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SPACE DEBRIS: LEGAL RULES FOR ITS MITIGATION AND PERSPECTIVES FOR REMEDIATION

A dissertation submitted to the Faculty of Law of the University of Pretoria

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1.1 Introduction

The United Nations (UN) Technical Report on Space Debris defines orbital debris[1] as:

> All man-made objects, including their fragments and parts, whether their owners can be identified or not, in Earth orbit or re-entering the dense layers of the atmosphere that are non-functional with no reasonable expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be authorized (UN, 1999).

The Inter-Agency Space Debris Coordination Committee (IADC) defines orbital debris as "all man-made objects, including fragments and elements thereof, that are orbiting the Earth or re-entering the Earth's atmosphere, that are non-functional".[2]

Space debris fragments are generated by satellite and upper-stage break-ups due to explosions and collisions, which account for most of the fragments in outer space.[3]

The debris in the Earth's orbit has reached a staggering number of over 128 million pieces that are smaller than 1 cm. There are approximately 900 000 pieces from one to ten cm. Debris larger than 10 cm now numbers 3 400 pieces.[4]

The United States of America (USA) is responsible for most of the debris in space, followed by Russia and China, and it is clear that the ripple effect of their space activities is adversely affecting the Earth's orbit.[5] The absence of binding space clean-up initiatives coupled with the lack of action from spacefaring countries may ultimately lead to the Earth's orbit becoming so clustered that it may become a challenge to launch spacecraft into space.

[1] Technical Report on Space Debris
[2] IADC Mitigation Space Debris Mitigation Guidelines Page 5
[3] Simpson (2007) 32
[4] https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers (Accessed 19 January 2020)
[5] Beardsley et al (2016) 217

The aim is to avoid the Kessler syndrome,[6] which is a scenario in which the space debris begins to collide, causing crashes and posing risks to the use and exploitation of the outer space environment.

The purpose of this study is to demonstrate that the current national and international frameworks do not adequately address the problem of outer space pollution and that political action will be necessary on a global scale.

In this dissertation, The Author has focused on the current Outer Space Treaty (OST) and agreements, and I describe how their shortcomings negatively affect the issues surrounding space “clean-up” solutions.

The international laws and principles pertaining to the outer space environment and its protection, and their related theories do not always align with the law in action. This dissertation reveals the lacunae of current space debris mitigation and remediation guidelines and measures from an international legal and policy perspective.

The relevant provisions of the OST, the Liability Convention and the Registration Convention as well as the principles set out in international law have therefore been studied in detail.

As the UN battles with the challenges of ensuring peaceful outer space use, various proposals for international organisations or agreements relating to space debris have been conceptualised and designed based on different institutional, economic, legal, financial, or funding frameworks. These proposals are crucial and should be subject to further research. However, this dissertation will not discuss all of them in detail.

1.2 Research Problem

There are various technical challenges associated with orbital debris. However, the hurdles of politics, unenforceable legal treaties, and national priorities in the space

[6] Lefebvre (2017) 146

arena pose an even greater challenge for space pollution mitigation and remediation solutions.

The notion that all spacefaring nations are collectively responsible for preserving the outer space environment can pose a challenge in the sense that some nations will wait for solutions to emanate from other nations, distancing themselves from actively participating in the process of solving space pollution issues.

1.3 Critical Research Questions

The research questions are:

1. Is the current legal framework that regulates the protection of the outer space environment and the issues around space pollution sufficient?
2. Is there a need for reform of the current legal framework governing the protection of the outer space environment and the issues pertaining to space pollution?
3. Should the current legal framework governing outer space be expanded to include remediation measures to be adopted by the UN Legal Subcommittee?
4. Are the current technical and technological advancements aligned with the existing outer space legal framework?

1.4 Research Aims

The aim of this dissertation is to show that the current international legal framework encompassed by the Outer Space Treaty and the Liability Convention does not appropriately address the issues emanating from the threat posed by the proliferation of space debris, and the liability and accountability of spacefaring nations in using the outer space environment.

A practical aim of the research is to provide an academic contribution to the discourse on the legal certainty of the benefits of proposed alternative regulatory binding mechanisms that could be enforced through the implementation of a new OST. Such a new treaty would encompass factors such as mandatory liability regimes, the ownership of space objects, the distinction between space debris and space objects, and alternative international environmental solutions.

1.5 Chapter Breakdown

The above-mentioned research questions and research aims are addressed in the following chapters:

1.5.1 Chapter 1: Introduction

Chapter 1 introduces the topic and the research questions, as well as the different aspects of space debris.

1.5.2 Chapter 2: Space Debris

In Chapter 2, the writer outlines the threat of space debris to the space environment and describes the different methods used for tracking and space debris.

The writer further elaborates on the orbital debris data gathered by the Space Surveillance Network and their availability for collision avoidance. Different categories of space debris and their sources are described.

1.5.3 Chapter 3: Legal and Technical Space Debris Regime

In Chapter 3, the writer discusses the relevance of the outer space legal regime with specific reference to the Outer Space Treaty, the Liability Convention, customary international law and the different general principles of international law.

The writer analyses the issues and the related rules of prevention and liability as well as customary international law, by discussing the relevant articles and principles in the literature.

1.5.4 Chapter 4: Remediation and Mitigation Measures

The author defines the meaning and nature of space debris remediation and enumerates examples of active debris remediation, such as laser removal, electro-dynamic tethers, and unmanned spacecraft, used to decrease the growing population of space debris. Chapter 4 addresses the flaws of existing active debris remediation (ADR), outlining areas for improvement and the challenge of making ADRs economically, financially, commercially and legally viable. Moreover, the author discusses the major roles international bodies such as the European Space Agency (ESA), the National Aeronautics and Space Administration (NASA), and the IADC in the remediation of space debris arena.

The author outlines the importance of and defines the meaning and nature of mitigation measures. A few examples are enumerated, and their principles listed and described. Chapter 4 also discusses the role of the UN Committee on the Peaceful Uses of Outer Space (COPUOS) and the ESA's efforts in mitigating space debris and provides and overview of the orbital debris practices of a few spacefaring states.

1.5.5 Chapter 5: Critical Analysis of Existing Legal and Technical Framework

The author considers the effectiveness of the existing legal and technical regimes respectively. The chapter analyses the effectiveness of IADC mitigation measures and identifies different areas for improvement. It also outlines the merits of existing measures, emphasising their relevance and remarking that legal principles of mitigation must adapt to the ever-changing nature of the technology used for mitigating space debris.

Chapter 5 further addresses the issues surrounding satellite registration and identifies flaws and areas for improving mitigation and remediation activities. The chapter further analyses the provisions pertaining to space debris and points out their areas of criticism, suggesting more improvements to different aspects of the Liability Convention and proposing the implementation of mandatory technical regulations.

1.5.6 Chapter 6: Dissertation Conclusion

Chapter 6 concludes the study by extracting the main themes of the preceding chapters and drawing conclusions from them.

Chapter 2: Space Debris

2.1 The Debris Problem

The size of space debris may range anywhere from as small as a speck of paint to large parts of discarded space vehicles or defunct satellites.[7] Space debris is a direct threat to not only operational satellites and human life in space but to the sustainability of outer space activities and the space environment.

Contrary to popular belief, space debris does not float motionlessly in outer space. In fact, space debris can move at a speed so great that if it were to collide with other space objects, the impact would create a massive debris cloud that has the potential of moving at a speed of over 10 000 miles an hour.[8] An example of this "chaos breeds chaos" scenario, known as the Kessler syndrome, unfolded in 2009 when an American satellite and a Russian satellite collided with one another in outer space.[9]

On February 10, 2009, an inactive Russian communications satellite- Cosmos 2251- collided with an active commercial communications satellite operated by U.S. operated Iridium Satellite LLC. This collision produced almost 2,000 pieces of debris, measuring at least ten centimetres (4 inches) in diameter, and thousands smaller pieces. Much of this debris still remain in orbit, and will do for more decades, causing further collision risks to other objects in Low Earth Orbit (LEO). This incident marked the first-ever collision between two satellites in orbit.[10]

2.1.1 Locating and Tracking Debris

The main challenge of tackling the issue of orbital debris to mitigate its dangers is to know where the debris is. This problem is threefold. First, the debris must be tracked. Second, the data collected must be made available. Third, there must be a practical method of converting the data collected into a useful predictive tool for satellite operators.[11]

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[7] Pelton (2015) 4
[8] Young (2016) 6
[9] Ibid
[10] http://swfound.org/media/205392/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf
[11] Diaz (1993) 6 *TELJ* 362 at 372

The US Space Surveillance Network (SSN)[12] is one of the few comprehensive debris monitoring systems. The system was originally designed to detect objects of a military nature but is simultaneously capable of monitoring other types of space objects, with significant limitations. The SSN consists of more than 20 radars and optical sensors located throughout the world.[13]

The SSN can collect information such as the altitude of an object, and its orbit, size, and composition.[14] However, the capabilities of the network are limited by the size and altitude of the debris.

Previously, in low earth orbit (LEO), the SSN was unable to detect or track objects smaller than 10 centimetres and could only track objects of 30 centimetres and larger continuously. Most of the published data are based on these figures. In 2003, the sensitivity of the SSN was much improved, allowing it to track objects as small as five centimetres in LEO.[15] The higher the altitude, the less the ability of the SSN's sensors to detect small objects. For the network to track objects in orbits with an altitude of 5 000 kilometres, an object must at least be one metre in size. Currently, about 15 000 officially catalogued objects are still in orbit. In addition to catalogued objects, more than 500 000 pieces of debris are trackable but have not been added to the SSN catalogue owing to delays in completing the detailed analysis required before an object can be catalogued.[16]

Other states also have debris-tracking capabilities. For example, Japan, the United Kingdom, Russia, Germany and France all contribute to the knowledge of space debris through observation of the space environment. Much like the United States, the Russian Federation has over 20 telescopes and radars used for orbital debris detection.[17] Japan also has telescopes and a radar used to observe orbital debris.[18] Various states of the ESA also use their telescopes and radars for space debris research.[19]

[12] https://celestrak.com/columns/v04n01/ (accessed 12 August 2019)
[13] Ramaswamy *et al* (2017) Pp 1-19
[14] https://aerospace.org/article/space-debris-and-space-traffic-management (Accessed 13 August 2019)
[15] Muñoz (2018) *CJIL* 233 at 236
[16] https://www.nasa.gov/mission_pages/station/news/orbital_debris.html
[17] Proceedings Sixth US/Russian Space Surveillance Workshop, 2005
[18] Proceedings of the 4th European conference on Space Debris, 2005
[19] https://www.esa.int/About_Us/ESA_Publications/ESA_Publications_Bulletin (Accessed 20 January 2020)

Recently, the ESA appointed Indra Space Surveillance to implement a surveillance and tracking system known as S3T for objects in LEO[20]. As part of its mandate, the company tracks and catalogues uncontrolled orbiting space objects through a radar with surveillance capabilities in orbits between 200 and 2000 km, where most orbital debris and the satellites that have to be protected are found.

