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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Legal Aspects of Active Debris Removal (ADR)

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Table of Contents

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List of Principal Acronyms and Abbreviations

ADR	Active Debris Removal
CAM	Collision Avoidance Manoeuvre
CONFERS	Consortium for Execution of Rendezvous and Servicing Operations
COPUOS	Committee on the Peaceful Uses of Outer Space (UN)
COSPAR	Committee on Space Research
ESA	European Space Agency
FCC	Federal Communications Commission (US)
GEO	Geostationary Orbit
GGE	Group of Governmental Experts
IAA	International Academy of Astronautics
IADC	Inter-Agency Debris Coordination Committee
ICJ	International Court of Justice
IGA	Intergovernmental Agreement (ISS)
IISL	International Institute of Space Law
ILC	International Law Commission
ISO	International Organization for Standardization
ISS	International Space Station
ITAR	International Traffic in Arms Regulations (US)
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
LEO	Low Earth Orbit
LSC	Legal Subcommittee (COPUOS)
LTS	Long-Term Sustainability
NASA	National Aeronautics and Space Administration (US)
NDCs	Nationally Determined Contributions
OECD	Organisation for Economic Co-operation and Development
OEWG	Open-Ended Working Group
OOS	On-Orbit Servicing
OST	Outer Space Treaty
RPO	Rendezvous and Proximity Operations
SSA	Space Situational Awareness
SSC	Space Safety Coalition
SSN	Space Surveillance Network
SSR	Space Sustainability Rating
STSC	Scientific and Technical Subcommittee (COPUOS)
SWF	Secure World Foundation
TCBMs	Transparency and Confidence-Building Measures
UK	United Kingdom
UN	United Nations

UNCLOS	United Nations Convention on the Law of the Sea
UNGA	United Nations General Assembly
UNOOSA	United Nations Office for Outer Space Affairs
UNSG	United Nations Secretary-General
US	United States
VCLT	Vienna Convention on the Law of Treaties

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

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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

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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:

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.

2 General Overview of Space Debris and ADR

This chapter will address the question as to why is space debris a problem and what are the issues relating to governance of ADR that need legal answers from international space law. To answer this question, the chapter will be divided into three sections. Section 2.1 will present a general overview of what space debris is. Section 2.2 will introduce the problems caused by the proliferation of space debris and the need for ADR to address the debris problem. Section 2.3 will introduce the current status of ADR missions and identify four issues relating to the governance of ADR activities. Section 2.4 will provide the conclusion of this chapter.

2.1 Overview of the Space Debris Problem

Space debris is a by-product of human activities in outer space, which includes inactive satellites and defunct launch vehicle orbital stages, discarded hardware such as separation bolts, fragments created as a result of spacecraft or orbital stages explosions and collisions, and tiny flecks of paint released by thermal stress or small particle impacts.[1] Historically, the primary sources of space debris in Earth's orbits have been: (a) accidental and intentional break-ups which generate long-lived debris and (b) debris released intentionally during the operation of rockets and spacecraft.[2] In the future, collisions involving non-manoeuvrable rocket bodies and spacecraft are predicted to become the dominant source of new debris.[3] Currently, catastrophic collisions, which are collisions that lead to the fragmentation of massive objects in orbit, are expected to occur every 5 to 9 years.[4]

There is no internationally binding definition of space debris. The most widely accepted definition is the one contained in the IADC Space

1 NASA. Frequently Asked Questions on Orbital Debris. <https://orbitaldebris.jsc.nasa.gov/faq/>.

2 Section 1 "Background", Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space ("COPUOS Space Debris Mitigation Guidelines"), endorsed by COPUOS at its 50th session and contained in UN Doc. A/62/20, annex, and endorsed by the UN General Assembly in its resolution 62/217 of 22 December 2007.

3 IADC. (2022). IADC Statement on Active Debris Removal ("IADC ADR Statement"), IADC-22-02, p. 1.

4 Ibid. See also IADC. (2013). Stability of the Future LEO Environment – An IADC Comparison Study ("IADC Study of 2013"). IADC-12-08, Rev. 1, p. 1.

Debris Mitigation Guidelines and the COPUOS Space Debris Mitigation Guidelines.[5] Space debris is defined for the purpose of these non-binding instruments as "all human made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional".[6] The IADC Space Debris Mitigation Guidelines further specify that "[a] spacecraft that can no longer fulfil its intended mission is considered non-functional", and this does not include "[s]pacecraft in reserve or standby modes awaiting possible reactivation".[7] Therefore, a spare satellite placed in orbit is not to be regarded as space debris. This definition describes the three characteristics of space debris, namely artificial nature, absence of functionality, and location. More specifically: (i) the term "space debris" includes objects of all sizes that are the product of human space activities and not of natural origin; (ii) these objects are either never functional or eventually become non-functional; and (iii) these objects are situated in Earth orbit or are re-entering the atmosphere.[8] As space debris concerns objects orbiting the Earth, it is sometimes also referred to as "orbital debris", defined as "any human-made object in orbit about the Earth that no longer serves a useful function".[9]

While orbits around the Earth are currently the most heavily used areas in outer space, there are activities that go further beyond to the Moon and other celestial bodies, which have thereby left artificial remnants in these areas. With regard to lunar debris, due to the heterogeneous mass distribution of the Moon, lunar satellites can suffer from instability in their orbits, which will over time become so elliptical that they eventually hit the lunar surface.[10] When it comes to Martian debris, there have been around eighteen spacecraft missions operating in Martian orbit as of August 2023, of which seven are currently active.[11] Unlike objects in Earth's orbits that can

5 IADC. (2021). IADC Space Debris Mitigation Guidelines, Rev. 3, IADC-02-01. Sec. 1, COPUOS Space Debris Mitigation Guidelines. These two sets of space debris mitigation guidelines will be discussed in more detail in Chapter 4 Section 4.1.1.

6 Sec. 3.1, IADC Space Debris Mitigation Guidelines. Sec. 1, COPUOS Space Debris Mitigation Guidelines.

7 Sec. 3.2.1, IADC Space Debris Mitigation Guidelines.

8 Hobe, S. (2012). Environmental Protection in Outer Space: Where We Stand and What is Needed to Make Progress with regard to the Problem of Space Debris. *Indian Journal of Law and Technology*, *8*(1), p. 2.

9 NASA. (2021). Space Debris and Human Spacecraft. <https://www.nasa.gov/mission_pages/station/news/orbital_debris.html>.

10 Kottke, J. (2021). Apollo 11's Lunar Module Might Still Be Orbiting the Moon. <https://kottke.org/21/07/apollo-11s-lunar-module-might-still-be-orbiting-the-moon>.

11 See "List of Mars orbiters" <https://en.wikipedia.ahnu.cf/wiki/List_of_Mars_orbiters>. For a comprehensive list of missions to Mars see NASA. Historical Log | Missions – Mars Exploration. <https://mars.nasa.gov/mars-exploration/missions/historical-log/>.

be routinely tracked and catalogued, the position of inactive Martian probes "is not known, nor what happened to them after completion of operation". [12]

With the increase of human activities in areas beyond Earth's orbit, debris may in the future become an issue in these areas when the number of artificial satellites increases there. Indeed, NASA Standard 8719.14C already encourages operators "to limit the release of debris while in Moon or Mars orbit".[13] This indicates that the issue of debris is also considered for missions beyond Earth orbit. Meanwhile, to address the debris issue of other celestial bodies, the different orbital mechanisms between the Earth and other celestial bodies would need to be taken into account, such as the difference in their mass and gravitational force as well as the existence and thickness of the atmosphere. As a result, different debris mitigation strategies may need to be devised. As submitted by Weeden and Chow, these different orbital areas "would almost certainly require a different or tailored governance framework".[14]

While it is also necessary to protect the environment of outer space beyond Earth orbit, the proliferation of space debris surrounding the Earth is currently the most concerning issue to be tackled. These non-functional man-made objects reside in regions of space in which most space activities take place, including crewed spaceflights such as the International Space Station (ISS) and China's Tiangong Space Station, and they pose a threat to the safety of space missions.[15] In addition, the number of existing debris in Earth's orbits is currently far greater than that in orbits around the Moon and Mars, and States may not have to face the problem of debris remediation in the latter areas if they could avoid the repetition of history and take effective measures to limit the creation of debris there from the outset.[16] Moreover, the congestion caused by the growth of space debris in Earth orbit can hinder access to further areas, which makes the stability of the orbital environment also essential for deep space missions, including

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12 Suchantke, I., Letizia, F., Braun, V., & Krag, H. (2020). Space sustainability in Martian orbits — First insights in a technical and regulatory analysis. *Journal of Space Safety Engineering*, *7*(3), p. 440. For active satellites, their position in the Martian environment can be monitored through telemetry data. See Suchantke et al., ibid.

13 Sec. 4.3.1.1, NASA Standard 8719.14C, Process for Limiting Orbital Debris, approved 5 November 2021.

14 Weeden, B. C., & Chow, T. (2012). Taking a Common-Pool Resources Approach to Space Sustainability: A Framework and Potential Policies. *Space Policy*, *28*(3), p. 168.

15 Shadbolt, L. (2023). *Technical Study Space Debris*. HDI Global Specialty SE ("HDI Study of 2023"), p. 9.

16 According to the Indian Space Research Organisation (ISRO), as of July 2023, there are six active lunar orbiters. The operating agencies of these objects are undertaking effective coordination to avoid critical conjunctions in the Lunar orbit. See ISRO. (2023). Current Space Situation around the Moon – An Assessment. <https://www.isro.gov.in/Current_Space_Situation_around_Moon_Assessment.html>.

those to the Moon and Mars.[17] Therefore, space debris in orbit around the Earth is at present the primary concern of the international community, and this dissertation will thus focus on the removal of debris orbiting the Earth.

According to the estimation of ESA, as of 6 December 2023, there are about 36,500 space debris objects larger than 10 cm, 1 million space debris objects between 1 cm and 10 cm in size, and 130 million space debris objects from greater than 1 mm to 1 cm.[18] This indicates that there are far more smaller debris than larger ones.[19] Only those objects above a certain size threshold are currently trackable. Routine ground-based radar and optical measurements performed by space surveillance systems allow the tracking and cataloguing of objects larger than 5-10 cm in LEO and objects larger than 0.3-1.0 m in GEO.[20] A main source of information on space debris is the United States (US) Space Surveillance Network (SSN), which catalogues around 27,000 objects in Earth orbit as of 3 February 2023.[21] Trackable debris only accounts for a small proportion (less than 1%) of the total space debris population, while the vast majority of the space debris population is too small to be tracked or catalogued, and hence the orbital position and trajectory of these small objects cannot be accurately known or predicted.[22]

The problem of space debris is aggravating because the amount of space debris is growing every year and is expected to increase continuously in the future. According to a report published by the IADC in 2023:

> "The environmental evolution results identify that a doubling of the space debris population may occur within 25 years and an increase of 10 times over the longer term due to an increasing rate of catastrophic collisions. Critically, even in the case of no further launches into orbit, it is expected that collisions among existing space debris objects will lead to a further growth in space debris population."[23]

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17 Choudhury, S. R. (2018). Space junk is a big problem and it's going to get worse. *CNBC*. <https://www.cnbc.com/2018/09/18/wef-tianjin-space-junk-is-a-big-problem-and-its-going-to-get-worse.html>.

18 ESA. (Last updated 6 December 2023). Space Debris by the Numbers. <https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers>.

19 Liou, J.-C. (2013). Engineering and Technology Challenges for Active Debris Removal. *Progress in Propulsion Physics*, *4*, p. 740.

20 ESA. (last updated April 2021). Frequently Asked Questions on Space Debris. <https://www.esa.int/Space_Safety/Space_Debris/FAQ_Frequently_asked_questions>.

21 NASA Orbital Debris Program Office. (2023). Monthly Number of Objects in Earth Orbit by Object Type. *Orbital Debris Quarterly News*. *27*(1), p. 12. It should be noted that not all tracked objects are catalogued, which requires an object to be tagged to a specific launch event. Weeden, B. (2011). Overview of the Legal and Policy Challenges of Orbital Debris Removal. *Space Policy*, *27*(1), p. 41. As of December 2023, the US SSN tracks around 44,600 objects in total. The information of the tracked objects is available at: <https://www.space-track.org/auth/login>.

22 Shadbolt (2023), *supra* note 15, pp. 7-8.

23 IADC. (2023). IADC Report on the Status of the Space Debris Environment ("IADC Report of 2023"). IADC-23-01, p. 6.

The projection of the IADC shows that the current space debris situation is heading in the direction of the Kessler syndrome. Another issue related to the congestion in the orbital environment is the placement of constellations consisting of hundreds and thousands of satellites in Earth orbit for the purposes of communication and Earth observation. Since 2019, the number of satellites in LEO has grown rapidly due to the deployment of several mega-constellations in Earth orbit by private companies such as SpaceX and OneWeb.[24] This sudden rise marks the start of "New Space", representing "an era dominated by commercial space actors and mega-constellations".[25] Largely as a result of these constellations, the current launch traffic is around 10 times the level observed in 2000.[26] In particular, SpaceX has 4,519 Starlink satellites in orbit as of July 2023, and it plans to eventually launch as many as 42,000 satellites in the Starlink constellation.[27] It has been estimated that the satellites to be launched over the next five years will outnumber those launched globally over the entire history of spaceflight.[28] The significant growth of launch traffic increases the chances of collision with the existing objects in orbit and can thereby accelerate the Kessler syndrome. The growing congestion in the orbital environment means that space debris is becoming an ever-pressing issue to be solved.

2.2 Risks Posed by Space Debris

Space debris orbits around the Earth at a speed of approximately 28,000 km per hour.[29] In particular, the relative velocity between many objects that come close to each other in LEO is often on the order of 10 km/s, which is ten times faster than a rifle bullet.[30] At such speeds, even a small debris piece has the potential to cause significant damage. As explained in the COPUOS Space Debris Mitigation Guidelines, "[t]he implementation of space debris mitigation measures is recommended since some space debris has the potential to damage spacecraft, leading to loss of mission, or loss of life in the case of manned spacecraft."[31] In addition, "there is also the risk of damage on the ground, if debris survives Earth's atmospheric re-entry".[32]

24 Shadbolt (2023), *supra* note 15, pp. 9-10.
25 Byers, M., & Boley, A. (2023). *Who Owns Outer Space? International Law, Astrophysics, and the Sustainable Development of Space.* Cambridge University Press, p. 54.
26 IADC (2023), *supra* note 23, p. 5.
27 Pultarova, T., & Howell, E. (3 August 2023). Starlink Satellites: Everything You Need to Know about the Controversial Internet Megaconstellation. <https://www.space.com/spacex-starlink-satellites.html>.
28 Krag, H. (2021). A Sustainable Use of Space. *Science*, *373*(6552), p. 259.
29 JAXA. (2023). Removal of Space Debris. <https://www.kenkai.jaxa.jp/eng/crd2/about/>.
30 Shadbolt (2023), *supra* note 15, p. 7.
31 Sec. 2, COPUOS Space Debris Mitigation Guidelines.
32 Sec. 1, ibid.

Accordingly, the risks posed by space debris can be classified as risks to satellites, to crewed spacecraft, and to the ground. On top of these risks, the continuous growth of space debris can also endanger the long-term sustainability of outer space activities. The following sections will introduce these risks.

2.2.1 Risks to Satellites

Debris of different sizes pose different levels of risk to space activities. Impact by debris larger than 10 cm can cause catastrophic break-ups, which may completely destroy the colliding spacecraft and generate hundreds and thousands of debris fragments, contributing to the run-away cascading Kessler syndrome.[33] A collision with space debris larger than 1 cm in size can pose a mission-ending threat to spacecraft.[34] A collision with debris larger than 1mm in size can lead to significant impact or loss of mission due to penetration of the fuel tank and other critical infrastructure.[35] As mentioned earlier, small debris objects are not trackable, and it is therefore not possible to warn about potential collisions with them. The only means to protect satellites from the impacts of small debris is to cover them with protective shields, which can significantly increase the survivability of satellites against debris up to 1 mm in size.[36] Hence, millimetre-sized debris objects pose the highest mission-ending risk to most operational spacecraft in LEO, for they are numerous in amount, unable to be tracked, and hard to be shielded against.[37]

Non-trackable debris is already suspected of being the cause of a number of spacecraft anomalies and failures, such as the Sentinel-1A debris collision in August 2016, where the solar panel of the satellite was likely struck by a 1 cm particle of debris. A collision with larger debris may likely lead to the fragmentation or disintegration of the satellite concerned, and a prominent example in this regard is the collision between Iridium 33 and Cosmos 2251 on 10 February 2009 at an altitude of 790 km, known as "the first accidental hypervelocity collision of two intact satellites" in orbit.[38] Iridium 33 was a 560 kg active communications satellite owned and operated by the US-based private company Iridium, and Cosmos 2251 was a decommissioned

33 ESA (2021), *supra* note 20.
34 NASA OIG. (2021). *NASA's Efforts to Mitigate the Risks Posed by Orbital Debris*. Report No. IG-21-011, p. 3.
35 Ibid.
36 JAXA (2023), *supra* note 29.
37 NASA (2021), *supra* note 9.
38 Johnson, N. (16 October 2009). The Collision of Iridium 33 and Cosmos 2251: The Shape of Things to Come. *Conference Paper at the 60th International Astronautical Congress (IAC)*, p. 2. <https://ntrs.nasa.gov/citations/20100002023>.

Russian satellite with a mass of approximately 900 kg.[39] The collision was unprecedented in terms of the amount of space debris created, for a total of 2370 fragments from the 2009 collision have been catalogued by the US SSN.[40] As such, the 2009 collision shows that the threat posed by space debris to operational satellites is not solely theoretical but indeed real.

Because the orbital environment is becoming increasingly crowded, it is important to reduce the risk of collisions. The US Combined Space Operations Center (CSpOC) alerts satellite operators of potential collisions involving objects 10 cm or greater in size.[41] ESA's Space Debris Office is in charge of providing debris alerting services for all ESA missions, as well as those of some partner and third-party missions.[42] After receiving a collision warning, satellite operators analyse the collision risk in more detail and if necessary, have their satellites perform collision avoidance manoeuvres (CAMs). According to ESA, each of its Earth-orbiting satellites conducts on average two CAMs per year.[43] The growing congestion in Earth orbit can lead to an increase in collision warnings and CAMs. These CAMs consume extra fuel and can interrupt mission operations. Hence, the space debris population should be properly controlled to reduce the need for CAMs.

2.2.2 Risks to Crewed Spacecraft

Similar to the risks posed to satellites, space debris can also threaten crewed space missions. Specifically, NASA considers space debris as "a major safety risk" to the ISS.[44] To deal with this risk, NASA has established a set of guidelines that define the operations to be taken according to the risk level, and a CAM will be conducted when the risk reaches a certain threshold.[45] As of May 2023, the ISS has conducted a total of 35 CAMs against tracked objects since 1999.[46]

Like satellites, the operation of CAMs for the ISS requires the awareness of the position and estimated trajectory of space debris, and therefore the

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39 NASA Orbital Debris Program Office. (2009). Satellite Collision Leaves Significant Debris Clouds. *Orbital Debris Quarterly News*. *13*(2), pp. 1-2.

40 NASA Orbital Debris Program Office. (2021). Accidental Collision of YunHai 1-02. In *Orbital Debris Quarterly News*, *25*(4), p. 1. See also Masson-Zwaan, T. L. (2009), Space law and the satellite collision of 10 February 2009, *COSPAR's Information Bulletin: Space Research Today*, *174*, p. 7.

41 Dural, S., Tugcular, U., & Daser, B. (2021). General Collision Avoidance Maneuver Decision Algorithm. *Proceedings of 8th European Conference on Space Debris*, p. 1.

42 ESA (2021), *supra* note 20.

43 Ibid.

44 NASA Orbital Debris Program Office. (2020). International Space Station Maneuvers to Avoid Debris. *Orbital Debris Quarterly News*. *24*(3), p. 1.

45 Ibid.

46 NASA Orbital Debris Program Office. (2023). ISS Maneuvers Twice in a Week's Span to Avoid Potential Collisions. *Orbital Debris Quarterly News*. *27*(2), p. 1

ISS can only dodge trackable debris which is the size of 5-10 cm and larger. Shields may protect ISS from smaller debris, but they have limitations. The US modules of the ISS are equipped with protective shields effective against space debris of about 1 cm and smaller, while other non-US modules of the ISS are not as well protected.[47] As an example of the collision risk, in May 2021, a hole of approximately 5mm in diameter caused by space debris was noticed on one of the Canadarm2's boom segments during a routine inspection.[48] Fortunately, the performance of Canadarm2 remains unaffected, and the robotic arm continues to conduct its planned operations.[49] Yet, the fact that no significant damage is caused may just be a "pure coincidence and luck",[50] and the continuous growth of space debris may expose the ISS to greater risks in the future.

In scenarios where the conjunction data is not precise enough to warrant CAMs, or where the close conjunction with space debris is not identified in time to enable CAMs, the control centre of the ISS may consider it the best course of action to move the crew into spaceships docked to the ISS to prepare for emergency evacuation.[51] For instance, in a close conjunction between the ISS and a piece of space debris on 15 November 2021, all seven astronauts onboard the ISS were forced to take shelter in their transport spacecraft until the immediate danger passed.[52] With the increase of crewed spaceflight in LEO, including the plans to construct commercial space stations in the future,[53] there is a growing need to properly deal with the risks posed by space debris to crewed spacecraft in order to ensure the safety of these missions.

2.2.3 Risks to the Ground

When objects in space re-enter Earth's denser atmosphere, the air drag converts their orbital energy into heat, and the heating process is usually sufficient to destroy these objects.[54] However, approximately 20-40% of the mass of larger-size spacecraft or rocket bodies, especially those parts made

47 NASA Orbital Debris Program Office (2020), *supra* note 44, p. 1.

48 Canadian Space Agency (CSA). (28 May 2021). Lucky strike: Canadarm2 Stays the Course After an Orbital Debris Hit. <https://www.asc-csa.gc.ca/eng/iss/news.asp#20210528>.

49 Ibid.

50 Datta, A. (3 June 2021). Op-ed | Damage to Canadarm2 on ISS Once Again Highlights Space Debris Problem. *SpaceNews*. <https://spacenews.com/op-ed-damage-to-canadarm2-on-iss-once-again-highlights-space-debris-problem/>.

51 NASA (2021), *supra* note 9.

52 Bartels, M. (16 November 2021). Space debris forces astronauts on space station to take shelter in return ships. *Space.com*. <https://www.space.com/space-debris-astronauts-shelter-november-2021>.

53 See e.g., Foust, J. (8 June 2023). From one, many: The race to develop commercial space stations and the markets for them. *SpaceNews*. <https://spacenews.com/from-one-many-the-race-to-develop-commercial-space-stations-and-the-markets-for-them/>.

54 ESA (2021), *supra* note 20.

of heat-resistant materials may survive the re-entry process and thus pose risks to the ground.[55] Since more than 70% of Earth's surface is covered by water and large portions of the land mass are inhabited, the risk to any single individual is estimated to be marginal.[56] However, between 100 and 200 metric tons of human-made objects re-enter the atmosphere every year in an uncontrolled fashion, and the risks posed by them cannot be completely ignored.[57] While there is to date no known injury caused by falling debris, a recent study estimates that there is an order of 10% chance that one or more casualties will be caused by re-entering rocket bodies over a decade.[58]

A prominent example of the risk to the ground is the re-entry of Cosmos 954 on 24 January 1978, a nuclear-powered reconnaissance satellite launched by the Soviet Union in September 1977.[59] Upon re-entry, the Cosmos 954 satellite disintegrated and scattered radioactive debris over a large area in the north of Canada.[60] Fortunately, the downfall of Cosmos 954 occurred in a relatively unpopulated area, and the crash did not cause any loss of life, physical injury, or direct damage to property.[61] Yet, due to the radioactive nature of the scattered debris, Canada undertook "operations directed at locating, recovering, removing and testing the debris and cleaning up the affected areas".[62] The purpose was to assess and minimise the hazard and to restore, to the greatest extent possible, the affected area to the condition that would have existed if the damage inflicted by the re-entry of Cosmos 954 satellite had not occurred.[63]

On 23 January 1979, Canada presented to the Soviet Union a claim for compensation in respect of the damage caused to Canada by the Cosmos

55 Ibid.

56 Ibid.

57 Krag (2021), *supra* note 28, p. 259.

58 Byers, M., Wright, E., Boley, A., & Byers, C. (2022). Unnecessary Risks Created by Uncontrolled Rocket Reentries. *Nature Astronomy, 6*, pp. 1093–1097.

59 NASA Space Science Data Coordinated Archive (NSSDCA). Cosmos 954. <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1977-090A>.

60 Canada. (last modified 3 September 2019). Previous Nuclear Incidents and Accidents: COSMOS 954. <https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/radiological-nuclear-emergencies/previous-incidents-accidents/cosmos-954.html>.

61 Galloway, E. (1979). Nuclear Powered Satellites: The U.S.S.R. Cosmos 954 and the Canadian Claim. *Akron Law Review*, *12*(3), p. 401. See also Carpanelli, E., & Cohen, B. (2014). Interpreting "Damage Caused by Space Objects" Under the 1972 Liability Convention. In *56th Proceedings of International Institute of Space Law*, Eleven International Publishing, p. 36.

62 Canada. (1979). Claim against the Union of Soviet Socialist Republics for Damage Caused by Soviet Cosmos 954. Note No. FLA-268. In American Society of International Law. *International Legal Materials*, *18*(4), pp. 903-904.

63 Ibid.

954 satellite in the amount of around six million Canadian dollars.[64] The claim was based on the Liability Convention, the Outer Space Treaty, and general principles of international law.[65] The dispute was ultimately settled by a compensation protocol signed between Canada and the Soviet Union.[66] According to this Protocol, the Soviet Union agreed to pay Canada the sum of three million Canadian dollars "in full and final settlement of all matters connected with the disintegration of the Soviet satellite Cosmos 954".[67]

2.2.4 Risks to Space Sustainability

Since 2005, modelling studies of the population of objects in Earth orbit conducted by the IADC have concluded that "the space debris environment in certain regions below 2000 km altitude is currently unstable".[68] The IADC Study of 2013 finds that even with 90% compliance with commonly accepted space debris mitigation measures, the LEO debris population is expected to increase by approximately 30% in the next 200 years.[69] The Study thus concludes that "to stabilize the LEO environment, more aggressive measures, such as active debris removal, should be considered".[70]

Compared to LEO, the space debris situation in GEO is less pressing. A study published by Liou indicates that the projected debris population growth in medium Earth orbit (MEO) and GEO is more moderate than LEO, which thus suggests that emphasis should be first placed on the removal of debris in LEO.[71] The general consensus within the space community is also that the risk of collisions in GEO is significantly lower than that in LEO.[72] However, this does not mean that GEO is completely free from the space debris problem. Mejía-Kaiser observes that between 2008 and 2018, "there was a net average increase of nine space debris objects per year (five non-re-orbited satellites, plus four rocket bodies)" in GEO.[73] A study published by Oltrogge in 2018 finds that a collision is likely to occur every four years

64 Ibid, p. 899.
65 Ibid.
66 Disintegration of COSMOS 954 over Canadian territory in 1978: Protocol Between the Government of Canada and the Government of the Union of Soviet Socialist Republics, done on 2 April 1981. Available at: <https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/bi-multi-lateral-agreements/can_ussr_001.html>.
67 Ibid.
68 IADC (2022), *supra* note 3, p. 1.
69 IADC (2013), *supra* note 4, p. 1.
70 Ibid, p. 17.
71 Liou, J. C. (2011). An Active Debris Removal Parametric Study for LEO Environment Remediation. *Advances in space research*, *47(11)*, p. 1868. MEO is the region between LEO and GEO (from 2,000 km to 35,000 km).
72 Shadbolt (2023), *supra* note 15, p. 12.
73 Mejía-Kaiser, M. (2020). Out into the Dark: Removing Space Debris from the Geostationary Orbit-Revised. In *Proceedings of the International Institute of Space Law 2019*, Eleven International Publishing, pp. 523-524.

for one satellite out of the entire GEO active satellite population against a 1 cm object, and every fifty years against a 20 cm object.[74] These findings indicate that the Kessler syndrome can also be triggered in GEO.[75] Compared to LEO and GEO, the risk of collision in MEO is considerably lower due to its large volume and the relatively low number of satellites in this region.[76] Hence, debris in this region is generally not regarded as a priority for removal.

With the growing congestion in the orbital environment, especially in the LEO region where large constellations of satellites are to be deployed, the space debris situation is predicted to worsen. According to the IADC Report of 2023:

> "The environmental evolution results identify that a doubling of the space debris population may occur within 25 years and an increase of 10 times over the longer term due to an increasing rate of catastrophic collisions. Critically, even in the case of no further launches into orbit, it is expected that collisions among existing space debris objects will lead to a further growth in space debris population. Consequently, even with widespread adoption of these guidelines and recommendations, or even stricter behaviours, the consensus is that the environmental impacts cannot be removed completely and additional steps may need to be taken, such as enabling the technology for active debris removal."[77]

This worrisome finding reveals several items of important information. First, the space debris population is expected to grow exponentially, which means that the problem is becoming far more serious than the results of the projection made a decade ago in the IADC Study of 2013. Second, the fact that space debris will continue to increase even without new launches indicates that the number of space debris in orbit has already reached a tipping point where the number of space debris will continue to grow through a self-sustaining cascade of collisions. Thirdly, in reality, the situation will be worse than the no-launch baseline, as the increase in launch traffic will add even more objects into Earth orbit and further increase the risk of collision. This means that the Kessler syndrome will be much more easily triggered than the no-launch scenario. In this situation, the key to improve the orbital environment is to reduce the amount of existing debris by ADR.[78]

74 Oltrogge, D. L., Alfano, S., Law, C., Cacioni, A., & Kelso, T. S. (2018). A Comprehensive Assessment of Collision Likelihood in Geosynchronous Earth Orbit. *Acta Astronautica*, *147*, p. 316.

