Legal aspects of Active Debris Removal (ADR): regulation of ADR under international space law and the way forward for legal development

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1 General Introduction

1.1 Research Context

On 4 October 1957, the Soviet Union launched the Earth's first artificial satellite into outer space, which inaugurated the beginning of the space era. The over six decades of exploration and use of outer space have produced immense benefits for humankind across the globe, and space technologies and applications have now an impact on almost all aspects of economic and social development. The pivotal role of outer space is underlined in United Nations General Assembly (UNGA) resolution 72/78 of 2017:

> "[T]here has been a significant rise in the importance to States of space science and technology applications, which enable greater understanding of the universe and of the Earth and contribute to advances in, inter alia, education, health, environmental monitoring, the management of natural resources on Earth, disaster management, meteorological forecasting, climate modelling, the protection of cultural heritage, information technology and satellite navigation and communications, and to the well-being of humanity through economic, social and cultural development".[1]

With the increase in breadth and width of space activities and the growing reliance of humankind on space technologies and applications, the space economy is thriving. According to Euroconsult's report on the value of the space economy published in 2023, the global space market grew by 8% and reached $424 billion in 2022, which is expected to reach over $737 billion within a decade.[2] The Bank of America Global Research estimates that the total global space economy will likely grow to approximately $1.1 trillion by 2030.[3] These estimations indicate that the importance of outer space will continue to increase in the future.

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1 UN Doc. A/RES/72/78 (14 December 2017). Declaration on the fiftieth anniversary 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, para. 7.

2 Euroconsult. (9 January 2023). Value of Space Economy reaches $424 billion in 2022 despite new unforeseen investment concerns. Available at: <https://www.euroconsult-ec.com/press-release/value-of-space-economy-reaches-424-billion-in-2022-despite-new-unforeseen-investment-concerns-2/>.

3 Bank of America. (27 January 2023). The New Space Era: Expansion of the Space Economy, p. 1. <https://institute.bankofamerica.com/content/dam/bank-of-america-institute/transformation/expansion-of-the-space-economy-january-2023.pdf>.

The burgeoning space sector now faces a severe threat – space debris, which is produced as a by-product of space activities. Space debris is commonly understood as all sorts of non-functional artificial objects orbiting the Earth or re-entering the atmosphere, ranging from inactive satellites and defunct launch vehicle orbital stages to fragments created as a result of on-orbit explosions and collisions.[4] As space debris is orbiting the Earth at high speed, even a tiny piece of debris, e.g., the size of 1 cm, can cause serious damage to operational satellites. Besides safety risks, space debris can also occupy valuable orbits and thereby threaten the opportunity of humankind to continuously benefit from space in the long term. Hence, the issue of space debris is becoming a growing concern of the international community.

From a technical perspective, the problem of space debris can be tackled through debris mitigation and debris remediation. Debris mitigation focuses on reducing the generation of *new* pieces of space debris in the course of space activities.[5] As such, the purpose of debris mitigation is to curtail the growth of the space debris population in Earth orbit, but not to reverse it.[6] Measures of space debris mitigation include limiting the release of mission-related objects during normal operations, avoiding on-orbit explosions and collisions, and performing post-mission disposal measures.[7]

Remediation means "correcting a fault or a deficiency".[8] In the context of space debris, remediation refers to the removal of *existing* space debris from outer space, also known as Active Debris Removal (ADR).[9] The term "active" means that the relocation of the debris pieces is realised through some *external* mechanisms, as distinct from the use of pre-launch installed systems such as drag augmentation devices to accelerate the natural decay of space debris.[10] An ADR operation can be realised in several ways, depending on the location of the debris object.[11] Objects located in the low

4 The Aerospace Corporation. (14 November 2018). Space Debris and Space Traffic Management. <https://aerospace.org/space-debris>.

5 UN Doc. A/AC.105/C.1/2012/CRP.16 (27 January 2012). Active Debris Removal — An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space: A Report of the International Interdisciplinary Congress on Space Debris Remediation and On-Orbit Satellite Servicing ("ADR Report of 2022"), p. 7.

6 Inter-Agency Space Debris Coordination Committee (IADC). (December 2022). IADC Statement on Active Debris Removal ("IADC ADR Statement"), IADC-22-02, p. 1.

7 Masson-Zwaan, T. L. & Hofmann, M. (2019). *Introduction to Space Law*. Wolters Kluwer, p. 113.

8 Ibid, p. 118.

9 Ibid. IADC ADR Statement (2022), *supra* note 6, p. 1. UN Doc. A/AC.105/C.1/2012/CRP.16 (2012), *supra* note 5, p. 7.

10 May, C. (2021). Triggers and Effects of an Active Debris Removal Marketplace. *The Aerospace Corporation*, January 2021, p. 2. Popova, R., & Schaus, V. (2018). The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space. *Aerospace*, *5*(2), 55, p. 8.

11 Masson-Zwaan & Hofmann (2019), *supra* note 7, p. 118. Losekamm, M. J. (2019). On-Orbit Servicing and Active Debris Removal: Technical Aspects. In Nakarada Pecujlic, A. & Tugnoli, M. (Eds.). (2019). *Promoting Productive Cooperation Between Space Lawyers and Engineers*. IGI Global, p. 168.

earth orbit (LEO) region can be de-orbited to accelerate their re-entry into the Earth's atmosphere.[12] When it comes to objects situated in or near the Geostationary Orbit (GEO) region, re-entry is generally not a viable option due to their long distance from Earth.[13] Hence, these objects can be boosted to a higher "graveyard orbit" to avoid their long-term interference with satellites in GEO.[14]

For the sake of consistency, the spacecraft that approaches, grapples and removes the targeted piece of debris is referred to in this dissertation as the "*removal spacecraft*". The debris that is captured and relocated by the removal spacecraft is referred to as the "*target debris object*". The need for ADR to stabilise the space debris population is stressed by the European Space Agency (ESA):

