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Lightyears behind: Potential solutions for the interpretative ambiguities left by Article VI of the Outer Space Treaty regarding non-State actors

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Contents

Chapter 1: Introduction

1. Abstract

Humanity may just be touching the edges of our own Solar System but space immediately outside of Earth – the orbital planes– is growing congested with space objects. The steady evolution of non-governmental space entities such as SpaceX has already contributed significantly to the space object population and this number is only expected to grow as constellations of thousands of privately owned satellites become more profitable activities. While the commercialisation of space has seen great leaps, the accompanying space law has only undergone small steps. Article VI of the Outer Space Treaty is the central provision in international space law outlining State responsibility for non-governmental entities in outer space. The due diligence obligations under Article VI have been interpreted in such a way that the current *status quo* carries a considerable risk of the outer space environment suffering from a "tragedy of the commons" in the shape of an unstoppable chain reaction of cascading, ultra-hazardous space debris. In light of this impending catastrophe and the growing need for sustainability in outer space, States will soon have to adopt near-universal standards of space traffic management and space debris remediation. Space law scholarship has frequently suggested that a central regulatory authority in the shape of the International Civil Aviation Organisation is the potential solution with the greatest chance of protecting the outer space environment from unsustainable practices. Opponents to a central regulatory authority advocate instead for a "bottom-up" approach to developing legal norms in space. Ultimately, this study will propose that the interpretation of due diligence under Article VI should be updated to reflect an obligation to conduct space traffic management and space debris remediation.

2. Research problem

Outer space, classically thought of as infinite, is growing crowded.[1] Non-governmental entities are participating in space activities at an unprecedented rate, thereby adding to the population of space objects and risk of space debris.[2] The current scope of the non-governmental presence in outer space was not adequately anticipated by the principles of the Outer Space Treaty.[3] Besides attaching responsibility for non-governmental entities to States and requiring the authorisation and continuous supervision of private activities, Article VI of the Outer Space Treaty affords States a sizable discretion in determining their own standards of due diligence.[4] An unharmonized body of national laws each containing their own licensing and administrative procedures has led to a *milieu* where exact standards of conduct are difficult to decipher.[5] There are currently no authoritative data sharing procedures or traffic rules in space, both of which will become urgently necessary as orbital planes experience a massive boom in their space object populations.[6] Space debris remediation will also soon be needed to remove harmful and non-functional objects from populated orbits.[7] Alas, space debris remediation is also not detailed in any of the binding obligations flowing from the Outer Space Treaty.[8] Development of legal

[1] Hunter H and Nelson E, 'Out of place in outer space?: exploring orbital debris through geographical imaginations' (2021) 12 Environment and Society 227, 229.

[2] Heinrich S and others, 'Space sustainability in the NEWSPACE Era: NO NEWSPACE without GREENSPACE' (2022) 9 Journal of Space Safety Engineering 464, 464.

[3] Blount PJ, 'Space traffic coordination: developing a framework for safety and security in satellite operations' (2021) 2021 Space: Science & Technology, 2.

[4] Article VI of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies ("Outer Space Treaty") 18 UST 2410; 610 UNTS 205; 6 ILM 386 (1967).

[5] Blount PJ, 'Space traffic management: standardizing on-orbit behavior.' American Journal of International Law 113 (2019): 120-124, 121.

[6] Ibid.

[7] McKnight D, 'A practical perspective on Space Traffic Management' (2019) 6 Journal of Space Safety Engineering 101, 105.

[8] Popova R and Schaus V , 'The legal framework for space debris remediation as a tool for sustainability in outer space' (2018) 5 Aerospace 55, 62.

obligations needed to regulate a highly active and populous outer space environment is lagging behind the technology and ambition making it presently achievable.[9]

Problems with the Article VI responsibility regime are unlikely to be addressed by a new multilateral instrument, with non-binding instruments being the preferred approach of States in this current era of space law.[10] Current trends in the creation of legal norms in space point to soft law as the unavoidable genesis point of new space law principles.[11] Non-binding instruments have been a mainstay of the international space legal order since the United Nations Committee on the Peaceful Uses of Outer Space ceased drafting treaties in 1979.[12] Recent soft law documents such as the 2007 Space Debris Mitigation Guidelines and 2019 Long-term Sustainability Guidelines are being heavily relied on to account for environmental and debris threats in outer space.[13] Any binding obligations pertaining to space traffic management and space debris remediation will therefore have to be built "from the bottom up".[14]

The research problem underlying this essay is how State responsibility can be interpreted to include space traffic management and space debris remediation. Soft law and public international law principles can produce an interpretation of States' obligations under Article VI regarding the authorisation and continuous supervision of non-governmental entities to obligate space traffic management and space debris remediation practices.

[9] Martinez KL, 'Lost in Space: An Exploration of the Current Gaps in Space Law' (2021) 11 Seattle Journal of Technology, Environmental & Innovation Law 322, 323.

[10] Jankowitsch P, 'The background and history of space law' in Frans von der Dunk and Fabio Tronchetti (eds), *Handbook of space law* (Edward Elgar Publishing 2015), 27.

[11] Hobe S, *Space law* (Nomos Verlag 2019), 47

[12] Ibid.

[13] Report of the Committee on the Peaceful Uses of Outer Space (UNCOPUOS) on its 50th session (June 15, 2007) UN Doc. A/62/20 (Annex) at 47 – 48 "'Space Debris Mitigation Guidelines"); see also Report of UNCOPUOS on its 62nd session (June 21, 2019) UN Doc (A/74/20) at para 163 and Annex II ("Long-term Sustainability Guidelines").

[14] Blount (n 5) 123.

3. Research questions

3.1. Main research question

How can State responsibility for the activities of non-governmental entities in outer space be interpreted to obligate States to adopt minimum standards of space traffic management and space debris remediation?

3.2. Sub-questions

1. Which ambiguities in the current State responsibility regime could non-governmental entities take advantage of?
2. How do the activities of non-governmental entities threaten to trigger a tragedy of the commons?
3. Why are space traffic management and space debris remediation necessary for sustainable use of the outer space environment?
4. How could space traffic management and space debris remediation be implemented as binding due diligence obligations?

4. Motivation and rationale

Non-governmental activities in outer space show no sign of slowing down.[15] Ambitions towards the mining of asteroids and colonisation of alien worlds are unlikely to cease.[16] We are at a possible divergence point in the future of human activities in outer space. Space is open as a common pool resource for States and non-governmental actors to use, with very little in the way of positive or negative obligations regulating their conduct.[17] This *status quo* could prove catastrophic should a sizable

[15] Muelhaupt TJ and others, 'Space traffic management in the new space era' (2019) 6 Journal of Space Safety Engineering 80, 80.

[16] Simon S, 'A cause for concern: Developing regulatory competitions in New Space' (2021) 187 Acta Astronautica 212, 212.

[17] Weeden BC and Chow T, 'Taking a common-pool resources approach to space sustainability: A framework and potential policies' (2012) 28 Space Policy 166, 168.

collision occur in an area of Earth's orbit with a high density of space objects and debris.[18] A single collision event could generate enough space debris to completely shift the paradigms of safety and sustainability which are applicable to all future space activities from that point forward.[19] Space actors are confronted with a situation where the consequences of unsustainable practices will only be felt once a point of no-return has been reached. The outer space environment, Low Earth Orbit ("LEO") in particular, is thus a quintessential example of common pool resource at risk of a "tragedy of the commons", which would be the utter ruination of the reliable access and use of outer space caused by space debris.[20]

Space traffic management and space debris remediation are vital processes which spacefaring State should adopt with urgency.[21] Future collision events can be prevented with universal standards of space traffic management which describe traffic rules and collision avoidance protocols.[22] Spade debris remediation is aimed at combating the threat posed by existing space debris and involves the removal of debris from populated orbital planes.[23] Neither of these processes are described in the UN Space Treaties – the accepted definition of "space debris", the greatest threat to modern space activities, must be extracted from soft law instruments such as the UN Space Debris Mitigation Guidelines.[24] Similar soft law instruments have begun to entertain obligations associated with space traffic management and space debris remediation, but no significant developments have been made on the front of

[18] Muñoz-Patchen C, 'Regulating the space commons: Treating space debris as abandoned property in violation of the outer space treaty' (2018) 19 Chi J Int'l L 233, 250 – 251.

[19] Salter AW, 'Space Debris: A Law and Economics Analaysis of the Orbital Commons' (2015) 19 Stan Tech L Rev 221, 225.

[20] Morin JF and Richard B, 'Astro-Environmentalism: Towards a Polycentric Governance of Space Debris' (2021) 12 Global Policy 568, 1 - 2.

[21] Maclay T and McKnight D, 'Space environment management: Framing the objective and setting priorities for controlling orbital debris risk' (2021) 8 Journal of Space Safety Engineering 93, 93.

[22] Morin J, 'Four steps to global management of space traffic' (Nature Publishing Group 2019), 25. [Available at: https://www.nature.com/articles/d41586-019-00732-7 (accessed 1 October 2022)].

[23] Slann PA, 'Space debris and the need for space traffic control' (2014) 30 Space Policy 40, 41.

[24] Popova and Schaus (n 8).

producing universal standards with any real possibility of widespread implementation.[25]

Solutions to the dearth of binding rules on space traffic management and space debris remediation must recontextualise States' obligations in light of the growth of commercial activities in space. Article VI of the Outer Space Treaty is the best vehicle to recontextualise State due diligence towards the regulation of non-governmental activities in outer space. An interpretation of the obligation to authorise and continuously supervise which recognises the need for space traffic management and space debris remediation would strike the best balance between top-down and bottom-solutions often proposed in literature.

This study will evaluate a "top-down" and a "bottom-up" solutions to implementing space traffic management and space debris remediation standards. The model of an international space traffic organisation resembling the International Civil Aviation Organisation is the most frequently cited suggestion in space law literature of a "top-down" body being able to implement space traffic management and space debris remediation practices.[26] A "bottom-up" solution would continue to rely on the trend of developing soft law to communicate suggested norms of conduct.[27] The overall hopes of such a model is that soft law standards are voluntarily implemented on a wide enough scale that their substantive obligations may meet the criteria of customary international law or a general principle of law.[28] Customary international and general principles can serve as evidence of a subsequent practice which could be used to aid in the interpretation of ambiguous treaty terms, in accordance with the customary rules of treaty interpretation.[29]

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[25] Doucet G, 'Outer space SARPs: A mechanism for implementation of space safety standards' (2019) 6 Journal of Space Safety Engineering 145, 146.

[26] Ibid.

[27] Goehring JS, 'Can We Address Orbital Debris with the International Law We Already Have? An Examination of Treaty Interpretation and the Due Regard Principle' (2020) 85 J Air L & Com 309, 335.

[28] Shelton D, 'Soft law' in David Armstrong *Routledge handbook of international law* (Routledge 2009), 76.

[29] Article 32 of the *Vienna Convention on the Law of Treaties*, 23 May 1969, United Nations, Treaty Series, vol. 1155, p. 331.

The interpretation of States' obligation to authorise and continuously supervise non-governmental activities could thus be modified through subsequent practice stemming from soft law. Due diligence and due regard are two principles of international law which, given the ambit of their current condition, may assist in birthing an interpretation of Article VI of the Outer Space Treaty whereby States are responsible for ensuring that non-governmental entities abide by space traffic management and space debris remediation standards.

5. Methodology and approach

This essay will rely on a desktop-research methodology which is descriptive, analytical, and doctrinal. The current laws and climate surrounding the development of space legal norms will be described with reference to the applicable treaties and pertinent soft-law instruments. The relationship between hard and soft law and the norms contained in both genres will be analysed to holistically determine the international consensus of how future space laws should come into being. This study will conclude with a doctrinal proposal of how space traffic management and space debris remediation should be interpreted as elements of States' due diligence responsibility.

6. Overview of literature

The binding UN Space Treaties relevant to the problems and solutions discussed in this study are the Outer Space Treaty and the Registration Convention. According to von der Dunk, Article VI of the Outer Space Treaty which describes State responsibility and aspects of due diligence must be read in conjunction with Article VIII of the Outer Space Treaty.[30] Article VIII of the Outer Space Treaty asserts the obligation to register space objects and the fact that the State of registry is the State which maintains control and jurisdiction over the registered space object.[31] The

[30] Jankowitsch (n 10) 137.

[31] Article VIII of the Outer Space Treaty.

process of registration is described in more detail in the Registration Convention.[32] Registration, as noted by von der Dunk, affirms quasi-territorial jurisdiction over a space object.[33] Linking to Article VI, Robison explains that identification of the State holding control and jurisdiction is necessary to determine the "appropriate State" and "national activities" for which States are internationally responsible.[34] In the current system, Taghdiri observes that only one of potentially multiple "launching States" is able to become the State of registry, therefore possibly encouraging States to advertise themselves as "flags of Convenience".[35] Hobe notes that on-orbit transfer of registration also escapes the current scope of the registration regime.[36] Baker opines that registration of a space object would theoretically apply to all space debris associated with the registered object, which would restrict space debris remediations from occurring without the consent of the State holding control and jurisdiction over the space debris[37]

Hertzfeld has elucidated that the minimum standard of conduct prescribed by Article VI coupled with the registration ambiguities in Article VIII of the Outer Space Treaty may threaten sustainability of LEO as *res communis*.[38] A due diligence requirement which fails to deal with space debris concerns in a congested LEO environment may set the stage for a chain reaction of cataclysmic collision events.

Hermer-Fried recalls that "Kessler Syndrome" (referring to an unstoppable cascade of destructive space debris hypothesised by NASA scientist Donald Kessler)

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[32] Convention on Registration of Objects Launched into Outer Space 28 U.S.T. 695, 1023 U.N.T.S. 15, 14 I.L.M. 43 (1975).

[33] Von der Dunk F, *National space legislation in Europe: issues of authorisation of private space activities in the light of developments in European space cooperation* (Brill 2011), 7.

[34] Robison CJ, 'Changing Responsibility for a Changing Environment: Evaluating the Traditional Interpretation of Article VI of the Outer Space Treaty in Light of Private Industry' (2020) 5 U Bologna L Rev 1, 12 -17.