75 Ibid.

76 Shadbolt (2023), *supra* note 15, p. 13.

77 IADC (2023), *supra* note 23, p. 6.

78 JAXA (2023), *supra* note 29.

2.3 Overview of the Status of ADR and Issues relating to its Governance

The above section shows that the orbital environment is becoming unsustainable, and ADR is necessary to stabilise the space debris situation. ADR involves the removal of debris "using dedicated spacecraft that have been designed expressly for this purpose".[79] An end-to-end ADR operation consists of many components, including "launch, propulsion, proximity operations, rendezvous, contact (capture or attachment), and finally, deorbit or graveyard manoeuvre".[80] As ADR is challenging from a technological point of view, only a few spacefaring agencies have the potential capability to undertake these activities.[81] In recent years, Russia, the US, China and ESA have all engaged in rendezvous and proximity operations (RPO) where they manoeuvre one spacecraft to approach another spacecraft.[82] Rendezvous refers to a "process wherein two space objects (artificial or natural bodies) are intentionally brought close together through a series of orbital manoeuvres at a planned time and place".[83] Proximity operations refer to a "series of orbital manoeuvres executed to place and maintain a spacecraft in the vicinity of another space object (artificial or natural bodies) on a relative planned path for a specific time duration to accomplish mission objectives".[84] RPO technologies are often used for the docking of supply and crew change spacecraft with the crewed space stations, and these are also key enabling technologies for ADR missions.[85] Capturing a target debris object can be realised in various ways, such as the use of nets, harpoons, robotic arms, and magnetic docking plates.

One issue to be considered by ADR operators is the strategy of target selection. As there are various kinds of space debris in orbit, ranging from defunct spacecraft and rocket stages to debris fragments, which kind of space debris should be removed first? According to NASA, the selection of removal targets depends on the goal to be achieved: if the goal is to alleviate risks to the current fleet of operational satellites, then the removal of small but still damaging debris should be prioritised; if the goal is to stabilise the long-term growth of the debris population, then ADR techniques need

79 Shadbolt (2023), *supra* note 15, p. 32.

80 Liou, J. C. (2012). Active Debris Removal and the Challenges for Environment Remediation. *28th International Symposium on Space Technology*, p. 5. <https://ntrs.nasa.gov/citations/20120013266>.

81 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, OECD Publishing, p. 32.

82 Byers & Boley (2023), *supra* note 25, p. 343.

83 Sec. 3.12, ISO 24330: 2022 "Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices", published on 1 July 2022. For more discussion see Chapter 4 Section 4.2.3 *infra*.

84 Sec. 3.12, ISO 24330, ibid.

85 Ibid, pp. 343-344.

to focus on large, massive objects such as defunct rocket bodies and non-functional satellites.[86]

The general consensus of the international space community is that the priority of ADR should be given to the removal of large, massive objects located in congested orbital areas.[87] This is because the higher the spatial density, the higher the probability of collision events with other objects.[88] In addition, the greater the mass of the derelict objects, the greater the amount of debris fragments that can be produced once such objects explode or collide with other space debris, which can potentially cause rapid spikes in the space debris population.[89] As pointed out in the International Academy of Astronautics (IAA) *Situation Report on Space Debris* of 2016, catastrophic collisions involving large space objects in orbit will, within a few decades, become the dominant source of the debris population, as the fragments created by these collisions may trigger further catastrophic collisions.[90] The Report follows by submitting that "[t]he only way to prevent the on-set of collisional cascading is to prevent collisions between large derelicts which may be enabled through active removal of mass from orbit".[91] In addition, the removal of large objects is considered to be more technologically feasible and economically efficient than the removal of small objects.[92]

Calculations by scientists show that to maintain an orbital environment similar to that of the current situation, it is necessary to remove five to ten pieces of large space debris from congested orbits per year.[93] However, as the calculation is made on the assumption of the current launch traffic and a high compliance rate with post-mission disposal measures,[94] more large objects may need to be removed from orbit with the deployment of large

86 NASA Orbital Debris Program Office. Debris Remediation. <https://orbitaldebris.jsc.nasa.gov/remediation/>.

87 JAXA (2023), *supra* note 29. See also ESA. Active Debris Removal. <https://www.esa.int/Space_Safety/Space_Debris/Active_debris_removal>.

88 Ibid.

89 Ibid. Shadbolt (2023), *supra* note 15, p. 9.

90 Bonnal, C. & McKnight, D. S. (Eds.). (August 2017). *IAA Situation Report on Space Debris – 2016*, International Academy of Astronautics, p. 14.

91 Ibid.

92 May, C. (January 2021). Triggers and Effects of an Active Debris Removal Marketplace. *The Aerospace Corporation*, p. 2. See also Pulliam, W. (2011). *Catcher's Mitt Final Report of DARPA*. Defense Advanced Research Projects Agency (DARPA), p. 2: "Although the greatest threat to operational spacecraft stems from medium debris (defined as 5 mm – 10 cm), no reasonable solution was found to effectively remove this size of debris object. Compliance with existing international debris mitigation guidelines coupled with the pre-emptive removal of the sources of future medium debris, is by far the most cost-effective strategy."

93 JAXA (2023), *supra* note 29. ESA, *supra* note 87. See also UK. (8 February 2022). Statement at Scientific and Technical Sub-committee of the COPUOS: Space debris. <https://www.gov.uk/government/news/uk-statement-at-scientific-and-technical-sub-committee-of-the-committee-on-the-peaceful-uses-of-outer-space-copuos-space-debris>.

94 JAXA, ibid.

constellations and the continuous growth of the space debris population. Due to the self-sustaining generation of space debris, ESA's internal studies show that "continuous removal actions starting in 2060 will only have 75% of the beneficial effect compared to an immediate start".[95] Therefore, the international community can respond more effectively to the space debris problem by starting to engage in the removal of large objects from space. Section 2.3.1 will introduce the current efforts made towards debris removal and Section 2.3.2 will outline the issues relating to ADR that require an answer from international space law for their governance.

2.3.1 Current Status of ADR Missions

The above discussion introduces why space debris is an issue and the necessity of ADR to address this issue. At the moment, ADR activities are still in a nascent phase, but they are in the process of becoming a reality. As noted in the IADC ADR Statement:

> "Several IADC member agencies, as well as other organizations, are investigating techniques and technologies that have the potential to support debris removal, or are developing pioneering missions, although routine debris removal operations are unlikely to commence in the near future."[96]

To present an overview of the current status of ADR, several pioneering ADR missions will be introduced in the order of their (planned) mission launch time. This will start with two ADR technology demonstration missions using replica debris objects, which are the RemoveDebris mission and the ELSA-d mission. Then, four ADR missions to remove existing derelict objects from orbit will be introduced, including China's Shijian-21 mission launched in 2021 and three planned ADR missions initiated by the Japan Aerospace Exploration Agency (JAXA), ESA and the United Kingdom (UK) Space Agency to be launched in the coming years.

Launched in 2018, RemoveDebris was the first mission to successfully demonstrate in orbit a series of ADR technologies. The mission was developed by a consortium led by the Surrey Space Centre, and the consortium members included Airbus Defence and Space, Surrey Satellite Technology Ltd (SSTL), and other partners.[97] The mission used a satellite platform (approximately 100 kg) as a mothercraft from which two CubeSats were

95 ESA, *supra* note 87.

96 IADC (2022), *supra* note 3, p. 1.

97 Surrey Space Center. RemoveDEBRIS. <https://www.surrey.ac.uk/surrey-space-centre/missions/removedebris>. For more details of the RemoveDEBRIS mission see Aglietti, G. S., Taylor, B., Fellowes, S., Ainley, S., Tye, D., Cox, C., Zarkesh, A., Mafficini, A., Vinkoff, N., Bashford, K., Salmon, T., Retat, I., Burgess, C., Hall, A., Chabot, T., Kanani, K., Pisseloup, A., Bernal, C., Chaumette, F., Pollini, A., & Steyn, W. H. (2020). RemoveDEBRIS: An In-Orbit Demonstration of Technologies for the Removal of Space Debris. *The Aeronautical Journal*, *124*(1271), pp. 1-23

ejected to be used as pseudo-debris targets.[98] After deployment, the mothercraft undertook four experiments: a net capture experiment, a vision-based navigation (VBN) experiment, a harpoon experiment, and a dragsail experiment for end-of-mission deorbiting of the platform.[99] The first three missions were successfully completed. The net and the harpoon were both proven as viable methods to capture space debris.[100] The VBN experiment tested technologies for the observation of debris and the determination of its distance and spin rate.[101] The drag-sail experiment was used to test post-mission disposal techniques.[102] Though some anomalies were manifested in this final experiment, the whole process from development to operation had provided important lessons which later enabled the successful production and operation of a new generation of drag-sails.[103] The mission was a success both in technological demonstration and in raising awareness of the issue of space debris in the general public.[104]

ELSA-d (End of Life Services by Astroscale-demonstration) is a technology demonstration mission performed by Astroscale, a leading ADR company founded in 2013 and headquartered in Japan.[105] Astroscale aims to contribute to debris removal through the provision of two kinds of services: end-of-life (EOL) and ADR.[106] The EOL service concerns the removal of future-launched spacecraft equipped with a docking plate (DP) for semi-cooperative removal, which targets the commercial large constellation market and its primary clients will be commercial satellite operators.[107] The ADR service concerns the removal of existing objects in space that are fully non-cooperative.[108] The primary target clients of the ADR service will be public actors since most of the existing debris objects "are the result of institutional missions and thus will be a market driven by governments and space agencies".[109]

Launched in March 2021, the aim of the ELSA-d mission is to demonstrate technologies and capabilities critical to EOL and ADR, including client

98 Saunders, C. (9 February 2015). RemoveDebris Mission: Briefing to UNCOPUOS. <https://www.unoosa.org/pdf/pres/stsc2015/tech-42E.pdf>.
99 Aglietti *et al.* (2020), *supra* note 97, p. 4.
100 Ibid, p. 20.
101 Ibid.
102 Ibid.
103 Ibid, pp. 20-21.
104 Shadbolt (2023), *supra* note 15, p. 32.
105 Astroscale. About. <https://astroscale.com/about-astroscale/about/>.
106 Weeden, C., Blackerby, C., Forshaw, J., Martin, C., Lopez, R., Yamamoto, E., & Okada, N. (2019). Development of Global Policy for Active Debris Removal Services. *First International Orbital Debris Conference*, p. 2.
107 Ibid.
108 Blackerby, C., Okamoto, A., Fujimoto, K., Okada, N., Forshaw, J. L., & Auburn, J. (2018). ELSA-d: An In-Orbit End-of-Life Demonstration Mission. In *69th International Astronautical Congress*, p. 1.
109 Weeden *et al.* (2019), *supra* note 106, pp. 1-2.

search, inspection, rendezvous, non-tumbling and tumbling docking, and de-orbit.[110] The mission consists of two satellites – a servicer satellite and a client satellite, with the latter servicing as a piece of replica debris installed with an Astroscale DP that enables magnetic docking.[111] The technologies tested in the ELSA-d program will be applied in Astroscale's other programs such as ELSA-M (End-of-Life Services by Astroscale-Multi), which is a commercial EOL service under development to capture and remove multiple satellites equipped with DPs in a single mission.[112]

While the above RemoveDebris and ELSA-d missions both target replica debris, the removal of existing debris from orbit has also been achieved. In October 2021, China launched the Shijian-21 satellite, which two months later approached and docked with a defunct Beidou-2 G2 navigation satellite.[113] In January 2022, Shijian-21 performed an engine burn, towing Beidou-2 G2 about 3000 km above the GEO belt, which is a very high orbit beyond the usual "graveyard" orbit of 300 km above GEO, and thus effectively moved the defunct satellite out of harm's way.[114] Shijian-21 then undocked from Beidou-2 G2 and returned back to GEO.[115]

While Shijian-21 was developed by China's State-owned company Chinese Aerospace Science and Technology Corporation (CASC),[116] the ADR projects planned by JAXA, ESA and the UK Space Agency involve more participation of the private sector. The Commercial Removal of Debris Demonstration (CRD2) is a JAXA program to actively remove large debris of Japanese origin in cooperation with private companies.[117] It aims to acquire ADR technologies to address the increasingly critical problem of space debris and to support the commercial activities of Japanese companies in the ADR market.[118] The CRD2 program will be carried out in two

110 Astroscale. (2022). ELSA-d Press Kit 2022, p. 4. <https://astroscale.com/wp-content/uploads/2022/02/ELSA-d-Press-Kit-2022-Lo-Res.pdf>.

111 Ibid.

112 Astroscale. ELSA-M. <https://astroscale.com/elsa-m>.

113 Jones, A. (27 January 2022). China's Shijian-21 Towed Dead Satellite to a High Graveyard Orbit. *SpaceNews*. <https://spacenews.com/chinas-shijian-21-spacecraft-docked-with-and-towed-a-dead-satellite/>.

114 Ibid. See also Byers & Boley (2023), *supra* note 25, p. 314.

115 Ibid.

116 Zhao, L. (25 October 2021). Satellite to Facilitate Space Debris Oversight. *China Daily*. <https://www.chinadaily.com.cn/a/202110/25/WS617603faa310cdd39bc70f2f.html>. CASC is a Chinese State-owned enterprise and the main contractor of China's governmental space programs. See CASC. About. <http://english.spacechina.com/n16421/index.html>.

117 JAXA. CRD2. <https://www.kenkai.jaxa.jp/eng/crd2/>.

118 Ibid.

phases.[119] Astroscale has been selected as the contractor for Phase-I of the program, which plans to launch its ADRAS-J (Active Debris Removal by Astroscale-Japan) satellite in 2023 to rendezvous with a discarded Japanese rocket upper stage, demonstrate proximity operations and acquire images of the target.[120] CRD2 Phase-II consists of the capture and removal of the target debris object and it will be launched in 2026.[121]

The ClearSpace-1 mission was procured by ESA in 2020 with a consortium led by Swiss startup ClearSpace to de-orbit an ESA-owned item of debris from space.[122] The mission is scheduled to be launched in 2025 and the target is a Vespa (Vega Secondary Payload Adapter) upper part with a mass of 112 kg.[123] The selected target is close in size to a small satellite and its relatively simple shape and sturdy construction make it an appropriate first goal, before progressing to more complex missions such as multi-object capture.[124] The ClearSpace-1 servicer is a medium-sized spacecraft equipped with four tentacles large enough to embrace and grip the target.[125] In addition to the removal of space debris and the verification of relevant technologies, the ClearSpace-1 mission also aims to "open a new market for in-orbit servicing and debris removal".[126] As ESA explains, paying for a service contract rather than directly procuring and running the entire mission represents a new business approach of ESA, which is intended as the first step towards establishing a new commercial space sector.[127]

The UK's first national space debris removal mission is planned to be launched in 2026. In October 2021, the UK Space Agency announced "a range of different initiatives aimed at supporting safe and sustainable

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119 For a detailed discussion of the CRD2 program see Yamamoto, T., Matsumoto, J., Okamoto, H. Yoshida, R., Hoshino, C., & Yamanaka, K. (2021). Pave the way for Active Debris Removal Realization: JAXA Commercial Removal of Debris Demonstration (CRD2). In *Proceedings of 8th European Conference on Space Debris*, pp. 1-8.

120 Astroscale. (22 August 2022). Astroscale Selected as Contract Partner for Front-Loading Technology Study in Phase II of JAXA's Commercial Removal of Debris Demonstration Project. <https://astroscale.com/astroscale-selected-as-contract-partner-for-front-loading-technology-study-in-phase-ii-of-jaxas-commercial-removal-of-debris-demonstration-project/>.

121 Henry, C. (12 February 2020). Astroscale Wins First Half of JAXA Debris-Removal Mission. *SpaceNews*, <https://spacenews.com/astroscale-wins-first-half-of-jaxa-debris-removal-mission/>.

122 ESA. (2020). ESA Purchases World-First Debris Removal Mission from Start-up. <https://www.esa.int/Safety_Security/ESA_purchases_world-first_debris_removal_mission_from_start-up>.

123 Ibid.

124 Ibid.

125 Biesbroek, R., Aziz, S., Wolahan, A., Cipolla, S. F., Richard-Noca, M., & Piguet, L. (2021). The ClearSpace-1 Mission: ESA and ClearSpace Team up to Remove Debris. In *Proceedings of 8th European Conference on Space Debris*, p. 2.

126 Ibid, p. 1.

127 ESA (2020), *supra* note 122.

space operations", including the research of a UK mission to clear hazardous space junk.[128] In September 2022, the UK Space Agency awarded £4 million to two UK companies, namely ClearSpace UK (the UK subsidiary of ClearSpace) and Astroscale UK (the UK and European subsidiary of Astroscale), for the design of missions to remove two defunct UK-registered satellites from LEO.[129] This design phase will finish with a preliminary design review, and upon its completion, the two companies, along with other industry partners, will receive further funding for developing this UK ADR mission.[130]

Besides the above missions and mission plans, NASA also has research projects under way for ADR technologies.[131] All these initiatives indicate a fast-growing concern about the increased collision risks resulting from the growth of space debris which may, in turn, lead to the further creation of space debris. This concern motivates States and space agencies to invest in ADR technologies and develop ADR missions. Driven by the common interest to preserve space sustainability, the international community may be able to prevent the "tragedy of the commons" from happening in space. The current missions represent a good start, but more efforts are needed, which will be discussed in the next section.

2.3.2 Issues relating to the Governance of ADR

It can be seen from the above ADR missions that China, JAXA, ESA and the UK Space Agency have all chosen massive objects as their mission targets, being either a defunct satellite, a discarded rocket stage, or in the case of ClearSpace-1, an item of debris close in size to a small satellite. Their target selection strategies indicate that ADR missions will start with the removal of large debris, which is in line with the aforementioned consensus view of the space community that ADR activities should prioritise the removal of large and massive objects, as they are the major source of fragmentation debris in the long term. Since large objects are usually tracked and catalogued, it is easier to identify their owners to address the relevant legal issues regarding their removal.

It was predicted by Masson-Zwaan and Hofmann in 2019 that the first ADR missions would likely focus on objects owned by the institutions aiming at

128 UK Space Agency. (26 October 2021). Press Release: UK Working with Global Partners to Clear up Dangerous Space Debris. <https://www.gov.uk/government/news/uk-working-with-global-partners-to-clear-up-dangerous-space-debris>.

129 UK Space Agency. (26 September 2022). UK Builds Leadership in Space Debris Removal and In-Orbit Manufacturing with National Mission and Funding Boost. <https://www.gov.uk/government/news/uk-builds-leadership-in-space-debris-removal-and-in-orbit-manufacturing-with-national-mission-and-funding-boost>.

130 Ibid.

131 Byers & Boley (2023), *supra* note 25, p. 315.

removing them.[132] The ADR missions mentioned earlier affirm this prediction, as all these missions choose targets that are owned or registered by the institutions engaging in or procuring the missions. This could help to avoid some complex legal questions such as jurisdiction and ownership.[133] However, there is no guarantee that every State, or space agency, will effectively remove its own debris. With the growing congestion in Earth orbit and the increasing necessity of ADR activities to stabilise the orbital environment, the removal of a space object under the jurisdiction of another State may need to be contemplated in the future. For instance, an operator of a large constellation may be interested in keeping a certain orbital plane free of debris to safeguard the safety of its satellites, for a collision caused by a debris item to one satellite may lead to knock-on collisions involving other satellites in the constellation, putting at stake the operator's investment.[134] As opined by Ted Muelhaupt, no one has a higher vested interest in keeping their orbits clean than operators of large constellations.[135] Owing to such interest, States with projects to deploy large constellations in space such as China can have a strong impetus to clear the orbits for the safe operation of their constellations.[136] With space becoming increasingly congested in the future, it can also be expected that States would wish to remove dangerous debris of other States when such debris threatens their key assets in space. Therefore, questions may arise as to the legal status of space debris, which State can exercise jurisdiction over debris objects to determine issues relating to their removal, and whether a State may remove a debris object under the jurisdiction of another State. How these issues are addressed under the current legal regime will be assessed in the next chapter.

As mentioned earlier, around five to ten large objects need to be removed from space per year to stabilise the orbital environment. The leading ADR missions demonstrate a promising trend towards space debris remediation, but it is still uncertain whether ADR missions will be conducted at a sufficient rate to halt the growth of space debris. In addition, while ADR is indispensable for a stable orbital environment, what is even more important is space debris mitigation, for if the future growth of space debris cannot be

132 Masson-Zwaan, T. L. & Hofmann, M. (2019). *Introduction to Space Law*. Wolters Kluwer, p. 119.

133 Ibid.

134 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. 11.

135 Werner, D. (15 November 2018). Will Megaconstellations Cause a Dangerous Spike in Orbital Debris? *SpaceNews*, <https://spacenews.com/will-megaconstellations-cause-a-dangerous-spike-in-orbital-debris/>.

136 China currently has plans for two large constellation projects, namely the 13,000-satellite Guowang (SatNet) project and the 12,000-satellite G60 Starlink project. See e.g., Jones, A. (29 December 2023). First Satellite for Chinese G60 Megaconstellation Rolls off Assembly Line. *SpaceNews*. <https://spacenews.com/first-satellite-for-chinese-g60-megaconstellation-rolls-off-assembly-line/>.

effectively mitigated, most of the required ADR effort would go to compensate for the generation of new debris.[137] Therefore, it is essential to ensure that States undertake appropriate measures to limit the creation of new space debris. Moreover, the existence of an obligation of debris mitigation is logically connected to that of debris remediation because if there is no legal duty to prevent the creation of space debris, then by extension, it would be difficult to argue that there exists an obligation to actively remove space debris.[138] These raise the question as to whether the current international legal framework governing space activities requires States to mitigate and remediate space debris.

All ADR techniques require some level of interaction with a space debris object, and this involves inherent risks of collision, especially during the RPO and contact phases where the distance between the removal spacecraft and the target debris object is relatively small. In particular, it should be noted that most existing debris objects are non-cooperative, meaning that they have neither the ability to communicate with the removal spacecraft nor dedicated interfaces for capture and physical connection.[139] In addition, the target debris objects are possibly tumbling, which makes it even more challenging to capture them.[140] In the worst case, the removal spacecraft could collide with the target debris object, which may create a debris cloud that closes off a valuable orbit for decades.[141] This debris cloud may cause damage to other spacecraft in orbit and accelerate the Kessler Syndrome.[142]

A further risk is that in an ADR operation, the removal spacecraft may need to change trajectories more frequently and on a larger scale than many other conventional space missions to approach, capture and remove the target debris object from congested orbital areas.[143] The need to cross orbits on the way up or down can increase the risk of collision with other objects in

137 ESA, *supra* note 87.

138 Mudge, A. G. (2022). Incentivizing 'Active Debris Removal' Following the Failure of Mitigation Measures to Solve the Space Debris Problem: Current Challenges and Future Strategies. *Air Force Law Review*, *82*(1), p. 123.

139 May, C. (2021). Triggers and Effects of an Active Debris Removal Marketplace. *The Aerospace Corporation*, p. 5.

140 Ibid.

141 Buckley, K. (2022). Active Debris Removal Rule No. 1 Must be "Do No Harm". *Aerospace America*. <https://aerospaceamerica.aiaa.org/departments/active-debris-removal-rule-no-1-must-be-do-no-harm/>.

142 Ibid.

143 Sec. 4.3.1, Japanese *Guidelines on a License to Operate a Spacecraft Performing On-Orbit Servicing*, published on 10 November 2021 by the National Space Policy Secretariat of the Cabinet Office of Japan. <https://www8.cao.go.jp/space/english/stm/index.html>. This document will be discussed in more detail in Chapter 5 Section 5.2.3.

orbit.[144] Like collisions between the removal spacecraft and the target debris object, collisions with objects of third parties could also trigger a chain reaction of further cascading collisions. Therefore, as submitted by Buckley, the primary rule for ADR activities should be to "do no harm", otherwise these activities may deteriorate rather than remediate the current space debris situation.[145] In addition, when the target of removal is a massive object in LEO, its de-orbiting may likely cause damage to the ground if such object cannot completely burn up in the process of atmospheric re-entry. In light of the inherent risks involved in ADR activities, the international liability regime for damage caused by these activities should be examined. The questions include whether and how liability can be established for the damage caused to other spacecraft, for damage caused on the ground, and for the generation of debris fragments that subsequently cause further damage to others.

Besides safety risks, ADR activities may also involve security risks due to the dual-use potential of the ADR spacecraft. As stated in a Report published by the UN Secretary-General in 2021:

> "Dual-use co-orbital systems include on-orbit servicing and active debris removal. On-orbit servicing satellites can refuel, repair and extend the life of other satellites. Active debris removal systems are intended to deorbit non-operational satellites. On-orbit demonstrations of the latter systems have used nets, harpoons, magnets or robotic arms. While such systems are regarded as important for ensuring the sustainability of outer space activities, such capabilities are inherently of dual use and could be used to damage, degrade or destroy a satellite."[146]

Due to its dual-use potential, the removal spacecraft may become a source of security concern. The European Union (EU) states that operations employing dual-use technologies such as ADR may be perceived as a threat and be (mis-)understood as hostile actions, especially in scenarios where "the intention behind the manoeuvre is not properly communicated".[147] Similarly, the view of the UK is that while ADR capabilities "offer significant opportunities to improve the space environment", these capabilities

144 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, p. 32.

145 Buckley (2022), *supra* note 141.

146 UN Doc. A/76/77 (13 July 2021), Report of the UN Secretary-General on Reducing space threats through norms, rules and principles of responsible behaviours ("UNSG Report of 2021"), p. 6.

147 The EU. (13 September 2022). Open Ended Working Group on reducing space threats through norms, rules and principles of responsible behaviours – EU Statement. <https://www.eeas.europa.eu/delegations/un-geneva/open-ended-working-group-reducing-space-threats-through-norms-rules-and_en?s=62>.

could be repurposed to attack a satellite.[148] In view of the dual-use character of ADR technologies and capabilities, it is important to understand how military activities are regulated under the current international legal framework for space activities and how this may impact ADR activities, as well as whether there are guidelines and principles to address the dual-use concerns over ADR.

2.4 Chapter Conclusion

Space debris refers to non-functional, human-made objects that are in Earth orbit or re-entering the atmosphere, such as rockets and satellites that have completed their missions, as well as objects that are fragmented or disintegrated from rockets and satellites. These debris objects are flying around the Earth at high speed and, because of their velocity, they pose collision risks to operational satellites and crewed spacecraft. Once a collision occurs, more space debris could be created, which can further worsen the orbital environment, especially when catastrophic collisions are concerned where massive objects are fragmented into pieces. This self-sustained cascading collision process is known as the Kessler syndrome, and it can lead to the run-away growth of space debris. Space debris mitigation is important to limit the generation of new debris, but this alone is not sufficient to stabilise the orbital environment, as even in the scenario of no future launches, the debris population will continue to grow. The problem is complicated by the deployment of large constellations consisting of hundreds and thousands of satellites in orbit, which can further increase orbital congestion and collision risks. To counteract the trend of the Kessler syndrome, ADR operations are needed to remove massive derelict objects from orbit before they become a future source of more debris. Some projects are currently taking place, but there is still a long way to go to reach the goal of removing five to ten large objects from space per year. As space debris is becoming a pressing issue, this dissertation will assess *whether the current international framework governing space activities imposes an obligation on States to mitigate and remove space debris.* [*Issue 1*].

ADR operations involve inherent risks of collision due to the technical complexity of these operations, and collisions may occur either between the removal spacecraft and the target debris object, or between these objects with space objects of third parties. The fragments generated by these collisions may cause subsequent damage. Therefore, it is important to understand *the international liability regime for damage caused as a result of space activities and the implications of this regime on ADR activities*. [*Issue 2*]

148 The UK. (14 September 2022). Statement by the United Kingdom at the 2nd session of OEWG. <https://meetings.unoda.org/meeting/57866/statements>.

An examination of the leading ADR missions shows that States and space agencies are currently focusing on the removal of their own space debris. The growing amount of space debris and the increasing congestion in Earth orbit can lead to a greater necessity for ADR operations, and the removal of space objects under the jurisdiction of another State may be needed in the future, such as when a State fails to effectively remove its dangerous debris. Therefore, the question is *whether the current legal regime allows the removal by one State of space debris under the jurisdiction of another State.* [*Issue 3*]

Finally, ADR technologies have an inherent dual-use nature, meaning that the technologies developed to remove debris, such as the robotic arm or other mechanisms designed to capture the target debris object, can also be used for hostile purposes such as to damage and destroy operational satellites of other States. Therefore, a key issue to consider is *how the current legal framework addresses the dual-use potential of ADR activities.* [*Issue 4*]

These four issues will be discussed in the following three chapters, including how these issues are regulated under the UN space treaties and general international law (Chapter 3), what is the contribution of non-legally binding instruments to the governance of these issues (Chapter 4), and how the current international legal framework for space activities may move forward to better address these issues (Chapter 5).

3 Application of the Hard Law Pillar to Space Debris and ADR

The previous chapter outlined four legal issues relating to space debris and ADR, namely (1) whether States have an obligation under the current legal framework to mitigate and remediate space debris; (2) what is the potential liability for damage caused as a result of ADR operations; (3) whether States are allowed to remove space debris of another State; and (4) how the dual-use potential of ADR systems is addressed under the current framework.

This chapter aims to examine how the UN space treaties and general international law address the above four issues and whether there are legal gaps for their regulation. As noted in Chapter 1, the term "space debris" is not mentioned in the UN space treaties, as space debris was not a serious issue at the time when these treaties were concluded. However, the silence in the text of the UN space treaties on this matter does not mean that they do not apply to the regulation of space debris. These treaties lay the foundations for the orderly conduct of space activities and they contain provisions that are relevant to the issue of space debris.[1] Also, international law is applicable to space activities by virtue of Article III of the Outer Space Treaty, which also contains rules and principles that can apply to the governance of space debris.

Sections 3.1 to 3.4 will discuss, respectively, how the above four issues are regulated under the UN space treaties and general international law. Section 3.1 will discuss whether the current international legal framework for space activities imposes a duty upon States to mitigate and remove space debris. Section 3.2 will discuss the liability regime established in the UN space treaties, including whether and how this liability regime applies to damage caused by space debris, and how this regime may affect ADR activities. Section 3.3 will assess the jurisdiction and ownership over space objects and the potential legal and political ramifications if a State removes a debris object under the jurisdiction of another State without prior consent. Section 3.4 will discuss the restrictions posed by the current legal regime on military activities in outer space and how these restrictions are relevant to the use of ADR technologies. Section 3.5 will provide the conclusions of this chapter.