Indra was developed by Spain, which has hence become one of the few countries in the world to have such technical capabilities, promoting Europe's independence by ensuring the security of satellites and space missions.

Indra develops and supplies the surveillance radar, coordinates the implementation and integration of the operations centre, and provides the radar and electro-optical sensors for gathering complementary information.

The new S3T system enables Spain to compile a catalogue of objects orbiting the Earth. The catalogue has several uses: warning of possible collisions of these objects with satellites and space infrastructure; an object re-entry warning service that includes information on the time and place where it hits the Earth; and a fragmentation service, which detects the presence of new debris populations and helps to identify the object from which the debris is generated.

The S3T autonomous catalogue is created and maintained through data obtained from the S3T sensor. The catalogue is steadily expanding and provides autonomy to the S3T system. As of early 2019, the S3T catalogue contained over 800 confirmed objects, of which around 10% are not included in public catalogues. The system is now receiving the tracks of LEO objects from the S3TSR and has started building its own independent catalogue.

There are approximately 70 000 uncontrolled objects orbiting the Earth, posing a significant danger to communications infrastructures and positioning systems as well as to the safety of the International Space Station.

[20] https://conference.sdo.esoc.esa.int/proceedings/neosst1/paper/479/NEOSST1-paper479.pdf (accessed 13th August)

2.1.2 Availability of Data

There are many organisations that monitor and track space objects and maintain various catalogues, but the US and Russian militaries currently have the most complete catalogues.[21]

It is highly important that the information gathered through tracking activities be distributed to public and private satellite operators for the purposes of predicting and avoiding imminent collisions and to ensure the possibility of early warning. This, however, can only be done if the orbits of the debris and target object are known with enough accuracy.

A satellite operator who has knowledge of objects in space that pose collision risks will be capable of taking precautionary measures to avoid collision, thus preventing further proliferation of space debris. Because collisions are the leading causes of space debris creation,[22] it is in the interest of all states to ensure the data are accessible to all satellite operators.

As a global network of ground-based and space-based radars with lasers and telescopes that tracked approximately 23 000 orbiting pieces of debris larger than 10 cm in LEO and 30 cm in Geostationary Earth Orbit in 2019, the SSN has catalogued 56% of the fragments originating from more than 500 recorded fragmentation events. While 38% of its catalogue accounts for larger space debris such as derelict spacecraft and upper stages of launch vehicles, only 6% of these items are functional satellites[23]

It has been practice to make the data from the SSN available through a NASA web page. However, this changed in 2004 with the enactment of the National Defense Authorisation Act for Fiscal Year 2004[24].

NASA and the US Department of Defense (DoD) work hand in hand and share responsibilities for supervising the space environment. DoD's SSN tracks discrete objects as small as five centimetres in diameter in LEO and about one metre in

[21] Weeden (2011) 27 Space Policy 38 at 41.
[22] https://aerospace.org/article/danger-orbital-debris (Accessed 11 January 2020)
[23] https://www.oecd-ilibrary.org/sites/d2d4146e-en/index.html?itemId=/content/component/d2d4146e-en&mimeType=text/html (Accessed 11 January 2020)
[24] https://www.congress.gov/108/plaws/publ136/PLAW-108publ136.pdf (Accessed 13 August 2019)

geosynchronous orbit. Using ground-based sensors and by inspecting the surface of returned satellites, NASA determines the magnitude of the population for objects less than 10 centimetres in diameter.[25]

The *Orbital Debris Quarterly News* is a publication of the NASA Orbital Debris Program Office which publishes some of the latest events in orbital debris research, offers orbital debris news and statistics, and presents project reviews and meeting reports, as well as upcoming events.[26] The articles are supported by illustrating graphs, charts, photographs, and drawings and provide a comprehensive analysis of the topics.

One of the fundamental responsibilities of the ESA's Space Debris Office is to consolidate knowledge on all space objects. The knowledge is consolidated, maintained and updated through the Database and Information System Characterising Objects in Space (DISCOS). DISCOS contains information on launch details, orbits histories, physical properties and mission descriptions for approximately 38 700 objects tracked since Sputnik-1 to date, including 10 million orbit records. DISCOS is a reliable and reputable source of space object data that is regularly used by almost 40 customers worldwide. DISCOS generates several automated 'products' − processed, refined data packages − which include a log of upcoming re-entries and publication-quality status reports[27] which satellite operators may use to avoid imminent collisions. Space debris catalogues and databases such as the above-mentioned ones are particularly crucial to satellite operators predicting and/or avoiding imminent collisions. Based on its surveillance and tracking system, NASA is often able to predict encounters or collisions well in advance, allowing time to move the station or satellite slightly, known as a "debris avoidance manoeuvre".

Debris avoidance is often planned by NASA when the probability of collision from a conjunction reaches limits set in the space shuttle and space station flight rules. Where the probability of collision is greater than 1 in 100 000, a manoeuvre will be conducted, provided that it does not negatively impact on mission objectives. Where the

[25] National Research Council (1995) 57
[26] https://orbitaldebris.jsc.nasa.gov/quarterly-news/ (Accessed 13 August 2019)
[27] https://www.esa.int/Safety_Security/Space_Debris/Analysis_and_prediction (Accessed 11 January 2020)

probability is greater than 1 in 10 000, a manoeuvre will be conducted provided that the crew of a particular station is not put in danger.[28]

Debris avoidance manoeuvres are often small and do not require a cumbersome process, usually occurring from one to several hours before the time of the conjunction. Debris avoidance manoeuvres with the shuttle can be planned and executed in a matter of hours.[29]

Satellite operators can also benefit from extensive space debris data by using the operational services offered by ESA's Space Debris Office pertaining to planned and ongoing missions within ESA and to third parties. These services include in-orbit collision avoidance (forecasts, prediction refinements, and avoidance manoeuvre recommendations), re-entry prediction and risk assessment (prediction of re-entry time and location, forecast of spacecraft disintegration and demise and on-ground risk assessment), and maintenance of space situational awareness information on all trackable objects in the DISCOS database.[30]

2.1.3 Making Data Useful

Satellite operators need a practical method for using the available data. Presently, there is a software tool available that uses data gathered by the SSN from all known orbital debris and compares it to all functioning satellites.

The tool is known as SOCRATES and is available free of charge on the CelesTrak webpage.[31] Twice a day, the programme compares satellites against all known debris and prepares a top 10 list of satellites that are at the highest risk of being hit by another known space object. Satellite operators can use this data to manoeuvre functioning satellites accordingly.

Similarly, the ESA has developed software known as MASTER (Meteoroid and Space Debris Terrestrial Environment), a model for the prediction of debris and meteoroid particle fluxes. This software provides rapid updates for experts and satellite operators

[28] Supra n 15
[29] https://www.oecd-ilibrary.org/sites/d2d4146e-en/index.html?itemId=/content/component/d2d4146e-en&mimeType=text/html (Accessed 11 January 2020)
[30] https://www.esa.int/Safety_Security/Space_Debris/Analysis_and_prediction (Accessed 13 August 2020)
[31] https://celestrak.com/SOCRATES/ (Accessed 13 August 2019)

using ESA's data to perform risk assessment and analysis of debris mitigation actions for missions currently in orbit, enabling them to be better prepared for future ones.[32]

Current space object catalogues only contain a limited description of existing space objects that are likely to cause collisions. Figures from environmental modelling performances show that around 166,8 million objects bigger than one millimetre may be circling the Earth.[33] This has prompted many private entities to commercialise the collecting, processing and analysing of space debris data in order solve the space debris data shortage. One such company that tracks and maps space objects via radars located in different parts of the world is US-owned company LeoLabs, which distributes the data to private and public entities. The advantage of this type of project and the related software is that they create data platforms which are essential for solving the shortage of space situational awareness data.[34]

Another solution in circumventing the space debris data shortage is data sharing. In an effort to raise situational awareness of data, many countries have entered into data sharing agreements. In 2017, the US Strategic Command was able to issue hundreds of warnings to their partners, with more than 80 confirmed collision manoeuvres from satellite operators.[35]

2.2 Size of Debris

Only a limited percentage of the debris in orbit is tracked and catalogued. The orbital parameters of these objects are entered into a catalogue, along with information on the object's origin and its radar or optical cross-section. It is important to note that only objects with known origins are catalogued. This means that small debris that is not catalogued and cannot be tracked, poses great risks to satellites.

The size of a piece of debris corresponds to the risk the debris poses if it strikes another object. For purposes of small debris analysis, sizes can be divided into three categories: debris larger than one centimetre, debris between 0,01 to one centimetre in size, and debris smaller than 0,01 centimetres. Debris smaller than 0,01 centimetres

[32] https://www.esa.int/Safety_Security/Space_Debris/ESA_makes_space_debris_software_available_online (Accessed 13 January 2020)
[33] Supra n 29
[34] Ibid
[35] Ibid

will usually only cause surface pitting and erosion and may have significant consequences over time, but individual impact with such small pieces of debris will usually not cause significant damage. Debris between 0,01 centimetres and up to about one centimetre in size can, depending on the structure of the satellite and where the debris hits, cause significant damage.[36] However, existing technology can equip satellites with shielding methods.[37]

2.2.1 Categories of Space Debris

In his article "Space Debris: Legal and Policy Implications," Howard Baker divides space debris into four categories, namely inactive payloads, operational debris, fragmentation debris and microparticulate matter[38]. The four categories are discussed in this section.

2.2.1.1 Inactive payloads or inoperative objects**[39]** *are those primarily made up of satellites that have run out of fuel for station-keeping operations or have malfunctioned and are no longer able to manoeuvre.*

2.2.1.2 Operational debris**[40]** *includes any intact object or component part that was launched or released into space during normal operations. The largest single category of this type of debris is intact rocket bodies that remain in orbit after launching a satellite.*

2.2.1.3 Fragmentation debris**[41]** *is created when a space object breaks apart. This type of debris is typically created through explosions, collisions, deterioration, or any other means. Some debris has been created intentionally. Examples include several reconnaissance satellites that China and the USSR have intentionally destroyed to prevent their recovery by other states.*

2.2.1.4 Microparticulate matter**[42]** *is created by surface degradation as the result of the gradual disintegration of the surfaces of a satellite due to exposure to the space environment.*

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[36] Supra n 14
[37] Proceedings of the International Conference on Energy Science and Applied Technology (2016)
[38] Baker (1989) 64
[39] Klinkard (2006) 7
[40] ibid
[41] Ibid
[42] Ferreira-Snyman (2013) Comparative and International Law Journal of South Africa 19

The proliferation of these types of space debris and the steadily increasing possibility of collision has cast doubt on the big sky theory, which is based on the premise that space is so vast that it is immune to congestion and will always be available for risk-free utilisation.[43]

The current space pollution problem ultimately calls for immediate technological and legal regulatory tools to slow down and perhaps reverse the proliferation of space debris.