[35] Taghdiri A, 'Flags of Convenience and the Commercial Space Flight Industry: The Inadequacy of Current International Law to Address the Opportune Registration of Space Vehicles in Flag States' (2013) 19 BUJ Sci & Tech L 405, 419.

[36] Hobe (n 11) 91.

[37] Baker HA, Space *debris: legal and policy implications* (Martinus Nijhoff 1989) 36.

[38] Hertzfeld HR, 'Unsolved issues of compliance with the registration convention' (2021) 8 Journal of Space Safety Engineering 238, 239.

is the incubating “tragedy of the commons” which States and non-governmental entities must act collectively to address.[39] Stubbe similarly concludes that Kessler Syndrome would compromise the interests and prosperity of future generations.[40] Collective action from an international space policy perspective would have to include a universal adherence to common standards of space traffic management along with a defined set of processes to ease the complex task of space debris remediation. [41]

Space traffic management and space debris remediation are both international collaborative efforts aimed at ensuring the sustainability of the outer space environment.[42] These processes have been the topic of much debate in the forums of soft law on account of the wide-ranging consequences they would have for all future space activities. The UNCOPUOS Long-term Sustainability Guidelines recommend that States increase data collection and sharing capabilities in addition to enhancing registration practices.[43] If followed, these Guidelines could lay the foundation for the management of space situational awareness data required for space traffic management and space debris remediation.[44] States are also encouraged by the Guidelines to “investigate and consider new measures to manage the space debris population in the long term”, which could be interpreted to include measures aimed at space traffic management and space debris remediation.[45]

[39] Hermer-Fried RL, (2019) "Kessler Syndrome: A United States' Statutory Solution for Satellite Debris Removal and the Mitigation of Orbital Collisions," Journal of International Business and Law: Vol. 18: Iss. 2, Article 9., 267, 267.

[40] Stubbe P, *State accountability for space debris: a legal study of responsibility for polluting the space environment and liability for damage caused by space debris* (Brill 2017) 223.

[41] Pelton JN, 'A path forward to better space security: Finding new solutions to space debris, space situational awareness and space traffic management' (2019) 6 Journal of Space Safety Engineering 92, 95 – 96.

[42] Haroun F and others, 'Toward the Sustainability of Outer Space: Addressing the Issue of Space Debris' (2021) 9 New Space 63, 65 – 66.

[43] Guideline A.5 and Guideline B.3 of the UN Long-term Sustainability Guidelines.

[44] McKnight (n 7) 104.

[45] Guideline D.2 of the UN Long-term Sustainability Guidelines.

The need for space traffic management and space debris remediation is urgent.[46] Doucet stresses that States have however been slow to develop any authoritative standards or practices which would be constitutive of universal obligations.[47] Two solutions are assessed at the conclusion of this study and both would involve a degree of sacrifice by States and non-governmental entities. The first solution is one considered in-depth by Doucet: the creation of an international space traffic management organisation with capabilities and a structure closely resembling that of the International Civil Aviation Organisation.[48] An international legal development of this magnitude would almost certainly require an amendment or addition to the Outer Space Treaty. The second solution examines the advantages and shortcomings of an actor-led, "bottom-up approach" to the development of space law which hinges on the widespread adoption of regular soft law instruments.[49]

A final recommendation given by this study is to synthesise aspects of the two discussed solutions to arrive at actionable first steps for space traffic management and space debris mitigation. Erhart and Boutovitskai believe that international environmental law principles such as the precautionary principle are rules of public international law which could be incorporated into soft law instruments to develop the scope of State responsibility for non-governmental entities in terms of Article VI of the Outer Space Treaty.[50] Goehring further notes that the requirement of due regard in Article IX of the Outer Space Treaty is in dire need of renewed attention to address the problem of space debris and argues that this principle is sufficient basis to regard space debris mitigation as an international law obligation.[51] As Goehring points out, the principle of due regard requires State action, just as Article VI requires the actions of authorisation and supervision to satisfy the obligation of due diligence in terms of non-governmental entities. Due regard as required by Article IX is therefore also a due

[46] Stubbe (n 40) 58.

[47] Doucet (n 25).

[48] Ibid.

[49] Goehring (n 27) 335.

[50] Erhart L and Boutovitskai M, *Transforming Article VI of the Outer Space Treaty into an Effective Mechanism of Space Debris Mitigation* (2021), 2.

[51] Goehring (n 27) 320.

diligence obligation upon States.[52] The relationship between Article VI and Article XI in delineating due diligence can therefore set the basis for soft law principles on space traffic management and space debris remediation. Specifically framed in the context of due diligence and due regard as laid out in Article VI and Article IX of the Outer Space Treaty, new guidelines on space traffic management and space debris remediation should draw from the existing body of public international rules. Directly linking space traffic management and space debris remediation to Article VI of the Outer Space Treaty would ground these young concepts in existing hard law whilst simultaneously broadening the scope of interpretation of Article VI through State practices. The final recommendation made by this study is that soft law guidelines on space traffic management and space debris remediation *which are consciously tailored* to expand the interpretation of States' due diligence under Article VI of the Outer Space Treaty, in light of public international law, could pose a satisfactory alternative to a top-down authority to govern the common pool resource of space.

7. Limitations and delineations

This study is concerned with the substance of the current State responsibility regime for private actors and how international law processes could be used to include space traffic management and space debris mitigation under that responsibility. As such, this study will focus primarily on Article VI of the Outer Space Treaty. Article VI may be the sole provision of the Outer Space Treaty outlining State responsibility for non-governmental entities but it does not operate in isolation. This study will therefore also turn attention to Articles I, III, VIII, and IX of the Outer Space Treaty, as the obligations put forward by these provisions all coalesce to provide a holistic view of States' due diligence obligations in space.

This study will not venture into any significant detail on liability for fault during space activities. Space traffic management and space debris remediation are nascent concepts of international space law intended to foster sustainable practices with an overall mind to preventing a tragedy of the commons. Discussions on State liability for

[52] Viikari L, 'Environmental aspects of space activities' in von der Dunk and Tronchetti (n 10) 762.

fault would have to occur after Kessler Syndrome[53] had been triggered. This study subscribes to the theme of establishing international obligations and principles to prevent the tragedy of the commons from ever occurring and will therefore focus primarily on how State responsibility could be interpreted to obligate States to effect space traffic management and space debris remediation.

International instruments will be the primary points of discussion in this essay as space traffic management and space debris remediation are activities which dispel international obligations. National legislation will be broadly described to address how the due diligence obligations put forward by Article VI are currently being interpreted and practiced by States. Analysis of national legislation will be general in nature as the primary inquires of this study focus on States' collective.

8. Chapter outline

Chapter 1 of this study introduces the study topic and accompanying research proposal.

Chapter 2 of this study describes and analyses the concept of "NewSpace" as well as the issues in the current regime of State responsibility under Article VI which could potentially contribute to problems of space debris.

Chapter 3 of this study describes the concepts of space traffic management and space debris remediation and analyses their necessity in preventing a tragedy of the commons caused by a proliferation of space debris.

Chapter 4 of this study describes and analyses two potential solutions to implementing space traffic management and space debris remediation before offering a final suggestion on the doctrinal implementation of a solution which re-interprets States' due diligence responsibilities prescribed by Article VI.

[53] "Kessler Syndrome", named after the NASA scientist who first proposed the concept, refers to a hypothetical cascade of space debris. This cascade would be self-generating as debris continues to collide, thereby creating further debris which inevitably becomes part of the cascade. By this token, Kessler Syndrome could conceivably be triggered by a single massive collision or debris-generating event. This concept will be explored in greater depth in Chapter 3 of this study.

Chapter 5 will conclude this study by summarising the key problems in the current space law regime and how adequate State responsibility towards non-governmental activities could ensure sustainable use of the outer space environment.

Chapter 2: “NewSpace” and the space debris problem of the regime developed under Article VI of the Outer Space Treaty

1. Introduction

This Chapter of the study must begin by reiterating that space debris is the greatest threat to space activities. Space debris travels at such high speeds in Earth’s orbit that even small items such as screws or flecks of paint become potentially deadly.[54] Individual pieces of debris between 1cm and 10cm are destructive enough to destroy satellites in LEO. A single debris-generating event thus has the potential to alter the course of the entire LEO environment.[55] Debris is therefore a primary operational concern for both governmental and non-governmental space actors seeking to conduct space activities.[56]

Compounding the problems of space debris is the commercialisation of outer space, which has already significantly altered the profile of space objects in LEO.[57] Non-governmental entrepreneurs are in the process of launching thousands of satellites into LEO in order to create satellite “mega-constellations”.[58] Non-governmental activities in outer space show no sign of slowing down as the commercial momentum of “NewSpace” gathers.[59] As it stands, the exponential growth of private space activities is inextricable from a growth in collision risks.[60]

[54] Stubbe (n 40) 37.

[55] Ibid, 38.

[56] Ferreira-Snyman A, 'Legal challenges relating to the commercial use of outer space, with specific reference to space tourism' (2014) 17 Potchefstroom Electronic Law Journal 1, 8.

[57] Pardini C and Anselmo L, 'Effects of the deployment and disposal of mega-constellations on human spaceflight operations in low LEO' (2022) Journal of Space Safety Engineering , 2.

[58] Jha D and others, 'Safeguarding the final frontier: Analyzing the legal and technical challenges to mega-constellations' (2022) Journal of Space Safety Engineering, 1.

[59] Pelton (n 41) 93.

[60] Jha and others (n 58) 2.

Article VI of the Outer Space Treaty describes that States bear responsibility for non-governmental entities conducting activities in outer space.[61] Article VI places an obligation on the "appropriate State" to "authorise" and "continuously supervise" any "national activities" being carried out by "non-governmental entities" in outer space.[62] These terms are ambiguous enough that the non-governmental activities such as the operation of mega-constellations operate in a problematic "regulatory void".[63]

2. "NewSpace" and the acceleration of under-regulated space traffic

2.1. A brief history of space law

To best understand the legal challenges dominating current discourse, the history of international space law leading up to this stage must first be considered. Each period of the historical development can be identified by several unique traits which have evolved into the current *status quo* which facilitates "NewSpace". The history of the international space law regime can be divided into three distinct periods.[64]

2.1.1. The first phase of international space law: creating the treaty regime

International space law began its first phase following the launch of Sputnik-1 in 1957.[65] A United Nations General Assembly Resolution would follow suit in 1958 to establish an ad hoc Committee on the Peaceful Uses of Outer Space.[66] The United Nations Committee on the Peaceful Uses of Outer Space ("UNCOPUOS") became a

[61] Article VI of the Outer Space Treaty.

[62] Ibid.

[63] Blount PJ, 'Renovating space: The future of international space law' (2011) 40 Denv J Int'l L & Pol'y 515, 529.

[64] Hobe (n 11) 43.

[65] Ibid.; see also Gupta B and Raju K, 'Understanding International Space Law and the Liability Mechanism for Commercial Outer Space Activities—Unravelling the Sources' (2019) 75 India Quarterly 555.

[66] Freeland S and Zhao Y, 'Rules of the" Space Road:" How Soft Law Principles Interact with Customary International Law for the Regulation of Space Activities' (2020) 44 J Space L 405, 407.

permanent UN body in 1959.[67] By 1979, UNCOPUOS had created five treaties to oversee international efforts in space.[68] The first and most important of these treaties is the Outer Space Treaty of 1967,which contains the major governing principles of space law.[69]

Following the Outer Space Treaty, four other UN Space Treaties would be accepted by the international community of States. These are: the 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space;[70] the 1972 Convention on International Liability for Damage Caused by Space Objects;[71] the 1975 Convention on Registration of Objects Launched into Outer Space;[72] and the 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies.[73] These treaties were all well-received by the international community, but the political willr to widen the scope of the UN Space Treaties was tarnished by the content of the Moon Agreement. The Moon Agreement sought to label all space resources as the "common heritage of mankind".[74] Moreover, a regime of benefit sharing which would handle all resources extracted from celestial bodies.[75] Whether disturbed by the potential effects on private industry or put off by the imprecise language used in the treaty, the Moon Agreement would receive the lowest number of ratifications of the UN Space Treaties, having received 18 as of 2022.[76] The Moon Agreement has been dubbed a "total failure" and a "dead

[67] Hobe S, *International space law in its first half century* (2006), 2.

[68] Ibid.

[69] Hobe S, 'The international legal order for outer space activities' (1993) ECSL Proceedings 28.

[70] Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space 19 U.S.T. 7570, 672 U.N.T.S. 119, 7 I.L.M. 149 (1968).

[71] Convention on International Liability for Damage Caused by Space Objects U.S.T. 2389, 861 U.N.T.S. 187, 10 I.L.M. 965 (1972) ("Liability Convention").

[72] Convention on Registration of Objects Launched into Outer Space 28 U.S.T. 695, 1023 U.N.T.S. 15, 14 I.L.M. 43 (1975) ("Registration Convention").

[73] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies 1363 U.N.T.S. 22, 18 I.L.M. 1434 (1979) ("Moon Agreement").

[74] Hobe (n 67) 2.

[75] Article 11 of the Moon Agreement.

[76] Hobe (n 67) 2.

instrument" in international law.[77] Poor reception of the Moon Agreement heralded the end of international consensus on space principles required to generate effective multilateral treaties.[78]

Despite avoiding the opportunity to develop further "hard" law, spacefaring States still recognised the need for widely communicated statements on best practices and standards for space activities. Avoiding additions or amendment to treaty law, the international community of spacefaring States opted for a series of non-binding "soft" law instruments which would be entirely voluntary.[79]

2.1.2. The second phase: a focus on non-binding principles

Space law entered its second phase after the conclusion and subsequent "failure" of the Moon Agreement, which is to date the last attempt at a binding multilateral space law instrument. This second phase would be categorised by a complete shift away from concluding binding legal instruments towards developing space law through the adoption of non-binding resolutions.[80] From 1982 to 1996, the growth of space law was determined by non-binding General Assembly Resolutions. The hopes of the second phase of space law would be to develop rules of customary international by presenting Resolutions as indication of state practice and *opinio juris*. [81]

2.1.3. The third phase: re-interpretation and setting the stage for "NewSpace"

The development of space law was dictated by the practice of States in using the non-binding resolutions of the second phase to aid in their interpretation of the main treaty texts of the first phase.[82] As the number of space-faring States grew, so too did the need for national legislation, which was in fact prescribed by the Outer Space Treaty. The third phase of space law mixes characteristics from the first and second

[77] Ibid.

