2023). Navigating Damages in Space Activities: Comprehensive Understanding of Damage in Space Activities. *Beijing Law Review*, 14, 1123-1141.

<https://doi.org/10.4236/blr.2023.143059>

Received: June 8, 2023

Accepted: August 4, 2023

Published: August 7, 2023

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Abstract

In today's era, advanced nations and the international community are reaping numerous benefits from the rapid advancements in space science and technology. However, with this progress comes an increasing risk of damage caused by space object collisions and the accumulation of space debris. In light of these challenges, I intend to propose an international framework based on the review of space treaties and liability conventions. This framework aims to establish a fair and comprehensive system for compensating victims of accidents and hazardous space activities. Within this framework, I will explore various aspects such as how does the globalization influence the space activities, the concept and extent of damages, including personal and mental harm, the scope of material losses, the possibility of compensating for environmental contamination, and the challenges associated with satellite data transmission and the location of damages. Additionally, I will advocate for the establishment of a space tribunal and regional cooperative agencies to ensure effective enforcement of regulations and international cooperation in addressing space-related issues and finally, the key risks of space activities.

Keywords

Space Activity, Space Accident, Space Damage, Space Treaty, Mental Damage, Equity and Complete Compensation

1. Introduction

Since the historic launch of Sputnik 1 by the former Soviet Union in 1957, the quest for space exploration has evolved into a competitive race between global superpowers. The United States and the Soviet Union initially vied for dominance, and more recently, China has emerged as a formidable contender, evoking

comparisons to the Three Kingdoms period. Alongside scientific advancements, commercial and military applications in space have flourished, highlighting the fusion of high-level precision and cutting-edge science that characterizes space development and launches. As nations, both advanced and underdeveloped, expand their involvement in space exploration, the collision of diverse interests becomes inevitable, consequently increasing the potential for human and property damage.

In the present era, space powers such as the United States, Russia, and China actively launch satellites, space shuttles, and space stations into the outer reaches. While many operational satellites remain stationary in low Earth orbit, a significant number of defunct artificial satellites and space debris fragments continue to orbit unpredictably, posing threats to life and property should they re-enter the Earth's atmosphere. Additionally, the 21st century has witnessed a surge in private and commercial satellite deployments, intensifying the risk of accidents, particularly collisions, and raising pressing issues regarding responsibility and compensation for resulting damages. Although the development and use of outer space are governed by the principle of peaceful exploration and are open to all nations, the rapid progress of space science and technology brings potential risks to human activities and the preservation of the space environment. Instances of collisions between space objects contribute to the proliferation of space debris, generating further hazards and complications.

In light of these challenges, it becomes imperative to address crucial questions concerning the provision of adequate and just recovery, prompt and sufficient compensation to victims, and affected nations in the wake of accidents caused by various space objects, including communication satellites. The issue of legal responsibility arises, along with an exploration of its origins and requirements. This research aims to delve into these matters and seeks to classify the responsibility structure surrounding space activities into four types, including absolute liability, liability for ordinary illegal acts, and liability arising from contracts and products based on the principle of freedom of contract.

In the realm of international space law, the Space Treaty of 1967 holds significant relevance, having established guidelines and regulations pertaining to space responsibility. As a starting point, the Liability Convention enacted in 1972 will be thoroughly reviewed, enabling an in-depth examination of the conceptual and scope-related aspects of damages, which form crucial prerequisites for compensation.

By delving into the complex terrain of space development and liability, this research aims to shed light on the challenges and intricacies associated with ensuring adequate compensation and assigning responsibility in an era marked by competitive participation in space exploration.

2. The Globalization and the Space Activities

The advent of globalization has had a profound impact on various aspects of human life, and space activities are no exception. Globalization, characterized by

the increasing interconnectedness and interdependence of nations and economies, has opened up new opportunities and challenges for space exploration, satellite communications, and other space-related endeavors. The globalization of space activities has led to collaborations between nations, the commercialization of space, and the emergence of a global space industry. However, it has also raised concerns regarding security, resource exploitation, regulatory frameworks, and equitable access to space. Understanding the influence of globalization on space activities is essential for navigating the opportunities and risks that arise in this rapidly evolving domain.

Globalization has had a significant impact on space activities in several ways:

International Collaboration: Globalization has facilitated increased international collaboration in space exploration and research. Space agencies and organizations from different countries come together to share resources, knowledge, and expertise, pooling their efforts to undertake ambitious space missions. Examples include the International Space Station (ISS), where multiple nations collaborate to operate and conduct experiments in space.

Access to Space Technology: Globalization has enabled the transfer and sharing of space technology among nations. Spacefaring nations often collaborate with emerging space nations, providing technical assistance, training, and access to space technologies. This has helped accelerate the development of space capabilities in countries that might not have had the resources to independently pursue space activities.

