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WHEN SPACE DEBRIS FALLS: LEGAL GAPS AT SEA

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Abstract:

The increasing number of activities in outer space, alongside the rising threat of space debris, presents significant challenges within international law, particularly concerning incidents that occur at sea. As states and private entities engage in satellite launches and space exploration, the risk of space debris impacting maritime vessels and ecosystems intensifies. Existing legal frameworks, including the Outer Space Treaty and the United Nations Convention on the Law of the Sea (UNCLOS), are often fragmented and inadequately equipped to address these cross-domain incidents. This paper critically examines the discrepancies between space law and maritime law, particularly regarding liability for damages. It highlights the inconsistencies in legal principles, which complicate the pursuit of justice for affected parties and undermine state accountability. To address these challenges, the paper proposes necessary legal reforms aimed at harmonizing space and maritime laws, advocating for the establishment of a cohesive regulatory regime. Such a framework would provide clear guidelines for liability, compensation mechanisms, and protocols for mitigating risks associated with space debris. By fostering international cooperation and dialogue among stakeholders, this research aims to bridge existing gaps and enhance the protection of both celestial and maritime domains in an increasingly interconnected world. Ultimately, it argues for a comprehensive legal approach that reflects the complexities of emerging hybrid threats, ensuring sustainable governance of outer space and ocean resources.

I. Introduction

The swift growth of human endeavours beyond our planet has sparked remarkable advancements in science, economy, and strategy. Yet, this expansion has also led to unforeseen challenges, most notably the escalating threat of space debris. Items such as defunct satellites, discarded rocket components, and fragments from collisions now orbit Earth, posing serious risks upon re-entry. This danger extends not only to life on land but also to marine ecosystems and vessels traversing the seas. A particularly illustrative case is the uncontrolled descent of China's Tiangong-1 space station in 2018. Although it resulted in no reported damage, this event highlighted the vulnerabilities associated with unregulated activities in space. It serves as a crucial reminder of the need for comprehensive oversight in our increasingly crowded orbital environment.[369]

International legal frameworks have historically treated outer space and the high seas as distinct domains, each governed by comprehensive but isolated instruments — notably, the 1967 Outer Space Treaty[370] and the 1982 United Nations Convention on the Law of the Sea (UNCLOS)[371]. The emergence of interactions that span both space and maritime

[369] (Mike Wall, *Kessler Syndrome and the Space Debris Problem*, Space.com, July 15, 2022, available at https://www.space.com/kessler-syndrome-space-debris).
[370] 610 U.N.T.S. 205
[371] 1833 U.N.T.S. 397

domains calls for a re-evaluation of the traditional compartmentalized approach to international law. Existing treaties fail to address several pivotal questions:

- Liability: Who is responsible when space debris inflicts damage on maritime vessels or marine environments?
- Compensation: What mechanisms are in place for victims seeking redress for such damages?
- Ownership Issues: What occurs when the ownership of debris is unclear or shared among multiple nations?

These critical issues underscore the inadequacies of current legal frameworks and highlight the urgent need for a more integrated and comprehensive approach to address the complexities of dual-domain interactions.

This article seeks to critically assess these questions, explore existing legal frameworks, identify gaps, and propose reforms to build cohesive, forward looking liability regime for the incidents involving both the domains.

II. Current Legal Framework and Their Shortcomings

A. Outer Space Treaty, 1967.

The Outer Space Treaty (OST) serves as the foundational framework of international space law, asserting that all activities conducted in outer space must benefit humanity. It explicitly prohibits any national appropriation of celestial bodies, reinforcing the principle that space is a shared domain. Article VII of the OST stipulates that states bear international responsibility for their national space activities, which includes actions undertaken by private entities. This provision underscores the obligation of nations to ensure that their space endeavours do not result in harm to other states or to the global community, thereby establishing a critical link between liability in space activities and potential impacts on other domains, such as maritime environments.[372]

While the Outer Space Treaty provides a broad framework for liability, its provisions are notably general and do not explicitly address damages that occur at sea. The treaty lacks definitions for key concepts such as space debris and does not establish a clear connection between space activities and the risks they pose to marine environments. This omission creates a significant gap in the legal framework, leaving critical cross-domain incidents inadequately addressed. As a result, there is an urgent need for legal reforms that can bridge these gaps and establish a more cohesive approach to liability. Such reforms should focus on clarifying definitions and establishing explicit connections between space activities and their maritime implications, ensuring that affected parties have a clear path for compensation. By addressing these deficiencies, we can promote accountability among space-faring nations while safeguarding both celestial and marine environments in an increasingly interconnected world.