[78] Freeland and Zhao (n 66) 431.

[79] Jankowitsch (n 10) 8 -9.

[80] Hobe (n 11) 43.

[81] Von der Dunk F 'International space law' in von der Dunk F and Tronchetti (eds) F, *Handbook of space law* (Edward Elgar Publishing 2015), 41; see also Hobe note 66 *supra* 3.

[82] Ibid.

phases.[83] Article VI of the Outer Space Treaty opens the door for States to implement national space legislation to better define their international obligations under treaty law. Private commercialisation activities in outer space further fuelled the need for States to implement the appropriate national frameworks.[84] Soft law has also proliferated during the third phase of space law. Significant strides in affordable space technologies have seen non-governmental space activities rocket to levels which could have hardly been foreseen almost 60 years ago.[85] This generation of space activities has been dubbed "NewSpace".[86]

2.2. NewSpace, an era of ground-breaking commercialisation in space

2.2.1. NewSpace defined

"NewSpace" refers to the "new era of growing commercialisation of space activities."[87] While no single definition of NewSpace dominates the discourse, the common characterisation of NewSpace references the unprecedented growth of commercial activity in space as hallmark of this "new era".[88] The paradigm has truly shifted from the Cold War era of the first phase of space law-making during which the future of capitalism on the global scale was uncertain.[89] Having 'won' the Cold War, capitalism and commercialisation is establishing itself at the final frontier of human

[83] Hobe (n 67) 4.

[84] Ibid.

[85] Heather S Fogo, 'A Legal Mirage: State Responsibility for Non-State Actor Interference with Space Systems' (2018) 55 Canadian Yearbook of International Law/Annuaire canadien de droit international 180, 182 – 183.

[86] Baumann I, El Bajjati H and Pellander E, 'NewSpace: A Wave of Private Investment in Commercial Space Activities and Potential Issues Under International Investment Law' (2018) 19 The Journal of World Investment & Trade 930, 930.

[87] Hobe (n 11) 212.

[88] Clormann MA, 'Negotiating Beyond-Planetary Challenges: The European Space Sector in the New Space Age' (Universität München 2021) 6; see also Pessoa Filho JB, 'Space Age: Past, Present and Possible Futures' (2021) 13 Journal of Aerospace Technology and Management, 3.

[89] Iacomino C and Ciccarelli S, 'Potential Contributions of Commercial Actors to Space Exploration' (2018) 1 Advances in Astronautics Science and Technology 141, 141 – 142.

advancement. The role that the private space industry grows into will henceforth influence the future of human space activities.[90]

The growth of affordable space technologies has propelled a private interest in outer space unforeseen by the drafters of the UN Space Treaties.[91] Non-governmental entities currently occupy a larger role in outer space activities than ever before in the history of spaceflight, demonstrating a “fundamental change” in the very structure of human space activities.[92] Due to the record levels of private activity in space and the new operational and legal challenges they bring, NewSpace has rightfully been described as a “rebirth” of the space race.[93] As it stands, a rejuvenated spate of updated legal authority legal may soon be required to control the impact private actors could have on the sustainability of the space environment.

2.2.2. NewSpace activities and satellite mega-constellations

Brittignham once remarked that there are three possible motivations for human space activities: scientific, militaristic, and commercial.[94] NewSpace entrepreneurs engage in space activities which are either profit driven or focussed on non-governmental entities. These activities are distinct from governmental activities which focus primarily on either the military or scientific applications of outer space.[95] Private space tourism is a typical example of a NewSpace activity.[96] Other burgeoning industries are emerging in outer space which may bridge the gap between space tourism and the eventual harvesting of space resources and the colonisation of other planets. In this vein, satellite “mega-constellations” set the precedent of non-

[90] Ziemblicki B and Oralova Y, 'Private Entities in Outer Space Activities: Liability Regime Reconsidered' (2021) 56 Space Policy, 2; see also Pekkanen SM, 'Governing the new space race' (2019) 113 American Journal of International Law 92, 93 .

[91] Blount (n 63) 518.

[92] Muelhaupt and others note 15 *supra* 80; see also Impey C, 'Unbound: Ethics, Law, Sustainability, and the New Space Race' (2021) 10 Studia Humana 1, 2.

[93] Simon S, 'A cause for concern: Developing regulatory competitions in NewSpace' (2021) 187 Acta Astronautica 212, 212.

[94] Brittingham BC, 'Does the world really need new space law' (2010) 12 Or Rev Int'l L 31, 32.

[95] Martinez (n 9) 339.

[96] Weibel DL, 'Following the path that heroes carved into history: Space tourism, heritage, and faith in the future' (2020) 11 Religions 23, 2.

governmental entities engaging in activities which may permanently alter the state of the outer space environment. [97]

A mega-constellation consists of hundreds to potentially thousands of satellites.[98] Moreover, these satellites may be smaller and less manoeuvrable than traditional, larger satellites.[99] These mega-constellations are largely planned to operate in LEO.[100] Traditionally, a handful of larger satellites would make use of Earth's geo-synchronous orbit ("GEO") to provide global coverage for communications services.[101] In the era of NewSpace, satellites are becoming smaller and the means to launch are also becoming cheaper.[102] LEO is therefore becoming a more financially beneficial environment for NewSpace satellite activities. It is easier to access LEO as opposed to GEO, and the closer proximity to Earth enables smaller satellites to still provide high-speed internet and communication services.[103] While global coverage using GEO satellites is obtainable with as little as three satellites, similar coverage in LEO requires hundreds to potentially thousands of smaller satellites.[104] These fleets of satellites in LEO are referred to as "mega-constellations", and their proliferation will fundamentally alter the state of LEO. [105]

SpaceX and OneWeb are two private space companies presently constructing mega-constellations in LEO by launching many small satellites.[106] Starlink, the mega-constellation belonging to SpaceX, has already been utilised to provide internet access to Ukraine in light of the communications difficulties caused by the ongoing Russian

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[97] Stockwell S, 'Legal "Black Holes" in Outer Space: The Regulation of Private Space Companies' (2020) 20 E-International Relations , 1.

[98] Muelhaupt and others (n 15) 80.

[99] Popova and Schaus (n 8) 2.

[100] Jha and others (n 58) 1.

[101] Bailey J 'LEO, GEO, MEO Satellites – What's the difference?' (2020) Simple Flying [Available at: https://simpleflying.com/leo-geo-meo-satellites-whats-the-difference/ (accessed 30 October 2022)].

[102] Pardini and Anselmo (n 57) 274.

[103] Jha and others (n 58) 1.

[104] Bailey (n 101).

[105] Filho (n 88) 4; see also Muelhapt and others (n 15) 1.

[106] Hobe (n 11) 24.

invasion.[107] The effects of mega-constellations have therefore become tangible. So far, the pursuit of mega-constellations has contributed an additional 3000 tonnes of mass towards the LEO space object population.[108] As of writing, Starlink plans to expand its fleet to 42 000 satellites.[109]

LEO will become increasingly congested as the deployment of mega-constellations continues.[110] Hobe argues that mega-constellations "raise a number of issues", such as their "restricted lifetime and manoeuvrability" potentially leading to "high collision risks".[111] The sheer volume of space objects that mega-constellations serve to add to LEO is a cause for concern. A more populated orbital environment will only worsen existing space debris issues which are already tenuously accounted for by existing treaty obligation.

3. Space debris and the potential catastrophe of "Kessler Syndrome"

3.1. Space debris in space law

The binding body of space law does not define "space debris".[112] *In lieu* of a formal definition of space debris provided by a treaty or binding instrument, soft law has been used to define space debris as "all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional".[113]

[107] Zhang J and others, 'LEO Mega Constellations: Review of Development, Impact, Surveillance, and Governance' (2022) 2022 Space: Science & Technology , 2.

[108] Boley, Aaron C., and Michael Byers. "Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth." *Scientific Reports* 11.1 (2021): 1, 3.

[109] Zhang and others (n 107) 2.

[110] Muelhapt and others (n 15) 81.

[111] Boley and Byers (n 108).

[112] Slann (n 23) 41.

[113] Space Debris Mitigation Guidelines (n 13).

Baker describes the sources of spaces debris as inactive payloads, operational debris, fragmentation debris, and microparticulate matter.[114] Inactive payloads are "those former active payloads which can no longer be controlled by their operator.[115] Operational debris refers to objects which remain in space as a by-product of space activities.[116] These include launch-stage rockets and "litter" left by personnel in space.[117] Microparticulate matter is the debris measured on a microscopic scale which might still influence space activities.[118] Space debris in the form of microparticulate matter includes gasses released from solid-propellant rocket motors.[119]

Fragmentation debris is the most considerable source of current debris. Destruction of space objects in orbits or other powerful explosions release a vast amount of debris.[120] The two most significant fragmentation events in space are the 2009 collision between the American Iridium-33 and Russian Kosmos 2251 satellites and the 2007 Chinese ASAT test.[121] These two events alone increased the existing space debris at the time by 70%.[122] The sudden and drastic impact these two fragmentation events had for the LEO environment is a testament to the fact that the paradigms of space safety can be completely uprooted by even a single collision event. [123]

3.2. Debris statistics

Statistics on space debris provided by the European Space Agency ("ESA") as of 11 August 2022 show that there are approximately 130 million space debris objects larger between 1mm and 1cm, 1 million space debris objects between 1cm and 10

[114] Baker (n 37) 4 – 9.

[115] Ibid 4.

[116] Ibid.

[117] Ibid.

[118] Ibid 8

[119] Ibid.

[120] Ibid 4 -5.

[121] Johnson NL, *Orbital debris: the growing threat to space operations* (2010), 1.

[122] Ibid.

[123] Pardini and Anselmo (n 57) 275.

cm, and 36 500 space debris objects larger than 10cm.[124] Millimetre-sized objects can lead to “clear hole penetrations” of spacecraft while debris objects around 1cm in size can cause “mission-critical damage”.[125] Impacts between spacecraft and debris objects of around 10cm size “will most likely entail a catastrophic disintegration of the target”.[126] LEO, the orbit most valuable for commercial space activities, is especially endangered by space debris. According to the ESA, space debris in LEO “is causing a significant number of close encounters, known as "conjunctions", between active satellites and other objects”.[127]

In light of the destructive potential of space debris and the urgent evasions it may cause, space debris has been largely considered the “most important threat” to space activities.[128] The urgent risk of space debris grows with the orbital space object population, which is set to significantly increase as mega-constellations continue to develop.[129] Satellite mega-constellations have “almost already doubled the population of active satellites in Low Earth Orbit.”[130]

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[124] ESA, ‘Space debris by the numbers’ (information last updated 11 August 2022) [Available at: https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers (accessed 30 October 2022)].

[125] ESA, ‘Hypervelocity impacts and protecting spacecraft’ [Available at: https://www.esa.int/Space_Safety/Space_Debris/Hypervelocity_impacts_and_protecting_spacecraft (accessed 30 October 2022)].

[126] Ibid.

[127] ESA, ‘ESA’s Space Environment Report 2022’ (2022) [Available at: https://www.esa.int/Space_Safety/Space_Debris/ESA_s_Space_Environment_Report_2022 (accessed 30 October 2022)].

[128] Munters W, 'Small satellites, large constellations and space debris: in dubio pro LEO?', *Commercial Uses of Space and Space Tourism* (Edward Elgar Publishing 2017) 64, 64.

[129] Popova and Schaus (n 8) 13.

[130] Heinrich and othersl(n 2) 1.

3.3. Kessler Syndrome

A high volume of space debris heralds a possible catastrophe. “Kessler Syndrome”, named after the NASA scientist who first hypothesised the notion, is the name given to the cascade of destructive debris which would render large portions of valuable orbits unusable.[131] At a critical tipping point the space debris population could grow to the level where a single collision could trigger a chain reaction wherein the increase of space debris becomes perennial and unstoppable.[132] Space debris would eventually destroy a significant portion of working satellites as the Earth becomes enveloped by an inescapable shell of rapidly moving, ultra-hazardous space debris.[133]

Projections vary regarding how much time is left to prevent the onset of Kessler Syndrome.[134] Some predictions state that without actively removing debris from the space environment, the space debris population may begin its unstoppable cascade sometime within the next half-century. An impenetrable layer of space debris in LEO would effectively imprison the human race on Earth.

As an analogy, Kessler Syndrome is uncontrollable conflagration which eventually destroys or renders unusable the common resource of space. The spark to trigger the inferno of Kessler Syndrome would be a collision between space objects such as satellites or some other energetic explosion of debris. A flame’s destructive potential is determined by its access to fuel. The fuel for Kessler Syndrome would be an orbital environment with a high density of space objects which may also contribute to the overall debris created by the catalysing debris event.

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[131] Pelton (n 41) 92 ; see also Kurt J, 'Triumph of the space commons: Addressing the impending space debris crisis without an international treaty' (2015) 40 Wm & Mary Envtl L & Pol'y Rev 305, 309 ; see also Larsen PB, 'Solving the space debris crisis' (2018) 83 J Air L & Com 475, 477.

[132] Zaefen CM, 'Handling “Space Debris” under the International Space Treaties Regime: Case Studies Analysis' (2021) 33 Environmental Claims Journal 194, 198.

[133] Hearey C, *WHEN YOU WISH UPON A “STARLINK”: EVALUATING THE FCC’S ACTIONS TO MITIGATE THE RISK OF ORBITAL DEBRIS IN THE AGE OF SATELLITE “MEGA-CONSTELLATIONS”* (AMER BAR ASSOC, ADMINISTRATIVE LAW & REGULATORY PRACTICE SECTION 321 N CLARK … 2020), 770.

[134] Hobe (n 11) 114.

Mega-constellations will drastically increase the space object population in the outer space environment.[135] Accompanying this larger space object population is a greater degree of debris-related risk which currently lacks the appropriate regulation to definitely avoid the possibility of Kessler Syndrome.[136] The large-scale commercialisation of outer space may ostensibly thrive in an environment of loose-regulation but the growth of commercialised space carries the consequence of ruinous debris risk.