Commercialization and Market Expansion: Globalization has opened up new opportunities for commercial space activities. Private companies from different countries are entering the space industry, offering launch services, satellite communications, remote sensing, and other space-related products and services. The global market for space-based applications has expanded, driven by the increasing demand for telecommunications, Earth observation, navigation, and other satellite-based services.

Space Governance and Policy: Globalization has prompted the development of international frameworks and agreements to govern space activities. Treaties such as the Outer Space Treaty and the Moon Agreement provide a legal foundation for the peaceful and responsible use of outer space, ensuring the equitable access and benefit-sharing of space resources among nations. Global cooperation is essential to address emerging challenges in space governance, including space debris mitigation, spectrum allocation, and space traffic management.

Data Sharing and Scientific Collaboration: Globalization has facilitated the sharing of space data and scientific findings among researchers and institutions worldwide. Satellites and space missions generate vast amounts of data that can be shared for scientific research, climate monitoring, disaster management, and other applications. International cooperation in data sharing and analysis promotes scientific advancements and enhances our understanding of the universe.

Cultural Exchange and Public Engagement: Space activities, particularly human space exploration, capture the imagination and interest of people globally.

Globalization enables cultural exchange and public engagement in space exploration, fostering international cooperation, promoting science education, and inspiring future generations to pursue careers in science, technology, engineering, and mathematics (STEM) fields.

Overall, globalization has brought nations together in space activities, fostering collaboration, technological advancements, economic opportunities, and scientific discoveries. It has transformed space exploration from a predominantly government-driven endeavor to a more diverse and interconnected global enterprise.

3. International Treaties Related to Space Damage

In order to address the issue of compensating for damages resulting from space activities, the international community has established a normative framework through the adoption of the Outer Space Treaty and the Liability Convention. The Outer Space Treaty of 1967 holds a pivotal role in interpreting matters pertaining to space. Similarly, the Space Liability Convention, implemented in 1972, serves as a crucial international law governing space damage and compensation. Furthermore, individual countries are actively enacting and enforcing domestic laws to protect victims affected by space-related damages within their jurisdictions. This section will delve into a comprehensive review of the provisions outlined in the Space Treaty and the Space Liability Convention, which form the foundation for space damage compensation. Subsequently, the research will explore the core aspects of space liability, including the conceptual framework and the extent of damages.

3.1. The Outer Space Treaty

The Outer Space Treaty serves as the cornerstone of space law, and Article 6¹ (Article 6 of the Outer Space Treaty) specifically addresses liability-related matters. It establishes the responsibility of states regarding their activities in outer space, whether carried out by governmental agencies or non-governmental entities. According to the Treaty, non-governmental entities engaged in space activities must obtain certification and ongoing supervision from the states party to the Treaty. The article also references the responsibilities of international organizations, emphasizing compliance with treaty obligations required by national authorities. Violation of the Outer Space Treaty not only breaches the legal framework governing space activities but also infringes upon the fundamental

¹Article 6 of the Outer Space Treaty “States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of nongovernmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried on in outer space, 6 including the Moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.”

principles of space law.

In terms of international responsibility, the principles of state responsibility outlined in Article 6 apply in space. However, there are certain deviations specified within the article. Notably, states are not absolved of responsibility for the actions of private subjects involved in space activities, regardless of whether due care was exercised. This means that private entities' space activities are held to the same standards of international responsibility as those of states. This provision serves as an incentive for countries to establish legislation permitting and continuously supervising space activities by individuals and corporations. Any breach of duty incurs international penalties. The key points of Article 6 can be summarized as follows:

States are directly responsible for space activities, regardless of whether they are carried out by government agencies, private companies, or other non-entities.

States must ensure that private enterprises adhere to the provisions of the Space Treaty, with responsibility falling on the state for any non-compliance, irrespective of negligence on the part of private entities.

When a country (or a supervised private enterprise) or its constituent parts cause damage to another country or its nationals, the responsible country is required to compensate for the resulting damage.

Article 7² (Article 7 of the Outer Space Treaty) of the Outer Space Treaty specifically addresses liability for damages. It states that any state party to the Treaty launching objects into outer space, including celestial bodies like the moon, is internationally liable for any damage caused to other states party to the Treaty or their natural or legal persons by these objects or their constituent parts. This provision affirms that states bear international responsibility as launching states under space law. However, further provisions are needed to guide the exercise of such responsibilities and the resolution of disputes arising from potential damages caused by space activities. In other words, the substantive legal aspects of liability are addressed, but the procedural legal content ensuring liability remains lacking.

The places where damages may occur include the ground, atmosphere, and outer space, including celestial bodies like the moon. Damage on Earth pertains to harm caused to individuals and property, commonly known as third-party damages on the ground. Damage in the atmosphere primarily refers to harm caused to aircraft, while damage in outer space refers to collisions with space objects belonging to other contracting parties. Consequently, the focus of Article 7 primarily encompasses damages occurring during the ascent, flight, descent, and landing of space objects in these locations.