B. Space Liability Convention, 1972.

Building on the OST, the 1972 Space Liability Convention (SLC) establishes a regime of absolute liability for damages caused by space objects on the Earth's surface, including the seas.[373] The practical challenges surrounding liability in space activities are significant. The Convention mandates that claims must be initiated by states through diplomatic channels, which poses barriers for private claimants who lack direct avenues for redress. Moreover, the absence of clear procedures for situations involving multiple launching states complicates the process further.

Liability attribution becomes especially complex when private enterprises, multi-state missions, and third-party launch services are involved. These factors can obscure ownership and operational control over space objects, making it difficult to determine accountability in the event of damages or incidents, particularly

[372] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Jan. 27, 1967, 610 U.N.T.S. 205

[373] Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 961 U.N.T.S. 187

when they impact other domains, such as maritime environments. This highlights the need for a more robust legal framework that can effectively address these complexities and ensure fair compensation for affected parties.

C. United Nations Convention on the Law of Sea, 1982.

UNCLOS serves as the principal treaty governing maritime conduct, including environmental protection obligations.[374] The United Nations Convention on the Law of the Sea (UNCLOS) does not explicitly address the risks associated with space debris that may fall into maritime zones. Article 1(4) defines "pollution," but this definition does not currently include debris originating from outer space.

As a result, while UNCLOS mandates that states take measures to prevent pollution of the marine environment, its relevance to space-derived debris remains unclear. This ambiguity undermines both environmental protection efforts and the mechanisms for compensating victims affected by such incidents. There is a pressing need for legal frameworks that can adequately integrate these emerging risks and ensure comprehensive protection for marine environments against space-related hazards.

III. Liability Challenges in Cross – Domain Incidents

A. Attribution and Jurisdictional Ambiguities

Attributing liability for damages caused by space debris presents unique challenges. The complexity of identifying the precise source of debris increases, especially when it originates from multi-national missions or commercial operators operating under various national jurisdictions. Furthermore, jurisdictional issues become more complicated in areas beyond national jurisdiction, such as the high seas, where no single state exercises sovereignty.

B. Gaps in Private Party Remedies

The current legal framework disproportionately favours state-to-state dispute mechanisms, often sidelining private entities like shipping companies, offshore platform operators, and undersea cable proprietors. Under the Space Liability Convention, private parties are required to petition their governments to initiate claims on their behalf, which is a politically sensitive and slow process. In contrast, maritime law under UNCLOS provides private actors with more direct access to remedies for pollution or maritime incidents, highlighting a significant asymmetry that needs urgent rectification.

C. Environmental Impact Blind Spots

Neither the Outer Space Treaty (OST), the Space Liability Convention (SLC), nor UNCLOS adequately address the ecological consequences of space debris re-entry. Toxic materials, such as hydrazine and beryllium, present in spacecraft can have devastating impacts on marine biodiversity. The absence of binding environmental impact assessment (EIA) obligations for de-orbiting space objects is a glaring omission in both space and maritime governance frameworks.

IV. Lessons from Analogous International Liability Regimes

Cross-domain environmental harm is not a new legal challenge, and valuable lessons can be drawn from existing regimes that have successfully addressed similar issues. These frameworks provide insights into how to establish effective liability mechanisms in the context of space debris impacting maritime environments.

1. International Oil Pollution Compensation Funds (IOPC Funds):

- Collective Compensation Mechanisms: The IOPC Funds demonstrate the effectiveness of establishing collective compensation systems funded by industry levies. These funds provide a structured approach to compensating victims of oil spills, ensuring that

[374] United Nations Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 397

resources are available for timely and adequate compensation.

- Industry Accountability: By requiring contributions from oil companies, the IOPC model holds the industry accountable for environmental damage. This principle can be applied to space activities, where satellite operators and launch providers contribute to a fund that addresses damages caused by space debris.
- Streamlined Claims Processing: The IOPC Funds have established clear procedures for claims submission and assessment, which could serve as a model for a similar system in the space-maritime context. This would enhance efficiency and transparency, making it easier for affected parties to seek redress.