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1 Masson-Zwaan, T. L. (2017), Legal Aspects of Space Debris. In Bonnal, C., & McKnight, D. S. (Eds.). (2017). *IAA Situation Report on Space Debris* – 2016. International Academy of Astronautics, pp. 145-146.

3.1 *Issue 1*: Obligation of Debris Mitigation and Remediation

This section will address the question as to whether the hard law pillar of international space law imposes an obligation on States to mitigate and remediate space debris. Sections 3.1.1 and 3.1.2 will discuss the relevance of some fundamental principles in the Outer Space Treaty for the governance of space debris, namely the principle of the freedom of exploration and use of outer space and the province of all mankind principle and under Article I of the OST, as well as the non-appropriation principle under Article II of the OST. Section 3.1.3 will examine Article IX of the OST, which is the most environmentally relevant provision in the UN space treaties. It will assess the concept of "due regard" and its application to the reduction of space debris, discuss whether the creation of space debris can be regarded as "harmful contamination", and analyse the consultation mechanism in the event of potentially harmful interference with space activities of other States. As Article III of the OST provides that space activities should be carried out in accordance with international law, Section 3.1.4 will assess the principle of prevention, which is regarded as a cornerstone of international environmental law, and discuss the application of this principle to space debris. Finally, Section 3.1.5 will discuss the international responsibility of States for national space activities under Article VI of the OST, which can serve as a basis for States to develop national space legislation to transpose their treaty obligations into their national legal order.

3.1.1 The Freedom of Exploration and Use of Outer Space and the Province of All Mankind Principle

The international framework for the regulation of space activities set out in the UN space treaties can be characterised as "a system of freedoms and limitations".[2] The fundamental principle for the conduct of space activities is the freedom of exploration and use of outer space as enshrined in Article I paragraph 2 of the Outer Space Treaty:[3]

> "Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies."

The ordinary meaning of "exploration" is "the activity of searching and finding out about something", and "use" means "to put something such

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. 6.

3 Viikari, L. (2008). *The Environmental Element in Space Law: Assessing the Present and Charting the Future*. Brill Nijhoff, p. 58.

as a tool, skill, or building to a particular purpose".[4] The two concepts are connected in that exploration can include a process to find out whether any subsequent use is possible.[5] As interpreted by Hobe, the term "use" should be understood broadly, meaning that "[a]ll kinds of activities that purport to make use of space in one way or another, including launching activities on Earth or the usage of satellites, may be covered by the legal regime of the use of outer space".[6] Therefore, in outer space, the "freedom to operate is the baseline rule".[7] This freedom is not unfettered but subject to restrictions under international law. Indeed, some restrictions are contained in paragraph 2 itself. The freedom should be exercised in accordance with the principle of equality, which can be interpreted as requiring States to take into account the opportunities of other States, especially the latecomers into the space field, to explore and use outer space. Also, space activities should be carried out in accordance with international law, which is further elaborated in Article III of the Outer Space Treaty. Moreover, since the freedom is granted to all States without discrimination of any kind, this right entails in itself an obligation to respect the enjoyment and exercise of the same freedom by others.[8]

A further qualification of the freedom of exploration and use of outer space can be found in Article I paragraph 1:

> "The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind."

This provision reflects the preamble of the Outer Space Treaty and prescribes the overall purpose and nature of the use and exploration of outer space. As the concepts of "for the benefit and interests of all countries" and "province of all mankind" are not clearly defined in the Outer Space Treaty and subsequent space treaties, the specific meaning of these concepts is subject to interpretation. Masson-Zwaan submits that these concepts convey a general message that "the use of space should somehow benefit humankind".[9] Viikari submits that by establishing space activities as the province of all humankind and not of a single State, the provision "urges, albeit in a rather general way, responsible behavior on the part of all users of outer space".[10] Von der Dunk observes that these concepts could "serve

4 Cambridge Dictionary. Available at: <https://dictionary.cambridge.org/dictionary/english/>.
5 Hobe, S. (2009). Article I. In *CoCoSL Vol. 1*, Heymann, p. 34.
6 Hobe, ibid, p. 35.
7 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. 60.
8 Masson-Zwaan (2017), *supra* note 1, p. 140.
9 Ibid.
10 Viikari (2008), *supra* note 3, p. 59.

as a check (or at least the possibility of creating such checks) on unfettered unilateral usage of outer space to the detriment of all others".[11] These observations point to the direction that States should carry out their space activities in a reasonable manner, bearing in mind that they are neither the sole users of outer space nor the sole beneficiaries of the use of outer space.

As noted in a 2022 White Paper published by Working Group 1 of the Net Zero Space initiative, the general principles contained in Article I of the Outer Space Treaty are threatened by the dangerous growth of space debris, as this greatly jeopardises the potential of current and future generations to benefit from the use and exploration of outer space.[12] Therefore, it could be argued that the generation of space debris runs afoul of Article I of the OST because turning space into a junkyard is certainly not in the interest of all States, and the resulting congestion can hinder States from freely exploring and using outer space.[13] This is particularly so when considering that the growing amount of space debris puts at stake the long-term sustainability of outer space activities, and one may thus use Article I as a legal basis to argue that States should properly balance their interests and those of all others when undertaking space activities and make reasonable efforts to limit the creation of space debris. Yet, since according to the current technology level, the creation of space debris is not completely evitable in the course of space activities, it is difficult to derive from Article I a clear obligation to mitigate space debris.[14]

3.1.2 The Principle of Non-Appropriation of Outer Space

Article II of the Outer Space Treaty, which sets out the "non-appropriation" principle, is closely linked to the principles enshrined in Article I. It provides that:

> "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."

11 Von der Dunk (2015), *supra* note 7, p. 57.

12 Net Zero Space initiative Working Group 1 (Net Zero Space WG1). (November 2022). White Paper on "*Fostering Better and More Interoperable Norms: Comparing Existing Binding National Requirements Relating to Space Debris*" ("Net Zero Space WG1 White Paper"), p. 7. <https://www.netzerospaceinitiative.org/activities>. The Net Zero Space initiative will be discussed in more detail in Chapter 5 Section 5.1.4.

13 Gable, K. A. (2008). Rules Regarding Space Debris: Preventing a Tragedy of the Commons. *Proceedings of the Fiftieth Colloquium on the Law of Outer Space*, American Institute of Aeronautics and Astronautics (AIAA), p. 258. See also Jakhu, R. S. & Ahmad, M. T. (13 November 2017). The Outer Space Treaty and States' Obligation to Remove Space Debris: A US Perspective. *The Space Review*. <https://thespacereview.com/article/3370/1>.

14 Gable, ibid. See also Schladebach. (2013). Space Debris as a Legal Challenge. *Max Planck Yearbook of United Nations Law*, *17*(1), p. 69.

The primary intent of the non-appropriation principle is to reinforce Article I of the OST, in that the appropriation of (a part of) outer space by one State would encroach upon the freedom of other States to freely explore and use outer space and would go against the principle that space activities should be conducted for the benefit and in the interests of all countries.[15] As the proliferation of space debris undermines *de facto* the freedom to explore and use outer space, Force proposes that "occupation of an orbital position becomes appropriation when it is no longer being 'used' or capable of furthering a legitimate purpose".[16] Following this understanding, "indefinite non-use of space becomes appropriation when a space vehicle's useful life is ended".[17] Should this argument be upheld, States leaving defunct objects in orbit are under an obligation to remove them, otherwise this may constitute a breach of Article II of the OST. While this reading is advantageous to ADR advocates and can certainly be a direction for future legal development, it appears to go beyond the scope of what Article II prescribes.

As a matter of fact, "[a]ll objects will eventually be pulled back to Earth by friction with the Earth's atmosphere or by disturbances in the orbit", though the longer the distance between such object and the Earth is, the longer such process will take.[18] Therefore, although a non-functional object can occupy one orbital slot, it is not always the same orbital slot that such object resides in. Rather, defunct objects are "scrambling" gradually towards the Earth at varying speeds according to their orbital altitude. As such, Bittencourt Neto describes space debris as "ghost spaceships" drifting in outer space in a state of limbo and waiting for their fate: be it collided, fragmented, or finally re-entering the atmosphere.[19] Due to this constant change of orbital position, it is difficult to argue that a defunct space object has physically "appropriated" a certain orbit.

Moreover, as Freeland and Jakhu submit, "[w]hat the Outer Space Treaty prohibits is an 'appropriation by use' but not 'use' of outer space, which is guaranteed".[20] This is reflected in the formulation of Article II, which prohibits "national appropriation … by means of use or occupation". The term "use" in Article II must be considered in conjunction with Article I, which

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15 Freeland, S. & Jakhu, R. (2009). Article II. In *CoCoSL Vol. 1*, p. 58.

16 Force, M. K. (2014). When the Nature and Duration of Space Becomes Appropriation: "Use" as a Legal Predicate for a State's Objection to Active Debris Removal. *Proceedings of the International Institute of Space Law 2013*, Eleven International Publishing, pp. 413-414.

17 Ibid, p. 419.

18 Masson-Zwaan, T. L. & Hofmann, M. (2019). *Introduction to Space Law*. Wolters Kluwer, p. 111.

19 Bittencourt Neto, O. de O. (2015). Chasing Ghost Spaceships: Law of Salvage as Applied to Space Debris. *Proceedings of the International Institute of Space Law 2014*, Eleven International Publishing, p. 153.

20 Freeland & Jakhu (2009), *supra* note 15, p. 58.

grants the freedom of use and exploration of outer space.[21] Read together, what Article II means is that "no amount of use of outer space will ever suffice to justify, from a legal viewpoint, a claim of" sovereignty over the whole or any part of outer space.[22] This reading is in line with the object and purpose of Article II, which, as reiterated by the US delegate to COPUOS in 1969, is to "prohibit a repetition of the race for the acquisition of national sovereignty over overseas territories" that developed in the past. Hence, the Outer Space Treaty "makes clear that no user of space may lay claim to, or seek to establish, national sovereignty over outer space".[23] In this sense, outer space is not subject to appropriation by way of use. The same reasoning is also applicable to occupation, which means that no amount of "occupation" of (a part of) outer space can justify an establishment of national sovereignty.[24] Creating a defunct object in the use of outer space does not mean that the State of registry has an intention to claim territorial jurisdiction or proprietary rights over a certain orbital spot. Should there be such an intention, the State concerned should at least use a spacecraft with the capability of station-keeping, instead of a debris object that is not controllable and decays naturally.

Considering that the continuous growth of space debris threatens the long-term sustainability of space activities, one may argue that Article II requires States "not to discard space debris to such an extent that outer space no longer can be used by all".[25] However, even this interpretation may encounter some difficulties in application, for the current space debris situation is not caused by any individual event but is the result of a cumulative process of human activities in outer space for over six decades. Therefore, although Article II sets forth a fundamental principle of space law prohibiting the establishment of sovereignty over outer space, it seems difficult to read from this Article a concrete obligation to mitigate and remove space debris.

3.1.3 Environmental Protection of Outer Space under the Outer Space Treaty

Article IX is the most fundamental article pertaining to environmental protection in the UN space treaties.[26] It consists of four sentences: the first two sentences codify several principles for carrying out activities in outer space, and the remaining two sentences deal with consultation in the event of potentially harmful interference.[27]

21 Ibid, p. 53.
22 Ibid.
23 Ibid. Cited from Valters, E. N. (1970). Perspectives in the Emerging Law of Satellite Communications. *Stanford Journal of International Studies*, *5*, p. 66.
24 Ibid, p. 54.
25 Gable (2008), *supra* note 13, p. 259.
26 Marchisio, S. (2009). Article IX. In *CoCoSL Vol. 1*, p. 170.
27 Ibid.

3.1.3.1 International Cooperation and Due Regard

Sentence 1 of Article IX of the Outer Space Treaty provides that:

> "In the exploration and use of outer space, including the moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty."

This provision sets out two principles for the carrying out of space activities, namely the principle of international cooperation and the principle of due regard. The former principle has been further elaborated in the *Space Benefits Declaration*.[28] The second paragraph of this Declaration provides that:

> "States are free to determine all aspects of their participation in international cooperation in the exploration and use of outer space on an equitable and mutually acceptable basis. Contractual terms in such cooperative ventures should be fair and reasonable and they should be in full compliance with the legitimate rights and interests of the parties concerned, as, for example, with intellectual property rights."

This indicates that States are not under an obligation to enter into international cooperation but can freely determine their partners and means of cooperation on fair, equitable and mutually agreed conditions.[29] This principle could serve as a basis for States to conclude bilateral, multilateral, regional or global cooperative agreements and arrangements to remove dangerous debris objects out of congested orbital areas.

As to "due regard", the notion was first used in international air law, which imposes a duty of due diligence upon operators of State and military aircraft to ensure the safety of the navigation of civil aircraft.[30] The principle of due regard also appears in several provisions in the United Nations Convention on the Law of the Sea (UNCLOS).[31] For instance, Article 87(2) of the UNCLOS requires States to exercise their freedom of the high seas "with due regard for the interests of other States in their exercise of the freedom on the high seas". This general principle means that one State's exercise of its freedoms should avoid interfering with another State's enjoyment of its

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28 UN Doc. A/RES/51/122 (13 December 1996). Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries ("Space Benefits Declaration").

29 Salmeri, A. (2020). Developing and Managing Moon and Mars Settlements in Accordance with International Space Law. In *Proceedings of the 71st International Astronautical Congress 2020*. International Astronautical Federation, p. 6.

30 Marchisio (2009), *supra* note 26, p. 175.

31 United Nations Convention on the Law of the Sea (UNCLOS), adopted 10 December 1982, entered into force 16 November 1994, 1833 UNTS 3.

rights.[32] Similarly, in the space law context, the due regard principle functions as a limitation to the freedom of exploration and use of outer space granted under Article I of the OST.[33] The notion of "corresponding interests" denotes that there is no unfettered unilateral interest in outer space, which reflects the principle that the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all humankind.[34] In addition, the due regard principle can be interpreted in its context, which includes the rest of Article IX of the OST. A combined reading with the consultation clause in sentences 3 and 4 of Article IX implies that "due regard" means not to cause "potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space".[35] As such, the due regard principle requires States to make reasonable efforts to ensure that the exercise of their rights in outer space does not interfere with, or compromise the safety of, the space activities of other actors.[36]

In carrying out their space activities, a decisive interest of States consists in the interference-free exploration and use of outer space.[37] Since space debris poses risks of collision to space operations, the creation of space debris adversely affects the "corresponding interests" of all States.[38] Hence, the due regard principle can be read as imposing an obligation upon States to exercise due diligence and conduct space activities "with a certain standard of care, attention or observance" to limit the generation of space debris which may undermine the interests of other States.[39] As to the way to exercise "due diligence", reference can be made to the International Law Commission (ILC)'s *Draft Articles on the Prevention of Transboundary Harm from Hazardous Activities* of 2001 ("Draft Articles on Prevention").[40] This document has developed and explained the concept of "due diligence"

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32 Schrijver, N. (2022). Chapter 15: Law of the Sea. In Rose, C. *et al*. *An Introduction to Public International Law*. Cambridge University Press, p. 311.

33 Marchisio (2009), *supra* note 26, p. 175.

34 Ibid, p. 176.

35 Byers, M., & Boley, A. (2023). *Who Owns Outer Space? International Law, Astrophysics, and the Sustainable Development of Space.* Cambridge University Press, p. 106.

36 Ibid, p. 175. Viikari (2008), *supra* note 3, p. 60. See also Marboe, I. (2012), The Importance of Guidelines and Codes of Conduct for Liability of States and Private Actors. In Marboe, I. (Ed.), *Soft Law in Outer Space: The Function of Non-binding Norms in International Space Law*, Böhlau Verlag, p. 137.

37 Stubbe, P. & Schrogl, K.-U. (2015). The Legal Significance of the COPUOS SDM Guidelines. In Hobe S., Schmidt-Tedd, B., & Schrogl K.-U. (Eds.). *Cologne Commentary on Space Law Vol. 3* ("CoCoSL Vol. 3"). Heymann, p. 646.

38 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. 188.

39 Marchisio (2009), *supra* note 26, p. 175.

40 ILC. (2001). Draft Articles on Prevention of Transboundary Harm from Hazardous Activities, with commentaries. *Yearbook of the International Law Commission*, *2001*, vol. II, Part Two.

in some detail and its subject matter, i.e., the prevention of transboundary harm, is of direct relevance to the governance of space debris. The notion of "transboundary harm" is defined in the document as "harm caused in the territory of or in other places under the jurisdiction or control of a State other than the State of origin whether or not the States concerned share a common border".[41] The commentary to the Draft Articles on Prevention provides further elaboration on the meaning of "transboundary harm":

> "This definition includes, in addition to a typical scenario of an activity within a State with injurious effects on another State, activities conducted under the jurisdiction or control of a State, for example, on the high seas, with effects on the territory of another State or in places under its jurisdiction or control. It includes, for example, injurious impacts on ships or platforms of other States on the high seas as well."[42]

This elaboration indicates that transboundary harm includes the injurious effects caused by activities under the jurisdiction and control of one State to places under the jurisdiction and control of another State. As will be discussed later, Article VIII of the Outer Space Treaty provides that the State of registry retains jurisdiction and control over its space object. Hence, transboundary harm includes the injurious impacts caused by a spacecraft of one State to the spacecraft of another State, as they are under the jurisdiction and control of their respective registering States. In addition, outer space is expressly mentioned in the commentary to the Draft Articles on Prevention, which notes that in some instances, significant transboundary harm could occur when "there is no territorial link between a State and the activity [that causes the harm] such as, for example, activities taking place in outer space or on the high seas".[43] Therefore, the Draft Articles on Prevention are directly relevant to space activities.

The commentary to the Draft Articles on Prevention points out the dynamic character of due diligence:

> "What would be considered a reasonable standard of care or due diligence may change with time; what might be considered an appropriate and reasonable procedure, standard or rule at one point in time may not be considered as such at some point in the future. Hence, due diligence in ensuring safety requires a State to keep abreast of technological changes and scientific developments."[44]

The dynamic nature of the obligations to protect the environment is also reflected in the *Gabčíkovo-Nagymaros* judgment of the ICJ, where the Court

41 Art. 2(c), ibid.
42 Commentary to Art. 2, para. 9, ibid.
43 Commentary to Art. 1, para. 10, ibid.
44 Commentary to Art. 3, para. 11, ibid.

noted that "newly developed norms of environmental law are relevant for the implementation" of the Treaty concluded between Hungary and Slovakia in 1977 concerning the construction and operation of the Gabčíkovo-Nagymaros system of locks.[45] Similarly, the International Tribunal of the Law of the Sea (ITLOS) referred to "due diligence" as a "variable concept" which may change in light of new scientific and technological knowledge.[46] Following this line of reasoning, the duty of States to pay due regard to the rights and interests of others may also evolve with the advancement of space technologies. In the future, when reliable and cost-efficient ADR technologies become available, one may infer from the due regard principle a duty of States to actively remove their space debris from orbit in order to safeguard the corresponding interests of all States.[47]

The commentary to the Draft Articles on Prevention also notes that the economic and technical capabilities of the State concerned are factors to be taken into account in determining whether such State has fulfilled its obligation of due diligence.[48] Hence, the specific requirements imposed by the due regard principle upon a certain State should be determined in accordance with the specific circumstances of such State. Moreover, the required degree of care to exercise due diligence is proportionate to the degree of hazard involved, and therefore "[t]he standard of due diligence has to be more severe for the riskier activities".[49] As ADR activities generally involve higher risks than conventional space missions, under the due regard principle, States engaging in ADR operations should exercise a high degree of due diligence and take necessary measures to ensure that these operations are conducted in a way that does not endanger the spacecraft of other States.[50]

3.1.3.2 Avoidance of Harmful Contamination

Article IX Sentence 2 of the OST provides that:

> "States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose."

45 *Gabčíkovo-Nagymaros Project (Hungary/Slovakia), Judgment, I. C. J. Reports 1997*, para. 112.
46 *Responsibilities and obligations of States with respect to activities in the Area, Advisory Opinion, 1 February 2011, ITLOS Reports 2011*, para. 117.
47 Blount (2019), *supra* note 38, p. 188.
48 Commentary to Art. 3, paras. 12-14, Draft Articles on Prevention, *supra* note 40.
49 Commentary to Art. 3, paras. 11&18, ibid. See also *ITLOS Advisory Opinion of 2011*, *supra* note 46, para. 117.
50 Blount (2019), *supra* note 38, p. 183.

Sentence 2 addresses two sorts of contamination, namely forward contamination and backward contamination. As to backward contamination, only those "adverse changes in the environment of the Earth *resulting from the introduction of extraterrestrial matter*" are to be avoided. This qualification restricts its scope to pollution caused by foreign organisms or bacteriological substances which originate outside the Earth. Therefore, the re-entry of debris objects back to Earth would generally not be considered as a form of backward contamination in the context of Article IX of the OST due to their terrestrial origin.[51]

With regard to forward contamination, the term "harmful contamination" is not specified in the UN space treaties and many questions are left unanswered. In particular, a key question is what constitutes "contamination" and whether this concept includes space debris, a term not addressed in any of the UN space treaties. If the answer is affirmative, then to what extent should the creation of space debris be deemed as "harmful"? It should be recalled that due to their high speed in orbit, even a tiny piece of debris can potentially threaten space missions. The early consideration of the issue of contamination in COPUOS suggests that emphasis was placed on biological, chemical and radioactive contamination.[52] This is reflected in the 1959 Report of COPUOS where the Committee highlighted that "certain activities related to lunar and planetary impacts might result in biological, chemical, and radiation contamination" and recommended the continuation of studies to "minimize the adverse effects of possible biological, radiological, and chemical contamination".[53] The term "contamination" is also used in some space-related instruments in the context of biological and radioactive contamination. Sentence 2 of Article IX of the OST is expressly referred to in the Committee on Space Research (COSPAR) Policy on Planetary Protection as the basis for an international standard on procedures to avoid organic-constituent and biological contamination in space exploration.[54] The Nuclear Power Sources Principles of 1992 provide that the design and use of space objects with nuclear power sources on board shall "ensure with high reliability that radioactive material does not cause a significant contamination of outer space".[55]

While it is clear that the term "contamination" includes biological, chemi-

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51 Stubbe, P. (2017). *State Accountability for Space Debris: A Legal Study of Responsibility for Polluting the Space Environment and Liability for Damage Caused by Space Debris*. Brill, p. 147.

52 Marchisio (2009), *supra* note 26, p. 171.

53 UN Doc. A/4141 (14 July 1959). Report of the Ad Hoc COPUOS, p. 47. See also Marchisio, ibid.

54 COSPAR. (2021). *COSPAR Policy on Planetary Protection.* Approved by the COSPAR Bureau on 3 June 2021, p. 1. <https://cosparhq.cnes.fr/scientific-structure/panels/panel-on-planetary-protection-ppp/>.

55 UNGA Resolution 47/68 of 14 December 1992, *The Principles Relevant to the Use of Nuclear Power Sources in Outer Space*, Principle 3.

cal and radioactive contamination, the question is whether this term is confined to these forms of contamination, or whether it is broad enough to also cover the generation of space debris. The Outer Space Treaty does not provide a clear answer and the issue is contested among scholars. Some scholars argue that "harmful contamination" refers only to the introduction of biological, chemical and radioactive substances into outer space.[56] Some scholars raise a question mark by stressing the vagueness of the terms used in the provision and the lack of guidance on their meanings.[57] Other scholars submit that the term should be read broadly and cover space debris because they have adverse impacts on space activities.[58]

To answer this question, it is important to interpret the term "harmful contamination" in light of the object and purpose of Article IX. As observed by Cheng, "[t]he purpose which Article IX serves may be illustrated by the United States Project West Ford, which consisted in launching into orbit a belt of tiny dipoles (needles) around the earth".[59] This implies that contamination can extend to "the mere introduction of physical material into space".[60] In addition, during the drafting process of Article IX of the Outer Space Treaty, the delegation of the Soviet Union stated that:

> "The entire draft Treaty was based on the idea of co-operation among all States. That meant, inter alia, that States must refrain from any experiment likely to interfere with the space activities of other States; *article VIII* covered that contingency by establishing machinery for consultation, and also provided that States should avoid harmful contamination."[61]

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56 Reynolds, G. H. & Merges, R. P. (Eds.). *Outer Space: Problems of Law and Policy*. 2nd ed., Westview Press, 1998, p. 209. Citing from Stubbe, P. (2010). Common But Differentiated Responsibilities for Space Debris – New Impetus for a Legal Appraisal of Outer Space Pollution. *ESPI*, *31*, p. 7. Wheeler, J. (2014). Space debris: The legal issues. *Royal Aeronautical Society*: "Space debris is not normally classed as 'harmful contamination'; the phrase being usually construed as biological or radioactive contamination." <https://www.aerosociety.com/news/space-debris-the-legal-issues>.

57 Viikari (2008), *supra* note 3, p. 60: "the OST fails to give guidance in determining the meaning of both 'harmful contamination' and 'adverse change in the environment'."

58 Marchisio (2009), *supra* note 26, pp. 176-177: "The definition of harmful contamination appears to be a broad concept, covering all possible kinds, forms or instances of harmful interference in outer space, deliberate or unintentional alike. […] In this sense, space debris are a form of harmful contamination." Stubbe & Schrogl (2015), *supra* note 37, p. 645: "Art. IX sentence 2 OST should […] be construed as prohibiting the introduction of undesired, man-made objects into outer space. This also covers space debris, which are man-made objects that have lost their function." Alby, F., Alwes, D., Anselmo, L., Baccini, H., Bonnal, C., Crowther, R., Flury, W., Jehn, R., Klinkrad, H., Portelli, C., & Tremayne-Smith, R. (2004). The European space debris safety and mitigation standard. *Advances in Space Research*, *34*(5), pp. 1260-1261.

59 Cheng, B. (1997). *Studies in International Space Law*. Oxford University Press, pp. 256-257.

60 Stubbe & Schrogl (2015), *supra* note 37, p. 645.

61 UN Doc. A/AC.105/C.2/SR.57 (12 July 1966). COPUOS LSC Summary Record - 5th Session, 57th Meeting, p. 12, emphasis added.

The "*article VIII*" mentioned in the above statement refers to the draft article proposed by the Soviet Union on the avoidance of harmful contamination of outer space, which was later incorporated into Article IX of the Outer Space Treaty. This indicates that the underlying intention of the harmful contamination provision is to avoid interfering with the space activities of others. In addition, the perception of outer space as a scientific laboratory that needs to be protected from contamination for the purpose of future scientific missions – the so called "sci-lab perception" – is perceived as having permeated the drafting process of the Outer Space Treaty and especially Article IX.[62] In accordance with this sci-lab perception, the aim of the due regard principle is to preserve outer space as an area that can be freely explored and used by all. The purpose of avoiding harmful interference and preserving outer space for future use can only be upheld if Article IX is interpreted in an evolutive manner, as new forms of interference and new threats to space sustainability can emerge with the development of space technologies. Since space debris represents a critical threat to the current and future use of outer space, all the above considerations point to the direction that the inclusion of space debris into the scope of "contamination" is in line with the purpose of Article IX.

An important question is whether the ordinary meaning of the term "contamination" is broad enough to cover physical substances like space debris, as treaty interpretation cannot go beyond the ordinary meaning of the term to be interpreted. The word "contamination" is defined in the Merriam-Webster Dictionary as "a process of contaminating: a state of being contaminated".[63] The definition of the word "contaminate" includes, *inter alia*, "to make unfit for use by the introduction of unwholesome or undesirable elements".[64] The creation of space debris can be regarded as the introduction of undesirable elements into outer space as they serve no useful purposes, and in this sense space debris "contaminates" the space environment.

As Gable submits, the term "contamination" can be broadly read as including the "deposition of space debris", and there is indeed "nothing to suggest that such a reading necessarily would be improper".[65] Evidence in this regard can be found in the US Safety Drinking Water Act, where the term "contamination" refers to "any physical, chemical, biological, or radiological substance or matter in water", and physical contamination includes "sediments".[66] While this evidence is admittedly remote from

62 Stubbe & Schrogl (2015), *supra* note 37, pp. 644-645.
63 See <https://www.merriam-webster.com/>.
64 Ibid.
65 Gable (2008), *supra* note 13, p. 259.
66 US Environmental Protection Agency. Types of Drinking Water Contaminants. <https://www.epa.gov/ccl/types-drinking-water-contaminants>.

space and comes from domestic legislation, it shows that hazardous physical substances can be covered under the ordinary meaning of the term "contamination". Therefore, while the dimensions of the space debris problem might not have been anticipated, or even contemplated, by the drafters of the Outer Space Treaty, the term "contamination" is a generic term that is broad enough to include physical contamination like space debris. This understanding is in line with the purpose of Article IX of the OST to avoid the introduction of materials into space that can interfere with the space activities of other States. This purpose provides room for an evolutive interpretation of the term "contamination", which can thus include the generation of space debris, something that might not be foreseen by the Treaty drafters but is now becoming a critical source of interference in outer space.

If space debris can be regarded as a form of "contamination", the next question is where the threshold of harmfulness lies. In other words, when would the generation of space debris be considered "harmful"? Hobe submits that "the definitional decision to limit 'space debris' to things that are in Earth orbit or re-entering the Earth's atmosphere might be relevant with respect to the qualification of 'harmful'".[67] As debris orbiting the Earth constitutes the most pressing issue to be dealt with, this kind of space debris could be considered the most "harmful" in comparison with debris generated in other areas of outer space. In addition, like the interpretation of the due regard principle, the meaning of harmfulness should be ascertained in the context of the rest of Article IX. Reading it in conjunction with the due regard principle, Stubbe submits that the contamination of space must be regarded as harmful when it "reaches a level that threatens the usability of outer space and therefore disregards the interests of other states".[68] Based on the sci-lab perception, Baker contends that the obligation to avoid harmful contamination was not intended to protect the outer space environment *per se* but only to avoid interference of one activity with another.[69] This argument can be supported by reading it in the context of sentences 3 and 4 of Article IX, where the obligation to undertake or the right to request international consultation is triggered in the event of potentially harmful interference. This also leads to an understanding that activities interfering with the current and future use of outer space can be regarded as "harmful".[70] In the absence of specific criteria, the determination of "harmfulness" has to be made on a case-by-case basis, taking all the relevant circumstances into

67 Hobe, S. (2012). Environmental Protection in Outer Space: Where We Stand and What is Needed to Make Progress with regard to the Problem of Space Debris. *Indian Journal of Law and Technology*, *8*(1), p. 5.

