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NAVIGATING THE CELESTIAL LABYRINTH: REGULATING SPACE DEBRIS IN THE AGE OF SPACE EXPLORATION

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INTRODUCTION

In the formidable expanse of the cosmos, where the extremity of human flair seems illimitable, a hidden menace hovers in the silence of space - the risk of Space Debris often called “Space Junk”. All contemporary explorations and developments in the sphere of space, which is the testimony to humanity forging ahead with remarkable strides in space explorations, products and commercial ventures taking place in extra-terrestrial areas, an unintended ramification emerges, admonishing not only the sustainability of our experiences but the very future of space exploration itself.

*Space debris encompasses both natural meteoroid and artificial (human-made) orbital debris. Meteoroids are in orbit about the sun, while most artificial junk is in orbit about the Earth (hence the term “orbital” debris)[2].

Any human-made object in orbit around the Earth no longer serves any proper function. Space debris comprises defunct satellites, discarded rocket stages, and fragments generated by past missions.

Initially inconspicuous in their isolation, these cosmic castaways have aggregated over decades into a formidable constellation encircling our planet. Their proliferation, however, is not merely a celestial curiosity; it poses an imminent threat to the stability and accessibility of Earth's orbital environment and its endeavours because there are more than 20,000 pieces of debris more significant than a softball orbiting the Earth. They travel at speeds up to 17,500 mph, fast enough for a relatively small amount of orbital debris to damage a satellite or a spacecraft at a rates even times faster than a fired bullet. There are over half a million pieces of debris the size of a marble or larger (up to 0.4 inches, or 1 centimetre) and over 100

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[2]Garcia, M. (2015) *Space debris and human spacecraft*, *NASA*. Available at: https://www.nasa.gov/mission_pages/station/news/orbital_debris.html (Accessed: 20 September 2023).

million pieces of debris-about .04 inches and more extensive. There is even smaller micrometre-sized debris.

As we stand in the face of an era characterised by the advent of lunar bases, Martian colonies, and asteroid mining, the imperative to address the issue of space debris has never been more pressing. This article endeavours to navigate the sophisticated and evolving landscape of space debris regulation. In this realm, international cooperation, innovative technology, and legal frameworks must converge to preserve the freedom and security of space activities.

In the following pages, we shall dive deep into the origins and events responsible for space debris, exploring the cascade effect known as the "Kessler syndrome" and its repercussions for future space endeavours. We will dissect the existing international legal frameworks, such as the Outer Space Treaty and related agreements, examining their adequacy in addressing the mounting challenges of space debris.

Moreover, we will investigate pioneering technological solutions that promise to clean up our orbital neighbourhood, ranging from autonomous debris removal systems to approaches that mitigate debris generation during launches. These technological advancements significantly complement the legal framework and ensure a sustainable celestial future.

{In scrutinising the complex interplay of law, science, and innovation, we shall strive to answer critical questions: How can we enforce space debris mitigation measures? What role should national governments, intergovernmental organisations, and private entities play in this endeavour? Can space debris management pave the way for unprecedented international cooperation transcending terrestrial boundaries?}

Space exploration has always symbolised humanity's quest for new horizons and infinite possibilities. Yet, to ensure that these dreams continue to thrive, we must confront the challenges that space debris poses with the same fervour and determination that led us to the stars. This article embarks on a journey through the celestial labyrinth, guiding us toward formulating effective, sustainable solutions that will protect our orbital realm and preserve the marvels of the universe for generations to come.

KESSLER SYNDROME

The proliferation of space debris, a complex issue in contemporary space law, poses a significant challenge to the sustainability of outer space activities. One looming threat

associated with this problem is the Kessler Syndrome, a concept named after NASA scientist Donald J. Kessler. This syndrome describes a cascade effect, where collisions among existing space debris generate more fragments, increasing the risk of further collisions in a self-perpetuating cycle. As a result, the Kessler Syndrome could render certain orbital regions unusable for generations, endangering both crewed and uncrewed missions. This article examines how the Outer Space Treaty of 1967, a foundational document in space law, addresses the evolving challenge of space debris, particularly in preventing the dire consequences of the Kessler Syndrome.