> "Even if humanity halted all new space launches tomorrow, projections show that the overall orbital debris population will continue to grow, as collisions between items already in orbit would generate fresh debris in a cascade effect. Hence, removal is a necessary addition to implementing sustainability measures for new missions. The consensus conclusion based on research done by ESA, NASA and many others is that the only way to stabilise the orbital environment is to actively remove large debris items that could in future break up into many smaller ones."[15]

As pointed out in the above statement, the reason that the amount of space debris will continue to increase even without new launches is because fragments generated by collisions among existing objects in orbit may be capable of fragmenting other objects upon subsequent collisions, leading to the runaway growth of space debris.[16] This self-sustained cascading collision process is known as the "Kessler syndrome", a theory proposed by NASA scientists Kessler and Cour-Palais in 1978.[17] To limit the occurrence of Kessler syndrome, the international community should take effective actions to curtail the growth of space debris and reduce the risk of collisional fragmentations. The actions needed include not only the development and

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12 Losekamm, ibid. Low-Earth orbit (LEO) encompasses Earth-centered orbits with an altitude of 2,000 km or less. See US National Aeronautics and Space Administration (NASA). (12 May 2022). LEO Economy FAQs. <https://www.nasa.gov/leo-economy/faqs>.

13 Losekamm, ibid. The GEO is a circular orbit 35,786 km in altitude above Earth's equator. Satellite in GEO travel at a rate that matches the Earth's rotation, which make them appear to be "stationary" over a fixed position above the Earth. See ESA. (30 March 2020). Types of Orbits. <https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits>.

14 Masson-Zwaan & Hofmann (2019), *supra* note 7, p. 118. ESA, ibid.

15 ESA Communication Department (December 2020). FAQ – Frequently Asked Questions: ADRIOS/ClearSpace-1. <https://download.esa.int/esoc/downloads/esa_ADRIOS-CS-1_FAQ_25112020_2.pdf>.

16 Ibid.

17 Kessler, D. J., & Cour-Palais, B. G. (1978). Collision frequency of artificial satellites: The creation of a debris belt. *Journal of Geophysical Research: Space Physics*, *83*(A6), p. 2637.

implementation of cost-effective and reliable space debris mitigation and remediation measures, but also the consideration and discussion of legal issues associated with ADR activities to ensure that these activities are carried out in a safe and orderly manner.

A related technological effort is On-Orbit Servicing (OOS), which can also contribute to slowing down the growth of space debris. The provision of services to existing satellites in orbit such as refuelling and repairing can prolong the operational lifetime of these satellites, which can postpone the need to launch new satellites to replace them and thus reduce the number of inactive satellites in outer space. For instance, in February 2020 and April 2021, Mission Extension Vehicle-1 (MEV-1) and Mission Extension Vehicle-2 (MEV-2) of Northrop Grumman and its wholly owned subsidiary SpaceLogistics, have docked respectively with two geostationary communications satellites of Intelsat to extend their operational lifetime by five years.[18] OOS and ADR have different focuses and target different kinds of objects. The focus of OOS is to prolong and revive client space objects through servicing operations.[19] Therefore, targets of OOS are generally objects that are technically and financially feasible to be reused.[20] For instance, through the aforementioned MEV-1 mission, Intelsat will be able to use the served Intelsat-901 satellite for another five years by paying Northrop $65 million, saving it the need to spend more than $300 million to build and launch a replacement satellite.[21] In contrast to OOS, the targets of ADR are usually objects that are either too complicated to be revived or no longer needed.[22] The aim of ADR is thus to remove defunct objects, especially those that are considered a long-term source of debris fragments, from congested orbital areas to reduce the risk of fragmentation events.[23]

In pursing technical strategies to solve the space debris problem, it is important to note that space debris is a global issue as it concerns all countries and space operators with regard to the exploration and use of outer space.[24] In fact, although the universe is immense, the total capacity of Earth's orbits

18 Northrop Grumman. (12 April 2021). News Releases: Successful Docking Paves the Way for Future On-Orbit and Life-Extension Services through Robotics. <https://news.northropgrumman.com/news/releases/northrop-grumman-and-intelsat-make-history-with-docking-of-second-mission-extension-vehicle-to-extend-life-of-satellite>.

19 Wilde, M., Harder, J., & Stoll, E. (2019). On-orbit Servicing and Active Debris Removal: Enabling a Paradigm Shift in Spaceflight. *Frontiers in Robotics and AI, 6:136*, p. 1.

20 Losekamm (2019), *supra* note 11, p. 167.

21 Smith, R. (9 September 2020). Northrop Grumman: Top Dog and First Mover in Satellite Repair. *The Motley Fool*. <https://www.nasdaq.com/articles/northrop-grumman%3A-top-dog-and-first-mover-in-satellite-repair-2020-09-09>.

22 Losekamm (2019), *supra* note 11, p. 167.

23 Wilde *et al*. (2019), *supra* note 19, p. 1.

24 NASA Office of Inspector General (OIG). (27 January 2021). *NASA's Efforts to Mitigate the Risks Posed by Orbital Debris*. Report No. IG-21-011, p. 17.

to accommodate satellites is not unlimited.[25] As stated in the preamble of the *Guidelines for the Long-term Sustainability of Outer Space Activities* ("LTS Guidelines") adopted by the UN Committee on the Peaceful Uses of Outer Space (COPUOS) in June 2019, "[t]he Earth's orbital space environment constitutes a finite resource that is being used by an increasing number of States, international intergovernmental organizations and non-governmental entities".[26] As a finite resource, the Earth's orbital space can be characterised as a common pool resource (CPR) owing to two characteristics.[27] First, the use of Earth's orbits is non-exclusive, meaning that no single actor can establish exclusive control over the resource and exclude others from using it. As will be further discussed in Chapter 3, outer space is free for exploration and use by all States without discrimination of any kind, and it is not subject to national appropriation by any means. In short, all States have equal rights to explore and use outer space, and the exercise of these rights is not subject to the permission of other States. Second, Earth's orbits are subtractable, meaning that the use by one actor diminishes the resources available to other actors. According to the general law of physics, "two objects cannot be in the same place at the same time".[28] Hence, the occupation of a certain orbital slot by a satellite or debris object would preclude others from using the same slot.