²Article 7 of the Outer Space Treaty Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies.

It is evident that the liability provisions of Article 7 constitute a special rule for state responsibility outlined in Article 6, incorporating the principles of tort liability involving projectiles. However, it should be noted that neither of these provisions offers guidance on the procedural legal content required to ensure liability.

The Author see that the liability in space activities can involve both contractual and product liability.

The Contractual liability refers to the legal obligations and responsibilities arising from agreements and contracts between parties involved in space activities. This includes contractual agreements between space agencies, governments, private companies, and other entities. These contracts typically outline the rights, obligations, and liabilities of each party regarding the performance, safety, and risk allocation of the space mission or activity.

Product liability, on the other hand, pertains to the responsibility of manufacturers, suppliers, and operators for any harm or damage caused by their space-related products or equipment. This can include liability for design defects, manufacturing defects, inadequate warnings or instructions, or any other issues that may lead to accidents, property damage, or personal injuries.

Space activities involve complex systems, advanced technologies, and high risks. In case of accidents, failures, or damages resulting from space activities, determining liability can be a complex legal matter. It often requires a thorough analysis of contractual obligations, technical specifications, industry standards, and applicable laws and regulations.

3.2. Liability Convention

The Liability Convention serves as the fundamental legal framework for addressing liability issues arising from space activities. It incorporates a dual liability structure that encompasses both absolute liability and traditional negligent liability. Article 2³ (Article 2 of the Liability Convention) of the Convention establishes the concept of absolute liability, stating that a launching state is held fully accountable for compensating damages caused by its space objects on the Earth's surface or to aircraft in flight. This absolute liability acknowledges the potential risks associated with space activities and holds the launching state responsible for the consequences of such hazardous endeavors. The scope of absolute liability under the Convention is geographically limited, covering land, sea, underground, and all artificial objects deployed in airspace.

On the other hand, Article 3⁴ (Article 3 of the Liability Convention) of the Liability Convention addresses liability for wrongdoing based on the tradi-

³Article 2 of the Liability Convention "A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the Earth or to aircraft in flight."

⁴Article 3 of the Liability Convention "In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible."

tional theory of international law. It stipulates that if damage occurs to space objects, persons, or property outside the Earth's surface, the launching country of the space object or individuals under its jurisdiction are liable only if they are at fault. Absolute liability under Article 2 is confined to land, water, and the atmosphere, while fault liability governs other areas of space. This provision specifies the responsibilities in cases of space object collisions, electromagnetic interference, or damages occurring in space other than the Earth's surface or atmosphere. When space objects from different launching countries collide, the principle of fault liability governs their mutual responsibility. However, the Liability Convention does not include provisions regarding negligence, which traditionally arises from a failure to exercise due care in the circumstances.

Additionally, liability in space activities may also involve contractual and product liability. Contractual liability arises from agreements or contracts between parties and is typically derived from national law. Parties are explicitly defined, and liability issues are often addressed through international treaties between states. Non-contractual liability, on the other hand, deals with damages that occur outside contractual relationships and resembles third-party liability in international law. Public legal instruments at the international level, such as the Warsaw Regime on Contractual Liability in International Air Transport, are relevant for imposing third-party liability. At the domestic level, codified laws, regulations, clear jurisdiction, and customary law play crucial roles. Furthermore, product liability can be imposed on space launchers, placing responsibility on them for damages caused by their products.

When discussing damage under the Liability Convention, several questions arise. Firstly, the interpretation of "damage" itself must be considered. Is it limited to physical injury or does it encompass mental and social well-being, such as loss of consortium, mental anguish, pain and suffering, or invasion of the right to privacy? Secondly, does it include only direct damage or also consequential damage that may not directly result from the act but from its consequences, such as loss of future earnings, profit, or damage indirectly resulting from spatial reconnaissance? Moreover, does it cover damage caused by atomic radiation or other advanced energy sources? These inquiries raise significant considerations regarding the scope and definition of damage within the context of the Liability Convention.

In determining the compensability of different types of damages, there are further questions to address. To what extent should loss of property use be compensated, as distinguished from damage to the property itself? Should psychic injuries to human beings be compensable? How can damage caused by pollution of the atmosphere through toxic fuels or radiation be quantified? Should a form of "moral" damages be assessed? These questions provoke discussion and shape the understanding of the concept of damage under the Liability Convention.

4. Space Damage and Related Issues

4.1. Occurrence of Damage

In addition to the concepts discussed earlier, the definition and scope of “damage” under the Liability Convention are crucial aspects to consider. The Convention defines “damage” as the “loss of life, personal injury, or other impairment of health; or loss of or damage to property” (Article 1(a) of the Liability Convention). This definition explicitly includes human and material damages. However, the interpretation of damage can vary depending on how broadly or narrowly it is understood.