INTRO TO OUTER SPACE TREATY:

The Outer Space Treaty, as it is known, was the second of the so-called "no armament" treaties; its concepts and some of its provisions were modelled on its predecessor, the Antarctic Treaty. Like that Treaty, it sought to prevent "a new form of colonial competition" and the possible damage that self-seeking exploitation might cause.[3]

How did OST come into existence?

Developments in rocketry led the United States to propose international verification of the testing of space items in early 1957, even before the October Sputnik launch. Their subsequent proposals for global and total disarmament included guidelines prohibiting the orbiting and implantation of weapons of mass devastation in space.[4]

President Eisenhower suggested in his address to the General Assembly on September 22, 1960, that the Antarctic Treaty's guiding principles be extended to include celestial bodies and outer space. To guarantee the peaceful use of space, the Soviet Union incorporated measures in its broad disarmament programme from 1960 to 1962. Foreign Minister Gromyko notified the General Assembly on September 19, 1963, that the Soviet Union desired to reach an agreement prohibiting the orbit of objects carrying nuclear weapons. It is vital to remember that national political events also significantly impacted the outcome of the

[3]*Outer Space Treaty*, *U.S. Department of State*. Available at: https://2009-2017.state.gov/t/isn/5181.htm (Accessed: 19 September 2023).

[4]*Outer Space Treaty*, *U.S. Department of State*. Available at: https://2009-2017.state.gov/t/isn/5181.htm (Accessed: 19 September 2023).

Outer Space Treaty. The Cold War's intense rivalry between the two superpowers in the 1960s resulted from the fact that they were the only ones able to launch satellites, giving them an advantage in negotiations for space treaties. An essential clause in Article IV of the Outer Space Treaty was created due tothe two superpowers' political compromise and agreement outside the UN. Therefore, the world community worked together to design the Outer Space Treaty. The fact that only a few states were exploring and using outer space at the time made this fact all the more enlightening.

The agreement entered into force in October 1967. So affirm the parties of the deal were contractually obligated to perform their space activities according to the accepted standards and objectives defined in the contract, which, as the name suggests, is an agreement in principle that can be comprehensive interpretations and is considered the basis on which more precise legal instruments. Some particular problems are worth noting for further clarification. These include four additional contracts and four military personnel of the principles adopted by the general assembly. The legal content of all these instruments is determined by the ideas and principles of 1967 The Outer Space Treaty, which was developed and expanded to become more specific regulations, including the procedure for resolving potential disputes of relevant space activities.

One is Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects launched into Outer Space in 1968. The treaty obliges States Parties to return any "alien" space objects found on their territory to their owners and to notify the Secretary-General of such things found. UNOOSA maintains a list of such return notices on the website of UNOOSA.[5]

Three articles of the Outer Space Treaty deal with issues related to orbital debris. Article VI states: "The States Parties to this Treaty bear international responsibility for their domestic activities in outer space." Article VII makes states parties to the treaty internationally responsible for damages caused by objects (and parts thereof) released by them. Finally, Article IX allows states with reason to believe that a proposed activity or experiment could potentially harm other space activities to request an inquiry into that activity or investigation.

[5]Robert.wickramatunga, *United Nations Office for Outer Space Affairs*, *Rescue Agreement*. Available at: https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/rescueagreement.html (Accessed: 19 September 2023).

CRITICAL ANALYSIS OF OUTER SPACE TREATY:

It is one of the essential documents that guide activities in outer space. Here are some pros and cons of the Space Treaty.

STRENGTHS

Avoiding the Use of Weapons: One of the most essential advantages of the Outer Space Treaty is that it prohibits placing nuclear weapons and other weapons of mass destruction in outer space. It promotes the peaceful use of outer space and contributes to global security by preventing the militarisation of outer space.

Ownership of Celestial Bodies: According to the treaty, no celestial body, including the Moon and other planets, can be nationally owned. It promotes the idea that space is a global commons and encourages international cooperation in space exploration.

Scientific cooperation: By promoting peaceful and cooperative activities in outer space, the treaty promotes international cooperation in space exploration and research, which can advance scientific knowledge and technology.