68 Stubbe, P. (2017). *State Accountability for Space Debris: A Legal Study of Responsibility for Polluting the Space Environment and Liability for Damage Caused by Space Debris*. Brill, p. 158.

69 Baker, H. A. (1987). Protection of the Outer Space Environment: History and Analysis of Article IX of the Outer Space Treaty. *Annals of Air and Space Law*, *12*, p. 163.

70 Ibid, p. 167.

account, including the amount and location of space debris created and the associated risks.

While the "harmful contamination" clause can arguably apply to space debris, it should be noted that the clause only requires States to "avoid" harmful contamination and to adopt "appropriate measures" to this end "where necessary". Therefore, this requirement "is at best an obligation of effort rather than an obligation of result, of *trying* in good faith rather than being *obliged* to avoid any contamination".[71] In other words, "[a]voidance may be the intent; it need not be the result", which thereby allows for "harmful contamination by default".[72] Hence, if a State has made reasonable efforts to mitigate space debris in carrying out space activities, the requirement to avoid harmful contamination would not be regarded as having been violated even when these activities ultimately create space debris. As the terms "appropriate" and "necessary" are not further defined in the Outer Space Treaty, the determination of what measures should be taken and when to take measures are largely left to the discretion of the State conducting potentially harmful space activities.[73]

In short, through teleological and evolutive interpretation, the creation of space debris can be regarded as a form of "contamination" in the context of Article IX. Such contamination is harmful if the generation of space debris threatens the long-term usability of outer space. However, the vague terms used in this provision make it difficult to verify whether there is a violation. Therefore, as Gable observes, "[w]ithout a more definite delineation, […] one could not use this provision to require and enforce measures of space debris mitigation".[74]

3.1.3.3 Appropriate International Consultation

Sentences 3 and 4 of Article IX provide a mechanism of consultation with regard to the avoidance of potentially harmful interference in outer space:[75]

> "If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A

71 Von der Dunk, F. G. (2010). Too-Close Encounters of the Third Party Kind: Will the Liability Convention Stand the Test of the Cosmos 2251-Iridium 33 Collision?. *Proceedings of the International Institute of Space Law 2009*, Eleven International Publishing, p. 205.

72 Baker (1987), *supra* note 69, p. 168.

73 Viikari (2008), *supra* note 3, p. 60.

74 Gable (2008), *supra* note 13, p. 259.

75 Marchisio (2009), *supra* note 26, p. 179.

> State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the moon and other celestial bodies, may request consultation concerning the activity or experiment."

The two sentences deal with, respectively, the obligation of the State conducting potentially harmful activities to undertake appropriate international consultations before proceeding with such activities, and the right of the potentially affected State to request consultation. The prevalent understanding of "consultation" is that the term involves "asking an opinion on, or common examination of, a specific problem".[76] Appropriate international consultation and information exchange could enable the States concerned to assess the potential risk of interference and to undertake responsive measures to mitigate such risk, such as to avoid a collision in space through effective coordination. Therefore, while the consultation clause "aims not to protect the environment per se but merely to safeguard other states' space activities", it may create a *de facto* spill-over effect for the protection of the space environment.[77]

The consultation clause provides a legal basis for States to share concerns and seek coordination. However, the practical value of the consultation clause may be compromised by its lack of specificity. The clause does neither set out procedures for consultation nor lay down dispute settlement mechanisms for disagreements arising therefrom.[78] It does not require the consultation to achieve any concrete result, nor does it expressly oblige the State concerned to effectively take into account any such result when eventually performing the planned activity.[79] In addition, the potentially affected State does not have a right of veto to bar the planned space activity.[80] As observed by Viikari, due to the ambiguity of the consultation clause, States are not particularly eager to consult with each other about their planned space activities, at least not when there are no direct deleterious impacts expected.[81] In fact, the provisions relating to consultation have seldom been directly used and invoked.

The ambiguity of the consultation clause could be remedied by reading the clause in the context of the rest of Article IX. The consultation clause is

76 Masson-Zwaan & Hofmann (2019), *supra* note 18, p. 21.
77 Viikari (2008), *supra* note 3, pp. 60-61.
78 Baker (1987), *supra* note 69, p. 169.
79 Viikari (2008), *supra* note 3, p. 61.
80 Viikari, ibid. In fact, the consultation provision is a compromise between the proponents of the possibility of veto in the event of potentially harmful interference and those States unwilling to accept a veto to their space activities. *See* Baker (1987), *supra* note 69, p. 155.
81 Viikari, ibid.

closely linked to the principles of due regard and international cooperation, in that undertaking international consultation "offers good faith evidence that states are taking the interests of other states into account and, by so doing, promotes international cooperation".[82] Therefore, a perfunctory approach towards consultation could be regarded as a failure to pay due regard to the interests of other States. Moreover, by referring to the *pacta sunt servanda* principle,[83] one can argue that States are required to undertake consultation in good faith and to make reasonable efforts to reduce potentially harmful interference. As stated in the ICJ's *Nuclear Tests* judgment:

> "One of the basic principles governing the creation and performance of legal obligations, whatever their source, is the principle of good faith. Trust and confidence are inherent in international co-operation, in particular in an age when this co-operation in many fields is becoming increasingly essential."[84]

This statement is particularly pertinent to the governance of outer space, where the inhospitable but fragile orbital environment, the high risk and heavy investment involved in space activities, and the growing dependence of humankind on space infrastructures, all call for appropriate consultation and coordination where needed to minimise the risk of harmful interference with other activities in outer space. Hence, the consultation clause should not be understood as providing "a mere formality which the State of origin has to go through with no real intention of reaching a solution acceptable to the other State".[85] In light of the good faith principle, "if the requesting state could demonstrate that potentially harmful interference would result from the proposed activity", the State planning and conducting such activity shall respond timely and properly to such request.[86] It would be difficult for a State to contend that it has complied with the consultation provisions if it undertakes activities that have been proven risky without prior consultation or proceeds with potentially harmful activities regardless of the consultation requests and results.

As noted by the COPUOS Legal Subcommittee (LSC), the space environment is "becoming increasingly complex and congested, owing to the growing number of objects in outer space, the diversification of actors in outer space and the increase in space activities".[87] The growing population of objects surrounding the Earth will make the consultation clause more important in the future, as there will be an increasing need for space

82 Baker (1987), *supra* note 69, p. 148.
83 Article 26, 1969 VCLT: "Every treaty in force is binding upon the parties to it and must be performed by them in good faith."
84 *Nuclear Tests (Australia v. France), Judgment, I.C.J. Reports 1974*, p. 253, para. 46.
85 Marchisio (2009), *supra* note 26, p. 180.
86 Baker (1987), *supra* note 69, pp. 164-165.
87 UN Doc. A/AC.105/1243 (24 June 2021). Report of the COPUOS Legal Subcommittee on its sixtieth session, para. 194.

operators to coordinate their activities for collision avoidance. Moreover, as Viikari submits, consultation and cooperation are particularly important when introducing new types of space activities whose consequences are as yet unclear.[88] Since ADR operations involve an inherent high risk of collision, there is a higher likelihood of harmful interference. Hence, States engaging in ADR operations should consult more actively with the potentially affected States. Meanwhile, the removal of a debris object under foreign jurisdiction could be regarded as "harmful interference" by the State of registry of such object. Therefore, the seeking and granting of consent for removal could be conducted through "appropriate international consultation" between the States concerned under Article IX of the OST.

3.1.4 Application of International Environmental Law to Space Debris

Article III of the Outer Space Treaty provides that States should carry out space activities in accordance with international law. This affirms the application of general international law, including international environmental law, to outer space.[89] In this sense, the principle of prevention, which functions as "the cornerstone of international environmental law",[90] is of relevance to the regulation of space debris. This principle can be traced back to the well-established Roman law maxim *sic utere tuo ut alienum non laedas* (use your own property in such a way that you do not injure that of other people), initially as a principle guiding the activities of individual citizens.[91] The principle was referred to in the *Corfu Channel* case, where the ICJ articulated the existence of certain general and well-recognised principles, including the principle that States should not "allow knowingly [their] territory to be used for acts contrary to the rights of other States".[92]

Specific to the context of environmental protection, a landmark case is the 1941 *Trail Smelter* arbitration, where the arbitral tribunal held that "under the principles of international law […] no State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence."[93] The principle of prevention was later embodied in Principle 21

88 Viikari (2008), *supra* note 3, p. 60.
89 Masson-Zwaan (2017), *supra* note 1, p. 141.
90 Dam-de Jong, D. A. (2022). Chapter 16: International Environmental Law. In Rose, C. *et al*. *An Introduction to Public International Law*. Cambridge University Press, p. 324. Sands, P., Peel, J., Fabra, A., & Mackenzie, R. (2018). *Principles of International Environmental Law.* 4th ed., Cambridge University Press, p. 201.
91 Viikari (2008), *supra* note 3, p. 150.
92 *Corfu Channel case, Judgment of April 9th, 1949: I.C.J. Reports 1949*, p. 22.
93 *Trail Smelter Arbitration (United States v. Canada)*, Arbitral Award (11 March 1941), Reports of International Arbitral Awards (RIAA), Vol. III, p. 1965.

of the *Declaration of the United Nations Conference on the Human Environment* of 1972 ("Stockholm Declaration"):[94]

> "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."

Principle 21 of the Stockholm Declaration was reaffirmed in Principle 2 of the 1992 *Rio Declaration on Environment and Development* ("Rio Declaration").[95] The aim of Principle 21/2 is to establish a balance between "two fundamental objectives pulling opposing directions", namely the sovereign right of States over their natural resources and their responsibility to avoid environmental damage.[96] Compared to the formulation of the principle of prevention in the *Trail Smelter* arbitration, Principle 21/2 added an important element to this principle.[97] Whereas in the *Trail Smelter* dispute the arbitral tribunal referred exclusively to environmental damage caused to the territory of other States, Principle 21/2 extends the responsibility of States to avoid causing environmental damage "in areas beyond the limits of national jurisdiction". As outer space is an area beyond the jurisdiction of any State pursuant to Article II of the OST, the principle of prevention can apply to the protection of the outer space environment. The customary status of this principle was confirmed by the ICJ in the 1996 *Nuclear Weapons* advisory opinion:

> "The existence of the general obligation of States to ensure that activities within their jurisdiction and control respect the environment of other States or of areas beyond national control is now part of the corpus of international law relating to the environment."[98]

Although Principle 21/2 does not expressly stipulate a particular threshold of harm, it is commonly accepted today that the principle of prevention only concerns the prevention of harm that exceeds a minimum threshold.[99] The roots of this qualification can be traced back to the *Trail Smelter* award,

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94 Declaration of the United Nations Conference on the Human Environment, Stockholm, 16 June 1972, UN Doc. A/CONF.48/14/Rev. 1.

95 Rio Declaration on Environment and Development, Rio de Janeiro, 13 June 1992, UN Doc. A/CONF.151/26.

96 Sands *et al*. (2018), *supra* note 90, p. 201.

97 Dam-de Jong (2022), *supra* note 90, p. 324.

98 *Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion, I. C. J. Reports 1996*, para. 29.

99 Brunnée, J. (2021). Harm Prevention. In: Rajamani, L., & Peel, J. *The Oxford Handbook of International Environmental Law*. 2nd ed., Oxford University Press, p. 272. Dam-de Jong (2022), *supra* note 90, p. 335.

which used the word "serious consequence".[100] This threshold is generally considered to be damage that may be qualified as "significant", defined by the ILC as "something more than 'detectable' but need not be at the level of 'serious' or 'substantial'".[101] The existence of the threshold of significance was affirmed by the ICJ in the *Pulp Mills*[102] and the *Costa Rica/Nicaragua*[103] judgments. As noted by the ILC, the term "significant" "is not without ambiguity and a determination has to be made in each specific case".[104] More specifically, the assessment of the "significance" of transboundary harm "involves more factual considerations than legal determination" and has to be made on a case-by-case basis, with account taken of the circumstances of a particular case and the period in which such determination is made. [105]

It should be further noted that the principle of prevention does not impose an obligation of result but an obligation of conduct. As such, the principle is not regarded as violated even if transboundary environmental harm actually occurs, insofar as the State concerned has taken all reasonable measures to prevent such harm.[106] This is affirmed by the ICJ in the *Pulp Mills* judgment where the Court pointed out that "the principle of prevention, as a customary rule, has its origins in the due diligence that is required of a State in its territory".[107] The Court further stated that:

> "A State is thus obliged to use all the means at its disposal in order to avoid activities which take place in its territory, or in any area under its jurisdiction, causing significant damage to the environment of another State."[108]

Therefore, the principle of prevention can be understood as imposing an obligation upon States to act with due diligence in order to avoid causing significant transboundary harm. Like the determination of "harmful" con-

100 *Trail Smelter* arbitration, *supra* note 93.

101 Commentary to Art. 2 of the Draft Articles on Prevention, *supra* note 40, para. 4. See also ILC. Draft Principles on Protection of the Environment in relation to Armed Conflicts, with commentaries: "the obligation of prevention in customary international environmental law […] only applies to harm above a certain threshold, most often indicated as 'significant harm". *Yearbook of the International Law Commission* (2022), vol. II, Part two.

102 *Pulp Mills on the River Uruguay (Argentina v. Uruguay), Judgment, I.C.J. Reports 2010*, para. 104.

103 *Certain Activities Carried Out by Nicaragua in the Border Area (Costa Rica* v. *Nicaragua)* and *Construction of a Road in Costa Rica along the San Juan River (Nicaragua* v. *Costa Rica), Judgment, I.C.J. Reports 2015*, para. 118.

104 Ibid.

105 Commentary to Art. 2 of the Draft Articles on Prevention, *supra* note 40, paras. 4 & 7.

106 Dupuy, P.-M., & Viñuales, J. E. (2018). *International Environmental Law.* 2nd ed., Cambridge University Press, p. 64. Dam-de Jong (2022), *supra* note 90, p. 335.

107 *Pulp Mills* judgment, *supra* note 102, para. 101.

108 Ibid. This statement was later reiterated in the *Costa Rica/Nicaragua* judgment. See *Costa Rica/Nicaragua* judgment, *supra* note 103, para. 104.

tamination under Article IX of the OST, there is currently no clear criterion on what constitutes "significant" environmental harm in outer space in the context of the principle of prevention. As such, the assessment of "significance" could involve the consideration of a number of factual elements such as the number of the debris created, the mass of the debris, and the orbital area where the debris is located. The IADC is currently performing work to set metrics for defining a sustainable space environment, and the release of this formula will help to provide "a quantitative interpretation of the space environment status and forecasts".[109] In addition, the Space Sustainability Rating (SSR) system, which uses a series of carefully devised metrics to assess the level of sustainability of space missions and operations, can also provide a useful point of reference for the determination of significance.[110]

3.1.5 State Responsibility for National Space Activities

With the growing participation of the private sector in space activities, especially since the start of the New Space era in 2019, there is a growing need to effectively regulate private activities in outer space to ensure that these activities are carried out in an orderly manner in compliance with the requirements under international space law. The regulation of the space activities of private entities is addressed in Article VI of the Outer Space Treaty, which provides that:

> "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 wording of this provision, which appeared for the first time in the 1963 *Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space* ("Declaration of Legal Principles"),[111] emerged as a compromise formula reached between the US and the Soviet Union. The Soviet Union wanted to reserve space activities "solely and exclusively" for States, while the US, which at that time had already plans for private space activities, did not wish to close the door for private entities to access outer space.[112] The formulation of Article VI reconciles these two competing interests, which paves the way for private entities to conduct space activities side by side with the public actors, while stipulating that States should assume international responsibility for space activities carried on by their

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109 IADC. (2023). IADC Report on the Status of the Space Debris Environment. IADC-23-01, p. 23.

110 The SSR system will be discussed in more detail in Chapter 4.

111 UN Res. 1962 (XVIII) of 13 Dec. 1963.

112 Gerhard, M. (2009). Article VI. In *CoCoSL Vol. 1*, *supra* note 5, p. 105.

private entities.[113] As such, the compromise is that the involvement of private entities in space activities is not precluded insofar as they are covered under the umbrella of the international responsibility of States.[114]

As States bear international responsibility for national space activities carried out by both governmental agencies and non-governmental entities, Article VI establishes a *lex specialis* to the general rule of attribution under international law for non-governmental space activities.[115] Under international law, "the general rule is that the only conduct attributed to the State at the international level is that of its organs of government, or of others who have acted under the direction, instigation or control of those organs, i.e. as agents of the State".[116] In contrast, the conduct of private persons or entities is generally not attributable to the State, "both with a view to limiting responsibility to conduct which engages the State as an organization, and also so as to recognize the autonomy of persons acting on their own account and not at the instigation of a public authority".[117] Different from this general rule, under the "space-specific attribution rule" enshrined in the first half of Article VI sentence 1 of the Outer Space Treaty, the conduct of private entities in carrying out outer space activities is attributable to the State like that of governmental agencies.[118] As Cheng observes:

> "This is where Article VI is not merely innovatory. It is almost revolutionary. Under it, it appears that States have assumed direct State responsibility for non-governmental national space activities. This means that every thing that is done by such non-governmental entities is deemed to be an act imputable to the State as if it were its own act, for which it bears direct responsibility. Thus a breach of whatever provision of the Space Treaty by such a non-governmental entity involves immediately the State's direct responsibility, as if it were a breach by the State itself. State responsibility occurs the moment the breach is committed,

113 Ibid, pp. 105-106. Kopal, V. (2008). Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. Available on the UN website: <https://legal.un.org/avl/ha/tos/tos.html>.

114 Von der Dunk, F. G. (2011). The Origins of Authorisation: Article VI of the Outer Space Treaty and International Space Law. *Space, Cyber, and Telecommunications Law Program Faculty Publications*, *69*, p. 6.

115 Stubbe (2017), *supra* note 68, p. 97.

116 See ILC. (2001). Draft Articles on Responsibility of States for Internationally Wrongful Acts (ARSIWA), with commentaries. Text adopted by the ILC at its fifty-third session, in 2001, and submitted to the General Assembly as a part of the Commission's report covering the work of that session (A/56/10), commentary to ARSIWA Chapter II, para. 2.

117 Ibid, paras. 2-3. It should be noted that a State may be held responsible for an omission when they should have acted under international law, such as to take necessary measures to prevent private entities under their jurisdiction from undertaking certain activities, but failed to act as the law so requires. In these situations, the State concerned is responsible for its own behaviour, i.e., failure to act. See ibid, para. 4.

118 Stubbe (2017), *supra* note 68, p. 97. As noted by the ILC, "[t]o show that conduct is attributable to the State says nothing, as such, about the legality or otherwise of that conduct". See ibid, para. 4.

> and not when the State is seen to have failed in its duty to prevent, suppress or repress such a breach."[119]

In other words, States assume international responsibility not only for their governmental space activities but also for those carried out by private entities. The international responsibility for the latter activities is further elaborated in Sentence 2 of Article VI, which provides that:

> "The activities of non-governmental 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."

Read in conjunction with Sentence 1, this provision requires States to perform their duty of authorisation and continuous supervision of private space activities in a manner that serves the purpose of assuring that these activities are carried out in conformity with international law.[120] As such, Article VI is often seen as a rationale for States to adopt national space legislation, as a way to implement their obligations under international space law in their national legal order.[121] By virtue of this provision, international obligations imposed on States such as the requirements to pay due regard to the activities of others and to avoid harmful contamination of outer space, can find their way to the national level and bind private entities. According to the national space law database maintained by UNOOSA, there are over forty countries that have enacted their national laws and regulations relating to the exploration and use of outer space.[122] It should be noted that Article VI does not expressly require States to establish national space legislation, and States may resort to other means to authorise and continuously supervise private activities in outer space, such as by doing so on an *ad hoc* basis through administrative procedures.[123] Yet, setting up a licensing regime under national law for the regulation of private space activities represents the easiest way to implement the obligation of authorisation and continuing supervision.[124] This method also has the advantage of providing regulatory certainty and predictability to private space operators.

Like for other space activities, States have international responsibility to authorise and continuously supervise ADR activities of private entities and to ensure that these activities are carried out in conformity with interna-

119 Cheng, B. (1998). Article VI of the 1967 Space Treaty Revisited – 'International Responsibility', 'National Activities', and 'The Appropriate State'. *Journal of Space Law*, *26*(1), p. 15.
120 Ibid.
121 Masson-Zwaan & Hofmann (2019), *supra* note 18, p. 20.
122 See UNOOSA. National Space Law Database. <https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html>.
123 Gerhard, M. (2009). Article VI. In *CoCoSL Vol. 1*, p. 119.
124 Masson-Zwaan, T. L. (2023). Widening the Horizons of Outer Space Law. Doctoral Thesis at Leiden University, *Meijers-reeks*, p. 11.

tional law. An example of the authorisation for private ADR activities is the licence granted by the UK Space Agency to the ELSA-d mission in March 2021, which sets a leading precedent for licensing future missions involving complex RPO in space, such as ADR.[125] The ELSA-d mission is commanded and controlled by Astroscale UK from a mission operations centre located in Harwell, UK.[126] This falls within the scope of the UK Space Industry Act of 2018, which applies to, among others, space activities carried out in the UK, including "operating a space object".[127] Therefore, a UK licence is required for the ELSA-d mission. As part of the licence application, Astroscale UK provided information to the UK Space Agency regarding the following subjects:

1. ELSA-d mission description and overview
2. Servicer and client spacecraft descriptions and orbital parameters
3. Safety and mission assurance
4. Debris mitigation
5. Deorbit, passivation, and re-entry hazards".[128]

It can be seen that mission safety and space debris mitigation are important elements for consideration in the licensing process. In particular, as ADR operations involve in general a higher risk of collision than other space activities, a clear process has been established for the ELSA-d mission to avoid collisions between the servicer and client spacecraft, as well as between them and space objects of other parties.[129]

As the ELSA-d spacecraft needs to communicate with several US earth stations, a request for authorisation has also been made to the US Federal Communications Commission (FCC) which regulates the use of radio frequency for space activities.[130] A "description of the design and operational strategies that will be used to mitigate orbital debris" is required for the application.[131] The FCC's rules provide that for non-US-licensed space stations, this requirement "can be satisfied by demonstrating that debris mitigation plans for the space station(s) for which U.S. market access is requested are subject to direct and effective regulatory oversight by the national licensing authority".[132] As the ELSA-d mission has already been licensed by the UK,

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125 Astroscale. (12 March 2021). ELSA-d Mission Licence Approved by UK Space Agency. <https://astroscale.com/elsa-d-mission-licence-approved-by-uk-space-agency/>.

126 FCC Report: ELSA-d CONOPS and Debris Mitigation Overview ("ELSA-d CONOPS Report"), p. 1. <https://fcc.report/IBFS/SES-STA-INTR2020-00086/2166969.pdf>.

127 Sec. 1, UK Space Industry Act. The Act received Royal Assent on 15 March 2018. <https://www.legislation.gov.uk/ukpga/2018/5/contents/enacted>.

128 ELSA-d CONOPS Report, *supra* note 126, p. 1.

129 Ibid, p. 11.

130 FCC International Bureau. (29 September 2020). Commission Request regarding Astroscale ELSA-d mission. <https://fcc.report/IBFS/SES-STA-20200113-00043/2729900>.

131 47 Code of Federal Regulations (CFR) § 25.114(d)(14).

132 47 CFR § 25.114(d)(14)(v).

in November 2021 the FCC authorised the communications of US earth stations with the ELSA-d spacecraft, after having evaluated its application.[133]

The ELSA-d case exemplifies the application of Article VI of the Outer Space Treaty in practice where the UK authorises an ADR technology demonstration mission through its licensing regime. In view of the complexity of ADR operations and the high risks involved, it would be beneficial for States to establish national guidelines to enhance the safety of ADR activities, and the US and Japan have already taken some initiatives in this regard.[134] Meanwhile, with more States engaging in ADR activities, it would be advisable for States to adopt guidelines at the international level so as to ensure consistency among different national guidelines. As shown in the ELSA-d case, an ADR operation may possibly require the authorisation of more than one State. Harmonised standards could facilitate the mutual recognition of licences among States, and a streamlined process would alleviate the administrative burdens of private entities in the application for authorisation.

3.2 *Issue 2*: International Liability for Damage Caused by Space Objects

This section will address the liability regime under current international space law and discuss how this regime may impact ADR activities. Article VII of the Outer Space Treaty establishes a general rule of liability for damage caused by space objects:

> "Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies."

As space activities are inherently dangerous, imposing liability for damage inflicted by space activities is the counterpart of the enjoyment of the freedom to explore and use outer space granted under Article I of the OST.[135] In this sense, the rationale for imposing liability on the States involved in the launch of a space object for damage caused by such object to other States is "the interest of the international community in securing a reliable State liability regime to respond to the ultra-hazardous activities of launching States".[136]

133 FCC. (8 August 2022). Facilitating Capabilities for In-space Servicing, Assembly, and Manufacturing. FCC 22-66, para. 5. <https://docs.fcc.gov/public/attachments/FCC-22-66A1.pdf>.

134 This will be discussed in more detail in Chapter 5 Section 5.2.

135 Kerrest, A. & Smith, L. J. (2009). Article VII. In *CoCoSL Vol. 1*, p. 130

136 Ibid, p. 129.

The general principle of liability under Article VII of the Outer Space Treaty has been elaborated in the Liability Convention, which establishes two separate patterns of liability, namely absolute liability and fault-based liability. The former applies to damage caused by a space object on the surface of the Earth or to aircraft in flight, and the latter applies to damage caused in outer space.[137] The rationale for distinguishing between absolute and fault-based liability according to the location of the damage caused is the degree of involvement in ultra-hazardous activities.[138] Entities carrying out space activities are regarded as having accepted the high risks associated with the operation of a spacecraft and are therefore on a more or less equal footing for risk sharing.[139] In contrast, uninvolved third parties on the ground cannot be regarded as having accepted such risks, which thus deserve special protection.[140]

For the establishment of liability, the injured State needs to prove the existence of "damage", defined in the Liability Convention as "loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations".[141] This definition speaks only of personal and property damage and does not mention damage to the space environment. As observed by Masson-Zwaan:

> "It is not clear whether this definition includes harm to the extra-terrestrial environment per se, without harm to persons or property. Environmental pollution may cause harm to persons or property; but then it would be the 'secondary' damage to persons or property resulting from the 'primary' damage to the environment that gives rise to compensation under the Convention".[142]

When there is no such "secondary" damage, it is generally understood that damage caused to the space environment per se does not give rise to liability under the Liability Convention. Hence, an entity creating space debris need not worry much about the risks of liability exposure, insofar as there is no subsequent damage caused to the property or persons of another State.[143] In this sense, the Liability Convention does not provide a strong incentive for States to limit the creation of space debris in the course of their space activities.

Under the Liability Convention, liability for damage caused by a space object is attributed to the "launching State" of such object, which is defined

137 Arts. II & III, Liability Convention.
138 Stubbe & Schrogl (2015), *supra* note 37, p. 647.
139 Ibid. See also Marboe (2012), *supra* note 36, p. 124. Masson-Zwaan & Hofmann (2019), *supra* note 18, pp. 27-28.
140 Ibid.
141 Art. I(a), Liability Convention.
142 Masson-Zwaan (2017), *supra* note 1, p. 142.
143 Viikari (2008), *supra* note 3, p. 69.

in the Convention as "(i) A State which launches or procures the launching of a space object; (ii) A State from whose territory or facility a space object is launched".[144] The liability regime is State-centered, meaning that a claim for compensation can only be presented to the launching State and not to a private entity.[145] Also, only States may present a claim, and private entities have no direct course of action under the Liability Convention but depend on their national States to present a claim for them.[146]

Wherever the location of damage, the Liability Convention is only applicable to damage caused by "space object". Accordingly, whether the Liability Convention can apply to damage caused by space debris depends on whether space debris is covered under the term "space object". Therefore, Section 3.2.1 will assess the relation between the terms "space object" and "space debris". Sections 3.2.2 and 3.2.3 will then discuss the two separate liability patterns established under the Liability Convention, namely absolute liability for damage caused on the ground and fault-based liability for damage caused in outer space. This will be followed by a discussion in Section 3.2.4 on the liability for knock-on collisions, i.e., situations where the debris created in a collision subsequently causes damage to third parties. Finally, Section 3.2.5 will address how the current liability regime may affect ADR activities.

3.2.1 Relation Between "Space Object" and "Space Debris"

The term "space debris" is neither mentioned nor defined in the UN space treaties, which use the operative terminology "space object". According to Article I (d) of the Liability Convention, the latter term "includes component parts of a space object as well as its launch vehicle and parts thereof". The same definition has been adopted in Article I(b) of the Registration Convention. This definition is "silent as to when, if at all, a space object or its component or fragmented parts, ceases to be a 'space object'.[147] In other words, the question is whether a space object can cease to exist and if so, when does this happen? It should be noted that each object launched into outer space will ultimately become non-functional after it has served its intended mission. In fact, some objects, such as rocket stages, are only designed to function till they reach a certain altitude, and will thus become non-functional shortly after launch. However, in terms of collision risks, non-functional objects, i.e., space debris, are no less dangerous than active satellites, especially when considering that they do not have manoeuvrabil-

144 Art. I(c), Liability Convention.

145 Art. IX, ibid.

146 Art. VIII, ibid. Masson-Zwaan (2017), *supra* note 1, p. 142.

147 Chatterjee, J. (2015). Legal Issues relating to Unauthorised Space Debris Remediation. *Proceedings of the International Institute of Space Law 2014*, Eleven International Publishing, p. 17.

ity to avoid collisions and that the majority of them are difficult or impossible to be tracked and dodged due to their small sizes.