2.3 Conclusion

Space debris has become the subject of great concern in recent years. Space debris generation will never be stopped completely, but it can be minimised by adopting some measures. Many methods of space debris mitigation have been proposed by various space experts, but most have limitations.

The planet has already been polluted so it is up to the spacefaring nations and the international community to ensure that the space is kept pollution-free for safe exploration of the space environment.

[43] Swartling (2018) 12

Chapter 3: Legal and Technical Space Debris Regime

3.1 Introduction

Existing international laws and policies have the potential to limit the creation of new space debris and to establish liability for collisions caused by debris. The legal framework for outer space activities consists of five international treaties, namely the 1967 Outer Space Treaty,[44] the 1968 Rescue Agreement,[45] the 1972 Liability Convention,[46] the 1975 Registration Convention,[47] and the 1979 Moon Agreement,[48] as well various UN General Assembly resolutions and countries' own space legislation. However, this part of the dissertation will only focus on the 1967 Outer Space Treaty, the 1972 Liability Convention, various aspects of customary international law and different general principles of international law from a space debris and outer space activities perspective.

3.2 International Space Law

The terms “space debris” and “orbital debris” are used frequently in academic and scientific writings that describe the impact of man-made space objects upon the space environment. Those terms, however, do not appear in or are defined in any of the treaties or UN resolutions that constitute the law of outer space.

Therefore, in order to examine what existing international rules – if any – govern space debris, a thorough analysis of each of the relevant international instruments is necessary to see their impact.

Two broad categories of rules can be identified: those that pertain to preventing the creation of space debris and those that regulate the consequences of space debris.

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[44] https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html (Accessed 20 January 2020)
[45] https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/rescueagreement.html (Accessed 20 January 2020)
[46] https://www.unoosa.org/oosa/oosadoc/data/resolutions/1971/general_assembly_26th_session/res_2777_xxvi.html (Accessed 20 January 2020)
[47] https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/registration-convention.html (Accessed 20 January 2020)
[48] https://www.unoosa.org/oosa/oosadoc/data/resolutions/1979/general_assembly_34th_session/res_3468.html (Accessed 20 January 2020)

International law is almost exclusively concerned with the latter whereas the former is concerned with non-binding technical policies and guidelines.

3.2.1 Rules of Prevention

The principal treaty of space law – the OST – contains a provision relating to attempts to prevent the creation of space debris. Article IX of the OST stipulates:

> In the exploration and use of outer space, including the moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space[49] ... with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination ...

Article IX continues, stating that states should consult with each other before engaging in activities which might cause "harmful interference" and that any state party has the right to request consultations if it believes another state's activities has caused or will cause harmful interference.[50]

The wording of Article IX creates a provision that binds a state to taking appropriate measures to ensure that its activities do not interfere with the interests of other states or cause harmful contamination. It could hence be inferred that a state which creates debris in the space environment could be considered to be acting without due regard for the interests of other states, causing harmful contamination.[51]

Two problems arise from this provision.

Firstly, it is not possible to operate in outer space without creating any space debris. In this case, the quantity of space debris could be relevant in gauging what amount of debris is acceptable and what is too much. The OST declares that space "shall be free for exploration and use by all states".[52] Under this provision, spacefaring nations could

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[49] Aoki (2013) 6
[50] Proceedings of the First European Conference on Space Debris (1993)
[51] Hobe *et al* (2017) 175
[52] Jakhu *et al* (2017) 12

claim that their national interests form reasonable grounds for the creation of the debris in question and that they were acting under the umbrella of international law.

Secondly, there is the issue of the enforcement and application of such an unclear obligation, to consult with other states. In the absence of specific guidelines, it is difficult for one state to prove that another state – by allowing debris to be created – has violated the due regard of harmful contamination clauses in Article IX.[53]

By virtue of Article IX, states are only encouraged but not obliged to limit the generation of new space debris in an unspecified manner. It is very unlikely that a state would ever want to be held internationally liable for creating ordinary space debris.

3.2.2 Rules of Liability

Articles VI, VII, and VIII of the OST establish the basic legal framework for dealing with all objects in outer space.[54]

Article VI is crucial because it makes a state internationally responsible and accountable for the activities of its non-governmental entities (i.e. individuals and corporations) which occur in outer space.[55]

When the OST came into effect, private commercial activity in space was still an unknown concept, but today non-governmental entities account for a significant proportion of space activity and can also be held accountable for creating new space debris.[56] By virtue of Article IV, states are directly responsible to other states for the consequences of space debris created by non-governmental entities.

Article VII deals with state liability. It states:[57]

> Each State Party to the Treaty that launches or procures the launching of an object into outer space ... and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party

[53] Ibid
[54] Hobe *et al* (2017) 104-143
[55] U.S Congress, Office of Technology (1986) 44
[56] Supra n 40
[57] Hobe *et al* (2017) Pp134-137

to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air or in outer space.

Article VII deals with various concepts that are crucial to the issue of space debris. First, it identifies four categories of "launching States", namely, a state that launches a "space object", a state that procures the launching of a space object, a state from whose territory a space object is launched, and a state from whose facility a space object is launched.[58]

According to this definition, more than one state may be jointly held liable because multiple states may be involved with one another with the above-mentioned categories. For instance, both China and Russia could jointly procure the launch of a satellite.[59]

Article VII holds a launching state responsible for damage caused by their space object and stipulates that the liability includes damage caused not only in outer space but also on Earth or in the atmosphere.

The Liability Convention supplements the liability regime established by Article VII of the OST. The provisions listed below are particularly relevant to the discussion of space debris.[60]

Article I of the Liability Convention defines damage as the "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 organisations".[61]

Articles II and III of the Liability Convention establish two categories of liability, based on where the damage occurred and the type of object that is damaged. Under Article II, a launching state is "absolutely liable" for damage on the surface of the Earth or to aircraft in flight.

[58] http://blogs.esa.int/cleanspace/2017/06/13/what-is-a-launching-state/ (Accessed 13 August 2019)
[59] Report of the International Law Commission to the General Assembly
[60] Noyes et al (1988) 13 *YJIL* at 225
[61] Kayser (2006) 37

Article III establishes a fault-based system for damage caused by a space object of one launching state together with a space object (including persons and property on board) of another launching state if the damage occurred in space.[62]

Article VIII of the Liability Convention is the last important section for analysing the consequences of space debris. It states that a "State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object ... while in outer space". The Registration Convention supplements this in its Article II, stipulating that "when a space object is launched into Earth orbit or beyond the launching state shall register the space object by means of an entry in an appropriate registry".[63]

The above-mentioned instruments show that only one state, which will always one of the launching states, will have jurisdiction and control of the space objects it launches.

Some authors argue that the discussion related to laws applicable to space must be divided in two parts, to pertain to non-functional payloads such as satellites that have run out of fuel, and other types of debris such as normal operational fragments or litter.

However, the distinction is superficial and does not carry much weight in the laws related to the consequences of space debris. Baker notes that every object launched into space has the potential to become debris.[64] Furthermore, the OTS and the Liability Convention deal with a state's liability caused by any object or its component parts launched into space.[65]

In this context, the word object and its meaning include every tangible part of a rocket and its payload, including paint, bolts and every other part of every component, all the way to microscopic level.

The popular view is that non-functional payloads and other pieces of space debris are all classified as space objects within the ambit of space law treaties.[66]

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[62] American Society of International Law (1998) 773
[63] https://www.faa.gov/about/office_org/headquarters_offices/ast/media/Conv_Regi_Objects_Launched.pdf (Accessed 13 August)
[64] Baker (1989) 64
[65] The Outer Space Treaty of 1967 & the Liability Convention of 1972
[66] Proceedings of the 4th European conference on Space Debris (2005)

From the above-mentioned discussion, it is clear that international space treaties deal with the liability of states who create space debris, but do not regulate the creation of the debris itself.

Whether these rules are adequate or not will discussed in the following chapters.

3.3 General International law

The Section below seeks to analyse whether there are established binding norms of Customary International Law and also analyses various General principles of international law pertaining to the protection of the environment and their implications within the outer space environment context.

3.3.1 Customary International Law

in space. Having analysed the limited regime applicable to space debris, any customary norms related to space debris will now be scrutinised.

Customary international law (CIL) is one of the sources of international law listed in paragraph 1 of Article 38 of the statute of the International Court of Justice. CIL is an aspect of international law involving general principles of custom. In other words, CIL is unwritten law, which is considered a binding form of law, falling immediately below treaties and within the hierarchy of international law.[67]

For a provision to become customary law, the rule must be a settled practice carried out in such a way as to be evidence of a belief that this practice is rendered obligatory by the existence of a rule of law requiring it.[68]

In 2018, the International Law Commission (ILC) adopted sixteen Draft Conclusions on the Identification of Customary International Law, setting out what can be considered as evidence of state practice and opinio juris.[69] The Draft Conclusions are intended to offer guidance on how the existence of rules of customary international

[67] 1945 *Statute of the International Court of Justice*
[68] *North Sea Continental Shelf Cases (Federal Republic of Germany v. Denmark and Federal Republic of Germany v. Netherlands*, [1969] I.C.J.
[69] ILC Draft Conclusions on Identification of Customary International Law, 2018

law and their content should be determined.[70] The Conclusions represent the methods utilised by states, international courts, organisations, and most writers. [71]

Although the ILC adopted sixteen Draft Conclusions, only Draft Conclusions 4, 5, 6, 7, 8, 9 and 10 will be discussed for the purpose of this thesis. They pertain to the identification of state practice and opinio juris with regard to space debris mitigation in outer space.

Part Three of the Draft Conclusions document is concerned with general practice and contains all the factors which must be considered when assessing whether general practice exists.[72]

Draft Conclusion 4 stipulates that it is primarily the conduct of states which must be identified and examined to determine whether there is evidence of general practice contributing to the formation and creation of CIL. This Draft Conclusion also states that in certain instances, the conduct of international organisations may contribute to the formation and expression of CIL rules. It further refers to the fact that the conduct of other actors may be considered when assessing the relevant practice, even if such conduct does not contribute towards the formation of binding customary international norms.[73]

According to Draft Conclusion 5, states' practice consists of the conduct of the state, in the exercise of its executive, legislative, judicial, or other functions. Commentary 1 of this Draft Conclusion confirms that in accordance with the principle of the unity of the state, the conduct of the state includes that of any organ of state in the exercise of its executive, legislative, judicial, or other functions.[74]

Commentary 2 specifically states that the conduct of any state organ is to be considered the conduct of the state, whether it is exercising a legislative, executive, judicial, or any other function. This commentary also states that a state organ includes

[70] ibid
[71] ibid
[72] Ibid at page 129
[73] See Draft Conclusions on Identification of CIL, page 130
[74] See Draft Conclusions on Identification of CIL, Page 132

any person or entity that has a status in accordance with the internal law of the state, the conduct of a person or entity to exercise elements of governmental authority.[75]

The efforts of spacefaring states pertaining to the remediation and mitigation of space debris may well be viewed as evidence of state practice. The conduct of states in attempting to solve the space debris issue is reflected in the orbital space debris practices of the various spacefaring nations. Based on Draft Conclusion 5 on general practice, the conduct of spacefaring nations and their space agencies – as organs of state – with regard to space debris mitigation mechanisms should be examined to determine whether such conduct constitutes state practice, which creates and gives expression to CIL norms.