In general, the problem with CPRs is that without effective management, they are susceptible to over-exploitation or over-pollution where "the actions of individual users, motivated by short-term gains, go against the common long-term interest of all users".[29] Specific to the space context, the amount of space debris has substantially outnumbered that of operational satellites and can lead to the depletion of finite orbital resources by occupying useful orbits. Therefore, the space debris problem is often referred to as a "tragedy of the commons" dilemma, which cannot be solved by any single

25 Palmroth, M., Tapio, J., Soucek, A., Perrels, A., Jah, M., Lönnqvist, M., Nikulainen, M., Piaulokaite, V., Seppälä, T., & Virtanen, J. (2021). Toward Sustainable Use of Space: Economic, Technological, and Legal Perspectives. *Space Policy*, *57*, 101428, p. 9.

26 Preamble of the LTS Guidelines, entitled "Context of the guidelines for the long-term sustainability of outer space activities", para. 1. See UN Doc. A/74/20 (2019), Report of the COPUOS on its sixty-second session, para. 163 & Annex II. The LTS Guidelines will be discussed in more detail in Chapter 4.

27 Undseth, M., Jolly, C., & Olivari, M. (2020). Space sustainability: The Economics of Space Debris in Perspective. *OECD Science, Technology and Industry Policy Papers*, No. 87, OECE Publishing, p. 15. See also Adilov, N., Alexander, P. J., & Cunningham, B. M. (2020). The Economics of Orbital Debris Generation, Accumulation, Mitigation, and Remediation. *Journal of Space Safety Engineering*, *7*(3), p. 447.

28 Blount P. J. (2019). On-Orbit Servicing and Active Debris Removal: Legal Aspects. In Nakarada Pecujlic, A., & Tugnoli, M. (Eds.). (2019). *Promoting Productive Cooperation Between Space Lawyers and Engineers*. IGI Global, p. 183.

29 Undseth *et al*. (2020), *supra* note 27, p. 15.

State alone but requires collective efforts of the international community.[30] The point is well articulated in *ESA's Annual Space Environment Report of 2023*: "As space debris poses a problem for the near Earth environment on a global scale, only a globally supported solution can be the answer."[31]

The way towards finding a globally supported solution to tackle the space debris problem may be challenging as different States can have diverging priorities and preferences, but there is always reason for optimism on account of the importance of outer space to humankind. As Masson-Zwaan observes, "[a]ll space actors, whether they are major space players, emerging spacefaring nations, international organisations or private commercial entities, have a common interest in safeguarding outer space for future use."[32] This is where space law is needed to steer and coordinate the collective efforts of the international community towards achieving the common goal of long-term space sustainability, including through the removal of space debris from outer space.

1.2 The Concept of International Space Law

This dissertation aims to assess the application of international space law to ADR activities, identify the regulatory gaps for the governance of these activities, and explore further steps to fill these gaps. For a legal assessment, it is important to first understand what the notion of "space law" means. The UN Office for Outer Space Affairs (UNOOSA) refers to "space law" as "the body of law governing outer space activities".[33] Lyall and Larsen describe space law as "a bucket that contains many different types of rules and regulations" that "may govern or apply to outer space and activities in and relating to outer space".[34] Tronchetti submits that "space law does not exist as a single, coherent, and comprehensive body of legal principles and rules" governing space activities, but should rather be seen as "a 'box' containing many different types of norms to deal with the practical problems"

30 Adilov *et al*. (2020), *supra* note 27, p. 447. ESA. (Last updated April 2021). Frequently Asked Questions on Space Debris. <https://www.esa.int/Safety_Security/Space_Debris/FAQ_Frequently_asked_questions>.

31 ESA. (2023). *ESA's Annual Space Environment Report*, issued on 12 September 2023. <https://www.esa.int/Space_Safety/ESA_s_Space_Environment_Report_2023>.

32 Masson-Zwaan, T. L. (2023). *Widening the Horizons of Outer Space Law*. Doctoral Thesis at Leiden University, *Meijers-reeks*, p. 57.

33 UNOOSA. Space Law. <https://www.unoosa.org/oosa/en/ourwork/spacelaw/index.html>.

34 Lyall, F., & Larsen, P. B. (2017). *Space Law: A Treatise*. 2nd ed., Routledge, p. 2. As explained by Lyall, there are two ways to organise a legal topic: one is "intellectual and systematic" where the law elaborates a series of basic concepts within a single phylum, while the other is to "see the topic as a label covering many matters". Space law belongs to the second category. See also ESA. What is Space Law?. <https://www.esa.int/About_Us/ECSL_-_European_Centre_for_Space_Law/What_is_Space_Law>.

associated with the exploration and use of outer space.[35] The description of space law as a "bucket" or "box" indicates that this concept represents a "conglomerate" of different rules, principles and norms adopted in various forms and in different contexts that are relevant to the governance of outer space activities.[36]

The foundation of the current legal framework for space activities is laid down in the five international treaties adopted under the auspices of the UN between 1967 and 1979, collectively referred to as the "UN space treaties". These treaties are the Outer Space Treaty of 1967,[37] the Rescue Agreement of 1968,[38] the Liability Convention of 1972,[39] the Registration Convention of 1975,[40] and the Moon Agreement of 1979.[41] At the core of the five treaties is the Outer Space Treaty, which sets forth the fundamental legal principles for the governance of outer space activities. In view of their widespread acceptance by States, some key principles have arguably acquired the status of customary international law and are thus binding on all States.[42]

The first four UN space treaties are widely ratified by States. As at 1 January 2023, the Outer Space Treaty has 112 ratifications and 23 signatures.[43] The Rescue Agreement and the Liability Convention each have around 100

35 Tronchetti, F. (2013). *Fundamentals of Space Law and Policy*. Vol. 26, New York: Springer, p. ix.

36 Von der Dunk, F. G. (2020). *Advanced Introduction to Space Law*. Edward Elgar Publishing, p. 9.

37 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space ("Outer Space Treaty" or "OST"), adopted 19 December 1966, entered into force 10 October 1967; 610 UNTS 205.