The silence on functionality in the definition of "space object" implies that a space object does not lose its status when it becomes non-functional. As Froehlich notes, "[w]hile the UN space treaties make clear that space objects include also their component parts, none of them see functionality as relevant in defining a space object".[148] Reading otherwise would lead to an unreasonable and absurd result, for a State could avoid its liability for damage caused by its non-functional object by simply claiming that such object had already ceased to function before the damage occurred. Therefore, a non-functional artificial object in orbit should be regarded simultaneously as a "space object" in the context of the UN space treaties and a piece of "space debris" as per the IADC/COPUOS definition.[149] Hence, as Masson-Zwaan submits, "an inactive satellite or even a lost screwdriver should logically still be regarded as (a component part of) a space object for which responsibility remains with the launching State and which can give rise to liability of the launching state, if damage occurs".[150]

The next question is that for the qualification as "space object", whether a distinction should be made between intact debris objects such as defunct orbital stages and debris fragments. Some scholars argue that the concept of space object (and its component parts) "is not broad enough to encompass all classes of space debris", which covers "[i]nactive satellites, rocket motors and other operational debris", but does not include "fragments and micro-particular matter".[151] The opposite view is that when a space object is fragmented into pieces, these fragments can be treated as "component parts" of the original object and should thus still be regarded as "space objects".[152] This dissertation advocates the latter view. The dictionary meaning of "component part" is "something (as a building or part of a building) that cannot be removed without substantial damage to itself or to the immovable

148 Froehlich, A. (2019). The Right to (Anticipatory) Self-Defence in Outer Space to Reduce Space Debris. In Froehlich, A. (Ed.). *Space Security and Legal Aspects of Active Debris Removal*, Springer, p. 74.

149 Su, J. (2016). Active Debris Removal: Potential Legal Barriers and Possible Ways Forward. *Journal of East Asia and International Law*, *9*(2), p. 408.

150 Masson-Zwaan (2017), *supra* note 1, p. 142.

151 Kim, Y., Popova, R., Schaus, V., Rossi, A., Alessi, E. M., Colombo, C., Gkolias, I., & Tsiganis, K. (31 January 2019). Proposal for Improved Mitigation Procedures and Guidelines. European Commission Horizon 2020: The Revolutionary Design of Spacecraft through Holistic Integration of Future Technologies - ReDSHIFT. Deliverable 2.4 "*Proposal for Improved Mitigation Procedures and Guidelines*", p. 10.

152 Cheng (1997), *supra* note 59, p. 506. Mudge, A. G. (2022). Incentivizing 'Active Debris Removal' Following the Failure of Mitigation Measures to Solve the Space Debris Problem: Current Challenges and Future Strategies. *Air Force Law Review*, *82*(1), p. 120. Chung, G. (2019). Jurisdiction and Control Aspects of Space Debris Removal. In Froehlich, A. (Ed.). *Space Security and Legal Aspects of Active Debris Removal*, Springer, p. 35.

property to which it is attached",[153] or "something determined in relation to something that includes it".[154] Therefore, it is possible to regard something released or detached from a spacecraft as the latter's "component part". In addition, since the amount of debris fragments substantially outnumbers that of intact space objects, accidental collisions are more likely to be caused by the former than the latter.[155] Hence, excluding debris fragments from the scope of "space object" would run contrary to the victim-oriented spirit of the Liability Convention, which is reflected in its preamble recognising "the need to elaborate effective international rules and procedures concerning liability for damage caused by space objects and to ensure, in particular, the prompt payment under the terms of this Convention of a full and equitable measure of compensation to victims of such damage". Such exclusion could even disincentivise States from minimising the risk of post-mission break-ups of their space objects, for after these break-ups, States would be exonerated from their liability for the subsequent damage caused by the debris fragments. A further justification for the inclusion of debris fragments into the scope of "space object" can be found in Article IV of the Liability Convention, which will be addressed in Section 3.2.4 below.

While the definition of the term "space object" is commented by some scholars as a "circular definition" which "fails to define the term 'space object' exhaustively while merely providing a vague inclusive boundary for the term",[156] it is this very character that suggests that any piece of space debris can be subsumed under the scope of this term. It is important to note that the purpose of defining the term "space object" is to establish liability for damage caused by a space object. Therefore, the phrase "'space object' includes the component parts of a space object" in the definition will only make practical sense when a component part is somehow detached or broken off from the original object and becomes a *distinct* object on its own. This is because before such separation, any damage caused by the component part would be directly attributed to the original object. For instance, a solar panel of a satellite is beyond doubt a "component part" of such satellite. However, when being an integral part of the satellite, any damage caused by the solar panel to other space objects through collision will evidently not be considered as damage caused by the solar panel, but by the satellite itself. It is only after the solar panel is detached from the satellite, whether as an intact item due to a loose screw, or as a broken part due to the disintegration of the satellite, that the term "component part" is activated and such solar panel becomes capable of causing damage as

153 Merriam-Webster Dictionary: <https://www.merriam-webster.com/legal/component%20part>.

154 The Free Dictionary: <https://www.thefreedictionary.com/component+part>.

155 ESA. (Last updated 12 September 2023). Space Debris by the Numbers. <https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers>

156 Chatterjee (2015), *supra* note 147, p. 17. Popova & Schaus (2018), *supra* note 2, p. 10.

a "space object" from a legal point of view. It is possible that such solar panel may later be disintegrated into more "component parts", and so forth. Therefore, it is reasonable to regard any debris piece detached from its parent body as a "space object" in view of the circular nature of the definition of this term.

Based on the above analysis, it can be concluded that the inclusion of non-functional satellites and rockets as well as debris fragments which have separated from these objects within the scope of "space object" is in line with both the definition of "space object" and the victim-oriented spirit of the Liability Convention. As articulated by Perek, "space debris are space objects which terminated their functions or fragmented from their parent bodies".[157] As such, space debris should be regarded as a subset of space objects under international space law. Hence, the Liability Convention can apply to damage caused by space debris.

3.2.2 Absolute Liability for Damage Caused on the Ground

Article II of the Liability Convention provides for a regime of absolute liability:

> "A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the Earth or to aircraft in flight."

Under this Article, for a claim of compensation, the injured State has to prove the existence of damage, identify the space object causing damage, and establish the causality between the damage and the space object concerned. The first and only time the Liability Convention has been invoked thus far concerns damage caused on the surface of the Earth by the re-entry of Cosmos 954, and the dispute did not go to an international court but was settled through negotiations between Canada and the Soviet Union.[158]

For ADR operations, Article II could be relevant in situations where the target debris object is de-orbited and re-enters into Earth's atmosphere. By mission design, the removal spacecraft may be disposed of together with the de-orbited target debris object as a combined stack, or it can re-boost

157 Perek, L. (2005). Ex Factor Sequitur Lex: Facts which Merit Reflection in Space Law in Particular with Regard to Registration and Space Debris Mitigation. In Benkö, M., & Schrogl, K. U. (Eds.). *Space Law: Current Problems and Perspectives for Future Regulation.* Eleven International Publishing, p. 41. See also Frigoli, M. (2019). Between Active Debris Removal and Space-Based Weapons: A Comprehensive Legal Approach. In Froehlich, A. (Ed.). *Space Security and Legal Aspects of Active Debris Removal*, *16*, Springer, p. 74: "A broad interpretation of the term 'space object' could arguably include 'space debris', considering that both space objects at the end of the their life-time and orbital fragments of the same are space debris".

158 See Chapter 2 Section 2.2.3 *infra*.

into a higher orbit to remove another debris object. In the latter case, the de-orbited debris object may re-enter in an uncontrolled fashion, for it does not have any propellant to adjust its trajectory. If the de-orbited debris survives re-entry and crashes into an aircraft in flight or causes damage to persons or property on the ground, the launching State of such object would be absolutely liable for the damage caused. Therefore, the re-entry risk and the potential liability exposure are issues to be considered by States engaging in ADR activities in the contemplation of post-mission disposal strategies.

3.2.3 Fault-Based Liability for Damage Caused in Outer Space

Article III of the Liability Convention provides for a fault-base liability regime:

> "In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible."

The phrase "elsewhere than on the surface of the Earth" is generally understood as meaning outer space.[159] To establish liability for damage caused by a space object, the victim State needs to prove "fault" of the launching State or of persons for whom the latter State is responsible. However, the Liability Convention does not define "fault" or provide a standard of care for the determination of "fault". According to the *Max Planck Encyclopedia of Public International Law*, "fault" is used to describe "a set of blameworthy psychological attitudes of the author of an act or an omission".[160] Such attitudes consist "either in the fact that the author of the act, or omission, albeit without intention or wish to cause an unlawful event, consciously conducts himself differently from the way which could avoid the event – *culpa* in its various degrees – or in the fact that the author foresees the unlawful events and facts – or omits an act – in order to cause it (*dolus*)".[161] On the basis of this definition, von der Dunk submits that "a 'fault' presumes a *choice* for the person at fault, a choice between at least two options of 'conduct', where that person whether by 'intention' or 'negligence' chose an option (that is by flawed 'judgment') leading to the harm concerned, where choosing another

159 As observed by Smith and Kerrest, the use of this phrase instead of directly referring to outer space in Article III is to avoid gaps in its application with regard to Article II of the Liability Convention. For instance, a collision between an ascending space object which has not reached outer space and a re-entering space object will fall under Article III. See Smith, L. J. & Kerrest, A. (2013). Article III (Fault Liability) LIAB. In Hobe S., Schmidt-Tedd, B., & Schrogl K.-U. (Eds.). *Cologne Commentary on Space Law Vol. 2* ("CoCoSL Vol. 2"). Heymann, p. 132.

160 Palmisano, G. (2007). Fault. *Max Planck Encyclopedia of Public International Law*, para. 5.

161 Ibid.

option would not have led to such harm".[162] Hence, if a State wilfully uses its space object to cause damage to a satellite of another State, the former State can presumably be held at fault.

However, in the absence of an established standard of care, it is difficult to prove "negligence" for damage caused in outer space. This difficulty can be illustrated in the accidental collision between American Iridium-33 and Russian defunct Cosmos 2251, the first-ever collision between two intact satellites in outer space.[163] Since neither Russia nor the US claimed compensation for the damage caused by this collision, the Liability Convention missed a chance to be tested and clarified.[164] Still, one may wonder which State would be held liable for the accident, if this were to be decided before an international court. As to Russia, while leaving a defunct satellite adrift in orbit in an uncontrolled fashion can beyond doubt pose risks to other space objects, Cosmos 2251 ceased to function well before the adoption of any international instruments recommending post-mission disposal measures. Therefore, Russia may argue that it should not be held at fault for not de-orbiting Cosmos 2251 and that Iridium should move its satellite to avoid the collision because Cosmos 2251 was a derelict satellite incapable of manoeuvring.[165] Meanwhile, since Iridium, the owner of Iridium 33, was incorporated and headquartered in the US, should the US be blamed for the collision? It should be noted that even the US space surveillance network, which is generally regarded as the most advanced space tracking system, could not precisely predict the occurrence of this collision.[166] In fact, even if the conjunction risk could be estimated, Iridium could still contend that it is not obliged to perform CAMs because the current space debris mitigation guidelines only recommend operators to "consider" CAMs when "available orbital data indicate a potential collision", and should therefore not be held faulty for the accident.[167]

The 2009 accident shows that on top of the ambiguity of the term "fault", factual elements such as the availability and reliability of orbital data for the calculation of collision risk can also complicate the task of establishing fault. It has been noted that different sources of information about the orbital

162 Von der Dunk (2010), *supra* note 71, p. 203.

163 See Chapter 2 Section 2.2.1 *infra*.

164 The reason for the absence of formal claims for compensation might be that the accident did not result in substantial economic damage on either side: Cosmos 2251 was already a defunct satellite before the collision and Iridium had a spare satellite to replace Iridium 33 so there was barely any interruption in service provision to its clients. See von der Dunk (2010), *supra* note 71, p. 204. Masson-Zwaan & Hofmann (2019), *supra* note 18, p. 28.

165 Listner, M. (2012). Iridium 33 and Cosmos 2251 three years later: where are we now?. *The Space Review*. <https://thespacereview.com/article/2023/1>.

166 Von der Dunk (2010), *supra* note 71, p. 204.

167 Listner, M. (2012), *supra* note 165.

location of space objects are not always in agreement.[168] This could lead to diverging results of conjunction assessment and calculation of collision risks. Finally, the lack of virtual possibility to conduct on-site investigations also makes it difficult to look for the "real" causes of the accidents.[169] The accuracy of orbital data will likely be enhanced through the advancement of space monitoring technologies. The development of soft law can also facilitate data communication by providing recommendations on achieving uniformity in the sharing of information, such as the harmonisation of standard units for basic orbital parameters.[170] While technological advancement may contribute to the ascertainment of fault from an evidentiary perspective, such advancement cannot solve the problem regarding the ambiguity of "fault" for the application of the Liability Convention. This problem could appear again in the context of Article IV of the Liability Convention, which applies to situations where space debris created by a collision between two space objects subsequently causes damage to a third party. This Article will be discussed in the next section.

3.2.4 Liability for Damage Caused by Knock-on Collisions

The aforementioned collision between Iridium 33 and Cosmos 2251 occurred in 2009 at an orbital altitude of 790 km, which is an area heavily used by communications satellites.[171] The large amount of debris created as a result of this collision might trigger a chain of collisions because of the physical characteristics of outer space.[172] In fact, shortly after the collision, a NASA Earth observation satellite had to conduct a collision avoidance manoeuvre to dodge debris resulting from the collision.[173] In addition, the ISS has performed several manoeuvres to reduce collision risk with fragmentation debris from the 2009 accident, and in some instances the ISS crew sheltered in the Soyuz spacecraft docked to the ISS as a precaution.[174] If the debris generated in the 2009 collision causes further damage to a third party, this would bring into play Article IV of the Liability Convention.

The liability patterns under Article IV accord with the patterns established

168 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, pp. 7-8.

169 Von der Dunk (2010), *supra* note 71, p. 205.

170 Sec. 2(a), UN Doc. A/RES/62/101 (10 January 2008). Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects.

171 Masson-Zwaan, T. L. (2009), Space law and the satellite collision of 10 February 2009, *COSPAR's Information Bulletin: Space Research Today*, *174*, p. 9.

172 Ibid.

173 Johnson (2009), *supra* note 38, p. 10.

174 NASA Orbital Debris Program Office. (2012). Increase in ISS Debris Avoidance Maneuvers. In *Orbital Debris Quarterly News*, *16*(2), pp. 1-2.

in Articles II and III of the Liability Convention which depend on the location of damage. Article IV(1) reads:

> "In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, and of damage thereby being caused to a third State or to its natural or juridical persons, the first two States shall be jointly and severally liable to the third State, to the extent indicated by the following:
> a. If the damage has been caused to the third State on the surface of the Earth or to aircraft in flight, their liability to the third State shall be absolute;
> b. If the damage has been caused to a space object of the third State or to persons or property on board that space object elsewhere than on the surface of the Earth, their liability to the third State shall be based on the fault of either of the first two States or on the fault of persons for whom either is responsible."[175]

Article IV affirms the understanding that debris fragments can be subsumed under the term "space object", for it applies to a situation where two objects collide and the debris resulting from the collision causes damage to a third State. Therefore, an interpretation excluding debris fragments from the scope of "space object" would lead to an absurd result, for there is no good reason to explain why damage caused by debris fragments generated as a result of a collision can trigger the application of the Liability Convention by virtue of Article IV, while that caused by debris fragments generated by other means such as an accidental explosion resulting from residual fuel cannot. Hence, a contextual reading indicates that debris fragments should still be regarded as "space objects".

The provision that the first two States involved in a collision are "jointly and severally liable" to the third State means that the third State may present a claim to each or both of them for the entire compensation due under the Liability Convention.[176] This, again, reflects the victim-oriented spirit of the Liability Convention. The third State does not need to identify which space object caused the damage but needs only to establish that the damage incurred was caused by a space object that was involved in the initial collision event.[177] The burden of compensation for the damage should be apportioned between the first two States in accordance with the extent to which they were at fault.[178] If the degree of fault attributable to them cannot be established, the burden of compensation should be apportioned equally between them.[179]

175 Article IV(1), Liability Convention.
176 Article IV(2), ibid.
177 Smith, L. J. & Kerrest, A. (2013). Article IV (Damage Caused Jointly by Two or More Space Objects/Third Party Liability) LIAB. In *CoCoSL Vol. 2*, p. 139.
178 Article IV(2), Liability Convention.
179 Ibid.

3.2.5 Implications of the Liability Regime for ADR Activities

The problem with the current liability regime for space activities is that it fails to create a favourable environment for ADR. As noted by Mudge, this regime disincentivises ADR when it comes to both the States creating space debris and the States wishing to carry out ADR operations.[180] As to debris-creating States, leaving space debris in orbit may incur potential liability if their space debris later causes damage to other space objects. However, to establish the liability of the debris-creating State, the victim State needs to identify the "launching State" of the debris involved, prove the existence of damage falling under the definition of "damage" contained in the Liability Convention, establish the causal link between the debris and the damage caused, and prove "fault" on the part of the launching State.[181] Specifically, the lack of a specific standard of fault, coupled with the difficulty of collecting evidence due to the remoteness of outer space, "will make the burden of proof quite heavy" for the claimant State.[182] This is perhaps one of the reasons why no claim for liability has ever been brought under the Liability Convention for damage caused in outer space, even though collisions have occurred.[183] In view of the complexity of holding a launching State liable for the damage its space debris causes, the current fault-based liability regime for damage caused in space does not provide a strong incentive for States to avoid or limit the generation of space debris. Rather, since absolute liability applies to damage caused on the surface of the Earth, States may be more inclined to leave their large and massive debris objects in space than to de-orbit them, for it may involve even greater risk of liability if these objects survive re-entry and cause damage on the ground.

At the same time, the Liability Convention may disincentivise States interested in ADR from undertaking ADR efforts. As noted in Chapter 2, ADR operations are inherently risky activities as collisions may occur and cause more debris if things go wrong. The debris fragments generated by collisions may cause further damage to other space objects. In addition, the frequent alteration of orbits in ADR operations results in a higher risk of collision with other space objects, which may also lead to knock-on collisions. Without knowing what "fault" means, States engaging in space activities are uncertain about how to avoid or reduce the risk of being held at fault.[184] Facing this uncertainty, States would be discouraged from removing either their own debris or space debris of other States on a for-hire basis.[185]

180 Mudge (2022), *supra* note 152, p. 91.
181 Masson-Zwaan (2009), *supra* note 171, pp. 7-8.
182 Masson-Zwaan & Hofmann (2019), *supra* note 18, p. 28.
183 Ibid.
184 Masson-Zwaan (2023), *supra* note 124, p. 224.
185 Mudge (2022), *supra* note 152, pp. 131-132.

In sum, the ambiguity surrounding the meaning of "fault" could raise liability concerns and thus constitute a legal hurdle for ADR activities. Under the current liability regime, States may tend to "ignore their space debris and leave it on-orbit" rather than to actively remove them from space.[186] Hence, to promote efforts to actively and safely remove space debris, it is necessary to clarify the meaning of "fault" for the establishment of liability for damage caused in outer space. How soft law may contribute to filling the gap of ambiguity in the current liability regime of space law will be discussed in Chapter 4.

3.3 *Issue 3*: Prior Consent as a Prerequisite for the Removal of Debris under Foreign Jurisdiction

This section will discuss the sovereign and ownership rights over space objects. Section 3.3.1 will discuss the jurisdiction and control retained by the State of registry over its space object, as well as the ownership right of objects launched into space, as set out in Article VIII of the Outer Space Treaty. As Article VIII of the OST has been elaborated in the Registration Convention, the rules of registration of space objects set forth in the latter Convention will be addressed in Section 3.3.2. As the jurisdiction and control over space objects may constitute an obstacle to debris removal, such as in situations where the State of registry fails to remove its dangerous debris object and also refuses to grant permission to others to do so, a question arises as to whether there are any legal grounds to justify non-consensual removal. Therefore, Section 3.3.3 will discuss some circumstances under general international law that may provide a defence for the non-consensual removal of space objects under foreign jurisdiction when certain conditions are met. Finally, the potential implications of non-consensual removal to international peace and security will be assessed in Section 3.3.4.

3.3.1 Jurisdiction, Control, and Ownership Regarding Space Objects

This section will discuss the question as to whether a State may remove a piece of space debris under the jurisdiction of another State. This issue is addressed in Article VIII of the Outer Space Treaty. The first sentence of this Article provides that:

> "A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body."

Jurisdiction, as an aspect of State sovereignty, "refers to a state's competence under international law to regulate the conduct of natural and juridical

186 Ibid, p. 131.

persons".[187] The notion of regulation embraces the exercise of all governmental authorities including legislative, executive and juridical.[188] Hence, Article VIII of the Outer Space Treaty affirms the power of States to enact and enforce law in relation to space objects carried on their registries.[189] Control means "the exclusive right and the actual possibility to supervise the activities of a space object" and any personnel thereof.[190] The whole concept of "jurisdiction and control" should not be read separately but as one block: "jurisdiction should induce control, and control should be based on jurisdiction".[191] Critically, the competence to "control" a space object is more than a technical capability.[192] Hence, a State's jurisdiction and control over its registered space object continues even if its technical control over such object is lost.[193] This can be understood by looking at the two dimensions of State sovereignty, an internal one and an external one. The internal dimension refers to the highest authority of a State to regulate its domestic affairs, and the external one indicates that a State cannot be submitted to the authority of another State without its consent, as all States are legally equal under international law.[194] Accordingly, the right of jurisdiction and control means not only a State's power to regulate and supervise its space object but also its competence to preclude other States from manipulating, capturing or relocating such object without its permission.

Article VIII speaks of "object launched into outer space" without adding further qualification, and it does not prescribe any temporal factor limiting the retention of a State's jurisdiction and control over its registered space object.[195] This implies that a State can continue to exercise jurisdiction and control over its registered space object even after such object loses functionality. In other words, "jurisdiction over a space object is not affected if and when it eventually becomes space debris".[196] This reading is in line with the foregoing analysis that the exercise of jurisdiction and control does not

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187 Crawford, J., & Brownlie, I. (2019). *Brownlie's Principles of Public International Law*, 9th ed., Oxford University Press, p. 440. For a general discussion on the notions of "sovereignty" and "jurisdiction" in international law see e.g., Truxal, S. (2017). *Economic and Environmental Regulation of International Aviation: From Inter-national to Global Governance*. New York: Routledge, pp. 35-49.

188 Ibid.

189 Schmidt-Tedd, B. & Mick, S. (2009). Article VIII. In *CoCoSL Vol. 1*, p. 157.

190 Ibid.

191 Ibid. See also Lafferranderie, G. (2005). Jurisdiction and Control of Space Objects and the Case of an International Intergovernmental Organisation (ESA). *German Journal of Air and Space Law (ZLW)*, *54*, p. 231.

192 Schmidt-Tedd & Mick (2009), ibid.

193 Mudge (2022), *supra* note 152, p. 124.

194 Van den Driest, S. (2022). Chapter 3: Subjects, Statehood, and Self-Determination. In Rose, C. *et al*. *An Introduction to Public International Law*. Cambridge University Press, p. 42.

195 Chung (2019), *supra* note 152, p. 33. See also Viikari (2008), *supra* note 3, p. 82: "Article VIII of the Outer Space Treaty assigns the jurisdiction, control and ownership of a space object to the state of registration for an indeterminate period of time […]".

196 Bittencourt Neto (2015), *supra* note 19, p. 160.

depend on the actual capability of technical control. In addition, while the expression "object launched into outer space" is not specifically defined in the Outer Space Treaty, the expression is used interchangeably with the term "space object" in the Registration Convention, which defines the latter term in the same way as the Liability Convention. A contextual reading of these treaties indicates that jurisdiction and control can extend also to debris fragments, meaning that States possess sovereign control over the fragments of their formerly intact space objects.[197] Reading otherwise would be asymmetric to the allocation and determination of responsibility and liability under the current legal regime, as the launching State can still be held liable for damage caused by its debris fragments.[198]

As a space object remains under the jurisdiction and control of the State of registry in perpetuity, any attempt by another State to remove that object without the express consent of the State of registry could be seen as illegal interference with such object and a breach of sovereignty. Hence, if a State wants to remove a certain debris object, it can only legally do so if it has jurisdiction and control over that object or with prior permission from the State on whose registry such object is carried.[199] In other words, as a report published by the US National Research Council (NRC) notes, "[n]o state has the legal authority to remove a debris object from space without the express consent of the object's state of registry".[200] The Report further states that "[a]bsent formal diplomatic engagement with other nations, the United States would be limited to retrieving only objects on its own registry."[201] Similarly, a statement of the Group of 77 and China at the 60th session of the LSC of COPUOS expresses the view that "no object should be removed without prior consent or authorization of the Registering State".[202] Accordingly, the consent of the registering State should be considered a "must-have" for the removal of debris under its jurisdiction.

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197 Mudge (2022), *supra* note 152, p. 126. Frigoli (2019), *supra* note 157, p. 58: "the registering State retains jurisdiction and control and ownership of the space object even if it is blown up into thousands of debris."

198 Su (2016), *supra* note 149, p. 408. See also Soucek, A. (2016). Legal and Practical Considerations of Registering Constellations and Space Debris. *IISL/ECSL Symposium on "40 years of entry into force of the Registration Convention: Today's practical issues*, p. 12.

199 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, p. 32.

200 NRC. (2011). *Limiting Future Collision Risk to Spacecraft: An Assessment of NASA's Meteoroid and Orbital Debris Programs* ("NRC Report of 2011"). The National Academies Press, p. 84. <https://nap.nationalacademies.org/catalog/13244/limiting-future-collision-risk-to-spacecraft-an-assessment-of-nasas>.

201 Ibid.

202 G-77 and China Statement during the 60th Session of the Legal Subcommittee of the UN COPUOS (2021), p. 5. <https://www.unoosa.org/documents/pdf/copuos/lsc/2021/statements/item_3_5_6a_6b_8_10_11_13_14_G77_China_ver.1_31_May_AM_LegalSC_280521.pdf>.

The use of the term "retain" in the provision suggests that it is not the act of registering that confers jurisdiction and control.[203] Hence, when a space object has not been registered, it does not mean that no State can exercise jurisdiction and control over such object. It should be noted that neither Article VIII of the Outer Space Treaty nor the Registration Convention which elaborates this Article prescribes a specific time limit for registration. Therefore, although it would be desirable for States to register their space objects immediately after a successful launch, there is no consistent State practice in this regard.[204] In the absence of specific timing, it can happen that a space object is not registered simply because this has not yet been done. In that scenario, it would be unreasonable to say that such an unregistered object is not subject to the jurisdiction of any State and can, as a corollary, be removed by any State without the need of prior permission. In the event of non-registration, other factors that demonstrate a link between a State and a certain space object, such as the act of launching and ownership, may become highly relevant in determining which State has jurisdiction and control over the unregistered object.[205]

At the same time, although registration does not in itself create jurisdiction and control, it confirms which State is entitled to exercise jurisdiction and control over a certain space object. As submitted by Chung, the act of registration "would offer better protection to the State of registry and its registered space object (or its debris) under international space law", which represents "the most compelling incentive for registration".[206] Therefore, it is beneficial for States to register their space objects in a timely manner as this can provide legal certainty to them. In addition, although there is no specific timing, States are obliged under the general principle of *pacta sunt servanda* to perform their treaty obligations in good faith. Therefore, for parties to the Registration Convention, not registering their space objects within a reasonable period may be regarded as a failure to fulfil their obligation of registration.

Article VIII Sentence 2 addresses the ownership of space object:

> "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."

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203 Masson-Zwaan & Hofmann (2019), *supra* note 18, p. 32.

204 Ibid.

205 Ibid. See also Jakhu, R. S., & Pelton, J. N. (Eds.). (2017). *Global Space Governance: an international study*. Cham: Springer, p. 344. Frigoli (2019), *supra* note 157, p. 56: "Ownership of a space object is a determining factor in identifying which state can exercise jurisdiction and control."

206 Chung (2019), *supra* note 152, pp. 37-38.

While a property is generally deemed as *res nullius* when its owner is no longer in a position to or has no intention to recover it, which entitles whoever finds it to lay claim to it, this is not the case in outer space.[207] Ownership of a space object is generally considered as perpetual since it is not affected by the location of such object under Article VIII of the OST.[208] Hence, "a space object continues to be owned by its owner(s) even if outwardly it appears to be uncontrolled and/or non-functional",[209] and even when the object has been fragmented into hundreds of space debris.[210] The argument can be supported by reading Article VIII of the Outer Space Treaty in the context of the Rescue Agreement, which complements Article VIII by prescribing the rights and obligations of all States Parties regarding the recovery and return of space objects that fall back to Earth outside the territory of the launching State.[211] It is likely that a falling object may be disintegrated and fragmented during the re-entry process, and the obligation to return suggests that ownership would still be attached to such object in spite of the disintegration.[212] As noted in a report published by the Organisation for Economic Co-operation and Development (OECD) in 2020, the UN space treaties "establish a strong property ownership regime of 'space objects'", under which "no nation may salvage, or otherwise collect, the space objects of other nations that are in space without the formal consent of the object's registered national owner".[213]

3.3.2 Registration of Space Objects

While Article VIII of the Outer Space Treaty affirms a jurisdictional link between a space object and the State on whose registry such object is carried, it does not impose an obligation on States to register its space object.[214] Neither does Article VIII specify which State should register an object launched into outer space or how a registration is to be made. These issues are addressed in the Registration Convention, which elaborates on Article VIII of the Outer Space Treaty. As set in its preamble, the purpose of the Registration Convention is to "provide for States Parties additional means

207 UN Doc. A/AC.105/C.1/2012/CRP.16 (2012), *supra* note 199, p, 31.

208 Frigoli (2019), *supra* note 157, p. 56. See also Force, M. K. (2016). Active Space Debris Removal: When Consent Is Not an Option. *The Air & Space Lawyer*, *29*(3), pp. 10-11.