The US government established the Orbital Debris Mitigation Standard Practices in 2001 to tackle the increasing amounts of orbital debris in the near-Earth space environment.[76] The USA' mitigation mechanisms can take the form of curtailing the generation of new debris, implementing operational procedures related the proliferation of debris and collision avoidance manoeuvres.[77]

NASA is an independent agency of the US federal government responsible for the civilian space programme, and for aeronautics and aerospace research. As part of the government's executive branch[78], NASA was the first space agency globally to issue a comprehensive set of orbital debris guidelines.[79] In addition to these guidelines, the agency has compiled procedural requirements,[80] processes,[81] and a handbook for limiting orbital debris.[82]

Japan's space debris mitigation framework consists of the Japan Aerospace Exploration Agency's debris mitigation standards.[83] This framework consists of the following mitigation requirements:

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[75] Ibid
[76] U.S Government Orbital Debris Mitigation Standard Practices
[77] https://orbitaldebris.jsc.nasa.gov/mitigation/ (Accessed 21 January 2020)
[78] See the U.S Federal Register volume 59, Issues 185-189
[79] Supra n75
[80] NASA's Procedural Requirements for Limiting Orbital Debris
[81] Process for Limiting Orbital Debris- NASA-STD-8719.14
[82] NASA's Handbook for Limiting Space Debris -NASA-HDBK-8719.14
[83] Compendium on Space Debris Mitigation Standards Adopted by States and International Organisations, Pp 37-38

- On-orbital break-ups
- Preservation of the GEO region
- Collison avoidance for launch vehicles and manned systems
- Minimising the damage caused by on-orbit collisions
- Reducing the orbital lifetime of a mission

Russia's national mechanisms with regards outer space include:[84]

- The Russian Federation's Law on Space Activity, which is concerned with the near-Earth space environment.[85]
- The Russian Federation Law on the Roscosmos State Corporation for Space Activities.[86] Article 14 of this legal instrument confirms that the main responsibility of Roscosmos is the management of activities to mitigate further debris generation in near-Earth space. These mitigating measures include designing, manufacturing, and testing space objects and space infrastructure.[87]

In addition to the above measures, Russia has also developed the Federal Space Programme of Russia for 2016-2025[88] to establish state policy on space activities. The priorities of this state policy include ensuring the environmental safety of space activities, the adoption of technologies and designs aimed at reducing space debris at launches, and the operation of rocket and space equipment.

Similarly, other states such as the United Kingdom,[89] France,[90] Germany,[91] and China[92] have substantial national legislation and standards dedicated to the mitigation of space debris and the preservation of the outer space environment.

Draft Conclusion 6 addresses the types of conduct regarded as state practice. The forms of state practice in terms of this Draft Conclusion include diplomatic acts and

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[84] Russian Federation Space Debris Mitigation Standards
[85] http://www.jaxa.jp/library/space_law/chapter_4/4-1-2-7/index_e.html (Accessed 21 January 2020)
[86] https://www.global-regulation.com/translation/russia/2947725/the-state-corporation-for-space-activities-%2522roskosmos%2522.html (Access 21 January 2020)
[87] Ibid
[88] Russia Space Programs and Exploration Handbook, page 119
[89] https://www.gov.uk/guidance/apply-for-a-license-under-the-outer-space-act-1986 (Accessed 21 January 2020)
[90] Compendium on Space Debris Mitigation Standards Adopted by States and International Organisations, Pp 24-27
[91] Compendium on Space Debris Mitigation Standards Adopted by States and International Organisations, Pp 28-30
[92] Zhao (2015) Pp 1-87

correspondence, conduct in connection with resolutions adopted by an international organisation or at an intergovernmental conference, conduct in connection with treaties, and executive conduct, including operational conduct.[93]

While there is evidence of state practice related to the space debris mitigation mechanisms employed by spacefaring nations, it is clear that such practices are performed by the relevant states or their space agencies in their capacities within the national arena. The absence of substantial evidence of state practice related to space debris mitigation in the international arena, in the form of diplomatic acts or correspondences, or conduct related to international organisation resolutions and treaties, can be interpreted as an indication that the first element of practice is not fulfilled in terms of CIL.

Draft Conclusion 7 states that when assessing the practice of a particular state, account the relevant state's practice as a whole must be considered. The Draft Conclusion also confirms that where the practice of a particular state varies, less weight may, depending on the circumstances, be given to that practice.[94] The space debris problem requires great progress and constant innovation from a technical and technological standpoint. To this end, each spacefaring nation has adopted a multitude of remediation and mitigation measures, varying in techniques and requirements. Hence, the element of consistency in state practice as stated by Draft Conclusion 7 Paragraph 1 cannot be established.[95]

Draft Conclusion 8 stipulates that the practice in question must be general and sufficiently widespread, representative and consistent.[96] As established above, the orbital debris practices of spacefaring nations vary so much that it is not possible for a uniform, widespread and representative practice to be established and to give expression to norms binding on CIL.

Draft Conclusion 9 states that the general practice under discussion must be accepted as law. In other words, the practice must be undertaken with a sense of legal right or

[93] See Draft Conclusions on Identification of CIL, Page 133
[94] See Draft Conclusions on Identification of CIL, Page 134
[95] See Draft Conclusion 7, para. 1, Page 135
[96] See Draft Conclusions on Identification of CIL, Pp 135-136

obligation. The Draft Decision stresses the importance of distinguishing practice accepted by law from mere usage or habit.[97]

While it true is true that spacefaring nations perform space orbital practice in accordance with their national laws, it is important to note that such practice is not performed in relation to obligations arising from binding CIL norms.

Draft Conclusion 10 discusses the various forms of evidence of acceptance as law.[98] From the preceding discussion, it is clear that the mitigation measures adopted by the various spacefaring nations have not yet been accepted as legally binding on an international level. Moreover, there is no evidence that the forms listed opinio juris in Draft Conclusion 10 suggest that space debris mitigation measures and mechanisms have been accepted as law by the practicing states. As such, the opinio juris element of the mitigation of space debris cannot be established with certainty.

The conclusion is that there is no specific customary international law governing space debris.

Even in the absence of binding customary international norms specific to space debris, the rules of general international law may still be applicable in

3.3.2 General principles of international Law

Article 38, Paragraph 1(c) of the Statute of the International Court of Justice identifies general principles of law that are recognised by civil society as a source of international law.[99] .The general principles of international law are those that give rise to international legal obligations. The adjective ‘general’ indicates that they are principles which are valid for all states in the world and are applied generally in all cases of the same nature arising in international law[100]. Examples such as the principles of non-intervention, justice, natural law, analogies to private law, principles of comparative law, considerations of humanity or non-discrimination are examples of such[101].

[97] See Draft Conclusions on Identification of CIL, Page 138
[98] See Draft Conclusions on Identification of CIL, Page 140
[99] Twirlay (2014) Pp93-111
[100] https://definitions.uslegal.com/g/general-principle-of-law/ (Accessed 20 January 2020)
[101] ibid

General principles of law are primarily used to fill gaps where treaties or CIL are silent on a rule of decision.[102] The general principles of international law also serve as a source of interpretation for conventional and customary international law, tools for developing new norms for conventional and customary law, a supplemental source to conventional and customary law, and a modifier of conventional and customary international law.[103]

Article III of the OST states that parties to the treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, among others in the interest of maintaining international peace.[104]Article III therefore creates the possibility of applying international law relating to state liability and responsibility as elements of the space debris regime.[105]

Article VI of the OST states that direct state responsibility for national activities extends to activities "carried on ... by non-governmental entities" for "assuring that national activities are carried out in conformity with the provisions" of the OST.[106] Article VI dictates that the activities of non-governmental entities in outer space be authorised and continuously supervised by the relevant state, placing a sense of duty on the relevant state.

Articles III and VI of the OTS create the possibility of applying the Corfu Channel[107] and Trail Smelter[108] principles to governmental and non-governmental activity in outer space, and emphasising a State's duty of due diligence.

The Trail Smelter dispute was an environmental law case involving the federal governments of Canada and the United States. The Trail Smelter, located in British Columbia since 1906, was owned by a Canadian corporation. From approximately

[102] https://law.gwu.libguides.com/c.php?g=515695&p=3525705 (Accessed January 2020)
[103] Bassiouni (2011) 462
[104] Supra note 40
[105] Dennerley (2018) 29 *EJIL* 281 (e-journal published 8 May 2018)
[106] Supra note 40
[107]United Kingdom of Great Britain and Northern Ireland v. People's Republic of Albania [1949] ICJ Rep 4

[108]The Trail Smelter Arbitration Case (United States Vs Canada) 1941, U.N. Rep. Int'L Arb. AWARDS 1905 (1949)

1925 to 1937, the ore smelting plant created tons of sulphur dioxide fumes which caused significant environmental damage to the state of Washington, for which the US Government sought and was awarded compensation from Canada.[109] The question which arose from this case was whether it is the responsibility of a state to protect other states against harmful acts of individuals within its jurisdiction.[110]

Two principles emerged from this case. The first one established that a state has an obligation to prevent transboundary harm. According to this principle, a state shall not permit the use of its territory in such manner as to cause injury in or to the territory of another state.[111]

The second principle is the polluter pays principle emerging from the Trail Smelter case was developed from the *Story Parchment Company v Porter Parchment Paper Company* case.[112] The principle is based on the premise that relief must be provided to the injured person and accountability attributed to the wrongdoer. In the Trail Smelter dispute, the relief was to be provide in the form of monetary compensation.[113]

Applying the transboundary harm and polluter pays principles entails that there must be a state claiming injury within its own territory and jurisdiction. In the absence of national appropriation, whether through a claim of sovereignty, use or occupation over the outer space region, it is evident that outer space is outside the traditional concept of national jurisdiction. The absence of jurisdiction in outer space leads to the absence of legal subject entitled to demand liability in case of damages caused by human activities in space.[114]

The Corfu Channel case was a landmark in the development of maritime law. The case was lodged in 1946 after explosions of mines in which some British warships suffered damage while passing through the Corfu Channel in a part of Albanian territorial waters. The ships were severely damaged, and some members of crew killed. The International Court of Justice found that Albania was responsible under

[109] https://intlpollution.commons.gc.cuny.edu/an-international-environmental-law-case-study-the-trail-smelter-arbitration/ (accessed 23 January 2020)
[110] Xiamen Academy of International Law (2010) 3 at 373
[111] Supra n107
[112] Story Parchment Company v Paterson Parchment Paper Company, 282 U.S. 555 (1931)
[113] Supra n107
[114] https://www.thespacereview.com/article/2855/1 (Accessed 22 January 2020)

international law for the explosions, damage and loss of life in the Albanian waters.[115] Consequently, the court established the principle of due diligence according to which every state is obliged not to knowingly allow its territory to be used to commit acts against the right of any other state.[116] In terms of the due diligence principle, Albania was under the obligation to warn others that its territorial waters were mined.[117]

This principle is closely associated with the good faith and neighbourly relations principle which places the duty on states to control the act of third parties where harm might be caused between states.[118] Dionisio Anziloti explains that the duty enshrined in this principle does not lie in prohibiting injurious acts but rather in formulating policies to prevent such acts.[119]

The issue in applying the Corfu Channel principles to outer space activities is that a state exercising control over a its territory is fundamentally different from exercising control over space activities. It would be difficult to demonstrate with certainty the absence of due diligence on the part on one state in matters of space debris and collision avoidance.