4. Article VI of the Outer Space Treaty

4.1. The text of Article VI of the Outer Space Treaty

The Outer Space Treaty is the pre-eminent source of essential international space law principles. Article VI of the Outer Space Treaty is the most authoritative rule within the current regime regarding the responsibility of States for the activities of non-governmental entities in outer space. Article VI reads as follows:

States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of nongovernmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried on in outer space, including the moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.[137]

[135] Stubbe (n 40) 30.

[136] Stockwell (n 97) 1.

[137] Article VI of the Outer Space Treaty.

The first sentence of Article VI permits non-governmental entities to carry out activities in outer space. Article VI unequivocally iterates that such activities are directly linked to and invoke the responsibility of the "appropriate State". A basic premise of State responsibility for non-governmental activities in outer space can be drawn as follows: the obligation to "authorise" and guarantee "continuous supervision" for "non-governmental activities" is an obligation which must be fulfilled by the "appropriate" State.

Several questions persist arise after a reading of Article VI. What exactly constitutes "national activities"? How can the "appropriate State" be identified? What exactly are the parameters of authorisation and continuous supervision? How would States dispel these obligations? These warrant a closer examination in the paragraphs and pages to follow.

4.2. "National activities" and the "appropriate State"

4.2.1. National activities

There is no exact definition of "national activities" in international space law.[138] Non-governmental entities may also carry out "national activities".[139] As von der Dunk notes, there are three "schools of thought" which have arisen in the absence of any uniform definition or State practice on "national activities" as referred to in Article VI of the Outer Space Treaty.[140] According to von der Dunk, the State responsible for "national activities" can be determined via personal jurisdiction, territorial jurisdiction, or by jurisdiction established through control, which may include quasi-territorial jurisdiction by dint of registration.[141] Of these three different interpretations, it is the third interpretation based on control and quasi-territorial jurisdiction that most robustly

[138] Von Der Dunk F, '1. The Origins of Authorisation: Article VI of The Outer Space Treaty And International Space Law', *National space legislation in Europe* (Brill Nijhoff 2011), 4.

[139] Cheng B, 'Studies in international space law' (1997), 606 – 607.

[140] Von Der Dunk (n 137) 6.

[141] Ibid 6 -7.

accounts for the factors needed to determine jurisdiction for purposes of State responsibility.[142]

Several other important definitions in space law which must be analysed to fully understand the scope of "national activities" mentioned in Article VI OST. These are the definitions of "launching State" and "space object". A "launching State" is defined as a State which "launches or procures the launching of an object into outer space", and any State "from whose territory or facility an object is launched".[143] From this definition there can be more than one launching State[144]. A "space object" is defined in the Liability Convention and Registration Convention as including "component parts of a space object as well as its launch vehicle and parts thereof".[145] The term is broad enough to include both satellites of any size and the rockets used to propel them into orbit. Any launch of a space object ascribes onto one or more States the label of a launching State and would therefore classify as a "national activity" of that State.[146]

4.2.2. Determining jurisdiction to find the "appropriate State"

Much like the term "national activities", the "appropriate State" as worded in the Outer Space Treaty is an ambiguous term.[147] An enquiry into the identity of the "appropriate State" in terms of Article VI of the Outer Space Treaty essentially boils down to a question of jurisdiction.[148] Issues of jurisdiction for space activities are the crux of Article VIII of the OST. Von der Dunk explains that "the idea is to read Article

[142] Katsiginis A, 'Falling through the Gaps of the Registration Convention: A Need for Revision' (2013) 7 Pretoria Student L Rev 9, 11; see also Jakhu RS, Jasani B and McDowell JC, 'Critical issues related to registration of space objects and transparency of space activities' (2018) 143 Acta Astronautica 406, 416.

[143] Article I of the Liability Convention.

[144] Ibid.

[145] Ibid.

[146] Hobe S, Schmidt-Tedd B and Schrogl K-U, *Cologne Commentary on Space Law: Outer Space Treaty*, vol 1 (BWV Verlag 2017), 389.

[147] Marboe I 'National space law' in von der Dunk F and Tronchetti F (eds), *Handbook of space law* (Edward Elgar Publishing 2015), 133.

[148] Hobe and others (n 146) 410.

VI and Article VII in conjunction", as registration of a space object should be carried out by the State which is responsible for it.[149] Article VIII reads as follows:

"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, and over any personnel thereof, while in outer space or on a celestial body. Ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their component parts, is not affected by their presence in outer space or on a celestial body or by their return to the Earth. Such objects or component parts found beyond the limits of the State Party to the Treaty on whose registry they are carried shall be returned to that State Party, which shall, upon request, furnish identifying data prior to their return."[150]

4.3. "Authorisation" and "continuing supervision"

Article VI of the Outer Space Treaty limits the freedom of exploration of outer space by private actors. Non-governmental entities are not free to explore and utilise outer space as with unchecked abandon. States ultimately bear final responsibility for the activities of non-governmental entities. Discharging this responsibility involves "authorising" non-governmental space activities and ensuring that outer space activities are "continuously supervised".[151] The prevailing trend in how States extinguish this obligation is through the implementation of national legislation.[152]

4.3.1. Authorisation

The obligation to "authorise" non-governmental activities has been viewed as the requirement incumbent on States to guarantee the "space worthiness" of the personnel and space objects involved in non-governmental activities.[153] Article VI is silent on the exact form or procedure that such "authorisation" should assume in

[149] Marboe (n 147) 136.

[150] Article VIII of the Outer Space Treaty.

[151] Article VI of the Outer Space Treaty.

[152] Hobe and others (n 147) 414.

[153] Hobe (n 11) 129.

national systems.[154] In fact, Article VI does not strictly require the establishment of national space legislation to govern a State's system of "authorisation".[155] All that Article VI requires is that States implement some form of appropriate legal or administrative mechanism to serve as the competent authority granting such "authorisation".[156]

A national "authorisation" process is most commonly characterised by a national licensing procedure.[157] The current trend is for States to request from non-governmental entities information such as the lifespan of a space object and the safety measures to be followed by the non-governmental entities.[158] States are afforded a broad discretion to satisfy their "authorisation" obligations prescribed by Article VI and the same holds true regarding the obligation to "continuously supervise" the activities of non-governmental entities in outer space.[159]

4.3.2. Continuous supervision

"Continuous supervision" refers to a State's capability to provide information on a specific space object on short notice[160] Supervision begins prior to the commencement of the space activity and persists throughout the entirety of the space object's lifespan.[161] "Continuous supervision" is a procedural requirement which States are afforded a wide discretion to interpret and implement through national laws.[162] There is no uniform conceptualisation of how continuous supervision should be undertaken to satisfy the obligation put forward by Article VI OST.[163] Examples of procedures

[154] Von der dunk Dunk (n 33) 32.

[155] Ibid.

[156] Ibid 49.

[157] Hobe (n 11) 128.

[158] Marboe (n 147) 134.

[159] Hobe and others (n 146) 420 – 421.

[160] Hobe (n 11) 129.

[161] Hobe and others (n 146) 421.

[162] Ibid 421 – 422.

[163] Ibid.

undertaken pursuant to the obligation to continuously supervise include "periodical reviews or audits once a licence has been granted to a private operation".[164]

5. "Flag of convenience" jurisdictions

5.1. Issues in the space law registration regime

Registration of a space object is a legal act undertaken by States which involves aspects of both Article VI and Article VIII of the Outer Space Treaty, along with the Registration Convention.[165] By registering a space object in accordance with Article VIII, a State insists itself to be the "appropriate State" for purposes of Article VI through establishing quasi-territorial jurisdiction over space activities.[166]

The Registration Convention better explains how States should go about requesting information to be held in a nationally maintained register, in addition to which registration information should be communicated to the Secretary General of the United Nations for inclusion in an international register of space objects.[167] As space industry and State practice has matured some cracks in the registration regime have been exposed. [168]

The Registration Convention permits only one launching State to be recognised as the State of registry.[169] This complicates space activities involving multiple launching

[164] Ferreira-Snyman A, 'Legal challenges relating to the commercial use of outer space, with specific reference to space tourism' (2014) 17 Potchefstroom Electronic Law Journal 1, 30.

[165] Von der dunk F, *National space legislation in Europe: issues of authorisation of private space activities in the light of developments in European space cooperation* (Brill 2011), 98 – 99.

[166] Von der Dunk F, 'Towards 'Flags of Convenience 'in Space?' (2012) Available at SSRN 2035534, 7; see also Hobe and others note 152 *supra* 408 - 409; see also Avveduto R, 'Past, present, and future of intellectual property in space: Old answers to new questions' (2019) 29 Wash Int'l LJ 203, 242.

[167] Katsiginis (n 142) 407.

[168] Jakhu and others (n 142) 434.

[169] Nelson JW 'Lost in space? Gaps in the international space object registration regime' (2018) EJIL:Talk! [Available at https://www.ejiltalk.org/lost-in-space-gaps-in-the-international-space-object-registration-regime/ (accessed 30 October 2022)].

States; the definition of a launching State can allow for up to at least four States involved in a space activity being deemed launching States.[170] According to the Registration Convention, in the event that more than one State fits the criteria of a launching State, these multiple launching States must reach consensus regarding which *one* of them will undertake to register the launched space object.[171] Under this system is the possibility of non-governmental entities "forum shopping" for States of registry with more lenient requirements for authorisation and supervision according to Article VI of the OST, as the State which registers a space object does so with the intention of holding jurisdiction and control over the space object..

5.2. Registration Convention allowing for "flag of convenience" approach

A "flag of convenience" situation gives non-governmental entities the discretion to choose which State's regulations will govern their activities.[172] This allows non-governmental entities to "forum shop" for State jurisdictions which might be more advantageous on account of their more relaxed regulations or license requirements.[173] The Registration Convention enables "forum shopping" by limiting the possible scope of space object registration to a single State.[174] While there can be multiple launching States, there can be only one State of registry.[175] A non-governmental entity can thus "shop" for and "purchase" a flag by ensuring that a space object is registered with the launching State with the most favourable conditions.

Conditions which may make a launching State an attractive State of registry for non-governmental activities involve how States decide to authorise and continuously supervise space activities States who realise their obligation to authorise and

[170] Article I of the Liability Convention.

[171]Article II.2 of the Registration Convention.

[172] Hamilton C, 'Space and Existential Risk: The Need for Global Coordination and Caution in Space Development' (2022) 21 Duke Law & Technology Review 1, 13.

[173] Linden D, 'The Impact of National Space Legislation on Private Space Undertakings: Regulatory Competition vs. Harmonization' (2016) 8 Journal of Science Policy & Governance, ISPG ,11.

[174] Ibid.

[175] Nelson (n 169).

continuously supervise through light-handed national licensing procedures would naturally be the more appealing option for NewSpace entrepreneurs. Should NewSpace continue to grow in an environment where non-governmental entities may pursue “flags of convenience” then what shall inevitably follow is a race to the bottom with potentially catastrophic side-effects for the outer space environment.[176]

A race to the bottom in the context of non-governmental entities pursuing “flags of convenience” would see States continually loosening authorisation and supervision requirements in order to become the most attractive option as a launching State.[177] Such a rollback on due diligence requirements would greatly increase the risk of triggering Kessler Syndrome already associated with the rising growth of satellites in LEO.[178] Even if States do not lessen their existing authorization and supervision requirements, there would be little incentive to implement more stringent due diligence which will be required to operate in an increasingly crowded LEO.

6. A potential tragedy of the commons

LEO fits the classification of a “global commons” or a “common pool resource” , often shortened to a “commons”.[179] A “commons” is defined as a resource which is simultaneously non-excludable and rivalrous.[180] They are non-excludable in the sense that actors cannot unilaterally inhibit or prevent other actors from accessing the commons. [181]Commons are rivalrous because use of the resource by one actor bears consequences for all other actors looking to access the commons.[182]

Free access to outer space is guaranteed by Article I of the Outer Space Treaty and as such States are barred from restricting other States from such access to outer

[176] Hamilton (n 172) 13.

[177] Simon (n 16) 216.

[178] Byers M, 'Cold, dark, and dangerous: international cooperation in the arctic and space' (2019) 55 Polar Record 32, 38.

[179] Morin and Richard (n 20) 1.

[180] Salter (n 19) 10 -11.

[181] Morin and Richard (n 20) 2.

[182] Ibid.

space.[183] The use of LEO by States and non-governmental activities is thus non excludable.[184] LEO is furthermore a rivalrous environment insofar as once a satellite has occupied a position in LEO, that position is subsequently unavailable to other space objects for the duration of that satellite's operational lifetime.[185] LEO thus fits the definition of a commons and is therefore susceptible to a "tragedy of the commons" triggered by unsustainable increases in space debris.[186]

A "tragedy of the commons" occurs when a common pool resource has been irreparably damaged depleted as a result of unregulated and unsustainable use of the resource.[187] Hardin in his seminal article '*The Tragedy of the Commons'* makes the classical example of a pasture as the common pool resource and overgrazing as the tragedy which destroys.[188] In this analogy, farmers seeking to utilise the pasture are highly incentivized to act selfishly as the consequences of their unsustainable practices are borne by the commons itself, and therefore divided amongst all other stakeholders in the commons.[189] There is thus an incentive on States and non-governmental entities to act quickly to take advantage of the "first come, first serve" approach which currently regulates access to the commons of outer space.[190] Non-governmental entities in particular can maximise their positive commercial outcomes by opting for a "flag of convenience" under the current and registration system

[183] Article I of the Outer Space Treaty.

[184] Salter (n 19) 10 – 11.

[185] Goswami T and Aggarwal S, 'SpaceX, OneWeb and the 'mega' effect of mega-constealltions on international space law' (2021)
[Available at:
https://www.jurist.org/commentary/2021/05/goswami-aggarwal-international-space-law/ (accessed 30 October 2022)].

[186] Tao H and others, 'Impact of Mega Constellations on Geospace Safety' (2022) 9 Aerospace 402, 403.

[187] Salter (n 19) 11.

[188] Hardin G, 'Tragedy of the commons' Science, New Series, Vol. 162, No. 3859 (1968), 1243, 1244

[189] Ibid.