209 UN Doc. A/AC.105/C.1/2012/CRP.16 (2012), *supra* note 199, p, 31.

210 Frigoli (2019), *supra* note 157, p. 56. See also Tallis, J. (2015). Remediating Space Debris: Legal and Technical Barriers. *Strategic Studies Quarterly*, *9*(1), p. 91: "Anything put into space remains the property of the entity that launched it — even if that property explodes into 5,000 pieces."

211 Art. 5, Rescue Agreement. See also UN Doc. A/AC.105/C.1/2012/CRP.16 (2012), *supra* note 199, p. 31.

212 Ibid.

213 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, OECD Publishing, p. 33.

214 Ibid, p. 31.

and procedures to assist in the identification of space objects".[215] As such, the Registration Convention operates in conjunction with the Liability Convention to identify the potentially liable State(s) for damage caused by space objects.[216]

Article II(1) of the Registration Convention provides that:

> "When a space object is launched into Earth orbit or beyond, the launching State shall register the space object by means of an entry in an appropriate registry which it shall maintain. Each launching State shall inform the Secretary General of the United Nations of the establishment of such a registry."[217]

This provision establishes a duty for States to establish and maintain an appropriate national registry of space objects. Under this provision, only a State qualified as "launching State" can register a space object in its national registry. The term "launching State" is defined in the Registration Convention the same way as in the Liability Convention, which refers to a "State which launches or procures the launching of a space object", and a "State from whose territory or facility a space object is launched".[218] When there is more than one launching State, they should jointly determine which one of them will register the space object in its national registry, and this State is referred to in the Registration Convention as the "State of registry".[219] Since States are only required to register space objects that are "launched into Earth orbit or beyond", there is no obligation to register objects that fail to reach orbit or spacecraft carrying out suborbital flight.[220]

Alongside the national registry, Article III of the Registration Convention asks the UN Secretary-General to maintain an international register of space objects.[221] This international register differs from the aforementioned national registry in that "registering a space object with the international register held by the Secretary-General of the United Nations does not play any role in allocating jurisdiction and control over that object".[222] In addition, while the Registration Convention leaves it to the State of registry to determine the contents of its national registry and the conditions under

215 Masson-Zwaan (2017), *supra* note 1, p. 142.
216 Viikari (2008), *supra* note 3, p. 75.
217 Art. II(1), Registration Convention.
218 Article I(a), ibid.
219 Art. I(c), ibid.
220 Schmidt-Tedd, B., Malysheva, N. R., Stelmakh, O. S., Tennen, L. I., & Bohlmann. U. M. (2013). Article II (National Registries/Registration Obligation) REG. In *CoCoSL Vol. 2*, p. 252.
221 Art. III(1), Registration Convention.
222 A/AC.105/C.2/2012/CRP.11 (2012). Responses to the Set of Questions Provided by the Chair of the Working Group on the Status and Application of the Five United Nations Treaties on Outer Space: Belgium, p. 4, para. 6(d).

which such registry is maintained,[223] it stipulates more specific requirements on the information to be recorded in the international registry. Article IV(1) of the Registration Convention provides that:

> "Each State of registry shall furnish to the Secretary-General of the United Nations, as soon as practicable, the following information concerning each space object carried on its registry:
> (a) Name of launching State or States;
> (b) An appropriate designator of the space object or its registration number;
> (c) Date and territory or location of launch;
> (d) Basic orbital parameters, including
>   i. Nodal period;
>   ii. Inclinations;
>   iii. Apogee;
>   iv. Perigee;
> (e) General function of the space object."

Besides the above information, the Registration Convention also provides that each State of registry may, from time to time, provide additional information to the UN Secretary-General concerning its registered space objects.[224] Furthermore, each State of registry shall notify the UN Secretary-General, to the greatest extent feasible and as soon as practicable, of its registered space objects which have been but no longer are in earth orbit.[225]

It has been noted that the information required to be provided is "vague and general", for while this is useful in identifying the launching State of a space object and the basic orbital parameters of such object at the time of registration, it is "not sufficient to allow for the object to be tracked with any precision, nor located in orbit at a future date".[226] As a result, the identification of specific objects in orbit is largely left to the space situational awareness (SSA) systems that track objects in space and maintain catalogues of their positions.[227] These catalogues do not have any legal effects attached to registration, but they constitute a useful source of data complementary to the information contained in the international register.[228]

The US currently maintains the most complete catalogue of space objects, while other States and international organisations such as China, Russia

223 Ar. II(3), Registration Convention.
224 Art. IV(2), ibid.
225 Art. IV(3), ibid.
226 Masson-Zwaan (2017), *supra* note 1, p. 143. Weeden, B. (2011). Overview of the Legal and Policy Challenges of Orbital Debris Removal. *Space Policy*, *27*(1), p. 41.
227 Weeden (2011), ibid.
228 Schmidt-Tedd & Mick (2009), *supra* note 189, p. 155.

and the EU have also developed their SSA capabilities.[229] Therefore, if a State intends to remove a debris object beyond its jurisdiction, it may use its own catalogue or request assistance from other States with SSA systems to "tag" such object to a specific launch event in order to ascertain its origin and identify the potential launching State.[230] Article VI of the Registration Convention could serve as a legal basis to request assistance:

> "Where the application of the provisions of this Convention has not enabled a State Party to identify a space object which has caused damage to it or to any of its natural or juridical persons, or which may be of a hazardous or deleterious nature, other States Parties, including in particular States possessing space monitoring and tracking facilities, shall respond to the greatest extent feasible to a request by that State Party, or transmitted through the Secretary-General on its behalf, for assistance under equitable and reasonable conditions in the identification of the object."

When a space debris object poses a substantial risk to the safety of space operations or to the long-term sustainability of the space environment, such as a massive derelict rocket body with a high risk of collision or explosion, it can be said that such object is of "a hazardous or deleterious nature", and the above Article VI could thus be applied in this case. When such object can be linked to a certain launch event, the State contemplating its removal may consult the international register maintained by the UN Secretary-General to ascertain the State of registry. In practice, this can be done by visiting the "Online Index of Objects Launched into Outer Space" published on the website of UNOOSA.[231] Once the identity of the State of registry is ascertained, the contemplating State may request approval from it for the debris removal.

3.3.3 Circumstances Precluding Wrongfulness and Non-Consensual ADR

The foregoing analysis indicates that States are entitled to clean up their own debris, but they can only remove a debris object under foreign jurisdiction with the authorisation of the State of registry of such object. This provision does not constitute a legal hurdle when ADR operations are conducted "on a 'for hire' (consensual) basis", namely when the State of registry agrees or even procures the removal services.[232] Under international law, consent by

229 Schrogl, K. U., Jorgenson, C., Robinson, J., & Soucek, A. (2018). Space Traffic Management: Towards a Roadmap for Implementation. *International Academy of Astronautics (IAA) June 2018*, pp. 96-98. For instance, the EU Space Surveillance and Tracking (EU SST), which has been in operation since 2016, provide data, information and services on space objects that orbit around the Earth. For more information see: <https://www.eusst.eu/>.

230 Weeden (2011), *supra* note 226, p. 41.

231 The online index is available at: <https://www.unoosa.org/oosa/osoindex/search-ng.jspx?lf_id=>.

232 Force (2014), *supra* note 16, p. 408.

one State to the commission of a given act by another State precludes the wrongfulness of such act in relation to the former State, provided that the consent is valid and to the extent that the act remains within the limit of the consent given.[233] Therefore, valid consent by the State of registry could justify the removal of a space object under its jurisdiction by another State, insofar as the removal operation remains within the limits of the consent given.

Meanwhile, if the State of registry of a dangerous space object neither consents to the removal of such object nor takes necessary initiatives to reduce the associated risks, Article VIII of the Outer Space Treaty could represent an obstacle for ADR operation.[234] Pursuant to this Article, States may be held internationally accountable for the non-consensual removal of space objects under the jurisdiction of other States.[235] Meanwhile, in the international legal field, lawbreakers are sometimes "excused for their actions because of the unusual circumstances they found themselves in".[236] In the context of non-consensual removal, the circumstances of *distress* and *necessity* are considered to be of the greatest potential relevance that may be invoked by the wrongdoing State to preclude the wrongfulness of its actions.[237] These two circumstances will be discussed in Sections 3.3.3.1 and 3.3.3.2 below.

3.3.3.1 Distress

The wrongfulness of an act of a State not in conformity with its international obligations can be precluded if the author of the act in question has no other reasonable way, in a situation of distress, of saving the author's life or the lives of other persons under the author's care.[238] As noted by the ILC, cases of distress involve mostly aircraft making emergency landings or ships entering ports in the territory of another State in a situation of emergency, such as under the stress of weather or following mechanical or navigational failure.[239]

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233 Art. 20, Draft articles on Responsibility of States for Internationally Wrongful Acts (ARSIWA), with commentaries. Text adopted by the International Law Commission at its fifty-third session, in 2001, and submitted to the General Assembly as a part of the Commission's report covering the work of that session (A/56/10). See also Chatterjee (2015), *supra* note 147, p. 27.

234 Bittencourt Neto (2015), *supra* note 19, p. 158.

235 Frigoli (2019), *supra* note 157, p. 58.

236 Byers & Boley (2023), *supra* note 35, p. 241.

237 Arts. 24 & 25, ARSIWA, *supra* note 233. In ARSIWA, the circumstance of "consent" is also listed as a circumstance precluding wrongfulness of an unlawful conduct. However, as noted by some scholars, whether it is appropriate to include consent in the secondary rule of international law is debatable. See e.g., Crawford & Brownlie (2019), *supra* note 187, p. 547: consent "seem[s] more akin to 'primary' rules, which define the content of obligations than to 'secondary' ones".

238 Art. 24, ARSIWA.

239 Commentary to Art. 24 of ARSIWA, para. 2.

Mirroring the cases involving aircraft and ships, a distress in space could be a situation where a crewed spacecraft encounters a serious anomaly which threatens the lives of the persons onboard. To save their lives, these persons may, for instance, seek shelter in a spacecraft of another State without prior permission and invoke the situation of distress as a justification. In the 2013 film Gravity, an American astronaut entered the Chinese Space Station and used the Chinese Shenzhou spacecraft to return to Earth after a life-threatening accident caused by a cloud of space debris.[240] This can be regarded as a circumstance of distress and the potential wrongfulness of getting onboard the spaceship of another State without prior permission could therefore be precluded.

The plea of distress requires that there is "no other reasonable way" to save the lives of the people in distress.[241] It seems difficult to conceive a scenario where a certain space object has to be removed in order to save the lives of astronauts. The practice of the ISS in the event of close conjunctions is to conduct CAMs and to shelter the astronauts onboard in an escape vessel according to the risk level.[242] Reference can further be made to the rules of the road to avoid collisions in space contained in the *Best Practices for the Sustainability of Space Operations* released by the Space Safety Coalition (SSC) in 2023.[243] Evidently, in the event of a high-risk conjunction between a crewed spacecraft and a *non-manoeuvrable* spacecraft, the suggested rule is that the crewed spacecraft should move.[244] Meanwhile, it is noteworthy that even when a high-risk conjunction involves a crewed spacecraft and a *manoeuvrable* non-crewed spacecraft, it is still the crewed spacecraft that should move unless otherwise arranged.[245] The underlying rationale is that "human safety is of paramount importance, crewed spacecraft often prefer to 'give way' (meaning to take evasive manoeuvring action), preferring to retain the highest levels of support and control over threat mitigation scenarios".[246] In other words, it is considered a safer option for the crewed spacecraft to manoeuvre for collision avoidance. In this sense, a possible situation that might satisfy the "no other reasonable way" condition could be that a crewed spacecraft has somehow lost its manoeuvrability and an ADR spacecraft happens to be available to remove in a timely manner a debris object threatening the crewed spacecraft.

240 Gravity (2013 film). Wikipedia. <https://en.wikipedia.org/wiki>.
241 Art. 24(1), ARSIWA.
242 NASA. (26 May 2021). Space Debris and Human Spaceflight. <https://www.nasa.gov/mission_pages/station/news/orbital_debris.html>.
243 SSC. *Best Practices for the Sustainability of Space Operations*, initially published in 2019 and updated in 2023. <https://spacesafety.org/best-practices/>.
244 Ibid, p. 15.
245 Ibid.
246 Ibid, p. 16.

3.3.3.2 Necessity

The state of necessity applies to situations where acting in a manner not in compliance with an international obligation of the responsible State is the only way to safeguard an essential interest against a grave and imminent peril.[247] In the *Gabčíkovo-Nagymaros* case, the ICJ considered the state of necessity as "a ground recognized by customary international law for precluding the wrongfulness of an act not in conformity with an international obligation".[248] By examining the work of the ILC, the Court identified five conditions that must be cumulatively satisfied for the invocation of necessary:[249]

(1) it must have been occasioned by an "essential interest";
(2) that interest must have been threatened by a "grave and imminent peril";
(3) the act being challenged must have been the "only means" of safeguarding that interest;
(4) the act must not have "seriously impair[ed] an essential interest" of the State towards which the obligation existed; and
(5) the State which is the author of that act must not have contributed to the occurrence of the state of necessity.

As to the first condition, "essential interest" can be the interests of a State, of a group of States, and of the international community as a whole. Therefore, a State may claim that its "essential interest" is at stake because its space asset vital to its national security is threatened by another space object. In the *Gabčíkovo-Nagymaros* case, the ICJ stated that "the concerns expressed by Hungary for its natural environment in the region affected by the Gabčíkovo-Nagymaros Project related to an 'essential interest' of that State".[250] The court also cited its statement in the *Nuclear Weapons* advisory opinion that "the environment is not an abstraction but closely related to the well-being of humankind, including generations unborn".[251] As humankind is becoming increasingly dependent on space infrastructures, the preservation of the usability and stability of the orbital environment can be regarded as an "essential interest" to be safeguarded.

To satisfy the second condition, the interest must be threatened by a "grave and imminent peril". Reference can be made to the statement of the ICJ in the *Gabčíkovo-Nagymaros* case:

> "The word "peril" certainly evokes the idea of 'risk'; that is precisely what distinguishes 'peril' from material damage. But a state of necessity could not

247 Art. 25, ARSIWA.
248 ICJ *Gabčíkovo-Nagymaros Project* judgment, *supra* note 45, p. 40, para. 51.
249 Ibid, pp. 40-41, para. 52.
250 Ibid, p. 41, para. 53.
251 Ibid. ICJ *Nuclear Weapons* advisory opinion, *supra* note 98, para. 29.

> exist without a 'peril' duly established at the relevant point in time; the mere apprehension of a possible 'peril' could not suffice in that respect. […] a 'peril' appearing in the long term might be held to be 'imminent' as soon as it is established, at the relevant point in time, that the realization of that peril, however far off it might be, is not thereby any less certain and inevitable."[252]

Accordingly, a merely apprehended or contingent peril is not sufficient.[253] Rather, the state of necessity requires the peril to be "clearly established on the basis of the evidence reasonably available at the time".[254] Therefore, a State seeking to invoke the state of necessity to justify its unauthorised removal of a debris object under foreign jurisdiction must prove the actual risk posed by such object to the essential interest concerned. This may be difficult when the essential interest to be safeguarded is the stability of the orbital environment, for this is mostly threatened by the accumulation of space debris generated in the over six decades of space activities rather than a single debris creation event. One possible scenario may be that a massive debris object is likely to be subject to a catastrophic fragmentation which could seriously threaten the long-term usability of a certain orbital area. In that scenario, the State invoking necessity may need to prove the risk magnitude, i.e., the risk of collision and the severity if such risk materialises.

The third condition requires that the conduct in question must be the only way to safeguard the essential interest.[255] This condition cannot be met even when other available means are more costly or less convenient.[256] This condition is difficult to prove when an operational spacecraft is threatened by approaching debris, as such spacecraft could simply conduct CAMs to reduce the risk, though this may consume additional propellant.[257] Meanwhile, the plea of necessity may be established in scenarios where a highly hazardous debris object threatening the space environment is removed without prior consent, provided that the risk of such object is clearly established and its removal is proven to be the only way to mitigate the risk. As noted by Popova and Schaus, the growing congestion in Earth orbit will probably induce the occurrence of accidents in outer space, and it is thus conceivable that the state of necessity might gain more relevance in the future and play a role in servicing as a ground for ADR operations.[258]

The fourth condition requires that the act in question does not seriously impair an essential interest of the State(s) towards which the obligation

252 ICJ *Gabčíkovo-Nagymaros Project* judgment, *supra* note 45, p. 42, para. 54.
253 Commentary to Art. 25 of ARSIWA, para. 16.
254 Ibid.
255 Art. 25(1)(a), ARSIWA.
256 Commentary to Art. 25 of ARSIWA, para. 15.
257 Wang, G. (2014). The Jurisdiction of Space Debris and the Legal Basis of Active Space Debris Removal. *Journal of Beijing Institute of Technology (Social Sciences Edition)*, *16*(6), p. 108.
258 Popova & Schaus (2018), *supra* note 2, p. 9.

exists, or of the international community as a whole.[259] In other words, necessity cannot justify an action by one State that causes serious harm to other States. When it comes to an unauthorised ADR operation, the State invoking necessity may assert that there are no substantial interests impaired as the target debris object is no longer functional. Meanwhile, the State of registry of such object may argue that the non-consensual removal has seriously impaired its essential interest because the object concerned contains sensitive data and thus involves national security interests.[260] In the end, the judges adjudicating the dispute may need to make "a reasonable assessment of the competing interests" involved.[261]

Finally, according to the fifth condition, the state of necessity cannot be relied on if the State invoking necessity has contributed to the situation of necessity.[262] Therefore, a State that has deliberately put its space assets in peril cannot later resort to the state of necessity to preclude the wrongfulness of its unlawful acts to safeguard these assets.

In sum, the circumstances precluding wrongfulness provide certain legal grounds for one State to remove space debris under the jurisdiction of other States, on the condition that the removing State acts within the ambit of these circumstances. When a valid consent is given by the State of registry, the State engaging in ADR activities should operate within the limits of such consent. In the absence of consent, circumstances such as distress and necessity may justify some "self-help" actions and preclude the wrongfulness of unauthorised ADR, provided that the pre-defined conditions for the invocation of these circumstances have been fulfilled. Specifically, the plea of distress is subject to the condition that there are "no other reasonable ways" of saving lives, and the circumstance of necessity is applicable only when acting in a manner not in conformity with international law is "the only way" of safeguarding an essential interest. These conditions denote the exceptional character of these two circumstances.[263]

3.3.4 Security Risks of Non-Consensual ADR

While the circumstances precluding wrongfulness represent legal tools at the disposal of ADR advocates,[264] any non-consensual ADR operations targeting objects under foreign jurisdiction should be conducted with caution due to the potential implications of these operations. This is because an unauthorised removal may lead to tension and conflicts, especially when

259 Art. 25(1)(b), ARSIWA.
260 See Section 3.3.4 *infra*.
261 Commentary to Art. 25 of ARSIWA, para. 17.
262 Art. 25(2)(b), ARSIWA.
263 Commentary to Art. 24 of ARSIWA, para. 6. Commentary to Art. 25 of ARSIWA, para. 1.
264 Force (2014), *supra* note 16, p. 418.

the target for removal is of technical and military sensitivity, which could threaten international peace and security. Specifically, it has been noted that "the space security nexus to jurisdiction and control over space objects continues *ad infinitum*", and therefore "circumventing the provisions of the existing regime that establish jurisdiction and control in the State of registry may have negative consequences for space security".[265] The interests underlying the jurisdictional link between a State and its space object are articulated in the NRC Report of 2011:

> "The question of whether or not a particular object is to be removed from space as 'debris' will be scrutinized through a strong filter of national interests and security. The legal principle that forbids one nation from taking the space object of another has deep roots: it goes back to the early days of the Cold War era when the USSR and the United States wanted to deny each other a facile excuse to seize one another's satellites in order to engage in reverse engineering. The Cold War is over, but the acute sensitivity regarding satellite technology remains."[266]

As space objects may remain technically and strategically sensitive even after they become non-functional following mission completion, it can be in the interest of States to protect these objects from arbitrary capture or removal of other States to avoid the divulgence of sensitive and classified information. Hence, as observed by Hall, "any unauthorized attempt on the part of one state covertly or overtly to salvage or remove inactive 'abandoned' spacecraft of another state from orbit will trigger international incidents and, possibly, military conflict".[267]

With regard to the security risks involved in a non-consensual ADR, reference can be further made to the UNSG Report of 2021.[268] The Report contains the views of States on the following three issues and a consolidated summary of these views:

1. "[E]xisting and potential threats and security risks to space systems, including those arising from actions, activities or systems in outer space or on Earth";
2. "[A]ctions and activities that could be considered responsible, irresponsible or threatening in outer space and their potential impact on international security";
3. "[F]urther development and implementation of norms, rules and principles of responsible behaviours and on the reduction of the risks of misunderstanding and miscalculations with respect to outer space".[269]

265 UN Doc. A/AC.105/C.1/2012/CRP.16 (2012), *supra* note 199, p. 33.

266 NRC (2011), *supra* note 200, p. 85.

267 Hall, R. C. (1967). Comments on Salvage and Removal of Man-Made Objects from Outer Space. *Journal of Air Law and Commerce*, *33*(2), p. 288.

268 UN Doc. A/76/77 (13 July 2021), Report of the UN Secretary-General on Reducing space threats through norms, rules and principles of responsible behaviours.

269 Ibid, p. 1.

All these issues address the need for consent of the State of registry for the performance of RPO to approach its space objects. Since RPO are in general part of an ADR mission, the views regarding RPO can apply *a fortiori* to ADR activities.

As to the *first* issue, the UNSG Report of 2021 states that:

> "Rendezvous and proximity operations, if carried out without advance notification, coordination or consent, could be interpreted as a threat or hostile act. The State whose satellite was the object of such a close approach would be unable to know the intent of the manoeuvring satellite."[270]

For the *second* issue, the UNSG Report enumerates a series of actions and activities that could be considered as responsible and irresponsible. Examples of responsible behaviours proposed by States include, among others: "Notification of manoeuvres and of rendezvous and proximity operations, including in order to coordinate operations, to avoid potential misunderstandings or to seek consent."[271] In contrast, RPO "that are carried out without sufficient transparency or prior communication, without consent or without cooperation, [or] that make contact without permission" can be regarded as irresponsible behaviour.[272]

Finally, with regard to the further development of rules and standards for RPO within the context of the *third* issue, the UNSG Report of 2021 outlines three possible elements including, *inter alia*:

> "Carry out [RPO] in an open and transparent manner, including by requiring prior consent before approaching the satellite of another State."[273]

It can be seen from the above consolidated views that the need for prior consent is underlined in the context of all these three issues, and RPO without prior consent may lead to misunderstandings and security concerns. The issue of ADR is addressed more explicitly in the replies submitted by some States. In particular, France expresses the view that:

> "Rendezvous operations, including active debris removal, pose a high risk to the space objects being approached. When consent has not been obtained for a rendezvous operation, such an operation may, under certain circumstances, be interpreted by the targeted State as an attack aimed at destroying or causing the loss of control of the space object being approached or inspected. Therefore, France considers that such operations should be subject to the prior and explicit consent of the relevant State."[274]

270 Ibid, p. 7, para. 16.
271 Ibid, p. 8, para. 18(b).
272 Ibid, p. 10, para. 19(f).
273 Ibid, p. 15, para. 36(a).
274 Ibid, p. 42.

It can be said that States share a common understanding that non-consensual ADR operations may be perceived as a threatening or even hostile action. Hence, even in scenarios where the conditions of invoking the circumstances for precluding wrongfulness may be satisfied, the benefits that can be gained from a non-consensual ADR operation should be properly weighed and balanced against the potential risk of tensions and conflicts that could be triggered by such operation.[275] States may raise these circumstances to the State of registry in the process of consultation and negotiation undertaken pursuant to Article IX of the Outer Space Treaty, so as to request the State of registry to either remove the debris itself or to grant permission for removal. If the consultation fails to achieve a concrete result and non-consensual removal is considered as imperative, the State engaging in such operation should take reasonable measures to minimise the risk of unwanted escalation. In any event, non-consensual removal, even when justifiable, is advisable to be treated as a careful exception.

Ideally, if States could conclude an international agreement specifying the conditions of non-consensual ADR, many legal issues and uncertainties associated with this kind of operations can be solved. However, in view of the diverging levels of strategic and military sensitivity of space objects, States may want to determine the granting of consent for removal on a case-by-case basis. Therefore, the development of commonly accepted conditions for ADR operations without the need for prior consent can be challenging, as States generally consider the unauthorised approaching to their space objects as a potentially threatening action, let alone capturing and removing them. Another challenge is how to ensure that these conditions are not abused for hostile purposes in order to assuage States that their national security interests would not be undermined. In view of these difficulties, it appears that a more feasible way forward for the development of space law to surmount the hurdle of jurisdiction and control would be to facilitate the happening of ADR operations on a consensual basis.

3.4 *Issue 4*: Legal Restrictions on the Use of ADR Technologies

Section 3.4 will discuss the rules and principles regulating the dual-use capabilities of ADR technologies. As mentioned in Chapter 2, ADR technologies have an inherent dual-use nature, meaning that they can be used both to remove a debris object from space and to destroy an active satellite of a potential adversary. In light of this potential, this section will assess the limitations posed by the current international legal regime on the use of ADR technologies. Section 3.4.1 will discuss the prohibition to place in orbit around the Earth nuclear weapons and weapons of mass destruction under Article IV(1) of the Outer Space Treaty and whether the deployment

275 Force (2014), *supra* note 16, p. 410.

of ADR systems in space may violate this provision. Section 3.4.2 will assess the relevance of the prohibition on the threat or use of force and the right of self-defence under the UN Charter to ADR activities.

3.4.1 Prohibition to Place Weapons of Mass Destruction in Outer Space

Article IV(1) of the Outer Space Treaty prohibits States from placing in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, installing such weapons on celestial bodies, or stationing such weapons in outer space in any other manner. As the provision is silent on any weapons other than those indicated above, the placement of conventional weapons in Earth orbit is not banned by this article.[276] The Outer Space Treaty does not define the term "weapon", and there is no internationally agreed definition of what a space weapon is. The difficulty of establishing a commonly accepted definition lies largely in the fact that many space mechanisms have the potential to be used for hostile actions if their operators so intend. According to the US, "[a]ll satellites with manoeuvring capabilities, if launched into the proper orbit, could technically be used to attempt to collide with another satellite, even if not optimized to do so".[277] Similarly, Germany notes that "a significant number of space objects can, to a varying degree, be used to target, disable or even destroy objects in space – even when not designed for such purposes originally."[278] The dual-use nature of many space objects complicates the task of determining whether these objects should be regarded as weapons. Because of this difficulty, the discussions on reducing space threats currently follow a behaviour-based approach, which focuses on how space activities are conducted, as distinct from a capabilities-based approach, which focuses on the capabilities of space objects.[279] Therefore, like many other space objects of dual-use nature, a removal spacecraft should not be regarded as a space weapon simply because of its potential capability to destroy another satellite, and what matters most is how such spacecraft is used.

The terms "nuclear weapons" and "weapons of mass destruction" are also not defined in the Outer Space Treaty. Since in the formulation of Article IV of the OST, "*any other* kinds of weapons of mass destruction" are prohibited alongside "nuclear weapons", weapons of mass destruction should be understood as referring to those weapons with a destructive power comparable with nuclear weapons.[280] In its 1996 *Nuclear Weapons* advisory opin-

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276 Masson-Zwaan & Hofmann (2019), *supra* note 18, pp. 18-19.
277 A/76/77 (2021), *supra* note 268, p. 97.
278 A/AC.294/2022/WP.6 (5 May 2022), Responsible behaviours as a practical contribution to the prevention of an arms race in outer space and to strengthening the international frameworks on space security: Submitted by Germany, para. 13.
279 See Chapter 5 Section 5.4.1 *infra*.
280 Schrogl, K.-U. & Neumann, J. (2009). Article IV. In *CoCoSL Vol. 1*, p. 76.

ion, the ICJ referred to the term "nuclear weapons" as "explosive devices whose energy results from the fusion or fission of the atom".[281] As to the meaning of "weapons of mass destruction", the UN General Assembly referred to this term in its resolution 32/84(B) of 1977 as "atomic explosive weapons, radioactive material weapons, lethal chemical and biological weapons, and any weapons developed in the future which might have characteristics comparable in destructive effect to those of the atomic bomb or other weapons mentioned above".[282] It follows that weapons of mass destruction should be understood as weapons that can cause a magnitude of catastrophe similar to that of atomic explosions.[283] According to the study of Dobos and Prazak, even if ADR systems could be used for hostile purposes, "the technology of the ADR system is probably not practical for the conduct of massive anti-satellite (ASAT) attacks if developed in a scope proposed by the supporters of active debris mitigation".[284] Therefore, a spacecraft designed to perform ADR missions and used for this purpose should not be regarded as a *weapon*, nor as a weapon of *mass destruction*.