2. Transboundary Air Pollution Regimes:

- Collaborative Frameworks: Instruments like the Convention on Long-Range Transboundary Air Pollution (1979) illustrate how states can collaborate to address invisible, boundary-crossing environmental threats. This regime emphasizes the importance of collective action and shared responsibility among nations to mitigate pollution that transcends borders.
- Monitoring and Reporting Mechanisms: Effective monitoring and reporting systems are crucial for identifying sources of pollution and assessing their impacts. A similar approach could be adopted for tracking space debris and its potential effects on maritime environments, enabling proactive measures to prevent harm.
- Joint Research Initiatives: Collaborative research efforts among states can lead to better understanding and solutions for transboundary pollution. Establishing joint initiatives focused on space debris mitigation and its maritime impacts could foster innovation and shared knowledge.

3. Nuclear Damage Compensation Models:

- Strict Liability Frameworks: Frameworks such as the Vienna Convention on Civil Liability for Nuclear Damage provide examples of strict liability combined with centralized claims processing. This model ensures that victims can claim compensation without needing to prove fault, streamlining the claims process and enhancing access to justice.
- Centralized Claims Processing: The centralized approach to claims processing seen in nuclear liability regimes can be adapted for space debris incidents. A dedicated tribunal or agency could handle claims related to space debris impacts, ensuring consistency and efficiency in adjudication.
- International Cooperation: The success of nuclear liability frameworks relies on international cooperation and harmonization of laws across jurisdictions. Establishing a similar cooperative framework for space-maritime liability would facilitate consistent application of laws and improve the overall effectiveness of the regime.

4. Environmental Liability Regimes:

- Polluter Pays Principle: Many environmental liability regimes operate under the "polluter pays" principle, which holds that those responsible for environmental harm should bear the costs of remediation and compensation. This principle is essential for ensuring accountability and incentivizing responsible behaviour in both space and maritime activities.
- Public Participation and Transparency: Effective liability regimes often incorporate mechanisms for public participation and transparency, allowing affected communities to engage in decision-making processes. Including stakeholders in discussions about space debris management and compensation would

enhance legitimacy and foster trust in the system.

These models offer valuable blueprints for creating a space-maritime liability regime that balances efficiency, equity, and accountability. By learning from the successes and challenges of existing international liability frameworks, we can address the pressing need for a comprehensive approach to cross-domain environmental risks. Implementing these lessons will not only improve the protection of marine ecosystems but also foster international cooperation and shared responsibility among space-faring nations, ultimately contributing to a sustainable future for both space and ocean resources.

V. Recommendations for Reform

A. Amending Existing Treaties

To address the inadequacies in current international frameworks, significant amendments to existing treaties are essential:

1. Space Liability Convention (SLC)

- Inclusion of Maritime Environments: The SLC should explicitly extend its liability framework to cover maritime environments. This would ensure that damages caused by space debris that impacts marine ecosystems are recognized and addressed within the legal framework.
- Recognition of Private Party Rights: The convention should be revised to allow private entities, such as shipping companies and offshore operators, to file claims directly. This would streamline the process and empower stakeholders who are currently reliant on state action, which can be slow and politically complicated.
- Joint and Several Liability: Introducing provisions for joint and several liability among multiple launching states would facilitate accountability. This means that if multiple states are responsible for the debris, any affected party could seek full compensation from any of those states, thus ensuring that victims are not left without recourse due to jurisdictional disputes.

2. United Nations Convention on the Law of the Sea (UNCLOS)

- Expanded Definition of Pollution: Amend UNCLOS to broaden the definition of pollution to explicitly include the impacts of space debris. This would recognize the unique nature of space-related pollution and its potential effects on marine environments.
- Duty to Mitigate: Establish a clear duty for space-faring nations to mitigate risks associated with orbital debris that could impact marine ecosystems. This would obligate states to take proactive measures to prevent space debris from entering maritime areas, thereby protecting biodiversity and marine resources.