[190] Runnels MB, 'On clearing Earth's orbital debris and enforcing the Outer Space Treaty in the U.S.' (2022) American Bar Association [Available at:
https://www.americanbar.org/groups/business_law/publications/blt/2022/01/orbital-debris/ (accessed 30 October 2022)].

embedded within Articles VI and VIII of the Outer Space Treaty and the Registration Convention.[191]

An uncontrollable cascade of space debris in LEO as described by Kessler Syndrome would potentially render all space activities impossible.[192] The human race would be confined to Earth by a prison of ultra-hazardous space debris. This scenario represents the quintessential “tragedy of the commons” as overpopulation of the LEO greatly increases the overall potential collision risk. Even a single collision between space objects would radically transform the current space debris profile. While collisions are certainly not a *fait accompli* of a congested orbital environment, the risk of collision nevertheless rises in tandem to the space object population in LEO.

7. Conclusion

State responsibility for non-governmental entities will become more important than ever before as NewSpace continues to grow. Article VI of the Outer Space Treaty obliges States to authorise and continuously supervise national activities. The full realisation of State responsibility under Article VI of the Outer Space Treaty relies on jurisdiction, a concept in space law delineated by the registration process laid out in Article VII of the Outer Space Treaty and the Registration Convention. Registration and authorisation of space objects helps to establish jurisdiction over the space objects.

Non-governmental entities are free to seek out “flags of convenience” for NewSpace activities and take advantage of the “patchwork” of national legislations requiring authorisation and supervision. This is problematic because NewSpace activities can dramatically alter the space object population, best evidenced by thousands of satellites which will come to operate in LEO as part of mega-constellations. Without universal minimum standards describing how to sustainably conduct NewSpace activities the orbital environment may become dangerously congested with space objects.

[191] Linden (n 173) 2 - 4.

[192] Filho (n 88) 5.

Additions to the orbital space object populations and the interactions between space objects already in orbit will need to be appropriately managed in order to prevent the onset of Kessler Syndrome with a degree of certainty. Factors which influence the data relied upon to conduct collision avoidance in orbit are constantly shifting. The metrics for effective safety in LEO are thus subject to sudden and dramatic change. Technical standards aimed at preventing Kessler Syndrome must confront this fact by being fluid, sufficiently universal, and focussed on sustainability of the space environment as *res communis.*

Chapter 3: The role of space traffic management and space debris remediation in preventing a tragedy of the commons

1. Introduction

Non-governmental activities involving the launch of satellites is expected to increase the current satellite population by tenfold.[193] Every space launch generates some level of space debris, a problem which has been left unaddressed by the UN Space Treaties.[194] This issue of uncertain regulation regarding space debris is compounded by the dearth of standardised space traffic rules.[195] Management of space traffic. provide much in the need of regulation to lessen the likelihood of triggering Kessler Syndrome. Some scholars are however of the view that the protracted beginning stages of Kessler Syndrome have already begun.[196] As they put it, management of the current space object population alone would not be sufficient to prevent the onset of Kessler Syndrome; instead, active removal of debris from LEO will also become necessary to ensure the sustainability of the space commons.

2. A lack of overall regulation of the space environment in NewSpace

NewSpace activities such as the operation of satellite mega-constellations operate in an advantageous regulatory void left by the ambiguities latent in Article VI of the Outer Space Treaty.[197] Article VI was drafted as a compromise between the competing Cold War ideologies, which were also the only spacefaring powers at the time of the

[193] Popova and Schaus (n 8) 2; Larsen (n 131) 481.

[194] Haroun and others (n 42) 63.

[195] Frandsen HO, 'Looking for the Rules-of-the-Road of Outer Space: A search for basic traffic rules in treaties, guidelines and standards' (2022) Journal of Space Safety Engineering, 232.

[196] Boley and Byers (n 107) 1.

[197] Runnels (n 189).

OST's drafting.[198] The United States advocated a system of free commercialisation with minimal restrictions being placed on private actors.[199] Strong Soviet opposition instead wished to make outer space the exclusive domain of States.[200] This eventually led to the principles of authorisation and continuous supervision in the final version of Article VI of the OST.[201]

The drafters of the Outer Space Treaty did not foresee the possibility of a high-density orbital population, especially one consisting of mostly non-governmental entities. As such, there are no binding "rules of the road" governing space object traffic in the outer space environment.[202] Space debris is also unaddressed by the binding space treaties.[203] It is instead overseen by a series of non-binding mitigation guidelines.[204] Mitigation measures are easily incorporated into the framework of Article VI of the Outer Space Treaty without the need for a new binding instrument.[205]

Mitigation alone, however, is insufficient to effectively counteract the space debris currently being created as a result of NewSpace activities.[206] Instead, debris must be actively removed from populated orbits.[207] Removing debris raises a number of legal issues which may not be adequately addressed by the current interpretation of the Article VI due diligence obligation. This Chapter will therefore assess how existing space law is capable of accommodating the needs for space debris mitigation, space debris remediation, and space traffic management.

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[198] Stubbe 2017 (n 40) 82; see also Blount (n 63) 518.

[199] Von der Dunk (n 137) 75.

[200] Ibid.

[201] Goswami and Aggarwal (n 184).

[202] Frandsen (n 194) 232; see also Haroun and others (n 42) 66.

[203] Zaefen (n 131) 195.

[204] Ferreira-Snyman (n 55) 8.

[205] Larsen (n 131) 491.

[206] Migaud MR, 'Protecting Earth's Orbital Environment: Policy Tools for Combating Space Debris' (2020) 52 Space Policy 101361, 3; see also Stubbe (n 40) 58; see also Popova and Schaus (n 8) 1; see also Haroun and others (n 42) 68.

[207] Migaud ibid, 7.

3. Space debris mitigation efforts

3.1. Definition

Before delving into discussions on nascent principles tailored at limiting space debris it would be beneficial to consider the current practices of States in space debris mitigation. Space debris mitigation is the label given to practices aimed at decreasing the generation of space debris through preventative measures. The UN Space Treaties do not directly refer to space debris in their description of States' responsibility for non-governmental entities or the general environmental protection principles. Space debris mitigation is therefore defined in soft law instruments such as the UNCOPUOS Space Debris Mitigation Guidelines.

3.2. Space debris mitigation guidelines

Mitigation guidelines are a form of voluntary obligations which addresses space debris concerns in lieu of binding treaty obligations.[208] The 2007 UNCOPUOS Space Debris Mitigation Guidelines are widely referred to for the definition of space debris, which is "all man made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional."[209] These guidelines contain generally-accepted debris mitigation principles which encourage State to:[210]

1. Limit debris released during normal operations.
2. Minimise the potential for break-ups during operational phases.
3. Limit the probability of accidental collision in orbit.
4. Avoid intentional destruction and other harmful activities.
5. Minimise potential for post-mission break-ups resulting from stored energy.
6. Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission.
7. Limit the long-term interference of spacecraft and launch vehicle orbital stages.

[208] Snyman (n 55) 8; see also Kurt (n 131) 312; see also Larsen (n 131) 479.

[209] Space Debris Mitigation Guidelines (n 13).

[210] Li L, 'Space Debris Mitigation as an International Law Obligation: A Critical Analysis with Reference to States Practice and Treaty Obligation' (2015) 17 International Community Law Review 297, 312.

4. Space traffic management

4.1. Definition

A space object population which is large enough and routinely sees space activities such as new launches and on-orbit servicing of space objects will require a uniform system of positional organisation to limit the potential of collisions.[211] The rules which would regulate traffic in Earth's orbit are collectively referred to as rules of space traffic management.[212] In the current space law regime no mention is made of space traffic management.[213] So far, discussions around space traffic management have failed to birth any binding obligations on States through a new treaty or custom to observe traffic rules in outer space.

4.2. Long-term Sustainability Guidelines

The UN Long-term Sustainability Guidelines affirm the contents of the UN Space Debris Mitigation Guidelines while recommending sustainability practices such as enhancing the practice of registering space objects and the sharing of information on space objects and orbital events.[214] The Guidelines also explain that conjunction assessments during all orbital phases of controlled flight falls under the obligation of States to continuously supervise space activities.[215] States are also encouraged to share operational space weather data and forecasts.[216] Soft law has therefore begun to lay the SSA data foundation necessary for space traffic management but traffic rules and enforcement procedures continue to elude the community of spacefaring States.

[211] Zhang and others (n 107) 13.

[212] Mrna D and Hruz M, 'New approach to defining the term Space Traffic Management based on linguistic analysis' (2021) 55 Transportation Research Procedia 313, 315.

[213] Stilwell RE, Howard D and Kaltenhauser S, 'Overcoming sovereignty for space traffic management' (2020) 7 Journal of Space Safety Engineering 158, 158.

[214] Guidelines A.5, B.2 and B.6 of the Long-term Sustainability Guidelines (n 13); see also Freeland and Zhao (n 66) 429.

[215] Guideline B.4 *supra*.

[216] Guideline B.6 *supra*.

5. Space debris remediation

5.1. Definition

Space debris remediation is not defined in the UN Space Treaties but the widely accepted explanation of the term used in literature refers to the removal of space debris from populated orbits.[217] Removal of debris is "active" solution to the space debris problem as opposed to the more "passive" requirements espoused by space debris mitigation soft law.[218] Debris can be remediated by removing it from orbit either by bringing the debris down to Earth or transferring the debris to a suitable "graveyard orbit", a portion of orbit where debris moves more slowly and is less likely to come into contact with other space objects.[219] Whether debris is pulled to Earth or pushed to other orbit, the physical act of remediation involves exerting force over a space object to change its current orbital position.

5.2. The necessity of active debris removal

The active removal of debris from orbit is urgently needed in light of the rising level of space activities and space objects in LEO.[220] Even if all spacefaring States were to unanimously comply with the UN Space Debris Mitigation Guidelines and Long-term Sustainability Guidelines from this moment onwards, the space debris already in orbit will continue to pose an ultrahazardous threat.[221] This threat will rise as the space object population in LEO grows regardless of the mitigation or sustainability measures attached to them. There will thus come an unavoidable point that remediation of debris becomes a necessity to ensure the continued sustainability of the global commons. [222]

[217] Slann (n 23) 41.

[218] Popova and Schaus (n 8) 7.

[219] Guardabasso P, Lizy-Destrez S and Ansart M, *Lunar Orbital Debris Mitigation: Characterization of the Environment and Identification of Disposal Strategies* (2021), 2.

[220] Zhang and others (n 106) 12.

[221] Ibid.

[222] Salter (n 19) 21.

6. Minimal provision for STM and SDR in the current space law

6.1. A lack of SSA data sharing standards

Complex space activities likes space traffic management and space debris remediation require an extensive shared basis of space situational awareness ("SSA") data.[223] SSA data is the umbrella term given to environmental and operational data in space which are needed to conduct space activities safely and sustainability.[224] SSA data include information on the space object such as its orbital path and collision avoidance capabilities.[225] This operational data is integrated with environmental data such as nearby space debris and other sources of harmful interference to paint a comprehensive picture of the threats which may be encountered by a space object.[226]

SSA data sharing efforts are frustrated by political and technical shortcomings.[227] Politically, States may also consider SSA data pertaining to military activities in outer space too sensitive to share amongst other space actors.[228] Good SSA data are able to comprehensively determine the future positions of space objects moving through orbit. Malevolent actors with access to comprehensive SSA data could more easily conduct anti-satellite activities. Sharing of SSA data is thus a double-edged sword for States – in exchange for integrated data providing safety amongst space actors, space activities become more susceptible to intentional interference.[229]

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[223] Green BD, *Space situational awareness data sharing: safety tool or security threat?* (McGill University (Canada) 2015), 2.

[224] Johnson-Freese J and Weeden B, 'Application of Ostrom's Principles for Sustainable Governance of Common-Pool Resources to Near-Earth Orbit' (2012) 3 Global Policy 72, 79.

[225] Polkowska M, 'Space situational awareness (SSA) for providing safety and security in outer space: implementation challenges for Europe' (2020) 51 Space policy 101347, 2.

[226] Lal B and Carioscia SA, *Evaluating Options for Civil Space Situational Awareness (SSA)* (2017), 2

[227] Green (note 223) 21.

[228] Ibid 3.

[229] Ibid.

From a technical standpoint no single spacefaring nation or non-governmental entity possesses the means to collect global SSA data without international co-operation.[230] Even the United States and its Space Surveillance Network lacks coverage in Asia and other areas in the Northern Hemisphere. [231] Improving global SSA data requires greater cooperation in collection and integration efforts. There are currently no binding standards ensuring the technical quality of SSA. States are also not obligated to exchange SSA data on a regular basis.[232] Global SSA data required to conduct effective space traffic management is non-existent at this point in time. Instead, States must utilise their individual discretions to collect, integrate, and share SSA data.[233]

6.2. A lack of enforcement for traffic rules

The current space law framework would have to be updated considerably to implement space traffic management as the UN Space Treaties collectively suffer from the lack of an enforcement mechanism in the event of a breach of their provisions.[234] A violation of outer space traffic rules would have to carry consequences to effectively dissuade unsustainable or reckless traffic in vulnerable orbital positions like LEO. Evasive manoeuvres in outer space are inherently dangerous. They are also expensive due to the expenditure of propellant. Removing the exclusive discretion of States to authorise such actions would naturally limit their freedoms provided to them by the Outer Space Treaty.

There is a dearth of authoritative “rules of the road” in outer space.[235] This is not surprising, as foreseeable space traffic at the time of the UN Space Treaties’ drafting is incomparable to the potential growth in space traffic over the next few years.[236] Rules of the road are due to become increasingly needed as satellite mega-

[230] Johnson-Freese and Weeden (n 224) 79.

[231] Ibid.

[232] Green (n 223) 96.

[233] Ibid.

[234] Kisiel E, 'Law as an Instrument to Solve the Orbital Debris Problem' (2021) 51 Env't L 223, 228.

[235] Frandsen (n 195) 232.

[236] Simon (n 16) 212.

constellations continue to proliferate. As it stands, there is no central authority or body of rules prescribing which space object should manoeuvre off its given course in the event of a predicted collision with another space object under the jurisdiction and control of another State.[237] One or both of the endangered space objects might be required to change their course, which is a significant action in outer space. Moving space objects in orbit requires the expenditure of propellant, an expensive resource.[238] Space traffic management rules therefore carry a considerable economic connotation, which is made bolder by the fact that space traffic management rules would require a curtailing of the current freedoms afforded to non-governmental entities. Rules restricting the operating distances between space objects, along with rules determining which space object would possess the right of way in the event of a predicted collision, are so far non-existent in the present body of binding space law.