38 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space ("Rescue Agreement"), adopted 19 December 1967, entered into force 3 December 1968; 672 UNTS 119.

39 Convention on International Liability for Damage caused by Space Objects ("Liability Convention"), adopted 29 November 1971, entered into force 1 September 1972; 961 UNTS 187.

40 Convention on Registration of Objects Launched into Outer Space of 1975 ("Registration Convention"), adopted 1974, entered into force 15 September 1976; 1023 UNTS 15.

41 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies ("Moon Agreement"), adopted 18 December 1979, entered into force 11 July 1984; 1363 UNTS 3.

42 Lyall & Larsen (2018), *supra* note 34, pp. 63-73. Masson-Zwaan, T. L. (2017). Legal Aspects of Space Debris. In Bonnal, C. & McKnight, D. S. (Eds.). *IAA Situation Report on Space Debris – 2016*, International Academy of Astronautics, p. 140. Popova & Schaus (2018), *supra* note 10, p. 4.

43 UNOOSA. Status of International Agreements relating to Activities in Outer Space. <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/status/index.html>. The signatory States are "obliged to refrain from acts which would defeat the object and purpose of a treaty" even though they are not formally parties to the treaty. Art. 18(a), Vienna Convention on the Law of Treaties (VCLT), adopted 23 May 1969, entered into force 27 January 1980, 1155 UNTS 331. Von der Dunk, F. G. (2017). Customary International Law and Outer Space. In Lepard, B. (Ed.). *Reexamining Customary International Law*. Cambridge University Press, p. 347.

ratifications and around 20 signatures. The Registration Convention has 75 ratifications and 3 signatures.[44] In contrast, the Moon Agreement has merely 18 ratifications and 4 signatures, and none of the major spacefaring nations are parties to it. As the Moon Agreement fails to achieve a meaningful number of ratifications, its practical value is rather limited.[45] Moreover, on 5 January 2023, Saudi Arabia notified the UN Secretary-General of its decision to withdraw from the Moon Agreement with effect from 5 January 2024.[46] This is the first-ever withdrawal from (one of) the five UN space treaties since their adoption and it puts the fate of the Moon Agreement further in question.[47]

International space law is generally understood as a branch,[48] or a *lex specialis*,[49] of general international law. As will be discussed in Chapter 3, in addition to the space law treaty regime, the applicable law to space activities also includes other rules and principles emanating from the formally recognised sources of international law reflected in Article 38(1) of the Statute of the International Court of Justice (ICJ), which include: (a) international conventions; (b) customary international law; and (c) general principles of law recognized by civilized nations.[50] Judicial decisions and the teachings of the most highly qualified publicists of the various nations can be used as subsidiary means for the determination of international law.[51] Therefore, the primary rules of international law, such as international environmental law and the law on the use of force, as well as the secondary rules of international law, such as the law of State responsibility and the rules of treaty interpretation, are applicable to the governance of space

44 While the number of ratifications and signatures of the Registration Convention are relatively smaller compared to the first three treaties, this number may still "be deemed to qualify as quasi-global acceptance" in view of the large measure of acceptance by those States in practice qualifying as registration States. See Von der Dunk, F. G. (2015). International Space Law. In von der Dunk, F. G. & Tronchetti, F. (Eds.). *Handbook of Space Law*. Edward Elgar Publishing, p. 40.

45 Freeland, S. (2012). The Role of 'Soft Law' in Public International Law and Its Relevance to the International Legal Regulation of Outer Space. In Marboe, I. (Ed.), *Soft Law in Outer Space: The Function of Non-binding Norms in International Space Law*. Böhlau Verlag, p. 12. Von der Dunk (2015), ibid, pp. 33-34.

46 The text of the withdrawal is available at: <https://treaties.un.org/doc/Publication/CN/2023/CN.4.2023-Eng.pdf>.

47 Saudi Arabia has not stated its reasons for withdrawal in its notification. For a discussion on this matter see Wedenig, S.-M. and Nelson, J. W. (26 January 2023) The Moon Agreement: Hanging by a Thread?. *IASL Commentaries on Air and Space Law*. <https://www.mcgill.ca/iasl/article/moon-agreement-hanging-thread>.

48 Von der Dunk (2015), *supra* note 44, p. 29.

49 Masson-Zwaan (2023), *supra* note 32, p. 33.

50 Art. 38(1), Statute of the International Court of Justice ("ICJ Statute"), adopted 26 June 1945, entered into force 24 October 1945. 33 UNTS 993. For a discussion on the sources of international law see e.g., Crawford, J., & Brownlie, I. (2019). *Brownlie's Principles of Public International Law*, 9th ed., Oxford University Press, pp. 18-44.

51 Ibid.

activities. The UN space treaties and other applicable rules and principles of general international law form the "hard law" pillar of international space law.

The other constituent part of international space law is its "soft law" pillar, which comprises written instruments that set out expected behaviours and recommended practices but do not emanate from the traditional sources of international law.[52] An important distinction between hard law and soft law is that unlike the former, the latter does not create legally binding rights and obligations.[53] Meanwhile, it should be noted that the distinction between hard law and soft law has no formal basis in the international legal field, which is created and employed by legal scientists as a descriptor of the law.[54] As there is no formal definition of "soft law", the meaning and scope of the term can be subject to different understandings. Some scholars define the term more restrictively to mean non-binding norms issued by *public authorities* which achieve its steering effect in a non-legal way.[55] Others understand the term more broadly to also include non-binding norms established by *societal institutions and entities*.[56] This dissertation adopts the broader view in light of the ongoing trend of privatisation and commercialisation of space activities. Specifically, private space companies like Astroscale and ClearSpace are leading efforts in the advancement and demonstration of ADR technologies and are working with public agencies to develop ADR missions.[57] Alongside technological development, the private sector has also been increasingly active in developing voluntary guidelines and recommended practices for space activities through industry associations and working groups. Some of these guidelines and practices move even ahead of the non-binding instruments adopted by public authorities, and in this sense, the private sector is pushing forward the boundaries of space law.

