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SAFEGUARDING THE CELESTIAL REALM: EVALUATING THE LEGAL FRAMEWORKS FOR SPACE DEBRIS MITIGATION

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ABSTRACT

The exploration and utilization of outer space have significantly expanded over the past few decades, driven by technological advancements and the pursuit of scientific knowledge. These have immensely helped society, and people of all strata of the society. From people in remote areas having access to the internet to powered tech innovations like connected cars⁶¹⁰ and Observation satellites once man reached space even the sky wasn't the limit. However, this increased space activity has also led to an alarming consequence: space debris. Space debris refers to defunct satellites, spent rocket stages, fragments from collisions, and other remnants of human space activities that clutter Earth's orbit.⁶¹¹ Space debris can be categorized by how it is created. About twenty percent of trackable debris is "inactive payloads," primarily consisting of inactive satellites that are no longer controllable.⁶¹² About twenty-six percent of trackable debris is "operational debris," which includes intact objects launched with a prior space mission such as "fuel tanks, insulation panels, sewage, rocket bodies, bolts and straps."⁶¹³ These objects pose a significant threat to active satellites, spacecraft, and future space missions as the risk of collision increases day by day. Addressing the issue of space debris requires effective legal and policy frameworks at both the international and national levels. This article aims to analyse the existing legal and policy frameworks for space debris mitigation, focusing on their effectiveness, limitations, and potential improvements.

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⁶¹⁰ [ESA - How space is connecting cars](#)

⁶¹¹ [Space Debris: Threat to Our Space Environment - satdh \(cmsodi.github.io\)](#)

⁶¹² Gabrielle Hollingsworth, Space Junk: Why the United Nations Must Step in to Save Access to Space, SANTA CLARA L. REV. 239, 242 (2013)

⁶¹³ *ibid*

The Growing Problem of Space Debris

Since the launch of Sputnik 1 in 1957, thousands of objects have been sent into space, and many of them have become defunct or lost control. In more than 60 years of space activities, more than 6050 launches have resulted in some 56450 tracked objects in orbit, of which about 28160 remain in space.⁶¹⁴ These objects continue to orbit Earth at high velocities, creating a hazardous environment for current and future space missions. The United States Space Surveillance Network (SSN) tracks—and catalogues these objects, covering objects larger than about 5-10 cm in low-Earth orbit (LEO) and 30 cm to 1 m at geostationary (GEO) altitudes.⁶¹⁵ Even a small piece of debris can cause severe damage due to the tremendous speeds at which they travel⁶¹⁶, making the issue a matter of utmost concern for space agencies and satellite operators worldwide.

The Need for Legal and Policy Frameworks

Space debris mitigation requires coordinated efforts at the global level. As space activities involve multiple nations and commercial entities, effective legal and policy frameworks are essential to establish guidelines, standards, and responsibilities for debris mitigation. Without such frameworks, the space environment could become increasingly cluttered and dangerous, hindering future space exploration and satellite operations. The Organisation for Economic Co-operation and Development (OECD)⁶¹⁷ published its first report on the cost of Space Debris the full range of protective and debris mitigation measures (e.g. shielding, manoeuvres and moving into graveyard orbit) which was estimated to amount to 5-10% of total mission costs.

INTERNATIONAL LEGAL FRAMEWORKS

Outer Space Treaty (OST)

⁶¹⁴ [ESA - About space debris](#)

⁶¹⁵ [ESA - About space debris](#)

⁶¹⁶ [Space Debris and Human Spacecraft | NASA](#), para 1.

⁶¹⁷ [Organisation for Economic Co-operation and Development](#)

The cornerstone of space law is the Outer Space Treaty (by the UNOOSA), adopted by the United Nations in 1967. The OST sets forth the fundamental principles governing the activities of states in outer space and includes provisions relevant to space debris mitigation.⁶¹⁸ Article IX of the treaty states that parties to the treaty shall avoid harmful contamination of space and celestial bodies. While this does not specifically mention space debris, it implies a responsibility to mitigate debris generation and potential harmful effects.

However, the OST has limitations. It lacks detailed provisions regarding space debris removal, and enforcement mechanisms are relatively weak. Additionally, it does not address the responsibilities of non-governmental entities or provide guidelines for collaborative efforts among nations. It establishes that all nations must be able to freely access space, thus creating the problem of a mass number of nations having access to the area thus leading to more than 70 nations having a space programme today.