6.3. The ambiguous legal status of space debris frustrates space debris remediation

Active debris removal faces a major obstacle in the current space law regime.[239] The definition of a "space object" is easily stretched to encompass even the smallest piece of debris.[240] Being a space object, a piece of space debris would be subject to the jurisdiction and control of the State of registry. The removal of debris from orbit by a non-launching or non-registered State is therefore subject to the permission of the State holding jurisdiction or control over the space debris.[241] Without the consent of the State of registry it is questionable whether a third-party would be permitted to remove space debris from orbit.[242] The pressing issue of funding for debris removal also requires innovative, workable solutions. Underlying these problems of jurisdiction and funding is the dilemma of identification relating to the State of registry for a piece of space debris. Even the newer soft law fails to adequately detail the procedures

[237] Larsen (n 131) 503.

[238] Stubbe (n 40) 50.

[239] Viikari (n 10) 758.

[240] Hertzfeld (n 38) 239.

[241] Svárovská N, 'Common but Differentiated Responsibilities for Space Debris Removal' (2021) 19 Astropolitics 1, 4.

[242] Larsen (n 131) 486.

surrounding space debris remediation.[243] The act of remediation may also raise national security concerns due to the potential dual functionality of remediation technologies for militaristic purposes.[244]

7. Conclusion

Space debris remediation and space traffic management have not yet been developed to the degree of space debris mitigation standards. Even then, space debris mitigation guidelines are considerably fettered by their soft law status. The need for space debris remediation and space traffic management will become more pressing as the space object and space debris populations continue to grow. These processes were not anticipated by the drafters of the UN Space Treaties and the current hard law may in fact hinder rather than help facilitate space traffic management and space debris remediation.

[243] Ibid 478.

[244] Plattard S and Smith A, 'Reducing vulnerabilities of space activities: A call for coordinated leadership at the global level' (2021) 8 Journal of Space Safety Engineering 323, 328.

Chapter 4: Potential solutions to current issues in the Article VI regime

1. Introduction

Ambiguities in the Article VI regime of State responsibility for non-governmental entities sets the stage for a potential tragedy of the commons in the form of Kessler Syndrome. The flags of convenience issue is enabled by an imprecise obligation to register space objects and the ability for non-governmental entities to select from a catalogue of national laws of varying scrutiny.[245] Authorisation and supervision in terms of Article VI of the Outer Space Treaty also neglects to account for space traffic rules. Under the current Article VI regime, space objects can easily enter LEO and, once there, are mostly unregulated in their movements. These two preconditions are the factors which may directly lead to a chain reaction of collision between space objects, effectively destroying the global common resource of Earth's orbital planes.

Hardin puts forward two solutions to guarantee sustainable use of the common pool resource.[246] The first solution would be to legitimise property rights over the common resource.[247] As space law is structured around the principle of non-appropriation and freedom of use, solutions to the tragedy of the commons problem will have to follow the second path proposed by Hardin – the establishment of a central regulatory authority.[248]

This Chapter will analyse the issues with most common suggestion of a central regulatory authority in international space law, which would be an international space traffic management organisation resembling the International Civil Aviation Organisation ("ICAO").[249] The advantages and shortcomings of a hypothetical space

[245] Hamilton (n 172) 14.

[246] Hardin (n 188) 1245.

[247] Ibid.

[248] Ibid.

[249] Von der Dunk F, 'Legal aspects of private manned spaceflight' in von der Dunk F and Tronchetti F (eds), *Handbook of space law* (Edward Elgar Publishing 2015), 715.

traffic organisation will be discussed before evaluating the efficiency of a “bottom-up” approach to establishing new principles of space law. This Chapter will conclude the research of this study by making a final recommendation that a re-interpretation of Article VI of the Outer Space Treaty in light of the general international law rules of due diligence and due regard strikes the best balance between the need for new binding rules of space law and the preferred soft law approach currently utilised by States.

2. The unlikeliness of a central space traffic management authority

2.1. A need to address safety and security in outer space

The Registration Convention was the treaty originally intended to cater for safety and security concerns with regards to space traffic through a process of registration and notification.[250] NewSpace has exposed cracks in this registration regime. Flags of convenience, the inability to transfer registration of space objects, and the ambiguous legal status of space debris are key issues with potential consequences for all space users. One of the most cited suggestions in literature to address the safety and security concerns attached to NewSpace is the creation of an international space traffic management organisation. [251]

2.2. Drawing inspiration from air law

In seeking an analogy for an international space traffic management organisation, recourse should be had to the field of air law.[252] The International Civil Aviation Organisation (“ICAO”) was established in terms of the Convention on Civil Aviation (“Chicago Convention”) to oversee civil aviation in the face of large aircraft capable of cross-continental flight becoming the norm.[253] ICAO possesses full legal personality

[250] Ibid 713.

[251] Pelton (n 41) 95.

[252] Doucet (n 25) 147.

[253] Article 43 of the Convention on Civil Aviation (1994) 15 U.N.T.S. 295 (“Chicago Convention”).

to operate in the legal systems of its Member States.[254] In terms of the Chicago Convention, ICAO is mandated to insure the "safe and orderly growth of international civil aviation throughout the world".[255]

ICAO exercises quasi-legislative and dispute settlement authority over its member States.[256] Moreover, the two most important bodies which comprise ICAO are the ICAO General Assembly and the ICAO Council.[257] The ICAO General Assembly exercises legislative powers within ICAO whereas the ICAO Council executive power within the ICAO Structure.[258] One of the primary functions of the ICAO Council is to approve standards and recommended practices which are then incorporated into the Chicago Convention as an Annex.[259] States may object to the implementation of technical standards contained in an Annex but in doing so are required to record a sufficient justification for their refusal.[260] The ICAO Council thus strictly speaking does not have the ability to create binding international law without State consent.[261]

Annexes to the Chicago Convention enable ICAO to steer the development of international civil aviation by keeping a roster of universal standards and practices which can be updated as the technical state of aviation changes with new technologies.[262] ICAO Annexes set the international standards for, amongst other things: personnel licensing;[263] rules of the air;[264] airworthiness of aircraft;[265]

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[254] Article 47 of the Chicago Convention.

[255] Article 44(a) of the Chicago Convention.

[256] Polkowska M, 'The development of air law: from the Paris Conference 1910 to the Chicago Convention of 1944' (2008) 33 AASL 59, 84.

[257] Article 43 of the Chicago Convention.

[258] Articles 49, 54 and 55 of the Chicago Convention.

[259] Article 54(l) of the Chicago Convention.

[260] Article 38 of the Chicago Convention.

[261] Polkowska (n 256) 85.

[262] Doucet (n 25) 147.

[263] Annex 1 to the Chicago Convention.

[264] Annex 2 to the Chicago Convention.

[265] Annex 8 to the Chicago Convention.

aeronautical telecommunication;[266] and air traffic services.[267] It cannot be contested that ICAO's ability to implement standards and recommended practices in the form of Annexes is a pivotal feature of a civil aviation system with a highly commendable safety rate.

The Annexes to the Chicago Convention mentioned above already touch on features which could be incorporated into an international space traffic management system. The obligation to authorise and supervise under Article VI is comparatively *laissez faire* and space traffic management at this stage is no more than a loose collection of informal agreements.[268] Instead of elevating standards and recommended practices to the status of Annexes, technical requirements in space law which should be universal are instead relegated to non-binding soft law instruments which States are able to interpret and implement as they see fit.[269] A civil space traffic organisation with a power resembling that of ICAO to implement standards of reliable universality would assuage many of the issues which currently plague international space law.[270] Moreover, ICAO has the power to serve as its own watchdog by implementing audits of its Members and removing aircraft from registries of convenience.[271]

Replicating this model of dispute resolution overseen by ICAO onto space law would fill the enforcement void which unsustainable NewSpace practices currently thrive in. Funding for space debris remediation would also be considerably easier under the aegis of a civil space traffic organisation which could draw from the wealth of its member States. Collective fears surrounding the dual-use capabilities of active debris removal technologies could also be addressed by differing decisions on

[266] Annex 10 to the Chicago Convention.

[267] Annex 11 to the Chicago Convention.

[268] Bast D and Krag H, 'Emergency Command Path for Space Traffic Management' (2019) 6 Journal of Space Safety Engineering 138, 138.

[269] Doucet (n25) 146.

[270] Ibid.

[271] Guillaume G, 'ICAO at the beginning of the 21st century' (2008) 33 Air and Space Law, 314.

remediation to a body resembling either the ICAO General Assembly or the ICAO Council.[272]

2.3. Stumbling blocks

ICAO exists because of the underlying Chicago Convention, which is the central document containing the legal principles of international civil aviation. One of the foundational principles of international air law concreted in the Chicago Convention is the principle of absolute sovereignty over territorial airspace.[273] States enjoy this absolute sovereignty and are therefore able to restrict access over their airspace as they deem fit.[274] This directly contrasts the foundational principle of international space law of freedom of access enshrined in the Outer Space Treaty.[275] Outer space is *res communis*, a global commons, and actors therefore cannot restrict other actors from accessing the resource.[276] The success of ICAO and of international civil air travel as a whole can be attributed to the interests States hold in the effective management of their property rights. This is one of two solutions to the tragedy of the commons problem touted by Hardin - the enforcement of property rights over a common resource.[277] Without the principle of absolute sovereignty over territorial airspace the skies of the world would be open to free to any with the ability to traverse them, which is the principle of *res communis* ingrained in the DNA of space law. Space law could theoretically be upheaved to incorporate sovereignty over portions of Earth's orbit but the probability of this occurrence is remarkably low. Instead, a civil space traffic organisation resembling ICAO would instead have to succeed on the basis of Hardin's second theoretical solution to the tragedy of the commons - the oversight of an absolute authority.[278]

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[272] Doucet (n 25) 148.

[273] Dodge MS, 'Sovereignty and the Delimitation of Airspace: A Philosophical and Historical Survey Supported by the Resources of the Andrew G. Haley Archive' (2009) 35 J Space L 5, 14 -15.

[274] Ibid 18.

[275] Article I of the Outer Space Treaty.

[276] Svec M, 'Outer Space, an Area Recognised as Res Communis Omnium: Limits of National Space Mining Law' (2022) 60 Space Policy 101473, 2.

[277] Hardin (n 188) 1245.

[278] Ibid.

The need for an authority to regulate traffic in Earth's orbit may seem obvious in light of the high potential of success. Unfortunately, the theory underlying the concept of a space traffic management authority with absolute authority over State launch activities must be considered in the context of the development of space law. An international space traffic organisation would have to be tethered to either an entirely new multilateral treaty or an additional Protocol to the Outer Space Treaty.[279] Either option would represent a stark break from the current trends in space law-making. This new piece of hard law would have to deal with the shortfalls in the classical registration process under the Registration Convention in order to appropriately expand the Article VI of the Outer Space Treaty to encompass space traffic management and space debris remediation. Ambiguities in the current system would have to be ironed out before standards and recommended practices can play the role they currently do in the ICAO system.

A reassessment of existing treaty principles to provide for space traffic management and space debris remediation would be undeniably the most significant development in space law since the epoch of the original UN Space Treaties. In this light, an international civil space traffic organisation on the level of ICAO seems extremely unlikely.[280] States and NewSpace actors cling to the freedoms afforded to them by the outdated treaty regime and are supremely reticent to forfeit these freedoms. To reliably prevent the onset of Kessler Syndrome the international community of spacefaring States would have to sacrifice their unmitigated access to outer space. While the tragedy of the commons would be prevented most effectively by an international civil space traffic organisation with powers comparable to ICAO, the forfeiture of existing rights would make this a very tough pill for States to swallow.

Despite the threat of Kessler Syndrome looming in the background of unsustainable NewSpace practices, States have not yet created universal standards of space traffic management and space debris remediation. It is therefore unlikely in the climate of current international space law that the perceived threat to the global

[279] Doucet (n 25) 147.

[280] Freeland and Zhao (n 66) 412.

commons would yet necessitate the arrival of an international civil space traffic management organisation.

3. The dangers of the bottom-up approach to space lawmaking

3.1. Bottom-up vs top-down

A bottom-up approach involves actors coming to consensus with one another and reaching agreement on rules and standards to govern future discourse between them. This contrasts a top-down approach whereby rules are determined by a central authority and thrust upon actors to follow. A bottom-up approach uses specialised soft law to communicate principles which are hopefully adopted to extent required to be deemed rules of customary international law.[281]

3.2. Soft law and customary international law

Soft law is "any written international instrument, other than a treaty, containing principles, norms, standards, or other statements of expected behaviour."[282] Space law has become replete with soft law since the end of the treaty making period.[283] Space debris mitigation is currently exclusively embodied in non-binding guidelines. The norms espoused by the UN Space Debris Mitigation Guidelines and UN Long-term Sustainability guidelines are only voluntary. Instead of seeking to establish firm rules of conduct, soft law may also "be drafted to consolidate a trend towards changes in customary law or stamp with approval one among conflicting positions on a legal issue."[284]

[281] Byrd LC, 'Soft Law in Space: A Legal Framework for Extraterrestrial Mining' (2021) 71 Emory LJ 801, 830.

[282] Shelton (n 28) 3.

[283] Freeland and Zhao (n 66) 415.

[284] Shelton (n 28) 9.

Once soft law has undergone sufficient incorporation in the affairs of States the principles which were initially non-binding may meet the criteria of customary international law, at which point obeisance to their obligations is no longer voluntary. Customary international law is said to exist after a rule has been adequately reflected by State practice and the belief of States that the principle in question is legally binding (*opinio juris)*.[285] As a source of law, customary international law is binding on all States regardless of express consent.[286] States are only exempt from the scope of a rule of customary international law if they had persistently objected to the rule throughout the course of the rule's existence.[287] The UNCOPUOS Space Debris Mitigation Guidelines have been labelled as customary international law due to their wide representation in national legislations of spacefaring States and subsequent reference in affirming documents such as the UNCOPUOS Long-term Sustainability Guidelines.[288]

As a basis for customary international law, soft law is an effective first step. Communicating expectations of behaviour in the form of soft law instruments helps to set the direction for the progression of custom. Rather than establishing new rules of conduct simply by virtue of their existence, soft law is used as a strategic gauge to hint at the contours of obligations which could eventually find footing either as customary international law or a general principle of law.