Responsibility for space debris: Liability for space debris is a critical aspect addressed in this agreement. It specifically outlines the responsibility for any damage caused by space objects on Earth and in outer space. This provision is crucial in safeguarding the environment and ensuring that countries are held accountable for their activities in the area. This agreement promotes responsible behaviour and supports sustainability principles by making governments liable for the consequences of their space operations.

SHORTCOMING

Lack of Enforcement Mechanism: One of the most significant areas for improvement of the Outer Space Treaty is the need for a robust enforcement mechanism. Although it has established principles and guidelines, there needs to be more mechanisms in place to ensure compliance. Violations can be challenging to deal with effectively.

Ambiguity and Gaps: The treaty was written when space activities were less advanced and needed to address some current challenges adequately. For example, there needs to be clear

guidelines regarding the commercial use of space resources, which has become an important issue in recent years.

Limited scope: Some critics argue that the treaty's provisions must be narrower to cover new technologies and space activities effectively. Therefore, more is needed to cope with the complexities of modern space exploration and development.

Weaponization Potential: The treaty prohibits installing nuclear weapons and weapons of mass destruction in outer space but does not explicitly mention conventional weapons in orbit. This leaves potential loopholes and concerns about the future weaponisation of space.

In summary, the Outer Space Treaty has played an essential role in promoting the peaceful uses of outer space and preventing the weaponisation of outer space. However, they also have limitations, such as the need for more robust enforcement mechanisms and ambiguous responses to current space challenges. Although efforts have been made to update and supplement this Convention, it remains the fundamental document in space law.

SHORTCOMINGS OR PITFALLS OF THE OUTER SPACE TREATY

Highlighting its Obsolescence:

When the treaty came into existence, only a few world powers were the first world countries able to launch missions into space, so when the treaty was drafted, it only stated the unrestricted use of outer space. The treaty prohibits installing nuclear weapons and other weapons of mass destruction in outer space but is silent on non-nuclear military activities in outer space. As interest in the militarization of space grows, more comprehensive agreements are needed to prevent the weaponisation of space.

Currently, no nation can counter or challenge first-world countries' superiority in outer space or the benefits it accrues to American ground military operations. As of the end of 2001, the United States had nearly 110 operational military satellites, accounting for over two-thirds of all military satellites in Earth orbit. There were about 40 people in Russia and about 20 in other countries.

No rules, treaty, or international order was formed after the same, which could regulate outer space debris. As time passed, no amendments or modifications were made to that treaty to control the growing problem of space debris. Also, the treaty does not offer a framework for the equitable utilisation of resources derived from celestial bodies, such as asteroids or the

Moon. The absence of clear guidelines creates potential conflicts, overexploiting these resources and further exacerbating space debris concerns.

Private companies are investigating the potential of mining asteroids and extracting resources from celestial bodies. However, this raises concerns and prompts discussions surrounding property rights and resource utilisation. The Outer Space Treaty addresses space-related matters and explicitly states that any state cannot take over space and celestial bodies. Nonetheless, there is a need to consider updating the treaty to accommodate the notion of private property rights and resource extraction in outer space. This development necessitates careful examination and revision to ensure a comprehensive and fair framework for utilising space resources by private entities.

INCIDENCES REGARDING SPACE JUNK DESTRUCTION AND LAWS RELATING TO OUTER SPACE:

There have been myriad incidents wherein space junk has been proven to be causing abdicable destruction because there lacks a proper regulatory system that would impede the events that follow because of space debris. The first instance of a satellite collision that took place in outer space wherein a communication satellite owned by America, Iridium-33 and a Russian military satellite, Kosmos2251, collided with a significant amount of intensity, building an alarming situation after approximately 2300 pieces got spread in the outer space and has been decaying since.[6]

In another instance, The SpaceX Crew-1 Dragon spacecraft's trunk re-entered the atmosphere on July 9, 2022, and its debris fell on several places, including Albury, Wagga Wagga, and Canberra in New South Wales, Australia. On August 26, 2022, Australia informed the United Nations Committee on the Peaceful Uses of Outer Space of three collected pieces of debris under the Rescue Agreement.[7]

[6] *2009 iridium-cosmos collision fact sheet - swfound.org*. Available at: https://swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf (Accessed: 19 September 2023).