One significant question is whether indirect damages are encompassed alongside direct damages. Does environmental pollution qualify as damage under this concept? Are costs incurred for preventive measures considered part of the damage, and does the notion of damage extend to mental and social well-being in addition to physical harm? Although the Convention provides the above definition, diverse interpretations are possible among scholars due to the numerous questions it raises.

All draft proposals submitted to the Legal Sub-Committee emphasized liability for damage occurring on the Earth’s surface, in the air, and in outer space. The United States Draft defines (United Nations, 1971) “damage” as loss of life, personal injury, destruction or loss of, or damage to property on Earth, in the air, and in outer space. The Belgium Draft convention, (Christol, 1980) in Article II, defines “damage” as any loss for which compensation may be claimed under the national law of the injured person, including legal costs and interests.

Article I⁵ of the Liability Convention enumerates four kinds of recoverable harm; namely, loss of life, personal injury, other impairment of health, and loss of or damage to property (Article I of the Liability Convention). This definition falls within the categories of actual, direct, general, foreseeable, or compensatory harm. It does not specify all possible types of damages for which compensation should be provided intentionally, as agreement on all the various kinds of damages would have been impossible.

Regarding personal injuries, it is debated whether recovery can be sought when harm results from physical impact with space object debris or contamination emanating from such objects.

Professor Foster argues that compensable harm does not require physical impact with a space object and that injuries to persons, accompanied by objective or substantially harmful physical or psychopathological consequences or resulting in an “impairment of health,” should be covered (Foster, 1972).

The World Health Organization defines health as “a state of complete physical, mental, and social being (World Health Organization (WHO), 1948).” Therefore, the term “other impairment of health” in the Liability Convention can be inter-

⁵Article I of the Liability Convention(a) The term “damage” means loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations.

preted as extending beyond the harm associated with loss of life and physical injury, potentially encompassing impairment of mental resources or faculties that would support claims for monetary compensation.

In summary, the Liability Convention covers direct damages resulting from an act without the intervention of any intermediate controlling cause. However, the interpretation and inclusion of indirect damages, environmental damages, preventive costs, and the broader concept of impairment of health in relation to mental and social well-being remain topics of debate within the Convention.

4.2. Personal Damage/Mental Damage

The interpretation of personal injury within the context of the Liability Convention involves some disagreement among experts. While there is consensus regarding the meaning of death, the understanding of “injury” or “other impairment of health” varies. Bodily injury and disease are generally accepted as forms of harm. For instance, if a person’s arm is amputated and they acquire a disease due to being hit by a fragment of a space object, it would be considered an injury and an impairment of health. However, the question arises concerning non-physical damage or illness.

The World Health Organization Charter defines health as encompassing complete physical, mental, and social well-being, rather than merely the absence of disease or infirmity. Therefore, the concept of loss of health includes both physical infirmities and mental or social distress. Psychological anxiety, for instance, can be seen as a form of pain and disease. An example that illustrates the inclusion of non-physical harm is the case of Australia’s claims against France regarding radioactive material released from French nuclear tests in the Pacific. Part of Australia’s claim was based on the psychological stress experienced by people in the contaminated area.

Heart attacks can also be considered in this context. For instance, there may be cases where a fragment of a space object falls in front of a person’s eyes without physical contact, resulting in a heart attack (Christol, 1982). A precedent for compensation in such cases can be found in the (Lusitania case) where relatives of victims were compensated for the shock they suffered. Indirect damages, including the costs of preventing such damages and the impact on direct victims and their future offspring, can also be considered (Gale & Hauser, 1988).

Including indirect harm to health within the definition of damage is justifiable based on precedent and the rationale behind liability agreements. Failing to provide compensation for non-physical harm would hinder the fundamental objective of restoring the original sacrifice, as intended by the liability agreement. The issue of whether compensation for mental damage is possible remains a topic of discussion. During the negotiation of the liability agreement, there was controversy over whether mental damage could be covered. This issue becomes more complex due to differences in interpretation between international and domestic law, similar to the debates within international aviation law.

In international law, damage caused to both states and natural persons is recognized, and mental damage is considered a loss alongside material damage. Mental damage infringes upon the dignity or sovereignty of a state, while material damage affects natural persons or property. In cases of moral harm, which involve a breach of treaty obligations, international law recognizes that such violations do not necessarily result in material damage. Nonetheless, the state that breached the treaty is obliged to provide appropriate monetary compensation to the injured state (Friedmann, Lissitzyn, & Pugh, 1969).