3.3. A lack of willpower as the main drawback of the bottom-up approach

Bottom-up approaches involving soft law as the catalyst for widespread legal developments requires at least one influential State to display the willpower to compromise on their present freedoms. In theory, the endorsement "superpower" such as the United States could very quickly legitimise any soft law instrument. It has been

[285] *North Sea Continental Shelf Cases (Federal Republic of Germany v. Denmark; Federal Republic of Germany v. Netherlands)*, I.C.J. Reports 1969, p.3, at 74 – 77.

[286] Crootof R, 'Change Without Consent: How Customary International Law Modifies Treaties' (2016) 41 Yale J Int'l L 237, 278.

[287] Stein TL, 'The approach of the Different Drummer: The principle of the persistent Objector in International Law' (1985) 26 Harv Int'l LJ 457, 458.

[288] Freeland and Zhao (n 66) 430.

argued on this basis that space traffic management and space debris remediation require “national leadership”.[289] The problems to this application are similar to the problems with a top-down approach. Whereas political willpower for the creation of binding treaties manifests in drafting, signing and ratification, a bottom-up approach seeking to implement space traffic management and space debris remediation still requires affirmative displays of State attitude towards adopting new obligations. This is where the weaknesses of soft law as a law-forming mechanism begin to show. The creation of soft law creates no rights and obligations. There is a complete reliance on State practice to hopefully follow. The lack of political willpower therefore poses an equal hurdle in both the bottom-up and the top-down approach as exclusive solutions to implementing space traffic management and space debris remediation.

4. Striking balance: re-interpreting Article VI of the Outer Space Treaty

4.1. Article VI as the most effective foundation for space traffic management and space debris remediation

The top-down and bottom-up solutions both fall-short in the face of pragmatism. States are highly unlikely to adopt new obligations, either through hard or soft law. This study will propose that Article VI of the Outer Space Treaty shows great promise for an updated interpretation which makes States responsible for implementing space traffic management and space debris remediation. Due diligence and due regard as general principles of law should be the lens through which the Article VI obligations to authorise and continuously supervise non-governmental activities are interpreted.[290] Soft law should thus be used an interpretative guide to establish an international practice of adopting universal standards and recommended practices through the auspices of already-binding Article VI obligations. This study therefore argues for an approach which is bottom-up in nature but is guided by general principles of law to circumnavigate the obstacle of State apathy towards space traffic management and space debris remediation.

[289] Blount (n 5) 120.

[290] Erhart and Boutivitskai (n 50) 4.

4.2. General principles of law as gap-filling mechanism in international law

Customary international law and general principles are similar insofar as they are both non-treaty sources of public international law.[291] Where these two sources depart is that while custom requires State practice and *opinio juris*, general principles of law require recognition either in the national municipal systems of States or from the international legal system.[292] General principles of international law can therefore be recognised from their representation in treaties, rules of customary international law, or the basic features and fundamental requirements of the international legal system.[293]

General principles of rules assist in preventing outcomes of *non liquet* in international disputes.[294] They are able to serve a gap-filling process by applying reasoning which has been concentrated through an iterative process, either by national legal systems or the international legal order.[295] Examples of general principles which apply in public international law include the principles of good faith and justice.[296] International environmental law has led to the illumination of several general principles of law, such as the prohibition of transboundary harm and the precautionary principle.[297] The value of general principles of law becomes apparent when *lacunae* treaty rules or customary international law may lead to unsatisfactory outcomes.

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[291] Article 38 of the ICJ Statue.

[292] Vázquez-Bermúdez M, 'Second Report on the General Principles of International Law' International Law Commision (2020) A/CN.4/741, 58.

[293]Ibid 39 – 47.

[294] Vázquez-Bermúdez M, 'First Report on General Principles' International Law Commission (2019) A/CN.4/732, 25.

[295] Bassiouni MC, 'A functional approach to general principles of international law' (1989) 11 Mich J Int'l L 768, 792.

[296] Ibid 772.

[297] Haroun and others (n 42) 67.

4.3. Article VI and the obligation of due diligence

Due diligence in international law is an objective standard for determining whether positive obligations have been adhered to.[298] Good faith is the basis of due diligence.[299] The principle of due diligence necessitates elements of due care or consideration for the interests of other States.[300] The interests of other States must be protected by positive obligations in order to raise questions of due diligence.[301] The principle of due diligence only applies to positive obligations whose breach may trigger State responsibility.[302]

Article VI of the Outer Space makes States responsible for the authorisation and continuous supervision of space activities, including those carried out by non-governmental entities.[303] Through authorisation and continuous supervision, States must ensure that the provisions of the Outer Space Treaty and the rules of international law are not violated by their national activities.[304] The obligation to authorise and continuously supervise is thus a due diligence obligation, as States are required to act positively to ensure a minimum standard of conduct.[305]

Article IX of the Outer Space Treaty necessitates protection of the outer space environment. Article IX obliges States to act in a manner "guided by the principle of cooperation and mutual assistance and shall conduct their activities in outer space … with due regard to the corresponding interests of all other State Parties to the Treaty".[306] Going further, Article IX mandates that States must "avoid harmful contamination" of outer space.[307] Due regard as phrased in Article IX can be read as

[298] Kulesza J, *Due diligence in international law* (Brill 2016) 264.

[299] Ibid 262.

[300] Ibid 263.

[301] Ibid 265.

[302] Ibid 266.

[303] Article VI of the Outer Space Treaty.

[304] Ibid.

[305] Erhart and Boutivitskai (n 50) 4.

[306] Article IX of the Outer Space Treaty.

[307] Ibid.

synonym for due care or due consideration, two recognised elements of due diligence.[308] With the growing need to guarantee safety and sustainability in the face of NewSpace, the due regard element of due diligence could be used to justify space traffic management and space debris remediation as a due diligence responsibility.

4.4. Due regard as a component of due diligence enabling space traffic management and space debris remediation

Article IX of the Outer Space Treaty contributes to the due diligence requirement mainly laid out in Article VI by requiring States to operate with "due regard" to the interests of other States.[309] An interest of this ilk which must be regarded by States is the mutual interest all States share in outer space as *res communis*. States cannot be said to have been acting with due diligence if conduct carried out according to their determined standards leads to the pollution or "harmful contamination" of the common pool resource.

Acceptance of due regard as a general principle of law can be found in the body of international environmental law.[310] Due regard in this context refers to obligations to prevent transboundary harm and to exercise precaution in activities with a possibility of negatively impacting the environment.[311] Sustainable development – directly acknowledged in space law by virtue of the UN Long-term Sustainability Guidelines- is another general principle of law which entails States to exercise a degree of due regard for the environment.

4.5. Suggested strategies for future soft law

The UN Space Debris Mitigation Guidelines and UN Long-term Sustainability Guidelines are examples of soft law which are largely accepted by the international community of spacefaring States but have been explicitly phrased to be non-

[308] Kulesza (n 298) 263.

[309] Article IX of the Outer Space Treaty.

[310] Li (n 210) 324.

[311] Ibid 327.

binding.[312] While the strategy for this inclusion by the drafters is appreciated, future soft law instruments would do well to chain prospective obligations more clearly to obligations which already exist. Due diligence and due regard are the obligations at the forefront of this study's suggestion. Soft law instruments should not shy away from acknowledging their role in expanding on these principles as evidence of subsequent practice.

4.5.1. A domino effect of different soft law instruments

Space traffic management, space debris remediation, SSA data sharing, space debris designation, authorisation and supervision of non-governmental activities, and standards for the operation of mega-constellations are all issues deserving of meaningful soft law instruments in the vein of UN Guidelines or Model National Laws. The key, as this study suggests, is to frame each of these individual process as subsequent State practices in terms of their due diligence and due regard obligations. If even one of the aforementioned issues garners sufficient recognition as a due diligence obligation then the other processes will naturally follow suit. For example, space traffic management cannot exist without SSA data sharing practices.[313] There is thus potential for a positive domino effect for the development of legal obligations through soft law which adequately defines a subsequent State practice.

4.5.2. Unequivocal soft law

The ideal soft law would be an instrument elaborating specifically on the parameters of due diligence and due regard in international space law. Authorisation and supervision lie at the heart of this hypothetical instrument. A universal authorisation process could require a higher quality of information than what is prescribed by the Registration Convention, effectively replacing the outdated processes contained therein. Universal authorisation standards could also account for spaceworthiness standards which better reflect the difficulties of a congested LEO environment.

In the view of this study, foundational aspects of space debris remediation could also fall under the heading of continuous supervision. Due diligence and due regard

[312] Space Debris Mitigation Guidelines and Long-term Sustainability Guidelines (n 13).

[313] Green (n 223) 2.

in terms of the obligation to continuously supervise non-governmental activities would require that the functionality of spacecraft be monitored. If a space object becomes non-functional the appropriate State should continue to supervise the activities said space object is involved in. This supervision could extend to an obligation to initiate debris remediation processes or consultations with other States. Moreover, an ideal hypothetical soft law instrument would also lay the basis for continuous updates. An interpretation of continuous supervision could delineate the necessity of flexible standards. Regularly updating and implementing new standards would surely satisfy the obligation to continuously supervise in light of due diligence and due regard requirements.

An effective system of space traffic management could be ‘decentralised’ and therefore move beyond the need for a regulatory authority by way of firmly established traffic rules in outer space.[314] These rules would need to be authoritatively phrased in order to ease the process of establishing rules of customary international or general principles of law. Traffic rules which obtain either of these statuses will be enforceable through the regular channels of dealing with breaches of international obligations. Should a violation of traffic rules which are either custom or general principles occur then the offending State will have committed an internationally wrongful act and may be responsible for reparations in the form of compensation or satisfaction.[315] The same logic holds true for rules on space debris remediation. Interpreting space traffic management and space debris remediation as due diligence obligations attaches the broader consequences of State responsibility to these processes.

[314] Stilwell RE, 'Decentralized Space Traffic Management' (2019), 4.

[315] ILC, ‘Draft Articles on Responsibility of States for Internationally Wrongful Acts, with commentaries’ (November 2001) Supplement No. 10 UN Doc A/56/10 (“ARSIWA”), 95 -109.

Chapter 5: Conclusion

To summate, this study has brought attention to the very real possibility of a tragedy of the commons presented by the growth of the NewSpace industry. The current picture of space law does not adequately account for the role that non-governmental entities will play going forward. Due diligence obligations are ostensibly dealt with by national law, but the myriad of different regulations exposes a potential for license shopping in the future. Authorisation and supervision processes being implemented by States do not presently require non-governmental entities to partake in space traffic management or space debris remediation according to universal standards. The most likely solution to this issue going forward is to modify current soft law trends to better reflect acknowledgement of the general principles of due diligence and due regard. An obligation to authorise and continuously supervise bolstered by clear due diligence and due regard standards can require space traffic management and space debris remediation practices. Future soft law should be worded so as to not shy away from embracing standards of due diligence and due regards towards non-governmental entities.

Bibliography

Treaties

1. Agreement Governing the Activities of States on the Moon and Other Celestial Bodies 1363 U.N.T.S. 22, 18 I.L.M. 1434 (1979).
2. Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space 19 U.S.T. 7570, 672 U.N.T.S. 119, 7 I.L.M. 149 (1968).
3. Convention on Civil Aviation 15 U.N.T.S. 295 (1994).
4. Convention on International Liability for Damage Caused by Space Objects U.S.T. 2389, 861 U.N.T.S. 187, 10 I.L.M. 965 (1972).
5. Convention on Registration of Objects Launched into Outer Space 28 U.S.T. 695, 1023 U.N.T.S. 15, 14 I.L.M. 43 (1975).
6. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies ("Outer Space Treaty") 18 UST 2410; 610 UNTS 205; 6 ILM 386 (1967).
7. Vienna Convention on the Law of Treaties, 23 May 1969, United Nations, Treaty Series, vol. 1155, p. 331.

Other international instruments

1. Report of the Committee on the Peaceful Uses of Outer Space (UNCOPUOS) on its 50th session (June 15, 2007) UN Doc. A/62/20 (Annex) at 47 – 48 ("'Space Debris Mitigation Guidelines").
2. Report of the Committee on the Peaceful Uses of Outer Space (UNCOPUOS) on its 62nd session (June 21, 2019) UN Doc (A/74/20) at para 163 and Annex II ("Long-term Sustainability Guidelines").

International Law Commission Reports and Draft Articles

1. International Law Commission, 'Draft Articles on Responsibility of States for Internationally Wrongful Acts, with commentaries' (2001) A/56/10.
2. Vázquez-Bermúdez M, 'First Report on General Principles' International Law Commission (2019) A/CN.4/732.
3. Vázquez-Bermúdez M, 'Second Report on the General Principles of International Law' International Law Commission (2020) A/CN.4/74.

Books

1. Baker HA, *Space debris: legal and policy implications* (Martinus Nijhoff 1989).
2. Cheng B, *Studies in international space law* (Clarendon Press 1997).
3. Frans G, *National space legislation in Europe: issues of authorisation of private space activities in the light of developments in European space cooperation* (Brill 2011).
4. Green BD, *Space situational awareness data sharing: safety tool or security threat?* (McGill University (Canada) 2015).
5. Hobe S, *Space law* (Nomos Verlag 2019).
6. Hobe S, Schmidt-Tedd B and Schrogl K-U, *Cologne Commentary on Space Law: Outer Space Treaty, vol 1* (BWV Verlag 2017)
7. Kulesza J, *Due diligence in international law* (Brill 2016)
8. Stubbe P, *State accountability for space debris: a legal study of responsibility for polluting the space environment and liability for damage caused by space debris* (Brill 2017).

Book chapters

1. Jankowitsch P, 'The background and history of space law' in von der Dunk F and Tronchetti F (eds), *Handbook of space law* (Edward Elgar Publishing 2015).
2. Marboe I 'National space law' in von der Dunk F and Tronchetti F (eds), *Handbook of space law* (Edward Elgar Publishing 2015).