Analogies from general international law into the law applicable to the use and exploration of outer space must be drawn carefully.[120]

The Corfu Channel Case and Trail Smelter Arbitration only apply to the space debris problem to a limited extent and might not be applicable to space, an area which is outside territorial jurisdiction.

Principle 21 of the 1972 Stockholm Declaration on transboundary environmental damage stipulates that “States have … the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States *or of … areas beyond the limits of national jurisdiction*.”[121]

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[115] Summary of Relevant Aspects of the Corfu Channel Case (Merits)
[116] Kulesza (2016) 2
[117] Supra n103
[118] Soto (1996) 3 ILSA Journal of International and Comparative Law at 197
[119] ILC Yearbook (1978) 188, at 195, para. 499
[120] Christol (1966) 2

[121] Declaration on the United Nations Conference on the Human Environment

Although the declaration is not legally binding[122], it is recognised as CIL, making it substantially similar to the provisions of article IX of the OTS.

Another general principle which could find its application in the outer space legal regime is the precautionary principle. This rule is reflected in Principle 15 of the Rio Declaration and in effect requires states either to avoid engaging in harm-producing activities or to weigh the benefits against the potential environmental damage and take appropriate steps to mitigate the anticipated environmental harm.[123] An article in the *Journal of Air, Law and Commerce* suggests that the application of the precautionary principles stems from the reasoning that the Moon and consequently outer space is a fragile environment because of the dangers attributed to outer space activities. It is therefore in the best interest of spacefaring nations to apply caution when exercising such activities in the outer space environment. [124]

Although none of the provisions of the legal regime governing outer space expressly mention the precautionary principle, general acceptance of the need to use caution is reflected in Article V of the OST, which requires states to inform the UN of "any phenomena they discover in outer space, including the Moon and celestial bodies, which could constitute a danger to the life or health of astronauts. General acceptance of the need to use caution is also expressed in OST Article IX, in which contracting states agree to "avoid harmful contamination" of the Moon.[125]

The precautionary principle could adequately be applicable to outer space because when applied to activities in Antarctica, it led to improved evaluation of impact prior to the event rather than after the event, to prohibitions on activities where characteristics of the area were unknown, and establishing limits on certain kinds of activities. Similar results could be attained by applying the Precautionary Principle to the outer space environment.[126]

The principle of preventive action could also find application within the outer space context. In terms of this principle, a state may be obliged to prevent damage within its

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[122] Ibid

[123] Soto (1996) 3 ILSA Journal of International and Comparative law at 201
[124] Larsen (2006) 71 J. Air L. & Com at 298
[125] Hintz (1991) 34 INT'L INST. SPACE L. 59 at 61
[126] Larsen (2006) 71 J. Air L. & Com at 304

own jurisdiction.[127] This principle entails that states have the duty to guarantee that the activities within their jurisdiction or control do not cause harm to the environment of other states or of areas beyond the limits of national jurisdiction. The preventive principle is always linked to the precautionary principle.

The efficacy of the existing “preventive principles” could be highly debatable as one can argue that they do not adequately address the challenges of space debris mitigation because we have already reached a point where significant damage to the outer space environment has been done. However, in the absence of an international legal regime specifically tailored to govern the space debris mitigation issues, they remain a significant solution since remediation alone cannot improve the status quo.

There is no certainty that the precautionary principle, the cooperation principle, the polluter pays principle, the due diligence principle or the preventive action principle can successfully be applied to the outer space environment, but what is certain is that the spacefaring nations along with the international community are becoming proactive in implementing space debris mitigating measures that can potentially lead to the creation of more solid and binding international rules.

4.4 Conclusion

As space activities increase in outer space, the law that governs activities in the space environment is becoming relevant and important to both spacefaring states and the international community. The preceding analysis provides an understanding of the relevance of some aspects of the current international space regime. The OST and other international environmental laws play a critical role in this regime, which sets out some principles and policies adopted by the international community to govern activities in outer space. However, the technological development has enabled space activities that have not been included into the existing legal framework. This development calls for international regulatory and policy changes with the aim to maintain peaceful space exploration and exploitation. Other issues, such as property rights to outer space resources, the protection of the space environment, and grounds for liability will grow in importance as the space technology and its relevance develop.

[127] Soto (1996) 3 ILSA Journal of International and Comparative law at 199

Throughout the analysis, it has been clear that the peaceful use of space exploration and exploitation is dependent on international co-operation. The principles discussed above are soft law instruments providing guidelines and standards of conduct that may influence states' practice, but they do not have the capacity to be binding upon states like treaties.

Chapter 4: Mitigation and Remediation Solutions

4.1 Debris Remediation

Space debris environment remediation consists of "efforts to manage the existing space debris population through active space debris removal with emphasis on densely populated orbit regions".[128] This method is curative in nature and includes the use of technology to remove debris from the Earth's orbit.

Examples of such technologies include lasers for the removal of small pieces of debris in LEO, electrodynamic tethers that attach to a piece of debris to make it re-orbit or re-enter**,** or even unmanned 'hunter' spacecraft that can manoeuvre to close proximity and attach themselves to large non-functional satellites. Orbiting trashcans, airbursts

[128] Letcher TM & Vallero DA (eds) (2019) 578

and debris-collecting nets can be added to the endless list of methods. [129] All of them present one common issue: affordability.

Active debris remediation (ADR) technology is still relatively in its infancy and will most likely require significant additional outlays before being widely available**.** All the proposed ADR methods have one inherent flaw or another. Some are inconsistent with the laws of physics, some are too technologically complex to effectively be implemented, some violate existing space treaties, and some even pose serious safety issues.[130]

Some scholars argue that removing large debris items each year may decrease the proliferation of space debris. This school of thought is questionable in the light of events such as the Iridium-Cosmos collision and the continued addition of new satellites to the high-debris zone.[131]

ADR is not only costly; even if a cost-effective solution could be found, who would bear the costs of the mission? The cost of removing a single space has been speculated to cost between $100 million and $500 million.[132] Russia, the USA and China's space activities create a significant portion of space debris. Would these states be willing to spend billions of dollars on the removal of a minimal amount of space debris?

At present, there are no economically or technically viable methods to remove debris from space. But even if such methods existed, the current rules of space law would present a major impediment.[133]

In order to drastically decrease the debris in space, states that clean up would have to be able to remove any debris and not just the debris emanating from their activities. For space debris removal operations to be cost-effective and successful, debris in similar altitudes and inclinations would need to be targeted, irrespective of who has jurisdiction and control over that debris.

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[129] http://adsabs.harvard.edu/full/2001ESASP.473..707B (Access 13 August)
[130] Chu et al (2013) 763

[131] https://swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf (Accessed 13 August 2019)
[132] https://www.cnbc.com/2018/09/18/wef-tianjin-space-junk-is-a-big-problem-and-its-going-to-get-worse.html (Accessed 22 January 2020)
[133] Tallis (2015) 9 *Strategic studies quarterly* at 89

However, under Article VIII of the OST and Article II of the Registration Convention, only a launching State can have jurisdiction and control over its space objects.[134] It means that no state may remove or change the orbit of any space objects that it has not launched and of which it is not the state of registry; to do so, it must obtain authorisation from the state of registry. Article VIII of the OST and Article II of the Registration Convention are an impediment to proposed solutions for the remediation of existing space debris and limiting its rapid proliferation.[135]

To solve the issue of obtaining authorisation for removing space objects, the implementation of intergovernmental agreements between spacefaring nations has been suggested by some scholars. This could be a practical alternative to having to obtain permission for every single object a cleaning state has to remove.

Space debris remediation will not be possible without adequate funding.

Persuading the private sector to become actively involved in solving the debris problem in the space is also a viable option for the promotion of space debris remediation solutions.[136] To this end, agencies such as the ESA and NASA have sponsored university projects instead of creating in-house teams for technological development and innovation.

Investing in the work of tertiary level students at various institutions creates public awareness and encourages private interest in solving the space debris problem. The rationale is that if the private sector had technology available, it would engage with governments to implement adequate legislation.

Many states have yet to ratify international instruments which could address the problem of space debris such as the UN Debris Mitigation Guidelines and the IADC Guidelines. Hence, cooperation, liability and responsibility are only possible between compliant states.[137]

No guidelines rules for space debris removal exist and no committee to draft relevant resolutions has been established. In other word, a regime for space debris remediation

[134] The Outer Space Treaty of 1967 & the Registration Convention of 19

[135] Supra n 131

[136] Moltz (2011) 64

[137] http://www.unoosa.org/pdf/publications/st_space_49E.pdf (Access 13 August)

has yet to be created.[138] A new regime would offer many possibilities for different options for funding remediation activities such as the implementation of a global fund or funds generated from states' donations towards space debris remediation. Some have proposed a fund filled by the imposition of taxes and licensing on spacefaring nations for launches and inactive objects in outer space.[139]

Another suggestion is to levy a tax or a fee on contributors to the orbital debris problem, which will contribute towards a "space clean-up fund". If the cost of further pollution of space is increased, potential orbital polluters will bear both the private and the social costs of their actions, resulting in a more efficient allocation of resources.[140] This approach is derived from the writings of the economist Arthur Pigou, who averred that actors must consider the costs, or negative externalities, they are imposing on others.[141]

It is clear that a new space remediation regime can only be implemented through global cooperation.

4.2 Debris Mitigation

This section provides an overview of different space debris mitigation instruments such as the mitigation guidelines adopted by the IADC and COPUOS respectively, on-orbit servicing of satellites and various orbital debris practices used by spacefaring nations.