Soft law takes a wide range of forms, including resolutions, declarations, recommendations, guidelines and standards. As observed by Pronto, it is often the case that hard law and soft law co-exist, where the former

52 Martinez, P. (2020). The Role of Soft Law in Promoting the Sustainability and Security of Space Activities. *Journal of Space Law*, *44*(2), p. 522. Masson-Zwaan (2023), *supra* note 32, p. 22.

53 Rose, C. (2022). Chapter 2: Sources of International Law. In Rose, C. *et al*. *An Introduction to Public International Law.* Cambridge University Press, p. 31.

54 Brünner, C. & Königsberger G. (2012). 'Regulatory Impact Assessment' – A Tool to Strengthen Soft Law Regulations. In Marboe, I. (Ed.), *Soft Law in Outer Space: The Function of Non-binding Norms in International Space Law*, Böhlau Verlag, p. 87. Pronto, A. N. (2015). Understanding the Hard/Soft Distinction in International Law. *Vanderbilt Journal of Transnational Law*, *48*, p. 943.

55 Knauff, M. (2010). *Der Regelungsverbund: Recht und Soft Law im Mehrebenensystem.* Mohr Siebeck, p. 228. Cited from Brünner & Königsberger (2012), ibid, pp. 88-89.

56 Brünner & Königsberger (2012), ibid, pp. 89-94. Druzin, B. H. (2017). Why Does Soft Law Have Any Power Anyway?. *Asian Journal of International Law*, *7*(2), p. 361.

57 See for more details Chapter 2 Section 2.3.1.

"provide[s] the context or the limits (boundaries, ceilings, and floors), and the details are 'filled-out' by" the latter.[58] This is the case of space law, where "the combination of 'hard' and 'soft' space law, consisting of treaties, resolutions and sets of guidelines, provides a flexible and mostly satisfactory legal framework" for the governance of space activities.[59] In fact, the UN space treaties are either preceded or accompanied by several non-binding instruments, which are of recommendary character but they may serve as a basis for the development of the space treaties, provide recommendations on the application of the space treaties, and govern issues not specifically addressed in the space treaties.[60] From this perspective, soft law and hard law are not competitive but complementary.[61] Together, they form the international legal framework for space activities.

In addition to the international instruments, many States have developed national regulatory frameworks to govern the conduct of space-related activities. As will be discussed in Chapter 3, States can use national space legislation to transpose their international obligations as well as the recommendations contained in the soft law instruments into their national legal order. Therefore, while the international requirements set forth in the UN space treaties are addressed to States, these requirements can be relevant to private entities by virtue of national laws. As such, "national laws, as well as activities by private entities performing them under the jurisdiction of individual States, must remain in full harmony with international obligations arising from the international law of outer space, which should be respected as the base of all 'space law'".[62] A State "may not invoke the provisions of its internal law as justification for its failure to perform a treaty".[63] Hence, national legislation can be used to implement the elements and aspects of the international instruments on space-related activities and may not contravene the obligations of States under international space law.

As mentioned earlier, space debris is a global problem calling for a global solution. In view of the international dimension of this problem, this dissertation will focus on international space law, with the aim to assess how issues relating to space debris and ADR are regulated under the existing international space legal regime and how this regime may be further developed to respond to the regulatory needs and challenges. National space legislation will be assessed in the context of the implementation and development of international space law.

58 Pronto (2015), *supra* note 54, p. 942.
59 Masson-Zwaan (2023), *supra* note 32, p. 5.
60 Masson-Zwaan & Hofmann (2019), *supra* note 7, pp. 6-7.
61 Brünner & Königsberger (2012), *supra* note 54, p. 88.
62 Kopal, V. (1999). Discussion Paper. *Proceedings of the Workshop on Space Law in the Twenty-first Century*, UNISPACE III Technical Forum, July 1999, Doc. A/CONF 194/7, pp. 11-19. Cited from Masson-Zwaan & Hofmann (2019), *supra* note 7, p. 15.
63 Art. 27, VCLT.

1.3 Research Questions

The central research question of this study is the following:

> Does the current international legal framework governing outer space activities adequately regulate Active Debris Removal (ADR) activities and, if it does not, what are the gaps and how can they be filled through legal development?

The central research question is divided into four sub-questions, each answered in a separate chapter:

1. Why is space debris a problem and what are the issues relating to governance of ADR that need legal answers from international space law? (Chapter 2)
2. How is the "hard law" pillar of international space law applicable to the identified issues relating to the governance of ADR and are there any regulatory gaps? If so, what are these gaps? (Chapter 3)
3. How does the "soft law" pillar contribute to filling the regulatory gaps in the hard law pillar for the governance of the identified issues relating to ADR and are there any remaining gaps? (Chapter 4)
4. How should international space law move forward to better regulate the identified issues relating to the governance of ADR? (Chapter 5)

1.4 Structure

The main body of this dissertation is divided into four chapters, preceded by this Introduction (**Chapter 1**), which will address respectively the above-mentioned four sub-questions. **Chapter 2** provides a setting of the scene by explaining what is space debris (Section 2.1), why space debris is a problem (Section 2.2), why ADR is needed to tackle this problem and what are the issues surrounding ADR that require governance by international space law (Section 2.3). The chapter ends with a conclusion (Section 2.4) providing an answer to the first sub-question, which will outline four issues relating to the governance of ADR that need legal answers from international space law, namely:

1) The existence of an obligation to control the generation of space debris;
2) The liability for damage caused as a result of space activities including ADR;
3) The possibility of removing space debris of other States;
4) The security risks regarding the dual-use potential of ADR systems;

In light of the four regulatory needs identified in the previous chapter, **Chapter 3** will examine the hard law pillar of international space law in order to assess whether and how this pillar provides a response to the four issues relating to the governance of ADR and whether there exist any gaps

that need to be filled for the better regulation of these issues. In response to the four issues, this chapter will focus on the following four questions:

a) Do the rules and principles in the hard law pillar impose an obligation on States to mitigate and remediate space debris? (Section 3.1)
b) What are the international liabilities for damage caused by space debris and how will these impact ADR activities? (Section 3.2)
c) What are the rights retained by the registering State over its space object and can a State remove space debris under the jurisdiction of another State? (Section 3.3)
d) How does the hard law pillar of international space law regulate the dual-use potential of ADR systems and what more is needed? (Section 3.4)