The question at hand is whether psychological harm constitutes an infringement that warrants compensation. During the review of liability agreements before the Foreign Relations Committee in the US, the State Department's legal counsel suggested that claims for damages such as suffering, humiliation, or mental harm would be admissible under the agreement. The Convention facilitates reparation for such claims by establishing the principle that compensation should be determined by international law and principles of justice and equity. Cases involving psychological harm exhibit a range of circumstances. For instance, in France and Belgium, a wife can seek compensation for the loss suffered by her husband, while in the United States, a spouse can make a claim for personal loss (Reis, U.S. Discuss 1970). This perspective was presented as a proposal to the COPUOS committee. However, it is worth noting that Foster points out that this issue was not explicitly addressed in the COPUOS Legal Subcommittee or in the Liability Convention (Foster, 1972).

Assigning a monetary value to mental suffering or loss of the ability to enjoy life poses challenges. Nevertheless, it is argued that reparations must be provided for such issues. Claims for damages due to mental harm are recognized in both international law and domestic legal practice, as evident in the United States. The United States has demonstrated its willingness to include such damages within the scope of claims, as supported by the Director General of NASA. Moreover, there is an interpretation allowing compensation for the mental suffering experienced by survivors of deaths caused by space objects and for the suffering endured by individuals injured by space objects under the liability agreement.

Additionally, loss of profits is recognized as a form of compensable damage or loss of property in international courts. Claims related to personal injury encompass not only medical expenses but also loss of profits, trauma, and suffering. It is important to note that damages may be reduced if the plaintiff contributed to the occurrence of such damages.

However, when examining precedents in the United States for non-physical harm such as insults, loss of a spouse, emotional distress, and shock, the interpretation falls back on the Senate's understanding of Article 7 of the 1967 Outer Space Treaty. The Senate's interpretation focused solely on physical harm and excluded considerations of electromagnetic interference between countries. This interpretation was limited in scope, but with the entry into force of the 1972 Liability Convention, a slightly expanded framework for international tort law was

established.

According to expert opinion from the American Law Association, damages that can be claimed in tort law encompass both general damages and special damages. General damages encompass losses resulting from property damage or loss of use. In cases of personal injury, special damages include loss of earning capacity, medical expenses, and related costs. Compensation is also available for non-pecuniary damages, such as fear, anxiety, loss of companionship, and loss of freedom. However, compensation for such damages is contingent upon demonstrating that the damage caused by the space object was accidental and unintentional.

The jurisdiction of domestic law has developed in various ways. For instance, the approach to reparation issues in the former Soviet Union differs from that in the United States. The former Soviet Union's focus has primarily been on institutional costs, such as hospital expenses, tuition fees, and national pensions, rather than individual human losses. During the negotiations of the liability agreement, the Soviet Union proposed laws governing the types of damage warranting compensation and the measurement of such damage. However, the Soviet proposal provided limited access compared to the concepts and practices prevalent in the United States.

In US judicial practice, damages are not limited to the physical pain experienced by the victim at the time of the tort or during the treatment and recovery process (*Dimare v. Cresci*, 1962). They also encompass direct emotional responses to the injury or mental reactions regarding the potential consequences, including fright, shock, fear, terror, anxiety, unhappiness, humiliation, depression, and inconvenience (*Capelouto v. Kaiser*, 1972). This broad term encompasses changes in personality resulting from unlawful acts. Compensation for suffering includes not only damages incurred from the date of the tort until the conclusion of legal proceedings but also those expected to occur in the future (*Merchant's Fast Motor Lines*, 1964).

4.3. Material Damage

This legal research paper explores the question of whether the Liability Convention covers indirect, consequential, remote, or unforeseeable consequences in relation to harm resulting from a tortious act that is not a direct result of the wrongful act. It discusses the discussions held during the seventh session of the Legal Sub-Committee, where delegates debated whether to explicitly exclude compensation for indirect damage due to its ambiguous nature (*Foster*, 1972). While some delegates supported excluding indirect damage, the majority agreed that it would be better not to reference it in the convention to avoid complications. The focus should instead be on the relationship between cause and effect, with the term "damage" being sufficient without the need to classify it as direct or indirect.

The paper emphasizes that the question of indirect damage was left open to be addressed on a case-by-case basis. It highlights that causation plays a crucial role

in the allocation of damages in international tort law, and the Liability Convention specifies that damages can only be recovered if the harm is caused by a space object of a launching state. However, the Convention does not explicitly state whether claims cover both direct and indirect damage.

The paper discusses (Peter Haanappel's) example of the Cosmos 954 incident, which illustrates how clean-up costs could be considered indirect or consequential damage. It suggests that Canada's search and rescue costs resulting from fulfilling its duty to mitigate probable damages could be categorized as indirect or consequential damage under the Outer Space Treaty (Haanappel, 1978).

The concept of "caused by" is analyzed from different perspectives. It is argued that it can be interpreted to allow recovery for both a direct hit by space debris and the additional consequences stemming from the initial impact (Foster, 1972). Alternatively, it can be seen as emphasizing the need for a causal connection between the accident and the damage. The delegates' failure to reach a conclusive decision on "direct" versus "indirect" causation implies that the word "cause" should only require a causal link between the accident and the resulting damage.