As defined by the IADC, "space debris mitigation consists of all efforts to reduce the generation of space debris through measures associated with the design, manufacture, operation and disposal phases of a space mission". This means that mitigation measures are preventive in nature and primarily seek to avoid creating further debris. They are be implemented in a variety of ways**.** For example, applying additional shielding to spacecraft can limit the effects of collisions and reduce break-up events**.**

[138] Ferreira-Snyman (2013) 46*The Comparative and International Law Journal of Southern Africa* Pp 19-51
[139] Proceedings of the forty-second Colloquium on the Law of Outer Space, page 177

[140] Salter (2015) Pp 12-13
[141] https://corporatefinanceinstitute.com/resources/knowledge/other/pigouvian-tax/ (Accessed 22 January 2020)

De-orbiting spacecraft at the end of their life to remove them through their own manoeuvres from congested orbits is one of the primary mitigation measures. It removes the debris by returning it into the atmosphere to burn up or moving it to "alternative graveyard orbits" where the probability that they will interfere with operational spacecraft is minimal.

4.3 On-orbit servicing of satellites

On-orbit servicing (OOS) refers to on-orbit activities conducted by a space vehicle that performs up-close inspection of another resident space object or makes intentional and beneficial changes to it. OOS operations are performed by vehicles called servicers. These activities include non-contact support, orbit modification (relocation) and maintenance, refuelling and commodities replenishment, upgrades, repairs, assembly, and debris mitigation.[142]

While OOS is a nascent industry, the potential market is significant since satellite operators may rely more on this method in the near future as a cheaper alternative to purchasing new, expensive satellite systems. Although this method has only been performed by government entities to date, OOS is bound to gain momentum as private space organisations are seeking to adopt cost-effective measures of preserving their satellites or space equipment.

OOS has gained more traction with the recent failure of Intelsat-29e. Intelsat suffered a fuel leak followed by a communications system failure, resulting in the loss of a satellite only three years into its 15-year design life.[143] This failure could have been prevented by OOS, which could have helped to salvage the space object, whereas replacing it will ultimately cost hundreds of millions of dollars. An OOS inspection would have played an important role in forecasting the system failure and modifying its orbit could have helped to move Intelsat-29e out of the GEO belt, thus removing a large piece of debris from a highly valued orbit. An OOS repair could have fixed the propellant leak and/or communications system failure, perhaps restoring some of the satellite's functions.[144]

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[142] Davies et al, On-orbit Servicing (April 2019)
[143] https://spacenews.com/intelsat-29e-declared-a-total-loss/ (Accessed 22 January 2020)
[144] Supra n140

4.4 Inter-Agency Debris Coordination Committee[145]

Formed in October 1993, the IADC is an international forum of governmental bodies for the coordination of activities pertaining to space debris and is made up of experts from the space agencies of major spacefaring states. The agency is known for its significant international efforts towards the prevention and mitigation of space debris.[146]

The main purpose of the IADC is to exchange information and facilitate cooperation on space debris research, review the progress of cooperative activities, and to identify debris mitigation options. Although the IADC does not create rules that are binding on member agencies, it developed and published the IADC Space Debris Mitigation Guidelines in 2002.[147]

The Guidelines are based on the fundamental principles enshrined in the national policies of the member agencies and were agreed to by consensus.[148] The Guidelines encourage all users of the Earth's orbit to take into consideration four basic areas when designing new spacecraft and operating existing ones, each of which is discussed below.

(1) Limitation of debris released during normal operations. The IADC Guidelines state that systems should be designed to avoid any release of debris where possible. When this is not possible, debris release should be planned in such a way as to limit the amount of debris in number, area, and orbital life.[149]

(2) Minimisation of the potential for on-orbit break-ups. The IADC Guidelines note that the potential for break-up can be decreased by taking steps to release or protect stored energy sources like propellant and batteries (a process known as passivation), by continuously monitoring the condition of spacecraft and taking action when necessary to avoid a break-up, and by avoiding intentional destruction that increases the risk to other spacecraft.

[145] http://www.unoosa.org/documents/pdf/icg/2018/icg13/wgs/wgs_23.pdf (Accessed 13 August)
[146] Scientific and Technical Presentations to the Scientific and Technical Subcommittee at its Thirty-fourth Session
[147] IADC Space Debris Mitigation Guidelines (2002)
[148] Ibid
[149] Ibid

(3) Post-mission disposal. The IADC Guidelines call for different procedures for different orbits. Spacecraft in LEO should be de-orbited, moved closer to Earth to lower the orbital lifetime, or directly retrieved. Spacecraft in GEO should be raised at least 235 kilometres above the nominal GEO altitude.[150] For all other orbits, spacecraft should follow the guidelines for LEO where possible, or at least be moved away from congested orbital areas.[151]

(4) Prevention of on-orbit collisions. When planning a mission for a spacecraft, the plan should take into account the probability of collision with all known objects during the spacecraft's lifetime.[152] Further, when reliable data are available, spacecraft should be manoeuvred to avoid collision risk and they should be designed in such a way that if the spacecraft does collide with small debris, the probability of a loss of control is low.

The IADC Guidelines, and even the IADC itself, are not a simplistic, quick solution for the space debris problem. The individual spacefaring states already have national rules or policies for orbital debris mitigation entrenched in their respective legislation. For instance, the mitigation rules of the USA are similar to the IADC Guidelines. The USA in fact promotes the IADC Guidelines and confirms that they align with its domestic policies.[153] The IADC Guidelines and the IADC itself play a crucial twofold role in solving the orbital debris problem. First, they have raised the awareness of the space debris on an international level. Second, they are a precursor for discussions in COPUOS.

4.5 United Nations Committee on the Peaceful Uses of Outer Space

COPUOS was created as an ad hoc UN committee shortly after the former USSR launched the first spacecraft, Sputnik I, on 4 October 1957.[154] The committee's objective is to consider international cooperation in space and analyse legal issues concerning the exploration of space. The full committee consists of the Scientific and

[150] Ibid
[151] Ibid
[152] Ibid
[153] Compendium on Space Debris Mitigation Standards Adopted by States and International Organisations, Page 53
[154] https://www.unoosa.org/oosa/en/ourwork/copuos/history.html (Accessed 23 January 2020)

Technical Subcommittee and the Legal Subcommittee, which meet annually and conduct their work on a consensus basis.

In its early years, COPUOS drafted all five extant space law treaties through its Legal Subcommittee.[155] However, since the Moon Agreement came into force in 1979, COPUOS has only forwarded a few non-binding principles to the UN General Assembly, which is a "significant departure from its previous law making efforts" and "reflects an increasing resistance on the part of some of the key players in space politics to create too strict a body of space law".[156]

A UN General Assembly Resolution in 1989 noted that "it is essential that Member States pay more attention to the problem of collisions with space debris and other aspects of space debris, and calls for the continuation of national research on that question."[157] This statement was issued shortly after the first US Presidential space policy addressing space debris was published in 1988.[158]

At the February 2003 session of the Scientific and Technical Subcommittee, the IADC presented its Space Debris Mitigation Guidelines, which prompted the subcommittee to create a Space Debris Working Group.[159] The group was tasked to revise and update the IADC Guidelines by working closely with the IADC.[160] This resulted in a 2006 draft set of "high-level qualitative guidelines" that are based on the work of the IADC, but are the product of the working group.[161] There are seven guidelines similar to those of the IADC, but these guidelines have been criticised for their lack of technical details.[162]

[155] ibid
[156] Jankowitsch (1998) 26 J. Space L. at 101
[157] International Co-operation in the Peaceful Uses of Outer Space, GA Res. 44/46, UN GAOR, 1989 at para. 23

[158] Report of the Scientific and Technical Subcommittee on the Work of its Fortieth Session, UN COPUOS, UN Doc. A/AC.105/804, 2003 at para. 121
[159] Report of the Scientific and Technical Subcommittee on the Work of its Forty-First Session, UN COPUOS, UN Doc. A/AC.105/823, 2004 at 20.
[160] Ibid. at 20, 41.
[161] Progress Report of the Working Group on Space Debris, Submitted by the Chairman of the Working Group, UN COPUOS, UN Doc. A/AC.105/C.1/L.284, 2006, at 2.
[162] Ibid at 3-4.

The working group encourages all states to voluntarily apply the Guidelines, recognising that there may be exceptions to their implementation in certain cases and that they are not legally binding under international law.[163]

Many delegations have attempted to add the topic of debris to the agenda, but no consensus is being reached. The Legal Subcommittee included the space debris topic to its informal discussions in 1995, but no tangible outcome has been seen yet.[164] The Legal Subcommittee has also been pressure by France and a few other states to consider drafting principles on the prevention of space debris for adoption by the full General Assembly.[165]

However, delegations who are against adding orbital debris to the agenda argue that since the Scientific and Technical Subcommittee's work on mitigating measures is still ongoing, it could be premature to start working on the subject in the Legal Subcommittee.[166]

4.6 Orbital Debris Practices of Other States and the ESA

There are many states are trying to mitigate the generation of orbital debris. The following discussion highlights the laws and technical practices of key spacefaring states in the quest for mitigating the creation of new space debris.

4.6.1 Practices of States

Although 107 states have signed the Outer Space Treaty, information about the debris mitigation measures of the majority of these states is not readily available or accessible. This section provides a selective survey of individual states, because only those that are capable of independently building and launching craft into space are being focused on. In the outer space context, this suggests that there is a greater

[163] Ibid at 2-3
[164] Report of the Legal Subcommittee on its Thirty-Fifth Session, UN COPUOS, UN Doc. A/AC.105/639, 1996 at para. 54

[165] UN COPUOS Legal Subcommittee, 41st Sess., 666th Mtg.
[166] Report of the Legal Subcommittee on its Forty-Fourth Session, UN COPUOS, UN Doc. A/AC.105/850

emphasis placed on the states who have contributed more practice than others because they have been more involved in mitigating space debris.[167]

In Russia, the "Law on Space Activity" contains a general provision prohibiting the creation of orbital debris.[168] The law stipulates that "harmful pollution of space, leading to unfavourable environmental changes, including intentional destruction of space objects in space is prohibited by the law in question." In 2000, the Russian Federal Space Agency implemented an orbital debris mitigation standard[169] which includes measures similar to the IADC Guidelines, such as passivation and minimising the release of operational objects. Furthermore, Russia has a debris tracking system second only to that of the SSN and contributes innovative approaches to debris modelling and shielding.[170]

Similarly, Japan formed a multi-agency orbital debris committee in 2000 to assist its government and to provide input to COPUOS and the IADC.[171] In addition to its contribution to debris observation, Japan plays a key role in the study of debris through its computer models and hypervelocity impact test facility.[172]

Some states, such as Argentina, Chile, the Netherlands, Poland, Spain and Switzerland have confirmed their adherence to the COPUOS Guidelines. There are other states such as Australia, Germany and Japan that have not enacted national legislation but have elaborated state policies or standards for space debris mitigation for their national space agencies.[173]

The United Kingdom adopted its Outer Space Act in 1986, which requires a licence to launch or operate a satellite, or perform any activity in space.[174] A licence holder *may* be required to "prevent the contamination of outer space" and to "avoid interfering with the activities of other states".