Space Debris Mitigation Guidelines

To complement the Outer Space Treaty, various international organizations, such as the Inter-Agency Space Debris Coordination Committee (IADC)⁶¹⁹ and the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)⁶²⁰, have developed non-binding guidelines for space debris mitigation. These guidelines recommend measures like post-mission disposal, launch vehicle fragmentation control, and operational practices to minimize debris generation.

While these guidelines serve as valuable reference points, they face challenges in achieving universal compliance. They lack the legal weight of treaties, making them voluntary and non-binding. As a result, some nations and commercial entities may choose not to adhere to the guidelines fully.

⁶¹⁸ [The Outer Space Treaty \(unoosa.org\)](#)

⁶¹⁹ [IADC \(iadc-home.org\)](#)

⁶²⁰ [COPUOS \(unoosa.org\)](#)

Liability Convention

The Liability Convention, another component of international space law, *“provides that a launching State shall be absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth or to aircraft, and liable for damage due to its faults in space. The Convention also provides for procedures for the settlement of claims for damages.”*⁶²¹ This convention encourages responsible space activities and indirectly incentivizes debris mitigation measures. However, it primarily focuses on liability for damage and does not explicitly address debris prevention or removal.

Legal Frameworks

United States Space Policy Directives

Many spacefaring nations have developed their national policies to address space debris. In the United States, the National Space Policy Directives provide guidance on space debris mitigation.⁶²² The directives emphasize cooperation with international partners, the use of best practices for debris mitigation, and research and development of technologies for active debris removal. On July 28, 2022, the White House Office of Science and Technology Policy released the National Orbital Debris Mitigation Plan which builds upon the **National Orbital Debris Research and Development (R&D) Plan** published in 2021.⁶²³

While these directives demonstrate the United States' commitment to space debris mitigation, their effectiveness is limited to national efforts. A comprehensive international approach is essential since space debris is a global problem that requires collective action.

European Space Agency (ESA) Regulations

The ESA has also taken significant steps in addressing space debris. ESA member states

have adopted regulations that require compliance with space debris mitigation measures for missions launched from their territories. These regulations include the use of propulsion systems for post-mission disposal, limiting debris releases, and reducing the risk of explosions during satellite decommissioning. European Space Debris Office **ESOC Mission Control** teams in Darmstadt, Germany, monitor and assess the **possibility** of potential collisions in orbit and **instruct** operators on how to keep their missions safe.⁶²⁴ Its Initiatives like the Space Surveillance and Tracking (**SST**) segment and CleanSpace are the forerunners to the cause.

Space Debris analysis is done with these tools that are provided by the ESOC:

- MASTER (Meteoroid and Space Debris Terrestrial Environment) model for the prediction of debris and meteoroid particle fluxes
- PROOF (Program for Radar and Optical Observation Forecasts) tool for planning and simulation of radar and optical observations on ground or in space
- DRAMA (Debris Risk Assessment and Mitigation Analysis) for the verification of the compliance of space missions with mitigation guidelines⁶²⁵

CHALLENGES AND FUTURE PROSPECTS

Despite the existence of legal and policy frameworks, several challenges hinder effective space debris mitigation:

Lack of Universality

The voluntary nature of many guidelines and the absence of binding agreements mean that not all nations and entities adhere to best practices for space debris mitigation. As space activities continue to diversify globally, achieving universal compliance becomes increasingly difficult.

⁶²¹ [Liability Convention \(unoosa.org\)](https://www.unoosa.org/)

⁶²² [President Signs Space Traffic Management Policy – Office of Space Commerce](#)

⁶²³ [White House Releases Orbital Debris R&D Plan – Office of Space Commerce](#)

⁶²⁴ [ESA - The cost of space debris](#)

⁶²⁵ [ESA - About the Space Debris Office](#)

Limited Enforcement Mechanisms

International space law lacks robust enforcement mechanisms to hold non-compliant entities accountable for irresponsible actions. The absence of penalties or consequences for violating space debris mitigation guidelines reduces the incentive for adherence.

Technology and Cost Barriers

Space debris removal and mitigation technologies are still in their early stages, and the cost of implementing such measures can be substantial. Commercial entities may be hesitant to invest in these technologies without clear regulatory requirements or financial incentives.

Need for Space Traffic Management

As the number of satellites and spacecraft in orbit increases, there is a growing need for effective space traffic management systems. Coordinating space activities and avoiding collisions would significantly contribute to space debris mitigation.