3. Munters W, 'Small satellites, large constellations and space debris: in dubio pro LEO?', in Wouters J, De Man P and Hansen R (eds) *Commercial Uses of Space and Space Tourism* (Edward Elgar Publishing 2017).
4. Shelton D, 'Soft law' in Armstrong J *Routledge handbook of international law* (Routledge 2009).
5. Von der Dunk F 'International space law' in von der Dunk F and Tronchetti (eds) F (eds), *Handbook of space law* (Edward Elgar Publishing 2015).
6. Von Der Dunk F, 'The Origins of Authorisation: Article VI of The Outer Space Treaty And International Space Law', in Von der Dunk F, *National space legislation in Europe* (Brill 2011),
7. Von der dunk F, 'National space legislation in Europe: issues of authorisation of private space activities in the light of developments in European space cooperation' in Von der Dunk F *National space legislation in Europe* (Brill 2011).
8. Von der Dunk F, 'Legal aspects of private manned spaceflight' in von der Dunk F and Tronchetti F (eds), *Handbook of space law* (Edward Elgar Publishing 2015).
9. Viikari L 'Environmental aspects of space activities' in von der Dunk F and Tronchetti F(eds), *Handbook of space law* (Edward Elgar Publishing 2015).

Journal articles

1. Avveduto R, 'Past, present, and future of intellectual property in space: Old answers to new questions' (2019) 29 Wash Int'l LJ 203.
2. Bassiouni MC, 'A functional approach to general principles of international law' (1989) 11 Mich J Int'l L 768.
3. Bast D and Krag H, 'Emergency Command Path for Space Traffic Management' (2019) 6 Journal of Space Safety Engineering 138.
4. Baumann I, El Bajjati H and Pellander E, 'NewSpace: A Wave of Private Investment in Commercial Space Activities and Potential Issues Under International Investment Law' (2018) 19 The Journal of World Investment & Trade 930.
5. Blount PJ, 'Renovating space: The future of international space law' (2011) 40 Denv J Int'l L & Pol'y 515.

6. Blount PJ, 'Space traffic coordination: developing a framework for safety and security in satellite operations' (2021) 2021 Space: Science & Technology.
7. Boley AC and Byers M, "Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth." Scientific Reports 11.1 (2021): 1.
8. Brittingham BC, 'Does the world really need new space law' (2010) 12 Or Rev Int'l L 31.
9. Byers M, 'Cold, dark, and dangerous: international cooperation in the arctic and space' (2019) 55 Polar Record 32.
10. Byrd LC, 'Soft Law in Space: A Legal Framework for Extraterrestrial Mining' (2021) 71 Emory LJ 801.
11. Clormann MA, 'Negotiating Beyond-Planetary Challenges: The European Space Sector in the New Space Age' (Universität München 2021) 6.
12. Crootof R, 'Change Without Consent: How Customary International Law Modifies Treaties' (2016) 41 Yale J Int'l L 237.
13. Dodge MS, 'Sovereignty and the Delimitation of Airspace: A Philosophical and Historical Survey Supported by the Resources of the Andrew G. Haley Archive' (2009) 35 J Space L 5.
14. Doucet G, 'Outer space SARPs: A mechanism for implementation of space safety standards' (2019) 6 Journal of Space Safety Engineering 145.
15. Ferreira-Snyman A, 'Legal challenges relating to the commercial use of outer space, with specific reference to space tourism' (2014) 17 Potchefstroom Electronic Law Journal 1.
16. Filho JB, 'Space Age: Past, Present and Possible Futures' (2021) 13 Journal of Aerospace Technology and Management.
17. Fogo HS, 'A Legal Mirage: State Responsibility for Non-State Actor Interference with Space Systems' (2018) 55 Canadian Yearbook of International Law/Annuaire canadien de droit international 180.
18. Frandsen HO, 'Looking for the Rules-of-the-Road of Outer Space: A search for basic traffic rules in treaties, guidelines and standards' (2022) Journal of Space Safety Engineering.
19. Freeland S and Zhao Y, 'Rules of the" Space Road:" How Soft Law Principles Interact with Customary International Law for the Regulation of Space Activities' (2020) 44 J Space L 405.

20. Goehring JS, 'Can We Address Orbital Debris with the International Law We Already Have? An Examination of Treaty Interpretation and the Due Regard Principle' (2020) 85 J Air L & Com 309.
21. Guardabasso P, Lizy-Destrez S and Ansart M, Lunar Orbital Debris Mitigation: Characterization of the Environment and Identification of Disposal Strategies (2021).
22. Guillaume G, 'ICAO at the beginning of the 21st century' (2008) 33 Air and Space Law , 314.
23. Gupta B and Raju K, 'Understanding International Space Law and the Liability Mechanism for Commercial Outer Space Activities—Unravelling the Sources' (2019) 75 India Quarterly 555.
24. Hamilton C, 'Space and Existential Risk: The Need for Global Coordination and Caution in Space Development' (2022) 21 Duke Law & Technology Review 1.
25. Haroun F and others, 'Toward the Sustainability of Outer Space: Addressing the Issue of Space Debris' (2021) 9 New Space 63.
26. Heinrich S and others, 'Space sustainability in the NEWSPACE Era: NO NEWSPACE without GREENSPACE' (2022) 9 Journal of Space Safety Engineering 464.
27. Hermer-Fried, Richard L. (2019) "Kessler Syndrome: A United States' Statutory Solution for Satellite Debris Removal and the Mitigation of Orbital Collisions," Journal of International Business and Law: Vol. 18: Iss. 2, Article 9., 267
28. Hertzfeld HR, 'Unsolved issues of compliance with the registration convention' (2021) 8 Journal of Space Safety Engineering 238.
29. Hunter H and Nelson E, 'Out of place in outer space?: exploring orbital debris through geographical imaginations' (2021) 12 Environment and Society 227.
30. Iacomino C and Ciccarelli S, 'Potential Contributions of Commercial Actors to Space Exploration' (2018) 1 Advances in Astronautics Science and Technology 141.
31. Jakhu RS, Jasani B and McDowell JC, 'Critical issues related to registration of space objects and transparency of space activities' (2018) 143 Acta Astronautica 406.
32. Jha D and others, 'Safeguarding the final frontier: Analyzing the legal and technical challenges to mega-constellations' (2022) Journal of Space Safety Engineering, 1.

33. Johnson-Freese J and Weeden B, 'Application of Ostrom’s Principles for Sustainable Governance of Common-Pool Resources to Near-Earth Orbit' (2012) 3 Global Policy 72.
34. Katsiginis A, 'Falling through the Gaps of the Registration Convention: A Need for Revision' (2013) 7 Pretoria Student L Rev 9.
35. Kisiel E, 'Law as an Instrument to Solve the Orbital Debris Problem' (2021) 51 Env't L 223.
36. Kurt J, 'Triumph of the space commons: Addressing the impending space debris crisis without an international treaty' (2015) 40 Wm & Mary Envtl L & Pol'y Rev 305.
37. Lal B and Carioscia SA, Evaluating Options for Civil Space Situational Awareness (SSA) (2017).
38. Larsen PB, 'Solving the space debris crisis' (2018) 83 J Air L & Com 475, 477.
39. Latimer Martinez K, 'Lost in Space: An Exploration of the Current Gaps in Space Law' (2021) 11 Seattle Journal of Technology, Environmental & Innovation Law 4.
40. Li L, 'Space Debris Mitigation as an International Law Obligation: A Critical Analysis with Reference to States Practice and Treaty Obligation' (2015) 17 International Community Law Review 297.
41. Linden D, 'The Impact of National Space Legislation on Private Space Undertakings: Regulatory Competition vs. Harmonization' (2016) 8 Journal of Science Policy & Governance, ISPG ,11.
42. Maclay T and Mcknight D, 'Space environment management: Framing the objective and setting priorities for controlling orbital debris risk' (2021) 8 Journal of Space Safety Engineering 93.
43. McKnight D, 'A practical perspective on Space Traffic Management' (2019) 6 Journal of Space Safety Engineering 101.
44. Migaud MR, 'Protecting Earth's Orbital Environment: Policy Tools for Combating Space Debris' (2020) 52 Space Policy 101361, 3.
45. Morin JF and Richard B, 'Astro-Environmentalism: Towards a Polycentric Governance of Space Debris' (2021) 12 Global Policy 568.

46. Mrna D and Hruz M, 'New approach to defining the term Space Traffic Management based on linguistic analysis' (2021) 55 Transportation Research Procedia 313.
47. Muelhaupt TJ and others, 'Space traffic management in the new space era' (2019) 6 Journal of Space Safety Engineering 80.
48. Muñoz-Patchen C, 'Regulating the space commons: Treating space debris as abandoned property in violation of the outer space treaty' (2018) 19 Chi J Int'l L 233.
49. Pardini C and Anselmo L, 'Effects of the deployment and disposal of mega-constellations on human spaceflight operations in low LEO' (2022) Journal of Space Safety Engineering.
50. Pekkanen SM, 'Governing the new space race' (2019) 113 American Journal of International Law 92.
51. Pelton JN, 'A path forward to better space security: Finding new solutions to space debris, space situational awareness and space traffic management' (2019) 6 Journal of Space Safety Engineering 92.
52. Plattard S and Smith A, 'Reducing vulnerabilities of space activities: A call for coordinated leadership at the global level' (2021) 8 Journal of Space Safety Engineering 323.
53. Polkowska M, 'Space situational awareness (SSA) for providing safety and security in outer space: implementation challenges for Europe' (2020) 51 Space policy 101347.
54. Polkowska M, 'The development of air law: from the Paris Conference 1910 to the Chicago Convention of 1944' (2008) 33 AASL 59.
55. Popova R and Schaus V, 'The legal framework for space debris remediation as a tool for sustainability in outer space' (2018) 5 Aerospace 55.
56. Robison CJ, 'Changing Responsibility for a Changing Environment: Evaluating the Traditional Interpretation of Article VI of the Outer Space Treaty in Light of Private Industry' (2020) 5 U Bologna L Rev 1.
57. Salter AW, 'Space Debris: A Law and Economics Analaysis of the Orbital Commons' (2015) 19 Stan Tech L Rev 221.
58. Simon S, 'A cause for concern: Developing regulatory competitions in NewSpace' (2021) 187 Acta Astronautica 212.

59. Slann PA, 'Space debris and the need for space traffic control' (2014) 30 Space Policy 40.
60. Stein TL, 'The approach of the Different Drummer: The principle of the persistent Objector in International Law' (1985) 26 Harv Int'l LJ 457.
61. Stilwell RE, Howard D and Kaltenhauser S, 'Overcoming sovereignty for space traffic management' (2020) 7 Journal of Space Safety Engineering 158.
62. Stockwell S, 'Legal “Black Holes” in Outer Space: The Regulation of Private Space Companies' (2020) 20 E-International Relations.
63. Svárovská N, 'Common but Differentiated Responsibilities for Space Debris Removal' (2021) 19 Astropolitics 1.
64. Svec M, 'Outer Space, an Area Recognised as Res Communis Omnium: Limits of National Space Mining Law' (2022) 60 Space Policy 101473.
65. Taghdiri A, 'Flags of Convenience and the Commercial Space Flight Industry: The Inadequacy of Current International Law to Address the Opportune Registration of Space Vehicles in Flag States' (2013) 19 BUJ Sci & Tech L 405.
66. Tao H and others, 'Impact of Mega Constellations on Geospace Safety' (2022) 9 Aerospace 402.
67. Von der Dunk F, 'Towards ‘Flags of Convenience ‘in Space?' (2012) Available at SSRN 2035534;
68. Weeden BC and Chow T, 'Taking a common-pool resources approach to space sustainability: A framework and potential policies' (2012) 28 Space Policy 166.
69. Weibel DL, 'Following the path that heroes carved into history: Space tourism, heritage, and faith in the future' (2020) 11 Religions 23.
70. Zaefen CM, 'Handling “Space Debris” under the International Space Treaties Regime: Case Studies Analysis' (2021) 33 Environmental Claims Journal 194.
71. Zhang J and others, 'LEO Mega Constellations: Review of Development, Impact, Surveillance, and Governance' (2022) 2022 Space: Science & Technology.
72. Ziemblicki B and Oralova Y, 'Private Entities in Outer Space Activities: Liability Regime Reconsidered' (2021) 56 Space Policy.

Conference papers

1. Hobe S, 'International space law in its first half century' (2006).
2. Hobe S, 'The international legal order for outer space activities' (1993) ECSL Proceedings.
3. Johnson NL, Orbital debris: the growing threat to space operations (2010).

Websites

1. Bailey J 'LEO, GEO, MEO Satellites – What's the difference?' (2020) Simple Flying [Available at: https://simpleflying.com/leo-geo-meo-satellites-whats-the-difference/ (accessed 30 October 2022)].
2. ESA, 'ESA's Space Environment Report 2022' (2022) [Available at: https://www.esa.int/Space_Safety/Space_Debris/ESA_s_Space_Environment_Report_2022 (accessed 30 October 2022)].
3. ESA, 'Hypervelocity impacts and protecting spacecraft' [Available at: https://www.esa.int/Space_Safety/Space_Debris/Hypervelocity_impacts_and_protecting_spacecraft (accessed 30 October 2022)].
4. ESA, 'Space debris by the numbers' (information last updated 11 August 2022) [Available at: https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers (accessed 30 October 2022)].
5. Goswami T and Aggarwal S, 'SpaceX, OneWeb and the 'mega' effect of mega-constealltions on international space law' (2021)[Available at: https://www.jurist.org/commentary/2021/05/goswami-aggarwal-international-space-law/ (accessed 30 October 2022)].
6. Morin J, 'Four steps to global management of space traffic' (Nature Publishing Group 2019), 25. [Available at: https://www.nature.com/articles/d41586-019-00732-7 (accessed 1 October 2022)].
7. Nelson JW 'Lost in space? Gaps in the international space object registration regime' (2018) EJIL:Talk! [Available at https://www.ejiltalk.org/lost-in-space-gaps-in-the-international-space-object-registration-regime/ (accessed 30 October 2022)].

8. Runnels MB, ‘On clearing Earth’s orbital debris and enforcing the Outer Space Treaty in the U.S.’ (2022) American Bar Association [Available at: https://www.americanbar.org/groups/business_law/publications/blt/2022/01/orbital-debris/ (accessed 30 October 2022)].