The examination of the hard law pillar shows that the UN space treaties and other applicable rules and principles under international space law provide some basic answers to the four regulatory needs, but certain gaps remain regarding the regulation of all these four issues. The chapter will end with a conclusion providing an answer to the second sub-question. (Section 3.5)

Chapter 4 will examine the soft law pillar of international space law to analyse how this pillar contributes to addressing the gaps in the hard law pillar relating to the four issues regarding space debris and ADR. Corresponding to the four issues relating to the governance of ADR, this chapter will focus on the following four questions:

a) How do the international space debris mitigation guidelines and the COPUOS LTS Guidelines address space debris and what is the relevance of these instruments to ADR? (Section 4.1)
b) How do soft law instruments contribute to the clarification of "fault" in the context of the Liability Convention and what are the initiatives taken by the commercial space industry for the development of guidelines and standards regarding the safety of ADR? (Section 4.2)
c) How are the recommendations on enhancing the efficiency of registration relevant to ADR and are they sufficient to facilitate the requesting of approval for debris removal? (Section 4.3)
d) How can Transparency and Confidence-Building Measures (TCBMs) contribute to reducing the dual-use concerns regarding ADR and what can be further done to more effectively address these concerns? (Section 4.4)

The examination of the soft law pillar shows that in spite of their voluntary nature, the non-binding instruments fill, to varying extents, the regulatory gaps in the hard law pillar for the governance of the four issues. The chapter will end with a conclusion providing an answer to the third sub-question, which summarises the contribution of soft law to address the four issues and outlines the remaining gaps that call for further legal development (Section 4.5).

Chapter 5 will explore how the current international space law regime may move forward to fill the remaining gaps and accommodate the regulatory

needs for the governance of space debris and ADR. To this end, it will examine several initiatives and discussions taking place at both the national and international levels that are relevant to the development of guidelines, norms and standards applicable to ADR. It will assess the potential of these initiatives for creating better mechanisms for the regulation of ADR activities and propose recommendations for further legal development to ensure that ADR activities are carried out in a safe and transparent manner in furthering the long-term sustainability of outer space activities. Reflecting the four issues outlined in Chapter 2, this chapter will focus on the following four questions:

a) In the absence of a clear obligation under international law to mitigate and remediate space debris, how can commitments to adopt appropriate debris mitigation and removal measures be shaped at unilateral, multilateral and global levels in order to preserve the long-term sustainability of the orbital environment? (Section 5.1)
b) What are the current initiatives to develop guidelines for ADR activities to ensure that these activities are carried out in a manner consistent with the aim of furthering the long-term sustainability of outer space activities and what is the potential path forward to develop safety guidelines for the design and operation of ADR missions? (Section 5.2)
c) How can space law develop to facilitate the seeking and granting of approval for ADR in order to promote the removal of space debris under the jurisdiction of another State on a consensual basis? (Section 5.3)
d) What are the current initiatives to develop norms, rules and principles of responsible behaviours in space to reduce space threats and how can these initiatives contribute to reducing the risk of misperceptions and security concerns over the dual-use character of ADR systems? (Section 5.4)

The chapter will end with a conclusion providing an answer to the fourth sub-question and summarising the proposals put forward for the future development of space law to govern space debris and ADR. (Section 5.5)

Chapter 6 will summarise the answers to the four sub-research questions and provide an answer to the main research question.

1.5 Methodology

This dissertation employs the method of doctrinal research, which intends to identify the law of a particular area, assess how the law is applicable to a given subject of interest, determine whether there are gaps for the regulation of this subject, and discuss the way forward to fill the potential gaps. More specifically, the dissertation will examine how the existing international legal framework for space activities applies to space debris and ADR, identify the potential gaps in the regulatory framework, and in light of these gaps, propose recommendations for the further development of the existing legal framework to better regulate ADR activities. Where

appropriate, references are made to other branches of international law for legal analysis. For instance, air law and the law of the sea are addressed in the interpretation of the notion of "due regard". Analogies are drawn from the law on climate change and international commercial law in the context of the further development of space law.

The method of interpretation of the treaties in the hard law pillar follows the rules codified in the Vienna Convention on the Law of Treaties (VCLT), which are recognised as customary international law.[64] The method of treaty interpretation is particularly essential because even the UN space treaties, which set out fundamental rules and principles specifically and exclusively governing space activities, do not expressly address the issue of "space debris". In fact, the term does not even appear in the texts of these treaties. At the time of the development of these treaties, "the problem of space debris was still a matter of distant future".[65] As a result, the drafters of the UN space treaties "did not, and probably could not, foresee the dimensions this problem would take", including the proliferation of space debris which significantly increases the risks of collisions, and the threat it poses to the safety of space operations.[66] In fact, environmental considerations were not among the highest-ranking items on the agendas of the spacefaring nations when the UN space treaties were drafted,[67] and it was not until the 1980s that the threat of space debris started to concern the space community.[68] As the UN space treaties do not expressly address space debris, they do not *a priori* contain any specific rules regarding ADR. Therefore, treaty interpretation is of critical importance to understand how the UN space treaties apply to the governance of space debris and ADR activities.

Article 31 of the 1969 VCLT provides that "[a] treaty must be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose". The

64 See, e.g., *Territorial Dispute (Libyan Arab Jamahiriya/Chad), Judgment, I.C.J. Reports 1994*, p. 6, para. 41; *Legal Consequences of the Construction of a Wall in the Occupied Palestinian Territory, Advisory Opinion, I.C.J. Reports 2004*, p. 136, para. 94. For a thorough list of the cases confirming the customary status of the general rule and means of treaty interpretation under the 1969 VCLT see International Law Commission (ILC), Draft Conclusions on Subsequent Agreements and Subsequent Practice in Relation to the Interpretation of Treaties, with commentaries. Adopted by the International Law Commission at its seventieth session, in 2018, and submitted to the General Assembly as a part of the Commission's report covering the work of that session (UN Doc. A/73/10), Conclusion 2 and its commentary.