Regarding material damage, the paper discusses the inclusion of indirect damages in the Compensation Convention. It acknowledges that accidents often result in both human and material damage, and the question arises as to whether indirect damages, such as economic losses suffered by third parties, should be considered compensable under the Convention. Different countries hold varying positions on this issue, but it is argued that an international convention should reconcile conflicts arising from diverse legal systems. To maintain justice and equity, indirect damages to property should be included as compensable damages to prevent disparities in compensation among nationals of different states.

Additionally, the paper highlights that the question of whether destruction caused by certain activities, such as remote sensing satellites or climate change technology misuse, can be considered as indirect damages may also arise.

In conclusion, this legal research paper addresses the issue of indirect and consequential damages under the Liability Convention. It provides analysis and insights into the discussions among delegates, the interpretation of the term "caused by," and the inclusion of indirect damages in the Compensation Convention. The paper emphasizes the importance of considering fairness and justice in determining compensable damages, particularly regarding material damage and the potential impacts of various activities in space.

4.4. Environmental Pollution

The concept of damage caused by pollution in space and on Earth is a critical aspect to consider. Various forms of environmental damage can occur, including damage resulting from space debris, harmful contamination and disturbance, nuclear and radioactive space activities, damage to the ozone layer, and damage caused by space stations and solar satellites.

Space debris poses a significant danger and contributes to environmental pol-

lution. The increasing amount of debris in space is a concerning factor. Damage caused by space debris can be categorized into several types. Firstly, it can cause damage by falling to the ground, potentially impacting structures and property. Secondly, collisions between space debris and other space objects can result in further damage. Additionally, space debris can interfere with remote communication and exploration systems. Furthermore, the presence of space debris poses risks to human beings and spacecraft.

In the early days of space activities, there were concerns about the contamination of Earth with returning space objects, including the potential presence of pathogens. Purification practices were initially followed by the United States and the Soviet Union to mitigate these risks. However, over time, such concerns diminished, and these practices ceased. Consequently, the possibility of contamination and damage to Earth still exists.

Another environmental concern is the damage to the ozone layer caused by rockets in the atmosphere. The emissions and exhaust gases from rocket launches can contribute to ozone depletion, which has significant implications for Earth's atmosphere and ecosystem.

The failure of nuclear fuel-powered satellites presents a particular challenge in terms of nuclear contamination. In such cases, when international and environmental interests are endangered and negatively impacted by states, it becomes crucial to determine who has the responsibility to address the situation and mitigate the risks.

Efforts to address these environmental concerns require collaboration and coordination among nations. International cooperation is necessary to develop policies and regulations that mitigate the environmental impact of space activities. It is essential to establish mechanisms for monitoring, managing, and mitigating pollution and damage caused by space debris, contamination, and other activities.

In conclusion, the concept of damage caused by pollution in space and on Earth encompasses various forms of environmental harm. Space debris, contamination, nuclear activities, ozone layer damage, and other factors pose significant risks. Addressing these challenges requires international cooperation and the development of policies and mechanisms to ensure the protection of both Earth and space environments.

4.5. Satellite Data (Photo and Video) Transmission Problemg

In addition to the environmental concerns mentioned earlier, there are additional factors that can impact space activities and cause damage. One such factor is the issue of electrical crosstalk and interference, which can disrupt satellite communication and data collection.

Satellite images and data transmitted by spacecraft are crucial for various purposes, including scientific research, weather monitoring, and communication. However, electrical crosstalk and interference can hinder the reception of these valuable resources. If the data transmission is disrupted or altered before

reaching its intended destination, it can render significant expenses and efforts useless. For instance, NASA relies on accurate and reliable data for its missions, and any disruption in communication can have severe consequences.

The potential for electronic data disruption or alteration raises concerns about the damage that can result from such acts. It may not be foreseeable that intentional or unintentional interference can cause damage, but the impact can be significant. In the case of satellite communication, interference can disrupt the mission of the satellite itself and impede the collection of vital information. This interference can occur due to various factors, including electromagnetic wave emissions from satellites during their operation.

While unintentional damages caused by electromagnetic wave emissions are a concern, deliberate acts of interference should also be taken into account. Intentional damage to satellite communication systems can be motivated by various reasons, such as espionage, sabotage, or disruption of communication networks. Such actions can have far-reaching consequences, affecting not only the specific mission of the satellite but also broader communication networks and the reliability of data transmission.

To ensure the integrity and effectiveness of space activities, measures need to be taken to mitigate the risks associated with electrical crosstalk, interference, and intentional damage. This includes implementing robust communication protocols, utilizing advanced encryption techniques to safeguard data, and developing strategies to detect and respond to interference incidents promptly.