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[167] Barnsley (2009)202 *MIL. L. REV*. at 53, 75–76
[168] *Russian Federation Law on Space*, Sect. I, art. 4, para. 2
[169] http://www.unoosa.org/pdf/pres/stsc2007/tech-26.pdf (Access 13 August)
[170] Ibid
[171] Supra n 81

[172] https://www.researchgate.net/publication/289486997_Optical_observation_technologies_for_space_debris (Accessed 13 August)
[173] Compendium on Space Debris Mitigation Standards Adopted by States and International Organizations

[174] *Outer Space Act 1986* (U.K.)

In his second UN report on the identification of customary international law, Special Rapporteur Sir Michael Wood refers to the concept of specially affected states. He stresses that due regard should be given to the practices of "states whose interests are specially affected",[175] where such states may be identified. He further states that any assessment of international practice should consider the practice of those states that are "affected by or interested to a higher degree than other states" in the rule in question, and that such practice should weigh heavily. Which states are "specially affected", depends upon the rule under consideration. It is important to note that there are instances where "specially affected states cannot be identified with certainty".[176] It is inevitable that the spacefaring nations who are active in outer space will often be "specially affected" and it is because of this that their practice is selectively assessed and given more weight.[177]

4.6.2 European Space Agency

The ESA operates a centres network that works hand in hand to coordinate orbital debris efforts in Europe.[178] The ESA experience with issues pertaining to orbital debris dates back to 1986 when a task force was created to study the issue; its report was published in 1988. The ESA has also implemented a European Code of Conduct for Debris Mitigation.[179]

Although the European Code is based upon the IADC Guidelines, it also contains additional details and explanations[180] consisting of 12 design guidelines and eight operational guidelines that all ESA members must adhere to in order to mitigate space debris. Each of the guidelines contains four categories: prevention, end of life, impact protection, and re-entry safety measures.

As previously discussed, the COPUOS Guidelines are not legally binding in the international arena. The Guidelines address the mitigation of creating new space debris but do not tackle the eradication of existing space debris in the Earth's orbits. To this effect, Froehlich suggests the creation of a universal space traffic management

[175] International Law Commission, Second Report on Identification of CIL
[176] Supra n 174

[177]ibid
[178] European Space Agency, European Space Operations Centre: Focal Point for ESA Space Debris Activities
[179] European Code of Conduct for Debris Mitigation, Issue 1.0, 2004
[180] Ibid

system.[181] The proposed system would allow spacefaring nations to manage and jointly control the launching of space objects and orbital activities. To date, these activities have been individually and informally performed by states through various space object tracking systems.

The efficacy of the existing mitigation guidelines seems to be affected by the uncertainty around the interpretation of hard laws and the non-binding characteristics of soft laws, as seen in Chapter 3.[182]

While there is a wave of new technology advancements in the form of innovative ideas, research plans and business models, these new mitigation mechanisms would have to be implemented against the backdrop of an outdated space regime that was formulated decades before. The need for establishing a set of space debris removal guidelines is imperative so that removal projects are not approved, financed, built and launched in a legal vacuum. An updated set of guidelines could have the potential to develop customary international law, thus creating a new outer space legal framework more suited to current and developing technology. As Froehlich has pointed out, the creation of an international launch and orbital tax could guarantee the funding of joint international action to eradicate space debris from the Earth's orbit. This would be similar to the rehabilitation fund that every mine in South Africa is obliged to have in order to ensure rehabilitation of land after exploitation.[183]

4.7 Conclusion

The current guidelines pertaining to space debris are limited to mitigating the problem, although it is crucial to establish remediation measures. The major spacefaring nations have created voluntary mitigation measures and are generally complying with them. The current *lacuna* in international law concerning orbital debris needs to be filled with enforceable rules and definitions that provide certainty and accountability.

Remediation should be enacted nationally in line with the example of states that have incorporated mitigation measures in their space laws and policies. More weight should be given to remediation at international level too. The mitigation guidelines adopted

[181] Froehlich (2018) 101
[182] Ibid
[183] Ibid at 102

by the IADC and COPUOS could serve as a model for the creation of remediation guidelines to which spacefaring nations could adhere.

Although the current space debris mitigation guidelines are not binding, it is argued that continued application by states coupled with the passage of time will create binding rules, eventually giving expression to customary international law pertaining to space debris mitigation.

Chapter 5: Critical Analysis of Existing Legal and Technical Framework

Chapter 5 considers the effectiveness of the existing regimes, reaching the conclusion that while the technical solutions are adequate, the legal mechanisms need improvement.

5.1 Technical Aspects

While the extant national and international legal frameworks are not adequately equipped to deal with the space debris problem and the pollution of the outer space environment, the mitigation measures try to alleviate these problems to some extent. For example, a 2004 NASA report on the history of satellite fragmentations concluded: "The lack of a significant increase in orbital debris in recent years can partly be attributed to implementation of debris mitigation measures on the part of launching agencies and organisations."[184] Furthermore, despite the increase in the total number of new trackable pieces of debris each year, the annual rate of new debris created has decreased since the late 1990s.

However, the success and effectiveness of mitigation measures cannot solely be based on an assessment of the amount of debris in outer space. A study conducted in 2007 that tried to quantify technical success by Nicholas L. Johnson, the then chief scientist and program manager of the NASA Orbital Debris Program Office, showed how challenging such an assessment can be.[185] A separate analysis had to be conducted for each category of space debris. Johnson's study concludes that debris mitigation efforts have started to show "a beneficial effect on the accumulation of operational debris such as rocket bodies and mission-related debris."[186]

It is safe to say that the space debris today would be much worse without the mitigation efforts by the international community.

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[184] NASA, *History of On-Orbit Satellite Fragmentations*
[185] Johnson N L et al (2007) 64 *Acta Astronautica*
[186] Ibid

The mitigation measures related to payloads have not been in effect long enough to produce tangible results, although if satellite operators adhere to the general mitigation guidelines of reducing inactive LEO satellites to 25 years, the debris population of this category will begin decreasing within decades. Fragmentation debris is the most difficult category to assess and is still increasing.

Another study predicts that end-of-life passivation efforts alone could reduce the amount of LEO debris by 50 percent over the next 100 years (compared to cases where passivation measures were not used).[187] If all LEO satellites are deorbited within 25 years, using a method other than passivation, the amount of debris in LEO can be reduced by more than 500 percent.[188]

Even if the measures are gauged to be effective, the existing debris situation in some areas is so severe that the long-term situation is not optimistic.

No internationally binding technical rules concerning debris mitigation measures exist, and states have expressed their reluctance to create any such rules through the Scientific and Technical Subcommittee of COPUOS.[189] Moreover, the IADC guidelines are merely suggestions that states are not obliged to comply with. If any binding mitigation rules were to be established, the process would be initiated with the Legal Subcommittee, which has yet to add the discussion to its agenda.[190]

If the Legal Subcommittee finally decides to implement a set of rules, the most likely result would be a set of principles forwarded to the UN General Assembly for action. Similarly, UN principles are generally not legally binding either. The General Assembly only makes recommendations and has no authority to create new law.[191] However, the International Court of Justice and other international tribunals have noted that "certain resolutions, whether they are of as strict legislative nature or not, are expressions of law and carry with them obligations in the juridical sense".[192]

[187] Supra n38
[188] ibid
[189] http://www.unoosa.org/oosa/en/ourwork/copuos/comm-subcomms.html (Accessed 13 August)
[190] Report of the Legal Subcommittee on Its Forty-Fifth Session, UN COPUOS, UN Doc.
[191] The Charter of the United Nations at art. 11.
[192] Castañenda (1969) 6

A requirement that is binding on states to comply with space debris mitigation policies is unlikely to be implemented in the near future.

5.2 Legal Aspects

Legal alternatives to the space debris issue will always be of a technical nature.[193] The principles of the law can only permit, encourage, or mandate certain technical procedures aimed at mitigating space debris. It is safe to say that the law is only the medium through which the real solution can be implemented. This is similar to the solutions proposed for other environmental problems. For instance, many states have established maximum levels of certain contaminants that may be found in the soil, water, or air. The requirement that factories have to reduce emissions by certain amounts to comply with environmental standards and that polluting entities pay fines and/or the costs of remediation is a concept that international space treaties could adopt.[194] These technical solutions to traditional environmental problems are usually implemented through legislation or administrative measures. Similarly, the issue of debris could be regulated by international principles or rules based upon technical standards.

The current legal regime governing objects in space was developed long before space debris was considered a hazard and consequently, there are currently no legal rules specifically implemented to mitigate and remedy the threats presented by space debris. These are the *lacunae* in international law concerning orbital debris that critics identify as the main problem.

Another source of criticism is the absence of explicit and meaningful protection of the space environment. Article IX of the Outer Space Treaty prohibits harmful contamination, but in a general, unenforceable way. Article IX is impractical because it contains no specifics or mechanisms for dispute resolution.[195] Another reason for criticism of this provision is that it deals with hazardous activities, while the imminent threat to the space environment stems from the effects of "normal, accepted space

[193] Jasentuliyana N (ed) (1992) 248
[194] Schachter (1991) 44 *Journal of International Affairs 457 at 462-463*

[195] Swenson (1985) 25 A.F. L. Rev. 70 at 79.

activities".[196] Moreover, the Liability Convention cannot be used as a means to enforce Article IX of the Outer Space Treaty. Although the Liability Convention provides for a negligence-based recovery system for damage in outer space, it only applies to space objects that are damaged in space but not to the space environment itself.[197]

The Liability Convention's rules do not help regulate space debris. Although the Convention provides for after-the-fact liability rules which can create incentives for the mitigation of space debris, these rules would never create an obligation to do so. Instead, states may just decide to ignore the rules and later accept the financial penalties. It can be deducted that liability rules are a poor substitute for preventative rules.[198] For liability rules to be fully effective, the rules have to be enforceable and unambiguous.

The Liability Convention's rules pertaining to damage in space are not designed to protect the space environment itself and should not be seen as a deterrent to the creation of orbital debris. There are two reasons why this is so. Firstly, there is the problem of identifying of the cause of damage. Due to the large population of uncatalogued debris of all sizes, collisions in space are likely to be the result of debris which is too small to be traced. This means that the operator of a damaged satellite will not know which states were the launching states and cannot institute a claim under the Liability Convention.