65 Perek, L. (2002). Space Debris at the United Nations. *Space Debris*, *2*(2), p. 124.

66 Masson-Zwaan & Hofmann (2019), *supra* note 7, p. 109.

67 Viikari, L. (2008). *The Environmental Element in Space Law: Assessing the Present and Charting the Future*. Brill Nijhoff, p. 55.

68 Aoki, S. (2012), The Function of 'Soft Law' in the Development of International Space Law. In Marboe, I. (Ed.), *Soft Law in Outer Space: The Function of Non-binding Norms in International Space Law*, Böhlau Verlag, p. 75.

ordinary meaning of the terms of the treaty will be used as a starting point for interpretation, for it is regarded as the best evidence of the finally agreed common intention of the parties.[69] The ordinary meaning will be understood in the context of the treaty as a whole, which may involve an examination of the remaining terms of the sentence and the paragraph, the entire article at issue, and the remainder of the treaty including its preamble.[70] According to the teleological interpretation, when there are ambiguities concerning the ordinary meaning of a particular treaty term, this dissertation will favour the interpretation which gives effect to the overall object and purpose of the treaty.[71] To ascertain the object and purpose of a treaty, recourse could be made to its title, preamble, a particular treaty provision with apparent relevance in this regard, and *travaux préparatoires*.[72]

Regarding ordinary meaning, one question is whether to look for the meaning at the time the treaty was concluded, or to adopt an evolutive approach to interpret the treaty terms, namely that the meaning of treaty terms may change over time. Both approaches have been used by international courts and tribunals for treaty interpretation, while an increasing trend can be observed for the courts and tribunals to use an evolutive approach to interpret treaty terms.[73] A landmark case in this regard is the *Navigational and Related Rights* case, where the key question was whether the phrase "for the purposes of commerce" in a boundary treaty concluded between Costa Rica and Nicaragua in 1858 covered commercial tourism, i.e., the transport of passengers for hire.[74] The Court, following its approach adopted in the *Aegean Sea Continental Shelf* case,[75] interpreted the term "commerce" in an evolutive manner to cover all modern forms of commerce including tourism.[76] In particular, the Court stated:

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69 Gardiner, R. (2015). *Treaty interpretation*. 2nd ed., Oxford University Press, p. 164. Crawford & Brownlie (2019), *supra* note 50, p. 365.

70 Villiger, M. E. (2009). *Commentary on the 1969 Vienna Convention on the Law of Treaties*. Brill, p. 427.

71 Crawford & Brownlie (2019), *supra* note 50, p. 365.

72 Fitzmaurice, M. (2021). Treaties. *Max Planck Encyclopedia of Public International Law*, para. 106.

73 Pascual-Vives, F. (2019). Evolutive Interpretation as a Method of Interpretation in Public International Law. In *Consensus-Based Interpretation of Regional Human Rights Treaties*. Brill Nijhoff, p. 79. Tanaka, Y. (2013). Reflections on Time Elements in the International Law of the Environment. *Zeitschrift fuer Auslaendisches Oeffentliches Recht und Voelkerrecht*, *73*, p. 174. For relevant case law see e.g., United States – Import Prohibition of Certain Shrimp and Shrimp Products, WT/DS58/AB/R (12 October 1998), *Report of the Appellate Body*, paras. 129-130. In this case, the Appellate Body of the World Trade Organization (WTO) interpreted the term "natural resources" in Article XX(g) of the 1947 General Agreement on Tariffs and Trade (GATT) as embracing both living and non-living resources by reference to modern environmental treaties relevant in this regard.

74 Crawford & Brownlie (2019), *supra* note 50, p. 365.

75 *Aegean Sea Continental Shelf*, *Judgment*, *I.C.J. Reports 1978*, p. 3, para. 77.

76 *Dispute regarding Navigational and Related Rights (Costa Rica v. Nicaragua)*, *Judgment*, *I.C.J. Reports 2009*, paras. 70-71.

> "[W]here the parties have used generic terms in a treaty, the parties necessarily having been aware that the meaning of the terms was likely to evolve over time, and where the treaty has been entered into for a very long period or is 'of continuing duration', the parties must be presumed, as a general rule, to have intended those terms to have an evolving meaning."[77]

Following this reasoning, there could be room for the evolutive interpretation of a generic term contained in a treaty intended for perpetual duration. The concept of "generic term" was defined by Judge Higgins in her declaration attached to the ICJ's *Kasikili/Sedudu Island* judgment as "a known legal term, whose content the parties expected would change through time".[78] The Outer Space Treaty, as its full title indicates, is a treaty of principles, and thus the entire Treaty "contains general prescriptions rather than detailed rules".[79] As Judge Manfred Lachs points out, many principles in the OST are "couched in very general and broad terms and supplemented with only a few specific rules, some of which themselves lack precision".[80] As to the duration of the Outer Space Treaty, there is no persuasive evidence showing that the Treaty is intended to operate for only a limited period of time. The fundamental principles set forth in the Outer Space Treaty have served to maintain the peaceful and orderly exploration and use of outer space for over five decades. With the continuous increase of States Parties to the Treaty, it can only be expected that the Outer Space Treaty will continue to provide the legal foundation for the governance of space activities in the future. The same conclusion can apply to other UN space treaties in view of their wide and increasing ratifications, with the Moon Agreement being the only exception, as it fails to achieve meaningful ratifications, especially those from the major spacefaring nations. In any event, since the Moon Agreement applies to activities pertaining to the Moon and other celestial bodies, its relevance to the governance of space debris surrounding the Earth is remote. Therefore, this dissertation will adopt an evolutive approach to interpret the generic terms in the UN space treaties. A contrary reading to exclude space debris from the scope of application of the UN Space Treaties simply because the issue of space debris might not have been contemplated by the drafters of the UN space treaties would lead

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77 Ibid, para. 66. See also *Legal Consequences for States of the Continued Presence of South Africa in Namibia (South West Africa) notwithstanding Security Council Resolution 276 (1970)*, *Advisory Opinion*, *I.C.J. Reports 1971*, p. 16, para. 53. In this advisory opinion, the Court interpreted the concepts embodied in Article 22 of the League of Nations Covenant by taking into consideration the subsequent development of international law following the conclusion of the Covenant.