Furthermore, international cooperation and the establishment of regulatory frameworks are essential in addressing these challenges. Collaborative efforts can lead to the development of guidelines and standards that promote responsible and secure space activities, reducing the likelihood of damage caused by interference.

In conclusion, the issue of electrical crosstalk, interference, and intentional damage is a significant concern for space activities. Disruptions in satellite communication and data collection can result in substantial financial losses and hinder scientific progress. Addressing these challenges requires proactive measures, including the implementation of reliable communication protocols, the use of advanced encryption techniques, and international collaboration to establish regulations that ensure the security and effectiveness of space missions.

4.6. Place of Occurrence of Damage

The allocation of responsibility for space damage is primarily categorized into absolute liability and fault liability. The determination of liability requirements differs depending on the location of the damage, specifically whether it occurs on the surface of the Earth or in an area beyond it. Therefore, in the context of discussing damage in space, the location of the damage holds significant importance. Due to the lack of clear distinction between space and airspace and the absence of explicit regulations, the topic necessitates careful consideration.

Currently, the distinction between space and airspace is primarily based on

the spatial theory, which asserts that the universe begins approximately 100 kilometers above the Earth's surface. According to this prevailing theory, any damage occurring below this altitude is regarded as falling within the responsibility of the party causing the damage under the principle of absolute liability. Absolute liability means that the responsible party is held liable for the damage regardless of whether any fault or negligence occurred.

By establishing the 100-kilometer threshold, it becomes possible to delineate the boundary between space and airspace for the purpose of determining liability. However, it should be noted that this threshold is a general guideline rather than an absolute rule. It provides a basis for legal discussions and is subject to further refinement and interpretation.

The concept of absolute liability in space activities recognizes the inherently risky nature of such endeavors and the potential for significant harm. It places a burden on the party conducting the space operation to ensure appropriate precautions and safety measures are in place to prevent damage to the surface of the Earth or any property and lives within that area. This principle encourages responsible conduct and underscores the need for strict adherence to safety protocols in space exploration and related activities.

The establishment of a clear framework for determining liability in space-related damage is crucial to ensure fairness, accountability, and the effective functioning of international space law. As the exploration and utilization of space continue to advance, it becomes increasingly important to address potential conflicts and disputes arising from damage caused by space activities. The ongoing development and refinement of legal frameworks, international agreements, and conventions play a vital role in shaping the principles of liability and providing guidance for parties involved in space operations.

In conclusion, the question of liability for space damage encompasses the concepts of absolute liability and fault liability, which are determined based on the location of the damage. The spatial theory, with the 100-kilometer threshold, currently serves as a guideline for distinguishing between space and airspace. Damage occurring below this threshold is subject to absolute liability, emphasizing the responsibility of the party causing the damage. However, the precise determination of liability in space-related damage requires ongoing discussions, legal developments, and international cooperation to ensure a fair and effective legal framework for space activities.

5. Risks of Space Activities

Space activities come with inherent risks that arise from venturing beyond Earth's atmosphere and pushing the boundaries of human exploration. These risks encompass a wide range of challenges, including technological failures, human health and safety concerns, environmental impacts, geopolitical tensions, and space debris. As we venture further into space, the risks associated with space activities become increasingly complex and significant. It is crucial to identify and mitigate these risks to ensure the safe, sustainable, and responsible advancement

of space exploration and utilization.

Launch Failures: One of the primary risks in space activities is the potential for launch failures. Rockets carrying satellites or astronauts may experience malfunctions or accidents during launch, resulting in the loss of valuable assets and endangering human lives.

Space Debris: The accumulation of space debris, including defunct satellites, spent rocket stages, and fragments from previous missions, poses a significant risk. Collisions with debris can damage or destroy operational satellites and spacecraft, creating a cascade effect that increases the amount of debris and further jeopardizes space activities.

Astronaut Health and Safety: Human space exploration involves significant risks to astronaut health and safety. Exposure to microgravity, radiation, isolation, and psychological stress can have long-term effects on astronauts' well-being. Ensuring adequate life support systems, medical care, and psychological support are crucial to mitigating these risks.

Communication and Navigation Failures: Space missions heavily rely on communication and navigation systems for data transmission and spacecraft control. Malfunctions or disruptions in these systems can lead to loss of communication, inaccurate positioning, and potential mission failure.

Regulatory and Legal Challenges: The legal framework governing space activities is complex and evolving. Issues such as liability for damages caused by space objects, national jurisdiction over space resources, and intellectual property rights in space pose legal challenges that need to be addressed to ensure responsible and sustainable space operations.

National Security Concerns: The dual-use nature of space technologies raises national security concerns. Military activities in space, including anti-satellite tests or weaponization, can escalate tensions and potentially lead to conflicts.