Secondly, the onus of proving negligence on the part of the other state is placed on the claimant state. Because outer space is open to all, states can put satellite wherever they want with the exception of GEO orbital slots. Merely placing a satellite into a particular orbit cannot be interpreted as negligence. Hence, if a collision occurs decades after a launch between objects from different states, which one could the claimant state identify as the negligent act?[199] It might be able to establish negligence using the IADC mitigation measures as legal grounds for establishing negligence for a claim under the Liability Convention.

[196] Ibid
[197] Ibid
[198] Ibid at 80
[199] Ibid

Under the Liability Convention, claims are presented to the appropriate launching state through diplomatic channels (Liability Convention, Article IX). If the states cannot settle the claim within one year, they must jointly establish a claims commission at the request of either party (Article XIV).

Such technical measures are clearly not designed to create a binding international norm, as the claimant state would not be precluded from arguing that failure to comply with the mitigation standards constitutes evidence of negligence. For instance, if a collision occurs between an inactive payload and an active satellite, the claimant state could argue that failure to remove the object from the Earth's orbit was an act of negligence.

Similar grounds could perhaps be used for damage arising from operational debris that could have been avoided by adhering to IADC guidelines.

Thirdly, a state seeking compensation must still establish cause. Two states can legitimately claim that another state's object caused the collision, but without much certainty. Since it is in practice impossible to prove identity, negligence, and causation, the Liability Convention is inadequate for mitigating space debris and instituting action for the damage caused by space debris.[200]

5.3 Recommendations

This dissertation has shown that space debris and the various space activities from spacefaring nations pose great risk to the outer space environment. This dissertation also revealed that the need for aligning current space debris remediation and removal with an adequate framework is a matter of urgency as space activities are on the rise with the involvement of not only government entities but private ones too. On this basis, the section below provides legal and technical recommendations on the way forward in the quest for curtailing the space debris problem and protecting the outer space environment.

[200] Lampertius (1992) 13 Mich. J. INT'l L.447 at 455-460

5.3.1 Final Recommendations

Over the years, many proposals have been brought forth for solving the space debris problem. Some authors propose an environmental regulatory framework that would mandate an environmental impact analysis for each launch.[201] However, enforcing such a rule entails conducting an environmental impact analysis, otherwise this will amount to self-policing and will be ineffective.

Some commentators strongly advocate against entrenching technical mitigation rules in a treaty owing to their inflexible nature and characteristic slow adaptation to ever-changing technology.

Others advocate for the establishment of a treaty-based regulatory body with the ability to adapt to more advanced mitigation measures, similar to the structure of the International Civil Aviation Organization (ICAO).[202] Another, less complex idea that has been proposed, is the codification of rules requiring states to cooperate with one another to mitigate space debris and to inform, consult, and negotiate with other states concerning debris issues.[203]

Other proposals would involve either the creation of a new treaty or modifications to existing ones that would allow states to "disown" objects on some sort of registry so that other states can move or remove them from space.[204] This proposal suggests that failure to disown an inactive object would amount to automatic fault under the Liability Convention.[205] Some even suggest that states should be required to remove non-functional satellites and that any other state would be entitled to use self-help measures to enforce the rule.[206]

Another group of scholars have proposed solutions that avoid the creation of new treaties, instead preferring UN General Assembly principles, codes of conduct similar to the IADC Guidelines, or other informal and voluntary regimes.[207] Yet another hybrid approach proposed is to start with informal, voluntary rules and then evolve to an

[201] McDermott, (1992) 36 A. F. L. Rev. 143 at 158

[202] Supra n64

[203] See The 66th Conference of the International Law Association, 1994

[204] Cheng (1997) 506

[205] Ibid

[206] Stubbe (2017) 361

[207] Mirmina (2005) 99 *Am. J. Int'l L.* 649 at 654

international convention that could be amended by protocols subject to technical knowledge and political will.[208]

States are very much aware of the scientific community's concern about orbital debris. Currently, the IADC Guidelines represent the measures that are technically feasible and affordable to optimise and maximise the use of outer space. Key spacefaring states have created or are in the process of creating their own national space debris mitigation policies or rules in line with the IADC Guidelines. This means that since the creation of the IADC, discussion is becoming more pragmatic and is no longer limited to pronouncements of responsibility, liability and environmental concepts.[209]

A shift from *ex post facto* punitive measures to proactive prevention – by promoting compliance with internationally adopted debris mitigation measures – can now be observed.[210]

A UN General Assembly resolution adopting space debris mitigation principles would emphasise the strong willingness of states to tackle the problem and would be a good first step towards solving the debris issue. However, more can be done. The crux of the issue here is not the willingness to do something about the problem, but what form the solution should take.

For a legal (as opposed to technical) space debris mitigation regime to be internationally accepted, it must meet specific criteria. First, there must be a fair flow of rights and responsibilities, because one-sided treaties in which only certain states enjoy all the benefits and others incur all the obligations will most likely not be ratified. As the biggest contributor of space debris, the USA is very unlikely to ever ratify a treaty with market-share liability, since it would hold very few benefits. Second, a mitigation regime should avoid implementing specific technical rules in a rigid treaty, because technological capability changes faster than traditional treaties can adapt. Third, the treaty should refrain from creating a new, permanent international organisation such as the International Civil Aviation Organization, because many states are strongly reluctant to be exposed to new international politics. Finally, the

[208] Kunstadter (1994) 178
[209] Proceedings of the Forth-Fourth Colloquium on the Law of Outer Space, 2002
[210] Ibid

new legal regime should be voluntary, since no states will be willing to surrender so much of their sovereignty over their outer space activities for the sake of solving the debris issue. Within these criteria, a treaty-based solution is feasible.

A treaty-based solution could be applied by making minor changes to existing treaties that can help to reduce the creation of new space debris. The revisions would need to be created through protocols so as not to disturb the existing regime.[211]

First, the term “space object” would have to be defined to make clear that it applies to space debris. Second, as states are encouraged to take “all appropriate measures” to reduce the creation of orbital debris, the phrase “all appropriate measures” should be defined in a technical document that would regularly be reviewed and could be amended easily with no requirement of approval from all states that are party to the treaty. The technical document could be based on or similar the IADC Guidelines. It could be modelled after the Radio Regulations of the International Telecommunication Union[212] or it could take the form of a technical commission such as the one created by the Montreal Plastic Explosives Convention of 1991.[213]

Third, a revised treaty should entail a system in which states may submit technical documents relating to a rocket or payload to an international organisation prior to a launch. The documents submitted by a state could be publicised and kept on file by other state for potential future dispute resolution and record purposes.[214]

Fourth, when one state seeks compensation from another state under the Liability Convention for damage that occurred in outer space, the fault rules to be applied must be made dependent on the status of the space objects and whether the state at fault complied with the technical annex at the time of the launch. For example, if the state at fault’s object were space debris and that state had failed to submit technical documents before the launch, or if the documents submitted do not prove that the

[211] See Protocol Section on https://en.wikipedia.org/wiki/Treaty
[212] https://www.itu.int/pub/R-REG-RR
[213] Convention on the Marking of Plastic Explosives for the Purpose of Detection
[214] See the Proceedings of the United Nations/ International Institute of Air and Space Law workshop at 32

object was compliant with the technical document, then this state could be strictly liable for damage to the claimant state's satellite.

It is safe to say that encouraging states to reduce space debris is more important than establishing liability. Since the proposed treaty should be an exchange of rights and responsibilities, creating strict liability for not complying with the proposed treaty should be sufficient incentive for voluntary compliance.

The technical documents to be submitted to a relevant international agency as annexures would have several functions. First, they would encourage compliance with mitigation measures, since failure to supply documents makes a state strictly liable. Second, since the documents are subject to inspection, they would serve as verification of compliance with the terms of the treaty. However, this proposition can be limited because states may not be at liberty to disclose certain classified and confidential data. Where there is no possibility of creating such a document without divulging sensitive data, failure to submit such document on the part of the relevant state means that this state would have to be held strictly liable.

The success of the proposal would largely hinge on the ability of identifying a particular piece of debris and associate it with a launching state.

Another area requiring improvement is the process of satellite registration. The Registration Convention[215] requires minimal information and it does not stipulate a period during which the information must be provided. Article IV(1) requires "as soon as practicable" only the name of the launching state, the object's designator, the date and location of the launch, the general function of the object, and basic orbital parameters.[216]

Furthermore, there is no requirement to separately identify each space object in orbit.[217] For instance, there is no requirement for a state to include rocket upper stages or fragmentation debris in the UN registry. The Registration Convention allows, but

[215] The 1976 Convention on Registration of Objects Launched into Outer Space
[216] Ibid
[217] Ibid

does not require, updates about space objects on the registry.[218]The UN registry cannot be used as an indicator of the location of any space object based on the data it contains.

States should also be encouraged to continue improving debris detection, tracking, and identification systems with the objective of creating a real-time computerised international database of debris.

5.4 Conclusion

Orbital debris is a major obstacle to the use and exploration of outer space, and there are no quick fixes. The rapid evolution of technology limits mitigation of the problem whilst remediation measures call for further development. Currently, the major spacefaring nations have implemented voluntary mitigation measures and are generally compliant. These measures have played a key role in preventing the generation of new debris, but better legal solutions are feasible. The shortcomings of international law related to space debris need to be supplemented by enforceable rules and clear definitions providing certainty and accountability.

All outer space users strive to access the outer space environment without the confines of the space debris issue. However, to make this happen, the users of space, individually and collectively, must be prepared to take the necessary action. The international community has a duty to actively engage in the development of State practice and legal and policy guidelines on space debris remediation in order to solve the problem of existing space debris.[219]

[218] https://www.faa.gov/about/office_org/headquarters_offices/ast/media/Conv_Regi_Objects_Launched.pdf (Accessed 13 August)
[219] 65th International Astronautical Congress, 2014

Chapter 6: Dissertation Conclusion

The purpose of this dissertation has been to show that the current space law regime and its implications for space debris mitigation and remediation have to be reformed in order to address shortcomings of a legal and technical nature.

Customary international law with respect to outer space activities and the outer space environment was explored. No evidence of state practices or opinio juris giving expression to customary international law could be established. Various environmental international law principles were explored and tested against the backdrop of pollution in the space environment. It has been argued that, contrary to general scholarly opinion, these environmental law principles apply to terrestrial cases.

The dissertation acknowledges that the current mitigation guidelines have played a major role in mitigating the creation of further debris but that the international community would benefit more if these guidelines were binding upon spacefaring nations, International organisations and relevant other public and private actors. It has emphasised that the UN's COPUOS should adopt remediation guidelines similar to the mitigation guidelines.

It has also been illustrated that while spacefaring nations do tackle the space debris problem individually, collective action may yield more positive results in solving the debris problem. It can thus be concluded that the current space legal framework requires reform in order to align with recent technical and technological developments employed to curtail the space debris problem.

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