78 ICJ: *Kasikili/Sedudu Island (Botswana v. Namibia)*, *Judgement* (13 December 1999), Declaration of Judge Higgins, para. 2.

79 Marchisio, S. (2009). Article IX. In Hobe S., Schmidt-Tedd, B., & Schrogl K.-U. (Eds.). *Cologne Commentary on Space Law Vol. 1* ("CoCoSL Vol. 1"). Heymann, p. 170.

80 Lachs, M. (2010). *The Law of Outer Space: An Experience in Contemporary Law-Making, by Manfred Lachs, Reissued on the Occasion of the 50th Anniversary of the International Institute of Space Law*. Martinus Nijhoff Publishers, p. 108.

to an absurd result, for this would make the core of the *corpus juris spatialis internationalis* inapplicable to the regulation of one of the largest threats to the long-term sustainability of space activities. This would run afoul of the object and purpose of the Outer Space Treaty as enshrined in its preamble, which aims to preserve "the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes", for the growing amount of space debris threatens the interests of humankind to benefit from the exploration and use of outer space in the long term.

As the singular form of the heading of Article 31 "General rule of interpretation" indicates, the employment of the various methods of interpretation prescribed in this Article would be a single combined operation.[81] Meanwhile, the title of Article 32 of the VCLT is "Supplementary means of interpretation", indicating that the methods prescribed in this Article are intended to play an ancillary role in treaty interpretation.[82] Article 32 permits the consideration of the preparatory work of the treaty to confirm the meaning that results from the application of Article 31 or to determine the meaning when the interpretation according to Article 31 does not provide sufficient clarity or leads to a manifestly absurd and unreasonable result. In consideration of the different roles assigned to the means contained in the two articles, this dissertation adopts a holistic approach to treaty interpretation, which uses the ordinary meaning as a starting point while also taking into account other relevant factors, including the position of a text within the treaty, the object and purpose of the treaty, and *travaux préparatoires*.

According to Article 38(1)(d) of the ICJ Statute, judicial decisions and the teachings of the most highly qualified publicists of the various nations can be used as subsidiary means for the determination of rules of international law. Where applicable, the relevant precedents of international courts and tribunals will be addressed when assessing the relevance of the rules and principles under international law to the governance of space debris and ADR.[83] In the meantime, scholarly contributions such as books and journal articles provide useful secondary sources to analyse the content of the rules and principles in both the UN space treaties and more broadly, general international law. Besides legal academic literature, this dissertation also uses other relevant sources such as news articles and websites.

In addition to the legally binding rules and principles, this dissertation also assesses the non-legally binding instruments that provide guidelines and

81 Villiger (2009), *supra* note 70, p. 435. Crawford & Brownlie (2019), *supra* note 50, p. 367.

82 Herdegen, M. (2020). Interpretation in International Law. *Max Planck Encyclopedia of Public International Law*, para. 10.

83 It should be noted that interpretation of the UN space treaties by international courts and tribunals is currently not available due to the lack of cases before such courts and tribunals. See Masson-Zwaan (2023), *supra* note 32, p. 13.

standards relating to space debris and ADR. These instruments are by definition non-legally binding under international law and therefore not "treaties" in the context of the 1969 VCLT.[84] Hence, the treaty interpretation rules under the VCLT do not apply to them. Nonetheless, as these instruments are intended to provide specific recommended practices and codes of conduct, they are generally formulated in more concrete terms than the UN space treaties. In addition, as soft law instruments cannot be formally enforced and their violation does not result in specific legally defined sanctions,[85] their importance lies mainly in implementation and adherence.[86] Hence, emphasis will be placed on how the non-binding instruments are relevant to the governance of space debris and ADR, how they are implemented, and how soft law may operate in conjunction with hard law to govern space activities. Moreover, the role of soft law for the future development of space law will be assessed, in order to identify whether soft law may serve as an appropriate vehicle for the development of norms to more effectively address issues relating to space debris and ADR.

On the basis of a normative analysis of the existing international legal framework for space activities, this research looks into *de lege ferenda* of space law, discussing how the existing legal framework can move forward to better accommodate the legal issues associated with ADR activities. While the ADR industry is still at a relatively nascent stage, there are already initiatives taken at both the national and the international levels that are relevant to the further development of international space law for the governance of ADR. As to the former, guidelines and standards adopted at the national level can inform the future development of international guidelines and standards. For instance, national standards on space debris mitigation were used as the foundation for the development of the IADC Space Debris Mitigation Guidelines, the first set of international guidelines of its kind. A similar path can be followed for the development of international guidelines governing ADR operations. As to the latter, the new Working Group on the Long-Term Sustainability of Outer Space Activities ("LTS 2.0 Working Group") established by COPUOS in 2019,[87] is also relevant to the development of safety guidelines for ADR activities to ensure that these activities are carried out in a manner in furtherance of the long-term sustainability of space activities. Another initiative is the Open-Ended Working Group (OEWG) on Reducing Space Threats through Norms, Rules, and Principles of Responsible Behaviours established by the UN General Assembly in 2021.[88] Discussions have taken place within the OEWG on the

84 Art. 2(1)(a), 1969 VCLT.
85 Brünner & Königsberger (2012), *supra* note 54, p. 87.
86 Aoki (2012), *supra* note 68, p. 58.
87 UN Doc. A/74/20 (2019). Report of the COPUOS on its sixty-second session, para. 165.
88 UN Doc. A/RES/76/231 (24 December 2021). Reducing space threats through norms, rules and principles of responsible behaviours, para. 5.

development of norms and principles of responsible behaviours to reduce the risk of misperceptions regarding space activities, which provide useful insights for addressing the security concerns over ADR. The relevant national and international initiatives will be assessed in the context of the future development of space law to govern ADR activities.