Economic Viability: Space activities require significant investments, and the economic viability of space ventures remains a risk. Market demand, cost overruns, delays, and the unpredictability of returns on investment pose challenges to the sustainability of space enterprises.

Overall, space activities involve inherent risks that need to be identified, managed, and mitigated. Continued advancements in technology, international cooperation, and regulatory frameworks are essential to ensure the safe, secure, and sustainable exploration and utilization of space.

6. Conclusion

The exploration and use of space present numerous challenges, including the potential for damage to human health, property, and the environment. This article examines the concept of damage in space activities, considering both direct and indirect impacts on individuals and property. It explores the scope of liability, the inclusion of mental and physical injuries, and the pursuit of fair compensation for victims. Additionally, it delves into the inherent risks involved in

space endeavors and the limitations of liability agreements in addressing certain types of damages.

- **Expanding the Definition of Health-Related Damage:**

Recognizing that health infringement extends beyond physical ailments, it becomes crucial to encompass mental and social well-being within the concept of damage assessment. Mental injuries accompanied by suffering fall within the category of damages, aligning with a broad interpretation of health. Thus, the liability agreement acknowledges human damages to include death, physical injuries, and psychological harm suffered by victims, whether directly or indirectly, due to space activities.

- **Comprehensive Approach to Damage Compensation:**

The Liability Convention emphasizes the need for compensation encompassing all physical, psychological, and fatal injuries resulting from space activities. Achieving accurate resolution of damages requires a thorough examination of losses incurred by individuals, corporations, and international government organizations. The liability agreement comprehensively considers both direct and indirect impacts on human beings and property. When seeking compensation, the focus lies in restoring the victim to a state where the accident did not occur, ensuring the best possible recovery.

- **Balancing Benefits and Risks:**

Space activities are considered beneficial to humanity, yet inherently risky. While precautions are taken to mitigate hazards, complete elimination of all risks is impractical. The negotiation phase of liability agreements has seen attempts to limit liability for nuclear damage resulting from space accidents, but consensus remains elusive. Nevertheless, claims for compensation for direct damages and mental injuries caused by space object malfunction or collisions are still possible.

- **Proposed Solutions for Enhanced Legal Framework:**

Establishment of a Space Activity Dispute Organization: Drawing inspiration from the successful resolution of maritime disputes through the establishment of a maritime law court, it is suggested to introduce a professional and systematic dispute settlement mechanism for future space-related conflicts. This may include the creation of an International Space Law Court, ensuring professional dispute resolution for space disputes.

Regional Cooperative Organization for Launch and Responsibility Issues: In addition to ongoing discussions within the Peaceful Use of Outer Space Committee of the United Nations, the establishment of a regional cooperative organization focused on launch and responsibility issues is proposed. This organization could foster collaboration, knowledge-sharing, and effective problem-solving specific to regional space activities.

Addressing liability and compensation in space activities necessitates a comprehensive legal framework. It requires a correct interpretation and application of existing international laws, as well as the establishment of long-term institutional and policy alternatives. Just as the saying goes, “where there is profit, there

is responsibility,” justice can be achieved by meticulously analyzing and applying the relationship between profit, damage, and compensation. To achieve this, the international community can take several actions.

Firstly, international treaties and agreements can be developed and implemented to establish clear rules and guidelines for liability and compensation in space activities. The United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) can play a role in formulating these international legal frameworks.

Strengthening and expanding the existing Liability Convention, formally known as the “Convention on International Liability for Damage Caused by Space Objects,” can provide a legal framework for addressing liability in space activities. This convention establishes the principle of absolute liability for space activities and provides a mechanism for compensation for damages caused by space objects.

Encouraging space actors to obtain insurance coverage and implementing risk mitigation measures can help ensure financial compensation in case of accidents or damages. Governments and space agencies can play a role in promoting insurance coverage and implementing safety regulations to minimize the likelihood of accidents and mitigate potential damages.

Promoting international cooperation among spacefaring nations, space agencies, and private entities is crucial in addressing liability and compensation issues. Sharing best practices, exchanging information, and collaborating on risk assessment and management can contribute to a more effective and fair system.

Establishing specialized dispute resolution mechanisms, such as international arbitration or mediation, can provide a means for resolving liability disputes in a fair and impartial manner. These mechanisms can help streamline the resolution process and ensure consistent interpretation and application of international space law.

Increasing public awareness about the risks and potential liabilities associated with space activities is essential. Educating the public, policymakers, and stakeholders about the legal framework, potential consequences, and responsibilities can foster a better understanding of liability issues and encourage responsible behavior in space activities.

Addressing liability and compensation in space activities requires the international community’s collaborative effort to develop comprehensive legal frameworks, promote responsible behavior, and ensure fair compensation for damages caused by space activities. By considering the establishment of a space activity dispute organization and a regional cooperative organization, we can enhance the effectiveness and fairness of resolving liability issues in space activities.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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