Disparities in the International Legal Framework

Inequitable Distribution of Responsibility

The Outer Space Treaty serves as a foundation for space law, aiming to promote peaceful and responsible use of outer space. However, the treaty lacks specific provisions on space debris mitigation, raising concerns about accountability and responsibility. As space activities primarily involve major spacefaring nations, the burden of mitigating space debris often falls on them, while emerging spacefaring nations or developing countries have a lesser role in generating debris but share the risks and consequences.

Power Imbalances in Non-Binding Guidelines

International organizations like the Inter-Agency Space Debris Coordination Committee (IADC) and the United Nations Committee on the

Peaceful Uses of Outer Space (COPUOS) have developed non-binding guidelines for space debris mitigation. While these guidelines offer valuable recommendations, they cannot compel powerful spacefaring nations to comply. Wealthier and technologically advanced nations may prioritize their interests, leading to disparities in adherence and enforcement.

Weaknesses in National Legal Frameworks

Fragmented Approaches

National legal frameworks for space debris mitigation vary widely from one country to another. Each nation adopts its own policies, guidelines, and regulations, leading to a fragmented approach to a global problem. Inconsistent standards and practices hinder the establishment of a cohesive and collaborative effort to tackle space debris.

Corporate Interests Over Public Good

In countries like the United States, national space policies are influenced by powerful aerospace corporations, which often prioritize profit-making ventures over the public good. This influence can lead to lax regulations and limited obligations for debris mitigation, as corporations prioritize cost-cutting measures over environmentally responsible practices.

Challenges to Effectiveness

Lack of International Cooperation

The issue of space debris is a global concern that requires comprehensive international cooperation. Unfortunately, the existing legal and policy frameworks lack the mechanisms to compel nations and entities to work together towards a collective solution. As a result, the responsibility for space debris mitigation remains fragmented and disjointed.

Enforcement and Accountability Gap

The absence of robust enforcement mechanisms is a significant challenge. While international space law sets liability for damage

caused by space objects, proving culpability for specific debris incidents can be challenging. This lack of accountability reduces the incentive for nations and commercial entities to adopt stringent mitigation measures.

Technological and Financial Barriers

The development and deployment of space debris mitigation technologies remain a challenge. The cost of implementing such measures can be substantial, and emerging spacefaring nations or commercial entities may find it difficult to afford these technologies, further widening the gap between powerful spacefaring nations and others.

Toward a More Egalitarian and Effective Approach

Inclusive and Collaborative Frameworks

An egalitarian approach to space debris mitigation necessitates inclusive and collaborative frameworks that involve all nations, regardless of their space capabilities. Binding agreements with clear responsibilities and consequences for non-compliance must be established to ensure equitable participation in debris mitigation efforts.

Reducing Reliance on Military and Dual-Use Space Technology

Military and dual-use space technology contribute significantly to space debris. A critical approach to space debris mitigation calls for greater transparency and scrutiny of military space activities, with a focus on adopting peaceful, civilian-oriented space exploration.

Empowering International Organizations

Strengthening the role of international organizations, such as the United Nations Office for Outer Space Affairs (UNOOSA) and COPUOS, is crucial to overcoming power imbalances and fostering global cooperation. These organizations should be granted greater authority to oversee space activities, set

standards, and coordinate debris mitigation efforts.

Encouraging Responsible Corporate Practices

National legal frameworks should prioritize the public good over corporate interests. Governments must take proactive steps to ensure that corporations adhere to stringent debris mitigation measures, holding them accountable for any adverse environmental impacts.

Technology Sharing and Financial Support

To bridge the technological and financial gap, wealthier spacefaring nations should actively support emerging spacefaring nations and commercial entities. This support could include technology sharing, capacity-building initiatives, and financial assistance to implement space debris mitigation measures.

Conclusion

An egalitarian and critical perspective on legal and policy frameworks for space debris mitigation reveals significant disparities, power imbalances, and challenges. To address the pressing issue of space debris effectively, nations must transcend self-interest and prioritize global cooperation. Binding agreements, international oversight, and responsible corporate practices are essential to achieving a sustainable and secure space environment for the benefit of all humanity. Existing legal and policy frameworks, such as the Outer Space Treaty and space debris mitigation guidelines, provide valuable guidance, but their effectiveness is hindered by the lack of universality and binding mechanisms. Nations and international organizations must continue to work together to enhance existing frameworks, develop new regulations, and foster technological advancements to address the growing problem of space debris effectively. Only through collective efforts can we ensure a safe and sustainable space environment for future generations.



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