[7] *SpaceX capsule confirmed as source of space debris that crashed on farm in Australia* (2022) *The Guardian*. Available at: https://www.theguardian.com/australia-news/2022/aug/03/spacex-capsule-confirmed-as-source-of-debris-that-landed-on-australian-farm (Accessed: 19 September 2023).

Long March-5 B's empty core stage performed an unplanned re-entry over Indonesia and Malaysia on July 31, 2022. Many people saw the re-entry; afterwards, booster components that had survived the re-entry were found in numerous locations around Indonesia and Malaysia.[8]

In the 1960s, there were less than 100 units of debris hovering in outer space, but over time, both the units and quantum have been increasing, and in the current days, we're witnessing space junk made with more than 60,000 objects.

Over 23,000 objects the size of softballs are now in orbit around the Earth. They can move up to 17,500 mph, fast enough to harm a satellite or spacecraft, even if it is only a little piece of orbital debris. Around 100 million bits of garbage are 04 inches (or one millimetre) or larger, and 500,000 pieces of debris are the size of a marble or larger (up to 0.4 inches, or 1 centimetre). Even additional debris with a diameter of 0.000039 of an inch or less is present.

SOLUTION IN CONTEMPORARY OR CURRENT TIMES:

1.) There has to be a regulatory body on an international podium with federal regulators that will work on instituting and laying the foundation of a legal chassis which would look into every country's space programs and shall accordingly place upon obligations and liabilities involving penalties and risk mitigation policies and outlays.

2.) Laws relating to outer space are incredibly primitive and lacking scope. In the current contemporary scenario, we must bring certain modifications that would suit the needs and requirements of the existing technology. We must ensure that our laws synchronise with the pace of technology moving forward. We have to broaden our horizons so that we do not witness a time when we fall short of regulations and laws that would mitigate conflicting situations.

3.) Liabilities being assigned to nations by the States engaged may be valuable for achieving accountability. This fund, which would subsidise the creation and introduction of debris

[8] *Long March 5B: Debris from Chinese rocket falls back to Earth* (2022) *BBC News*. Available at: https://www.bbc.com/news/science-environment-62333546 (Accessed: 19 September 2023).

removal technologies, might receive contributions from nations. This fund would ensure that all countries can access the tools required for space debris clean-up. Also, measures could include requirements for deorbiting defunct satellites, placing them in a graveyard orbit, and designing spacecraft with features that reduce debris generation during operational lifetimes.

4.) Upkeep of protocols to specify detailed rules that include controlling spacecraft design specifications, enforcing collision prevention measures, and regulating end-of-life disposal procedures

5) A regular review mechanism should be adopted, where the treaty's working committee should be equipped to introduce periodic review mechanisms, ensuring that it remains relevant and adaptable to evolving space challenges. This would enable swift adjustments to regulations as technology and understanding of space debris become.

6) To enhance the safety of space activities, the treaty should encourage nations to share orbital data of active satellites and space debris. An international registry of space objects could be established, ensuring real-time information exchange between different space organisations in other regions. This would further enable collision avoidance manoeuvres when necessary.

7) To address the growing issue of space debris removal, an additional protocol or amendment could establish guidelines for actively removing defunct objects. This protocol could outline criteria for prioritising the reduction of specific things and fostering international cooperation in debris removal efforts.

8) International organisations shall adopt an extensive and impactful Space Debris Removal Framework and thus shall also bolster ventures which are working in the same direction. To address the growing issue of space debris removal, an additional protocol or amendment could establish guidelines for actively removing defunct objects. This protocol could outline criteria for prioritising the reduction of specific things and fostering international cooperation in debris removal efforts.

CONCLUSION

The overall crux that we may derive through this article is that even though space exploration seems to be a lucrative motion when it comes to forming futuristic goals, as we are approaching the age of technology ameliorations, there is a growing need to keep in check those advancements. We live in an age where we witness injunctions regarding nuclear and bio-weapons usage being modified and updated. They are becoming the topic of discussion in worldwide summits and conferences by famous leaders since the time demands a need for it addressed and sooner shall the space laws become equally prevalent, a legal framework should be worked upon.