As to the restrictions on the use of removal spacecraft, reference can be further made to the preamble of the Outer Space Treaty, which recognises "the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes". The notion of "peaceful" is commonly understood as meaning "non-aggressive".[285] This interpretation is congruent with the fact that the current legal regime does not completely rule out military activities and that space has been used for military purposes such as reconnaissance since the dawn of the space age.[286] In this sense, the use of a removal spacecraft for non-aggressive purposes, including removing one's own debris or removing a debris object under the jurisdiction of another State on a consensual basis, should be regarded as a form of peaceful use of outer space. This argument can be supported by referring to Article II of the Convention for Establishment of a European Space Agency, which provides that the purpose of ESA "shall be to provide for, and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications".[287] Similarly, China's national space policy issued in 2022 affirms that "China upholds the principle of exploration and utilization of

281 ICJ *Nuclear Weapons* advisory opinion, *supra* note 98, para. 35.
282 UN Doc. A/RES/32/84-B (12 December 1977). Prohibition of the development and manufacture of new types of weapons of mass destruction and new systems of such weapons.
283 Carus, W. S. (2012). *Defining "Weapons of Mass Destruction"*. Center for the Study of Weapons of Mass Destruction, Occasional Paper 8, pp. 11-14.
284 Dobos, B., & Prazak, J. (2019). To Clear or to Eliminate? Active Debris Removal Systems as Antisatellite Weapons. *Space Policy*, *47*, p. 222.
285 Lyall, F., & Larsen, P. B. (2017). *Space Law: A Treatise*. 2nd ed., Routledge, p. 496.
286 Blount (2019), *supra* note 38, p. 181. See also Blount, P. J. (2019). Chapter 5: Peaceful Uses of Outer Space. In Masson-Zwaan & Hofmann (2019), *supra* note 18, pp. 67-68.
287 ESA. ESA's Purpose. <https://www.esa.int/About_Us/Corporate_news/ESA_s_Purpose>.

outer space for peaceful purposes".[288] As both ESA and China emphasise the peaceful purposes of their space activities, their engagement in ADR missions indicates an understanding that ADR activities conform to the peaceful principle. Hence, as Blount submits, "there is no legal prohibition that disallows the deployment and use of [ADR] technologies for peaceful purposes".[289]

In sum, the placement of removal spacecraft in orbit around the Earth and the use of such spacecraft for the purpose of removing space debris on a consensual basis are allowed under the Outer Space Treaty. The use of ADR technologies for the remediation of space debris also conforms to the principle of peaceful purposes of the Outer Space Treaty. As mentioned earlier, Article III of the Outer Space Treaty affirms the application of international law to space activities. Specifically, Article III requires space activities to be carried out "in accordance with international law, including the Charter of the United Nations ("UN Charter"),[290] "in the interest of maintaining international peace and security and promoting international co-operation and understanding". The explicit reference to the UN Charter and to the maintenance of international peace and security indicates the intention of the drafters of the Outer Space Treaty to make the rules and principles related to security matters under international law applicable to outer space.[291] In this regard, Articles 2(4) and 51 of the UN Charter are of particular relevance: the former prohibits the threat or use of force, and the latter recognises the rights of individual and collective self-defence.[292] The next section will discuss the limitations imposed by these two Articles on the use of ADR technologies.

3.4.2 The Prohibition on the Threat or Use of Force and the Right of Self-Defence

Article 2(4) of the UN Charter prescribes a general prohibition on the threat or use of force:

> "All Members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state, or in any other manner inconsistent with the Purposes of the United Nations."

288 State Council Information Office of China. (January 2022). *China's Space Program: A 2021 Perspective*. The text of the policy is available at: <https://www.cnsa.gov.cn/english/n6465645/n6465648/c6813088/content.html>.

289 Blount (2019), *supra* note 38, p. 182.

290 Charter of the United Nations, adopted 26 June 1945, entered into force 24 October 1945, 1 UNTS XVI.

291 Azcárate Ortega, A., & Lagos Koller, H. (2023). The Open-Ended Working Group on Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours: The Journey So Far, and the Road Ahead. *Air and Space Law*, *48*(Special), p. 22.

292 Masson-Zwaan (2017), *supra* note 1, p. 140.

Besides being enshrined in the UN Charter, the prohibition of use of force is also a rule of customary international law, binding also the very few States that are not parties to the UN Charter.[293] Article 2(4) prohibits not only the use but also the *threat* of force. However, in practice, it is not uncommon for political or military leaders of States to express threats to use force against other States, and such threats do not necessarily constitute a breach of Article 2(4).[294] Threats are generally not regarded as a violation of Article 2(4) to the extent that they remain "political rhetoric of a general nature", unless they become "sufficiently specific".[295] As such, it may amount to a "threat of force" under Article 2(4) when, for instance, a State threatens to use its removal spacecraft to capture or destroy a specific military satellite of another State.

Article 2(4) prohibits the threat or use of force "against the territorial integrity or political independence of any state, or in any other manner inconsistent with the Purposes of the United Nations". The Purposes of the UN are enshrined in Article 1 of the UN Charter, which includes to "maintain international peace and security".[296] To this end, States should "take effective collective measures for the prevention and removal of threats to the peace, and for the suppression of acts of aggression or other breaches of the peace".[297] The requirement to maintain peace accords with space law since "a central goal of the regime is the maintenance of international peace and security".[298] The use of dual-use technologies for hostile purposes can be destabilising, which may lead to tensions and conflicts in outer space. Therefore, pursuant to Article 2(4) of the UN Charter, States should refrain from using or threatening to use ADR systems for forcible actions against other States, including to impinge on the rights of other States to explore and use outer space by interfering with their space activities.[299]

The lawful exercise of the right of self-defence as enshrined in Article 51 of the UN Charter constitutes an exception to the prohibition on the use of force.[300] Article 51 provides that nothing in the Charter "shall impair the inherent right of individual or collective self-defence if an armed attack occurs against a Member of the United Nations, until the Security Council has taken measures necessary to maintain international peace and security". For a self-defence to be warranted, it must be taken in response

293 Blokker, N. M. & Dam-de Jong, D. A. (2022). Chapter 11: Law on the Use of Force. In Rose, C. *et al*. *An Introduction to Public International Law*. Cambridge University Press, p. 216.
294 Ibid.
295 Ibid.
296 Art. 1(1), the UN Charter.
297 Ibid.
298 Blount (2019), *supra* note 38, p. 182.
299 Ibid.
300 ICJ *Nuclear Weapons* advisory opinion, *supra* note 98, para. 38.

to an "armed attack".[301] In the *Nicaragua* judgment, the ICJ distinguished "the most grave forms of the use of force (those constituting an armed attack) from other less grave forms".[302] The Court further stated that the "scales and effects" are to be considered when assessing whether a certain act constitutes an "armed attack", as distinct from other less grave forcible actions such as a mere frontier incident carried out by regular armed forces.[303] Accordingly, not every use of force necessarily amounts to an armed attack, and only the latter entitles a State to resort to self-defence under Article 51 of the UN Charter.[304] However, it should be noted that there is "no clear watermark for distinguishing armed attacks from uses of force", and the determination has to be made by taking all the relevant facts and circumstances of each specific case into account.[305]

Although it is not expressly stipulated in Article 51 of the UN Charter, every lawful exercise of the right of self-defence must meet the conditions of necessity and proportionality.[306] As stated by the ICJ in the *Nicaragua* judgment, there is a "specific rule whereby self-defence would warrant only measures which are proportional to the armed attack and necessary to respond to it, a rule well established in customary international law".[307] The customary status of the principles of necessity and proportionality was also affirmed by the ICJ in the *Nuclear Weapons* advisory opinion and in the *Oil Platforms* judgment.[308] Necessity is generally understood as meaning that the victim State has no other reasonable option in the circumstances than to resort to forceful actions to defeat the armed attack.[309] This does not require the use of force to be the only available means to respond to an armed attack but that non-forceful measures are insufficient to address the situation.[310] Proportionality requires that the scope, duration, intensity and effects of the defensive response correspond to the original armed attack.[311]

As the inherent right of self-defence is enshrined in the UN Charter and has

301 Ibid.

302 *Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. United States of America). Merits, Judgment. I.C.J. Reports 1986*, p. 101, para. 191.

303 Ibid, p. 103, para. 195.

304 Schmitt, M. N. (2017). *Tallinn Manual 2.0 on the International Law Applicable to Cyber Operations*. Cambridge University Press, p. 341. Sarah, M. (2014). The Legality and Implications of Intentional Interference with Commercial Communication Satellite Signals. *International Law Studies*, *90*, p. 171.

305 Blokker & Dam-de Jong (2022), *supra* note 293, p. 224.

306 Ibid, p. 225.

307 ICJ *Nicaragua* judgment, *supra* note 302, paras. 176 & 194.

308 ICJ *Nuclear Weapons* advisory opinion, *supra* note 98, para. 41. *Oil Platforms (Islamic Republic of Iran v. United States of America), Judgment*, *I. C. J. Reports 2003*, paras. 43, 73-74, & 76.

309 Crawford, J., & Brownlie, I. (2019). *Brownlie's Principles of Public International Law*. 9th ed., Oxford University Press, p. 722. Schmitt (2017), *supra* note 304, p. 348.

310 Schmitt (2017), ibid, pp. 348-349.

311 Brownlie & Crawford (2019), *supra* note 309, p. 722. Schmitt (2017), ibid, p. 349.

been affirmed by the ICJ, it is applicable in outer space by virtue of Article III of the Outer Space Treaty. As observed by Zhao and Jiang, there is no international law denying the existence of the right of self-defence in outer space, and any denial of such right would put States in a disadvantaged position to safeguard their national security and other essential interests in space.[312] Moreover, the existence of the right of self-defence in the space domain has been explicitly affirmed in national and international policy documents issued by some Western States. The US National Space Policy of 2020 states that the US "will continue to use space for national security activities, including for the exercise of the inherent right of self-defence".[313] The North Atlantic Treaty Organization (NATO)'s overarching Space Policy also addresses expressly the threat to space assets and the issue of space-related self-defence.[314] In particular, the Policy states that:

> "At the 2021 Brussels Summit, Allies agreed that attacks to, from, or within space present a clear challenge to the security of the Alliance […]. Such attacks could lead to the invocation of Article 5. A decision as to when such attacks would lead to the invocation of Article 5 would be taken by the North Atlantic Council on a case-by-case basis".[315]

Article 5 is the cardinal provision of the North Atlantic Treaty, which sets out the principle of collective defence in response to an attack against one or more NATO members.[316] Attacks to and within space can be conducted by using direct-ascent and co-orbital anti-satellite systems to damage the space assets of other States.[317] Attacks can also be from space to Earth by using jammers, lasers and projectiles ejected from orbit to damage targets on the ground.[318] The use of removal spacecraft for hostile purposes can

312 Zhao, Y., & Jiang, S. (2019). Armed Conflict in Outer Space: Legal Concept, Practice and Future Regulatory Regime. *Space Policy*, *48*, p. 54.

313 US. (9 December 2020). *National Space Policy of the United States of America*, p. 3. Available at: <https://www.faa.gov/sites/faa.gov/files/2022-04/National_Space_Policy.pdf>.

314 NATO. (17 January 2022). *NATO's overarching Space Policy*. Available at: <https://www.nato.int/cps/en/natohq/official_texts_190862.htm?selectedLocale=en>.

315 Ibid, para .12. Article 5 of the North Atlantic Treaty, which sets out the principle of collective defence, is the cardinal provision of the Treaty. It provides that if a NATO member is the victim of an armed attack, each and every NATO member will consider this armed attack as against all members, and will take necessary actions to assist the member attacked "in exercise of the right of individual or collective self-defence recognized by Article 51 of the Charter of the United Nations … including the use of armed force". See NATO. (14 April 2021). Collective Defence – Article 5. <https://www.nato.int/cps/en/natohq/topics_110496.htm>.

316 NATO. (2 September 2022). Founding Treaty. <https://www.nato.int/cps/en/natohq/topics_67656.htm>.

317 Mutschler, M. M. (2010). Keeping Space Safe: Towards a Long-Term Strategy to Arms Control in Space. *Peace Research Institute Frankfurt (PRIF) Report*, *98*, p. 5.

318 Cohen, R. S. (28 May 2020). What's a Space Weapon? The Answer Can Be Complicated. *Air & Space Force Magazine*. <https://www.airandspaceforces.com/whats-a-space-weapon-the-answer-can-be-complicated/>.

be characterised as a threat *within* space and may potentially trigger the exercise of self-defence by NATO.

As the destructive effects of these different types of space-related threats vary, the methods taken and their intensity can be factual elements to be considered when assessing the "scale and effects" of a certain forcible act. For instance, the use of high-end kinetic capabilities against a substantial amount of space assets, such as a constellation of navigation or communication satellites, is more likely to surpass the threshold of armed attack than the use of low-end jamming which only causes temporary and reversible effects. This does not mean that signal jamming cannot constitute an armed attack. As noted by the ICJ in its *Nuclear Weapons* advisory opinion, neither Article 2(4) nor Article 51 of the UN Charter refers to specific weapons, and thus these provisions "apply to any use of force, regardless of the weapons employed".[319] Therefore, the use of non-kinetic systems, such as cyber-attack and satellite signal interference can also rise to "use of force" and "armed attack" if its scale and effects reach the requisite threshold of intensity.[320]

In sum, under international law, the removal spacecraft should in principle not be used for aggressive actions such as destroying satellites of other States, though it may be used in an exercise of the right of self-defence in response to an armed attack. One question to consider is whether the right of self-defence can serve as a legal ground for the removal of a debris object of another State without prior consent. This will require the existence of an armed attack in the first place. A potential scenario could be that a State somehow creates or releases space debris with an aim to cause damage to the space assets of another State, and the intensity of such hostile action crosses the gravity threshold of armed attack. In that event, the victim State, if its technology so allows, may remove the incoming space debris to safeguard its space assets, to the extent that this constitutes a necessary and proportional response to such attack.

3.4.3 Lack of Specific Rules to Address Dual-Use Concerns

The discussion in this section shows that removal spacecraft designed and used for the purpose of space debris remediation should not be regarded as "weapons" or "weapons of mass destruction" in outer space. As such, deployment and use of removal spacecraft in orbit around the Earth does not constitute a violation of the Outer Space Treaty. In the meantime, international law imposes restrictions on the use of removal spacecraft. Pursuant to the prohibition on the threat or use of force in international relations under the UN Charter, the threat or use of removal spacecraft for aggressive

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319 ICJ *Nuclear Weapons* advisory opinion, *supra* note 98, para. 39.
320 Schmitt (2017), *supra* note 304, p. 339 et seq. Sarah (2014), *supra* note 304, pp. 171-172.

actions against other States is prohibited, although States are entitled to use such spacecraft to respond to an armed attack under certain conditions.

Meanwhile, the legality of deploying and using removal spacecraft for ADR operations does not mark the end of the analysis.[321] As mentioned in Chapter 2, owing to their dual-use potential, even when ADR operations are conducted solely for benign purposes, such as the removal of one's own hazardous objects from congested orbits, these operations could still be mistaken as embodying a hostile intention. Therefore, while the current legal regime imposes limitations on the use of ADR technologies for forcible actions, it does not specifically address how ADR activities should be carried out in a way to reduce the potential security concerns arising from the dual-use potential of ADR technologies.

3.5 Chapter Conclusion

This chapter aimed to answer the questions of how the hard law pillar of international space law applies to the four issues relating to the governance of ADR and whether there exist regulatory gaps. An examination of the rules and principles under the UN space treaties and general international law shows that these rules and principles lay down the fundamental legal framework for space activities including ADR. Yet, they do not specifically address the issue of space debris, and there are legal gaps for the regulation of each of the four issues, which will be summarised below.

As to *Issue 1*, The UN space treaties and general international law do not impose upon States an explicit obligation to mitigate and remove space debris. As a baseline, according to the Outer Space Treaty, States have the right to freely explore and use outer space, to the extent not prohibited by international law. Space debris is a side effect of the exercise of such freedom. With the growth of space debris and the increase of actors and activities in outer space, the issue of space debris is becoming a threat to the operational safety and long-term sustainability of outer space, which raises a need to regulate the creation of space debris. The current international legal framework for space activities contains some general provisions that are relevant in this regard, but they are not precise enough to effectively oblige States to tackle this problem. More specifically, the Outer Space Treaty provides that space activities should be carried out for the benefit and in the interests of all countries, and that outer space is not subject to national appropriation by any State. In addition, States should conduct space activities with due regard to the rights and interests of other States, should avoid harmful contamination of outer space, and should undertake appropriate

321 Blount (2019), *supra* note 38, p. 182.

international consultation in the event of potentially harmful interference. Pursuant to the principle of prevention under international environmental law, States should prevent the causing of significant environmental harm to areas beyond the jurisdiction of any State, including outer space. All these are applicable rules for regulating the behaviours of States in carrying out space activities, but the vagueness of their terms and formulation makes it difficult to verify whether a certain debris generation event constitutes a breach of the relevant principles and rules. This is further complicated by the fact that current technology does not enable a complete avoidance of space debris in the course of space activities. These legal and factual factors make it difficult to draw from these general provisions a clear duty to mitigate and even remove space debris. Therefore, it would be difficult to rely solely on these general rules and principles to hold a State accountable for the space debris it creates, which probably explains why the Outer Space Treaty has seldom been invoked to condemn debris generation events as violations. As Masson-Zwaan observes: "There is an increasing amount of space debris, while no clear obligation exists to clear it up".[322] Since the projected run-away growth of space debris puts the future use of outer space at stake, more efforts are needed to supplement the current hard law pillar of space law. To address the space debris problem, the international community has adopted several non-legally binding instruments to mitigate the creation of space debris and preserve the long-term sustainability of outer space activities. What steps have been taken and whether they are sufficient to tackle the space debris problem will be discussed in the next chapter.

As to *Issue 2*, the current liability regime established in the UN space treaties applies to damage caused by space objects. Through treaty interpretation, especially in light of the victim-oriented spirit of the Liability Convention, it can be concluded that space debris, including both defunct spacecraft and debris fragments, falls within the scope of "space object". Therefore, a launching State may be held liable for the damage caused by the space debris it creates to the persons or property of another State. Absolute liability applies to damage caused on the ground, which is intended to provide better protection to third parties not involved in space activities. Fault-based liability applies to damage caused in outer space. The Liability Convention does not provide a definition or standard of care for the determination of fault, which could make it difficult for the victim State to establish liability of the launching States for damage caused in outer space. As such, the Liability Convention does not provide a strong motivation for States to mitigate or remove space debris, for leaving debris in orbit does not necessarily give rise to liability. On the contrary, the Liability Convention may disincentivise ADR operations. In view of the inherent risk

322 Masson-Zwaan, T. L. (30 April 2021). Still No Obligation to Clear up Space Debris. Available at: <https://www.universiteitleiden.nl/en/news/2021/04/tanja-masson-zwaan-still-no-obligation-to-clear-up-space-debris>.

involved in these operations, States engaging in ADR may be concerned about their risk of liability exposure when something goes wrong in these operations, especially when considering that the meaning of "fault" remains ambiguous. In other words, States are uncertain about how they may plan and execute their ADR operations in such a manner to reduce the risk of being held at "fault" if these operations cause damage in outer space, which could discourage States from engaging in ADR operations. To enhance legal certainty and mission safety for ADR operations, guidelines for ADR operations should be developed. The relevance of soft-law instruments for the determination of "fault", and the industry-led initiatives to develop guidelines and recommended practices for the design and operations of ADR missions will be addressed in the next chapter.

As to *Issue 3*, the State of registry retains jurisdiction and control over its space object pursuant to Article VIII of the OST. As satellites and rocket stages do not lose their legal status of "space object" when they become non-functional, the removal of a decommissioned object from outer space can only be carried out either by the State of registry itself or by another State with the express consent of the State of registry. Non-consensual removal would constitute a violation of Article VIII of the OST. There are some circumstances that may be invoked to preclude the wrongfulness of non-consensual removal under certain conditions, but they must be used with caution because this could raise international conflicts. Even defunct space objects can contain sensitive information, and the removal of these objects without the consent of their States of registry may be regarded as a hostile and even threatening act. To reduce the risk of unwanted escalation, ADR operations should be carried out on a consensual basis, and the future direction for legal development should thus be to facilitate the seeking and granting of approval and the entry into cooperative arrangements for debris removal.

As to *Issue 4*, Article IV(1) of the Outer Space Treaty prohibits the placement of nuclear weapons and weapons of mass destruction in outer space. There is no legally binding definition of what constitutes a weapon in space, and the dual-use potential of many space systems makes it difficult to draw a clear line between weapons and non-weapons in outer space according to their capabilities. ADR mechanisms should not be considered as weapons when they are used for peaceful purposes, namely to remove debris from orbit in conformity with international law. Pursuant to the UN Charter, States are also prohibited from using, or threatening to use, ADR systems for forcible actions against other States. An exception to the prohibition on the use of force is the right of self-defence, which can only be lawfully exercised in response to an armed attack, and in accordance with the principle of necessity and proportionality. While the current legal regime imposes some restrictions on the use of ADR mechanisms for aggressive actions, the use of such mechanisms for peaceful purposes may still raise security concerns due to their dual-use potential. Therefore, it is essential to ensure that ADR activities are carried out in a manner that reduces the risks of dual-use concerns. In this regard, Transparency and Confidence-Building Measures (TCBMs) are particularly relevant as the implementation of these measures can reduce or even eliminate misunderstandings and miscalculations. The relevance of TCBMs to ADR will be discussed in the next chapter.

In sum, although the hard law pillar of international space law contains some basic provisions to address the four issues outlined in Chapter 2, it does not provide sufficient answers to the governance of these issues. The next chapter will turn to the soft law pillar of space law to see whether and to what extent it contributes to filling the regulatory gaps in the hard law pillar.

4 Relevance of the Soft Law Pillar to Space Debris and ADR

The previous chapter assessed the application of the hard law pillar of international space law to debris removal and identified gaps that need to be remediated in further legal development. This chapter will examine the soft law pillar of space law and assess whether and how the gaps in the UN space treaties and general international law for the governance of space debris and ADR are addressed in this pillar. "Soft law" is a term used for non-binding instruments such as resolutions adopted by the UN General Assembly and sets of guidelines produced by other bodies, including the subsidiary organs of the UN such as COPUOS.[1]

It is noteworthy that "the first chapter in the book of space law" is written in the form of UN General Assembly resolutions, which are soft law instruments because they do not have legally binding force.[2] Before the conclusion of the Outer Space Treaty, the UN General Assembly adopted several resolutions for the governance of space activities. Among these resolutions, Resolution 1962(XVIII) of 1963 is "the first significant document formulating legal principles for the conduct of outer space activities".[3] The nine basic principles enshrined in the 1963 Declaration of Legal Principles were, with only relatively minor amendments, incorporated into the Outer Space Treaty four years later. In addition, it is generally understood that these nine basic principles express customary international law, binding all States of

1 Byers, M., & Boley, A. (2023). *Who Owns Outer Space? International Law, Astrophysics, and the Sustainable Development of Space.* Cambridge University Press, p. 278.

2 Cheng, B. (1997). United Nations Resolutions on Outer Space: "Instant" International Customary Law?. In *Studies in International Space Law*. Oxford University Press, p. 125. For a general introduction to the UN General Assembly resolutions see UN. How Decisions are Made at the UN. <https://www.un.org/en/model-united-nations/how-decisions-are-made-un>. One may also say that the book of space law has a "preface", as several scholars and practitioners contributed their thoughts and considerations regarding space law even before the launch of Sputnik 1. For a historical outline of the development of space law see Masson-Zwaan, T. L. & Hofmann, M. (2019). *Introduction to Space Law*. Wolters Kluwer, pp. 1-4.

3 Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space. UNGA Res. 1962(XVIII) of 13 December 1963 ("Declaration of Legal Principles"). Traunmüller, K. (2012). The 'Declaration of Legal Principles Governing the Activities of States in the Exploration of Outer Space': The Starting Point for the United Nations' Law 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. 145.

the international community.[4] This illustrates that soft law and hard law are not isolated but intimately connected, as the establishment of the former may contribute to the development of the latter.

After the "golden age" of space law treaty-making between the 1960s and 1970s, no new space treaties were adopted within the UN. Instead, the development of space law took again the form of soft law. This started from the four UN General Assembly resolutions addressing certain special and technical categories of space activities,[5] namely satellite direct television broadcasting,[6] remote sensing of the Earth from space,[7] the use of nuclear power sources in outer space,[8] and international cooperation in the exploration and use of outer space.[9] These resolutions, together with the aforementioned 1963 Declaration of Legal Principles, are collectively referred to as the five sets of principles on space-related activities. Following the adoption of these five "Principles resolutions", the UN General Assembly adopted other space-related "Practice resolutions" that address certain concepts contained in the UN space treaties.[10] These resolutions provide recommendations on issues relating to the application of the concept of "launching State",[11] the enhancement of registration practices,[12] and the development of national legislation for space activities.[13]

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4 Frigoli, M. (2019). Between Active Debris Removal and Space-Based Weapons: A Comprehensive Legal Approach. In Froehlich, A. (Ed.). *Space Security and Legal Aspects of Active Debris Removal*, Cham: Springer, p. 53. See also Lee, R. J., & Freeland, S. R. (2004). The Crystallisation of General Assembly Space Declarations into Customary International Law. *Proceedings of the Forty-Sixth Colloquium on the Law of Outer Space 2003*, American Institute of Aeronautics and Astronautics, p. 126. Gabrynowicz, J. I. (2006). The Outer Space Treaty and Enhancing Space Security. In *Building the Architecture for Sustainable Space Security: UNIDIR Conference Report*, 30-31 March 2006, p. 113. It is also noted that the incorporation of the principles contained in the Declaration of Legal Principles into the Outer Space Treaty "by and large marginalized any discussion on whether" the Declaration reflected customary international law. See von der Dunk, F. G. (2015). International Space Law. In von der Dunk, F. G. (Ed.), *Handbook of space law*. Edward Elgar Publishing, p. 38.

5 Jankowitsch, P. (2018). The Outer Space Treaty: Its First Fifty Years. *Proceedings of the International Institute of Space Law 2017*, *60*, pp. 7-8.

6 UNGA Resolution 37/92 of 10 December 1982.

7 UNGA Resolution 41/65 of 3 December 1986.

8 UNGA Resolution 47/68 of 14 December 1992.

9 UNGA Resolution 51/122 of 13 December 1996.

10 Tapio, J. & Soucek, A. (2019). National Implementation of Non-Legally Binding Instruments: Managing Uncertainty in Space Law?. *Air and Space Law*, *44*(6), pp. 567-568.

11 Application of the concept of the "launching State", adopted by the General Assembly in its resolution 59/115 of 10 December 2004.

12 Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects, adopted by the General Assembly in its resolution 62/101 of 17 December 2007.

13 Recommendations on national legislation relevant to the peaceful exploration and use of outer space, adopted by the General Assembly in its resolution 68/74 of 11 December 2013.

In addition to the UN General Assembly resolutions, there are other non-binding instruments governing space-related issues produced within the framework of the UN and other international bodies such as the IADC and the International Organization for Standardization (ISO). Among these instruments, some address topics that are of direct relevance to space debris including the mitigation of space debris and the preservation of long-term space sustainability, which merit more detailed discussion in this chapter. Also deserving specific attention is the 2013 *Report of the Group of Governmental Experts on Transparency and Confidence-building Measures in Outer Space Activities* ("GGE Report of 2013"),[14] which provides measures that can assist in building confidence and reducing misperceptions among States regarding space activities, and could thus be useful to address the dual-use concerns of ADR.

Alongside the legal developments made by States and international bodies, the commercial space industry is playing an increasingly active role in developing voluntary, consensus-based guidelines and best practices through industry associations and working groups.[15] These industry-developed documents usually embody the commitments of the endorsing entities to make their best efforts to achieve compliance. In view of the ever-growing trend of privatisation and commercialisation of space activities, the endorsement of private space actors can have important practical implications even though the documents are not formally adopted by governmental entities. Moreover, the documents produced by the commercial industry can serve as a basis for further legal development at the international level. A prominent example in this regard can be found in the documents published by the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) regarding commercial RPO and on-orbit servicing.[16] These documents provide guidance for the design and execution of missions involving RPO and they informed the development of the ISO Standard 24330:2022 which addresses the same area.[17] Therefore, the picture of the international legal regime governing space activities would be incomplete without including the contributions of the commercial space industry.

The aim of this chapter is to examine whether and how the soft law pillar of international space law contributes to filling the regulatory gaps in the

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14 The text of the GGE Report of 2013 is contained in UN Doc. A/68/189 (29 July 2013).

15 FCC. (24 April 2020). Mitigation of Orbital Debris in the New Space Age, Report and Order and Further Notice of Proposed Rulemaking. FCC 20-54, para. 11. <https://docs.fcc.gov/public/attachments/FCC-22-66A1.pdf>.

16 The publications of CONFERS are available at: <https://satelliteconfers.org/publications/>.

17 ISO 24330:2022 "*Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices*", published on 1 July 2022. <https://www.iso.org/standard/78463.html>.

hard law pillar for the governance of the four issues relating to ADR and whether there are any remaining gaps. These four issues will be addressed respectively in Sections 4.1 to 4.4. Section 4.1 will focus on several sets of international guidelines and standards relevant to the protection of the outer space environment, and discuss how these instruments are relevant to the prevention and reaction against space debris. Section 4.2 will assess how soft law instruments could contribute to the clarification of the notion of "fault" for the attribution of liability for damage caused in outer space, and discuss the initiatives taken by the commercial space industry for the development of technical and safety standards and best practices applicable to ADR operations. Section 4.3 will discuss the recommendations regarding the registration of space objects and highlight the need for further legal development to facilitate the requesting and granting of approval for the consensual removal of space debris. Section 4.4 will assess the relevance of TCBMs in addressing potential security concerns related to ADR activities. Section 4.5 will conclude this chapter and assess the role of soft law for the future development of space law to govern ADR activities.

4.1 *Issue 1*: International Guidelines and Standards Relevant to the Control of Space Debris

Chapter 3 points out that the hard law pillar of international space law does not impose a clear obligation upon States to mitigate or remediate space debris. As noted by Popova and Schaus, the lacunae in the binding law regarding effective mechanisms for the protection of the outer space environment from the hazard posed by space debris have not remained completely unaddressed by the international community.[18] Rather, States and international organisations have engaged in cooperative regimes to tackle the space debris problem through the development of non-legally binding instruments.[19] This section will discuss several soft law instruments that provide useful guidance to address the space debris problem. Section 4.1.1 will discuss several international mechanisms on space debris mitigation, with emphasis placed on two major sets of space debris mitigation guidelines that have gained wide acceptance within the international community, namely those adopted by the IADC and COPUOS. After assessing the substance of these international instruments, the section will discuss their application to ADR activities and their implementation in practice. Section 4.1.2 will examine the LTS Guidelines adopted by COPUOS in 2019, including the development of this instrument, its relevance to space debris

18 Popova, R., & Schaus, V. (2018). The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space. *Aerospace*, *5*(2), p. 10.

19 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.184.

and ADR, and the implementation of the LTS Guidelines. Section 4.1.3 will conclude this section.