B. Establishment of a Unified Claims Tribunal

A dedicated tribunal, the International Cross-Domain Claims Tribunal (ICDCT), should be established to adjudicate disputes involving space debris impacts on maritime assets. This tribunal would serve several critical functions:

- Acceptance of Claims: It should be empowered to accept claims from both states and private parties, ensuring that all affected stakeholders have access to justice.
- Expert Composition: The tribunal should consist of experts in space law, maritime law, and environmental law, ensuring that decisions are informed by a comprehensive understanding of the issues at hand.
- Binding and Enforceable Awards: The tribunal must have the authority to issue binding and enforceable awards, providing a reliable mechanism for compensation and accountability.

Such a tribunal could be modelled after the International Tribunal for the Law of the Sea (ITLOS) or established under the auspices of the Permanent Court of Arbitration, leveraging existing frameworks while addressing the unique challenges posed by cross-domain incidents.

C. Mandatory Insurance and Compensation Fund

The establishment of a Global Space Debris Compensation Fund is imperative for ensuring timely and equitable compensation for affected maritime stakeholders. This fund could be financed through several mechanisms:

- Mandatory Insurance Premiums: All satellite launches should be subject to mandatory insurance premiums that contribute to the fund. This would create a financial safety net for potential claims arising from space debris incidents.
- Annual Contributions by Space-Faring Nations: Countries that engage in space activities should contribute annually to the fund, reflecting their responsibility for the potential impacts of their space operations on marine environments.
- Penalties for Non-Compliance: Implementing penalties for failure to adhere to debris mitigation guidelines would incentivize compliance and generate additional resources for the fund.

This compensation fund would ensure swift, depoliticized compensation to affected parties, promoting fairness and accountability in the face of cross-domain environmental harm.

D. Technological Enhancements

Investing in technological advancements is crucial for improving debris attribution and risk management:

- Mandatory Transponder Tagging: All launched objects should be equipped with mandatory transponders that facilitate real-time tracking. This would enhance the ability to identify the source of debris and hold responsible parties accountable.
- Global Debris Tracking Initiatives: Establishing comprehensive global tracking systems would enable better monitoring of space debris and its potential risks to maritime operations. This information could be shared with relevant stakeholders to enhance situational awareness.
- Space-to-Sea Debris Impact Forecast System: Developing a forecasting system that alerts maritime operators to potential hazards from space debris would significantly reduce the likelihood of incidents. This proactive approach could help mitigate risks and minimize claims.

E. Environmental Impact Assessment (EIA) Protocols

To safeguard marine ecosystems from the impacts of space debris, robust Environmental Impact Assessment (EIA) protocols must be implemented:

- Mandatory EIAs: Before any de-orbiting activities, mandatory EIAs should be conducted to assess potential marine environmental harms. This would ensure that the ecological implications of de-orbiting are thoroughly evaluated and addressed.
- Binding International Guidelines: Establishing binding international guidelines for safe re-entry zones would help prevent space debris from entering ecologically sensitive areas. This would protect marine biodiversity and minimize environmental degradation.

VI. Conclusion

In summary, the growing intersection of space activities and maritime vulnerabilities underscores a critical need for reform in international law. As space exploration and

satellite deployment continue to expand, the risks associated with space debris impacting marine environments become increasingly significant. The current legal frameworks, which treat space and maritime activities as separate domains, are insufficient to address the complexities and consequences of cross-domain incidents. To effectively safeguard both marine ecosystems and the interests of affected stakeholders, a multi-faceted approach is essential. This includes amending existing treaties like the Space Liability Convention and UNCLOS to encompass the realities of space debris, establishing a dedicated tribunal for adjudicating related claims, and creating a Global Space Debris Compensation Fund to ensure timely and fair compensation.

Moreover, leveraging technological advancements for tracking and monitoring space debris, alongside implementing robust Environmental Impact Assessment protocols, will further enhance our ability to mitigate risks. These reforms are not merely regulatory adjustments; they represent a necessary evolution of international law to uphold principles of accountability, environmental stewardship, and justice. By bridging the divide between space and maritime governance, we can create a more cohesive and responsive legal framework that not only protects the environment but also ensures that all stakeholders have access to remedies in the face of emerging challenges. The time for action is now; proactive measures will lay the groundwork for a sustainable future where both space and oceanic resources are preserved for generations to come.

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