4.1.1 International Space Debris Mitigation Guidelines and Standards

This Section will discuss a series of international non-binding instruments on space debris mitigation and will be divided into five sub-sections. Section 4.1.1.1 will discuss the IADC Space Debris Mitigation Guidelines, which is the first international document that is specialised in the field of space debris mitigation.[20] The IADC Space Debris Mitigation Guidelines were used as a foundation for the development of the COPUOS Space Debris Mitigation Guidelines, which will be addressed in Section 4.1.1.2. Section 4.1.1.3 will introduce other space debris mitigation guidelines and standards developed at the international level, which are the ISO Standard 24113,[21] the International Telecommunication Union (ITU) Recommendation ITU-R S.1003.2,[22] and the European Code of Conduct for Space Debris Mitigation (ECoC).[23] Section 4.1.1.4 will assess the application of the space debris mitigation guidelines to ADR operations. Section 4.1.1.5 will discuss whether the international space debris mitigation guidelines have been sufficiently complied with in practice to limit the growth of space debris.

4.1.1.1 IADC Space Debris Mitigation Guidelines

The IADC is an international forum for the coordination of activities related to the issues of man-made and natural debris in space.[24] It was formed in 1993 by its four founding members, namely NASA, ESA, the Russian Space Agency (RSA, now Roscosmos), and the National Space Development Agency of Japan (NASDA, now JAXA).[25] The IADC has currently thirteen member agencies, including twelve national space agencies and ESA, which represents virtually all major spacefaring nations.[26]

The primary purpose of the IADC is "to exchange information on space debris research activities between members, to facilitate opportunities for

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20 Yakovlev, M. (2005). The "IADC Space Debris Mitigation Guidelines" and Supporting Documents. *Proceedings of the 4th European Conference on Space Debris*, p. 1.

21 ISO Standard 24113 "*Space systems — Space debris mitigation requirements*", last updated in May 2023. <https://www.iso.org/standard/83494.html>.

22 ITU Recommendation ITU-R S.1003.2 (12/2010) "*Environmental protection of the geostationary-satellite orbit*". <https://www.unoosa.org/documents/pdf/spacelaw/sd/R-REC-S1003-2-201012-IPDF-E.pdf>.

23 *European Code of Conduct for Space Debris Mitigation* ("ECoC"), Issue 1.0, adopted on 28 June 2004. <https://www.unoosa.org/documents/pdf/spacelaw/sd/2004-B5-10.pdf>.

24 IADC. About. <https://www.iadc-home.org/what_iadc>.

25 Johnson, N. (2012). Origin of the Inter-Agency Space Debris Coordination Committee. In *Orbital Debris Quarterly News*, *16*(4), pp. 3-4.

26 For the IADC membership see IADC website: <https://www.iadc-home.org/what_iadc>.

cooperation in space debris research, to review the progress of ongoing cooperative activities and to identify debris mitigation options".[27] The IADC consists of a Steering Group and four specified Working Groups (WGs) covering measurements (WG1), environment and database (WG2), protection (WG3) and mitigation (WG4).[28] At the 17th meeting of the IADC in October 1999, a new Action Item (AI 17.2) was adopted to develop a set of consensus-based space debris mitigation guidelines.[29] WG4, together with the Steering Group, developed and refined a draft set of mitigation guidelines during 2001-2002.[30] In 2002, The IADC member agencies adopted the IADC Space Debris Mitigation Guidelines by consensus, which were subsequently updated in 2007, 2020 and 2021, with clarifications and target values added to the guidelines in these updates.[31] The IADC also publishes and updates the *Support to the IADC Space Debris Mitigation Guidelines*, which provides specifications on "the purpose, feasibility, practices, and tailoring guide for each recommendation" contained in the IADC Space Debris Mitigation Guidelines.[32]

The IADC Space Debris Mitigation Guidelines describe existing practices that have been identified and evaluated for limiting the generation of space debris in space activities.[33] The guidelines are applicable to mission planning and the design and operation of spacecraft and launch vehicle orbital stages, with a focus on the following four areas:[34]

Area (1): Limitation of debris released during normal operations;
Area (2): Minimisation of the potential for on-orbit break-ups;
Area (3): Post-mission disposal;
Area (4): Prevention of on-orbit collision.

With regard to *Area (1)*, the IADC Space Debris Mitigation Guidelines recommend that spacecraft and launch vehicle orbital stages should be designed not to intentionally release debris during normal space opera-

27 Art. 1, Terms of Reference (ToR) for the IADC. IADC-93-01 (Rev. 11.6), initially adopted 25 October 1993, last updated 3 October 2018.

28 IADC, *supra* note 24.

29 Johnson, N. L. (2006). Recent Developments in Space Debris Mitigation Policy and Practices. In *NASA Technical Reports Server*, p. 1. <https://ntrs.nasa.gov/citations/20060052514>.

30 See Compendium of Space Debris Mitigation Standards Adopted by States and International Organizations (15 May 2023) ("Space Debris Compendium"), p. 94. The Compendium has been developed as a contribution of Canada, the Czech Republic and Germany to COPUOS in 2014. ESA provided support in compiling and finalizing the Compendium. The Compendium is available on a dedicated UNOOSA webpage: <https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html>.

31 IADC Space Debris Mitigation Guidelines (2021), p. 2.

32 IADC. Support to the IADC Space Debris Mitigation Guidelines. IADC-04-06 Rev. 5.8, June 2021, Foreword.

33 Sec. 1, IADC Space Debris Mitigation Guidelines (2021).

34 Secs. 1&2, ibid.

tions, or at least to minimise the adverse impact of the released debris on the orbital environment.[35] In addition, the risk of the intentionally released debris must be properly assessed to ensure that their hazard to other space objects is "acceptably low in the long-term".[36]

As to *Area (2)*, the IADC Space Debris Mitigation Guidelines provide recommendations on the avoidance of accidental break-ups and intentional destructions.[37] According to the Guidelines, the potential of accidental explosive break-ups should be minimised both during and after mission operations. As to the former, spacecraft and orbital stages should be designed in such a way to prevent or minimise the risk of failure that could lead to accidental explosive break-ups during operational phases.[38] The probability of occurrence of such break-ups should be at least below 10^{-3} in order.[39] For the minimisation of accidental break-ups after the completion of mission phases, the spacecraft and orbital stages should be duly passivated, i.e., all on-board sources of stored energy should be depleted or made safe when they are no longer required for mission operations or post-mission disposal.[40] Besides accidental break-ups, the IADC Space Debris Mitigation Guidelines also recommend the avoidance of intentional destruction of space objects and other harmful activities that may significantly increase on-orbit collision risk.[41] If intentional break-ups cannot be avoided, they should be conducted at sufficiently low altitudes to reduce the adverse environmental impacts.[42]

With regard to *Area (3)*, the IADC Space Debris Mitigation Guidelines provide detailed recommendations for two protected regions, namely the GEO Protected Region and the LEO Protected Region. The IADC Guidelines define GEO as "Earth orbit having zero inclination and zero eccentricity, whose orbital period is equal to the Earth's sidereal period".[43] The altitude of GEO is around 35,786 km above the Earth's surface.[44] The GEO Protected Region is defined as a segment of the spherical shell that is ± 200km GEO altitude with ±15 degrees latitude.[45] For the post-mission disposal of GEO objects, the IADC Guidelines recommend the re-orbiting of these objects to a higher orbit that remains outside the GEO Protected Region for at least

35 Sec. 5.1, ibid.
36 Ibid.
37 Sec. 5.2, ibid.
38 Sec. 5.2.2., ibid.
39 Ibid.
40 Sec. 5.2.1, ibid.
41 Sec. 5.2.3, ibid.
42 Ibid.
43 Sec. 3.3.3, ibid.
44 Ibid.
45 Sec. 3.3.2(2), ibid.

100 years.[46] To fulfil this objective, the IADC Guidelines provide a formula describing the minimum increase in perigee altitude with an eccentricity less than or equal to 0.003.[47] According to this formula, the perigee altitude of end-of-mission spacecraft and launch vehicle orbital stages should be increased by at least 235 km above GEO.[48]

The LEO Protected Region is defined as the "spherical region that extends from the Earth's surface up to an altitude of 2,000 km".[49] For the post-mission disposal of LEO objects, the IADC Space Debris Mitigation Guidelines recommend that these objects should be de-orbited, preferably through direct re-entry, or where appropriate be manoeuvred into an orbit with an expected residual orbital lifetime of 25 years or shorter.[50] This guideline is often referred to as the "25-year rule". The success rate of post-mission disposal is recommended to be at least 90%, which is set to limit the adverse impact of space activities on the long-term sustainability of the orbital environment.[51] For spacecraft and orbital stages that are to be disposed of by re-entry into the atmosphere, the IADC Space Debris Mitigation Guidelines recommend that "debris that survives to reach the surface of the Earth should not pose an undue risk to people or property".[52] More specifically, the IADC Guidelines recommend using the threshold of 10^{-4} for limiting casualty risk per single re-entry event.[53] This Casualty Expectation (E_c) threshold is also reflected in the space debris mitigation guidelines and standards of several space agencies,[54] such as NASA Standard 8719.14,[55] the ESA Re-entry Safety Requirement,[56] and the JAXA Space Debris Mitigation Standard.[57]

Finally, as to *Area (4)*, space operators are recommended to estimate and limit the probability of accidental collision with known objects when developing the design and mission profile of their spacecraft and orbital stages.[58] If reliable orbital data and conjunction assessments are available, operators should consider the coordination of launch windows for launch vehicle orbital stages and the implementation of CAMs for spacecraft in

46 Sec. 5.3.1, ibid.
47 Ibid.
48 Ibid.
49 Sec. 3.3.2(1), ibid.
50 Sec. 5.3.2, ibid.
51 Ibid.
52 Ibid.
53 Ibid.
54 Support to the IADC Space Debris Mitigation Guidelines, *supra* note 32, p. 33.
55 NASA Standard 8719.14C "*Process for Limiting Orbital Debris*", approved 5 November 2021.
56 *ESA Re-entry Safety Requirements*, issue 1, revision 0, ESSB-ST-U-004, issued on 4 December 2017.
57 *JAXA Space Debris Mitigation Standard*, JMR-003B, revised in 2011.
58 Sec. 5.4, IADC Space Debris Mitigation Guidelines.

orbit.[59] Besides the collision avoidance with known objects, the IADC Space Debris Mitigation Guidelines also recommend designing spacecraft to limit the impact of collisions with small debris that could cause a loss of control, which is usually achieved through the use of shielding structures.[60]

The IADC Space Debris Mitigation Guidelines, as the first international instrument on space debris mitigation, has been explicitly referred to and implemented in many national and international mechanisms on space debris mitigation. The Guidelines were also used as a foundation for the development of other sets of international space debris mitigation guidelines and standards including the COPUOS Space Debris Mitigation Guidelines,[61] which will be discussed in the next section.

4.1.1.2 COPUOS Space Debris Mitigation Guidelines

The COPUOS Space Debris Mitigation Guidelines are the result of many years of work by COPUOS and its Scientific and Technical Subcommittee (STSC).[62] COPUOS started to address the issue of space debris in the late 1970s and early 1980s with some studies concerning the factual information of space debris conducted by then.[63] However, these early initiatives did not create significant waves but only small ripples in COPUOS.[64] It was not until 1994 that a new item "space debris" was added to the agenda of the COPUOS STSC.[65] On the basis of the research conducted according to a multi-year work plan in furthering the understanding of space debris, the COPUOS STSC adopted a technical report on space debris in 1999 and agreed to have it widely distributed for further deliberations.[66]

In 2001, the Subcommittee agreed to establish a work plan for expediting the international adoption of voluntary space debris mitigation measures.[67] In 2003, the IADC presented its space debris mitigation guidelines to the COPUOS STSC, and the Subcommittee began its review of the IADC guidelines according to its work plan.[68] This bridged the work between the IADC

59 Ibid.
60 Ibid.
61 Space Debris Compendium (2023), *supra* note 30, p. 94.
62 Preface of the COPUOS Space Debris Mitigation Guidelines. The text of this instrument is available at: <https://www.unoosa.org/pdf/publications/st_space_49E.pdf>.
63 Perek, L. (2002). Space Debris at the United Nations. *Space Debris*, *2*(2), p. 124.
64 Ibid, p. 125.
65 UN Doc. A/AC.105/571 (10 March 1994), Report of the Scientific and Technical Subcommittee on the Work of its thirty-first Session, para. 64.
66 Ibid, para. 35. The text of the technical report is contained in UN Doc. A/AC.105/720 (1999).
67 UN Doc. A/AC.105/761 (2 March 2001), Report of the COPUOS Scientific and Technical Subcommittee on its thirty-eighth session, para. 130.
68 UN Doc. A/AC.105/804 (5 March 2003), Report of the COPUOS Scientific and Technical Subcommittee on its fortieth session, para. 121.

and COPUOS with regard to the development of space debris mitigation guidelines.[69] In 2007, the COPUOS STSC adopted its space debris mitigation guidelines at its forty-fourth session,[70] which were then endorsed by the Committee at its fiftieth session[71] and later by the UN General Assembly in its Resolution 62/217 of 2007.[72]

The development of space debris mitigation guidelines from the IADC to COPUOS indicates the acceptance by the global space community of a set of debris mitigation measures initially developed by a smaller "club" of leading spacefaring nations.[73] In fact, while the membership of the IADC represents leading space agencies in the world, COPUOS has currently over a hundred member States with a wide range of diverging space capabilities.[74] In addition, the members of the IADC are agencies while those of COPUOS and the UN General Assembly are States. Therefore, the adoption of the COPUOS Space Debris Mitigation Guidelines can be seen as embodying a stronger political commitment at a broader scale to limit the generation of space debris.

Like the IADC Guidelines, the COPUOS Space Debris Mitigation Guidelines are not legally binding under international law.[75] States and international organisations are encouraged to voluntarily take measures to ensure that these guidelines are implemented to the greatest extent feasible, through space debris mitigation practices and procedures.[76] The COPUOS Space Debris Mitigation Guidelines contain seven guidelines developed on the basis of the technical content and basic definitions of the IADC Space Debris Mitigation Guidelines.[77] As such, the substance of the COPUOS Guidelines reflects that of the IADC Guidelines.[78] As mentioned earlier, the IADC Space Debris Mitigation Guidelines focus on four areas. COPUOS Guideline 1 reflects the first area and provides that space systems should be designed to avoid or minimise the intentional release of objects during normal operations. COPUOS Guidelines 2, 4 and 5 correspond to the second

69 Soucek, A. (2015). Historical Background and Context of COPUOS SMD Guidelines. In Hobe S., Schmidt-Tedd, B., & Schrogl K.-U. (Eds.). In *CoCoSL Vol. 3*, p. 614.
70 UN Doc. A/AC.105/890 (6 March 2007), Report of the COPUOS Scientific and Technical Subcommittee on its forty-fourth session, para. 99 & Annex IV.
71 UN Doc. A/62/20 (2007), Report of the COPUOS on its fiftieth session, para. 118.
72 UN Doc. A/RES/62/217 (2007), Resolution adopted by the General Assembly on 22 December 2007, para. 26.
73 Stubbe, P. (2015). SDM Rationale. In *CoCoSL Vol. 3*, p. 624.
74 For COPUOS membership see: <https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html>.
75 Sec. 3, COPUOS Space Debris Mitigation Guidelines.
76 Ibid.
77 Sec. 2, ibid.
78 For the correspondence between the IADC Space Debris Mitigation Guidelines and the COPUOS Space Debris Mitigation Guidelines see Space Debris Compendium, *supra* note 30, pp. 98-99.

area and they address the minimisation of accidental break-ups during and after operational phases as well as the avoidance of intentional destruction of on-orbit objects and other harmful activities. COPUOS Guidelines 6 and 7 correspond to the third area and address the post-mission disposal of objects in the LEO and GEO regions to limit their long-term inference with these regions. COPUOS Guideline 3 reflects the fourth area and recommends operators to limit the probability of accidental collision in orbit.

The main difference between the space debris mitigation guidelines of the IADC and those of COPUOS is that the former contain more specific technical details while the latter represent "a set of high-level qualitative guidelines".[79] For instance, the IADC Guidelines provide for the 25-year residual lifetime rule and the 90% success rate for the post-mission disposal of LEO objects.[80] In comparison, the COPUOS Guidelines provide only that LEO objects that have terminated their operational phases "should be removed from orbit in a controlled fashion" or at least "be disposed of in orbits that avoid their long-term presence in the LEO region".[81] While the COPUOS guidelines do not provide numerical limitations, the Reference section of the instrument expressly states that "[f]or more in-depth descriptions and recommendations pertaining to space debris mitigation measures, Member States and international organizations may refer to the latest version of the IADC space debris mitigation guidelines and other supporting documents".[82] Therefore, the lack of quantitative measures in the COPUOS Guidelines could be remedied by referring to the IADC Guidelines. Hence, the update of the IADC Guidelines can have practical implications for the implementation of the COPUOS Guidelines.[83]

4.1.1.3 Other International Guidelines and Standards regarding Debris Mitigation

In addition to the space debris mitigation guidelines adopted by the IADC and COPUOS, other international bodies have also developed their guidelines and standards to limit the creation of space debris. Like the COPUOS Space Debris Mitigation Guidelines, the ISO 24113 was also developed on the basis of the IADC Space Debris Mitigation Guidelines. The ISO is an independent, non-governmental international organisation with a membership of 169 national standards bodies.[84] Through its members, the

79 Sec. 2, COPUOS Space Debris Mitigation Guidelines.
80 Sec. 5.3.2, IADC Space Debris Mitigation Guidelines.
81 Guideline 6, ibid.
82 Sec. 6, ibid.
83 Like the IADC Space Debris Mitigation Guidelines, the COPUOS Space Debris Mitigation Guidelines are also intended as a living document which "will be reviewed and may be revised, as warranted, in the light of new findings", though the instrument has thus far not yet been updated. See Sec. 5 "Updates", COPUOS Space Debris Mitigation Guidelines.
84 ISO. About us. <https://www.iso.org/about-us.html>.

ISO brings together experts to share knowledge and develop voluntary, consensus-based, market-relevant international standards that support innovation and provide solutions to global challenges.[85] Space debris is one of the global challenges that the ISO is dealing with through the publication of international standards and technical reports addressing this matter.

The development of standards typically takes place within the ISO's Technical Committees (TCs) and Sub-Committees (SCs).[86] TC20 "Aircraft and space vehicles" is responsible for the development of internationally accepted standards for aircraft and space vehicles.[87] Its Subcommittee 14 (SC 14) "Space Systems and Operations" is tasked with developing international standards that reflect best practices for space systems and operations.[88] It has developed a family of standards addressing space debris mitigation, which are organised in a hierarchical structure.[89] At the top of the hierarchy is ISO Standard 24113 which was first published in 2010 and updated in 2011, 2019 and 2023. The latest version ISO 24113:2023 "defines the primary space debris mitigation requirements applicable to all elements of unmanned systems launched into, or passing through, near-Earth space".[90] It contains a set of high-level debris mitigation requirements that are intended to reduce the growth of space debris and to minimise casualty risks associated with the atmospheric re-entry of space debris.[91] Detailed processes and implementation measures associated with these requirements are provided in a series of lower-level standards.[92]

The ISO standards serve to "formulate the recommendations contained in the IADC and UN guidelines in such a way that they can be readily applied" from an engineering perspective.[93] As noted by Kato *et al.*, while the international space debris mitigation guidelines "provide a common understanding for the adoption of mitigation measures, they are not necessarily written in a style that is suitable for application in the commercial

85 Ibid.
86 Ibid.
87 ISO/TC 20 "Aircraft and Space Vehicles". <https://www.iso.org/committee/46484.html>.
88 Stokes, H., Akahoshi, Y., Bonnal, C., Destefanis, R., Gu, Y., Kato, A., Kutomanov, A., LaCroix, A., Lemmens, S., Lohvynenko, A., Oltrogge, D., Omaly, P., Opiela, J., Quan, H., Sato, K., Sorge, M. & Tang, M. (2020). Evolution of ISO's Space Debris Mitigation Standards. *Journal of Space Safety Engineering*, *7*(3), p. 325.
89 Ibid.
90 Sec. 1 "Scope", ISO 24113:2023, *supra* note 21.
91 Foreword, ibid.
92 Ibid.
93 Ibid, p. 2. See also Stokes *et al.* (2020), *supra* note 88, p. 326. Similarly, Oltrogge summarises that ISO standards "exist to codify, in an implementable and verifiable way, what international guidelines seek to accomplish". See Oltrogge, D. (2019). Space Standards at the ISO Level. *ESA-ECSL Space Debris Workshop: Regulation, Standards and Tools*, p. 13. <https://conference.sdo.esoc.esa.int/proceedings/ecsl19/paper/5>.

world", which "can lead to differences in interpretation".[94] To enhance the standardisation of implementation, these guidelines need to be translated "into a set of measurable and verifiable requirements to minimise the creation of debris during the launch, operation, and disposal of space systems".[95] This challenge is addressed by the ISO, which has developed standards that can be applied in a variety of ways, including voluntary implementation by space operators, introduction in commercial contracts, and incorporation into the national and international mechanisms relating to space debris mitigation measures. Specifically, the European Coordination on Space Standardization (ECSS) adopted the ISO 24113:2011 as the ECSS-U-AS-10C standard in 2012.[96] Following the updates of the ISO 24113 in July 2019 and May 2023, the ECSS-U-AS-10C was also revised accordingly, first in December 2019 and later in February 2024, adopting the requirements of the updated ISO 24113 with a few modifications and additions to accommodate the needs of the ECSS members.[97]

Another international forum for the development of space debris mitigation measures is the ITU, which is the UN specialised agency for information and communication technologies.[98] Communication through radio links is essential for space operations, which are needed not only for the connection between a space object and its mission control centre for Telemetry, Tracking and Command (TT&C), but also for the execution of missions assigned to the space object such as navigation and Earth observation.[99] Hence, it is important for space operators to have "reliable and interference-free radio connection for their space assets and services".[100] In this regard, the ITU, through its Radiocommunication Sector (ITU-R), and its executive arm, the Radiocommunication Bureau (BR), is the global agency responsible for the management of radio-frequency spectrum and satellite orbit resources.[101]

In December 2010, the ITU-R published Recommendation ITU-R S.1003-2 (12/2010) "*Environmental protection of the geostationary-satellite orbit*", which

94 Kato, A., Lazare, B., Oltrogge, D., & Stokes, P. H. (2013). Standardization by ISO to ensure the sustainability of space activities. *Proceedings of the 6th European Conference on Space Debris*, p. 1.

95 Ibid.

96 Space Debris Compendium, *supra* note 30, p. 92.

97 ECSS-U-AS-10C Rev.2 – Adoption Notice of ISO 24113: Space systems – Space debris mitigation requirements (9 February 2024). See also Ventura, S. (21 September 2021). ESA Space Debris Mitigation and Re-entry Safety Framework – Status and Novelties. *Presentation at ESA Clean Space Industrial Days*, p. 2. <https://indico.esa.int/event/321/contributions/6330/attachments/4389/>.

98 ITU. About ITU. <https://www.itu.int/en/about/>.

99 Masson-Zwaan & Hofmann (2019), *supra* note 2, p. 133.

100 Ibid.

101 ITU. (Updated October 2021). ITU-R: Managing the Radio-Frequency Spectrum for the World. <https://www.itu.int/en/mediacentre/backgrounders/Pages/itu-r-managing-the-radio-frequency-spectrum-for-the-world.aspx>.

"provides guidance about disposal orbits for satellites in the geostationary-satellite orbit and comments on the increase in debris due to fragments resulting from increased numbers of satellites and their associated launches".[102] The document, which applies to the operation of satellites in the GEO, is addressed to ITU Member States.[103] As a recommendation of the ITU Radiocommunication Assembly, ITU-R S.1003.2 is not legally binding.[104] It describes the GEO as "a unique resource that offers significant benefits to operators" for its physical characteristics and associated usability and recognises that the proliferation of space debris in this orbit would increase collision risks, which may damage or degrade the telecommunications functions of satellites.[105] Focusing on the environmental protection of the GEO region, ITU-R S.1003-2 provides the following four recommendations to limit the accumulation of non-functional objects in GEO:

1. Minimise debris released into the GEO region during the placement of a satellite in orbit;
2. Strive to shorten the lifetime of debris in elliptical transfer orbits with the apogees at or near GEO altitude;
3. Remove decommissioned satellites above to a graveyard orbit;
4. Carry out the removal to graveyard orbit with particular caution in order to avoid radio frequency interference with active satellites.[106]

In addition to the international mechanisms regarding space debris mitigation with more or less a global outreach, efforts have also been taken at the regional level to limit the generation of space debris. On 28 June 2004, ESA and four major national space agencies in Europe, namely the Italian Space Agency (ASI), the British National Space Center (BNSC)[107], the French Space Agency (CNES) and the German Aerospace Agency (DLR), adopted the European Code of Conduct for Space Debris Mitigation.[108] The ECoC is consistent with the IADC Space Debris Mitigation Guidelines while providing greater technical detail and explanations.[109] The application of the ECoC "is voluntary and should be applied by the European Space Agency,

102 ITU-R S.1003.2 (12/2010), p. 1. This document was first adopted in 1993 as ITU-R S.1003-0 (04/93), revised in 2004 as S.1003-1 (01/2004), and later revised in 2010 as ITU-R S.1003.2 (12/2010). The text of the document is available at: <https://www.itu.int/rec/R-REC-S.1003/en>.

103 Space Debris Compendium, *supra* note 30, p. 101. The ITU has currently 193 member States, which is virtually universal membership. *See* ITU. List of ITU Member States. <https://www.itu.int/en/ITU-R/terrestrial/fmd/Pages/administrations_members.aspx>.

104 Ibid. ITU-R Recommendations are approved by ITU Member States. Their implementation is not mandatory; however, they enjoy a high reputation and are implemented worldwide. See ITU. ITU-R Recommendations. <https://www.itu.int/pub/R-REC>.

105 ITU-R S.1003.2 (12/2010), *supra* note 102, p. 1.

106 Ibid.

107 The BNSC was replaced on 1 April 2010 by the United Kingdom Space Agency (UKSA).

108 Space Debris Compendium, *supra* note 30, p. 103.

109 Ibid.

by national space agencies within Europe and their contractors".[110] The signing agencies also recommend the application of the ECoC "by any other space project conducted in Europe, or by a European entity acting outside Europe, including operators".[111]

In order to tailor the ECoC to the needs of ESA projects, ESA developed the "Requirements for Space Debris Mitigation for ESA Projects" (ESA/ADMIN/IPOL(2008)2), which came into force on 1 April 2008.[112] This 2008 document was superseded in 2014 by the administrative instruction "Space Debris Mitigation Policy for Agency Projects" of the ESA Director General.[113] In November 2023, as part of ESA's Zero Debris approach that sets out the Agency's goal to significantly limit the generation of space debris by 2030, ESA updated its Space Debris Mitigation Policy.[114] The objectives of the new Policy are to carry out space activities in an environmentally sustainable manner, preserve space for future generations and work towards "zero debris" by 2030.[115] To achieve these objectives, the 2023 Policy states that it is ESA's policy and commitment to, *inter alia*, mitigate space debris and implement the COPUOS Space Debris Mitigation Guidelines.[116]

The above discussion shows that the international instruments regarding space debris mitigation are closely connected, which is reflected in the fact that some instruments served as the basis for the development of others as well as the express cross-reference among these instruments. As Dupuy submits, "repetition" plays an influential role in the development of soft law, especially "in the international environmental 'soft' law-making process".[117] More specifically, "[c]ross-reference from one institution to another, the recalling of guidelines adopted by other apparently concurrent international authorities, recurrent invocation of the same rules formulated

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110 Art. 2.2, the ECoC.

111 Ibid.

112 Klinkrad, H. & Bohlmann, U. (2009). Requirements on Space Debris Mitigation for ESA Projects. *Presentation to the 48th session of the Legal Subcommittee of the UN COPUOS*, p. 3. <https://www.unoosa.org/pdf/pres/lsc2009/pres-07.pdf>. See also ESA. Mitigating Space Debris Generation. <https://www.esa.int/Safety_Security/Space_Debris/Mitigating_space_debris_generation>.

113 ESA, Space Debris Mitigation Policy for Agency Projects, issued on 28 March 2014, ESA/ADMIN/IPOL(2014)2.

114 ESA. ESA Space Debris Mitigation Policy, issued on 3 November 2023, ESA/ADMIN/IPOL(2023)1. The text of the document is available at <https://technology.esa.int/upload/media/ESA-ADMIN-IPOL-2023-1-Space-Debris-Mitigation-Policy-Final.pdf>. See also ESA. New Space Debris Mitigation Policy and Requirements in effect. <https://esoc.esa.int/new-space-debris-mitigation-policy-and-requirements-effect>. ESA. ESA's Zero Debris Approach. <https://www.esa.int/Space_Safety/Clean_Space/ESA_s_Zero_Debris_approach>.

115 Sec. 2, ESA Space Debris Mitigation Policy (2023).

116 Ibid.

117 Dupuy, P.-M. (1991). Soft Law and the International Law of the Environment. *Michigan Journal of International Law*, *12*(2), p. 424.

in one way or another at the universal, regional and more restricted levels, all tend progressively to develop and establish a common international understanding".[118] Hence, while the international instruments on space debris mitigation have different addressees and focuses, their close connection and overall consistency enhance their power to steer the behaviour of States towards the limitation of debris creation.

4.1.1.4 Application of the Space Debris Mitigation Guidelines to ADR Activities

The space debris mitigation guidelines, as their titles suggest, focus on limiting the future generation of space debris. The mitigation of space debris is indispensable for controlling the growth of space debris, for the positive effects resulting from future ADR missions could be offset if space activities fail to effectively limit the creation of more debris. In the meantime, as mentioned in Chapter 2, debris mitigation measures alone are insufficient to halt the continued increase of space debris, for the debris population is projected to continue growing even without any new launches, because collisions among existing objects in orbit will generate additional debris according to the Kessler syndrome. Therefore, debris remediation is also necessary to stabilise the orbital environment, and international instruments regarding ADR need to be developed like the space debris mitigation guidelines.

While the current space debris mitigation guidelines do not expressly address ADR, they still bear some relevance to the issue. First, with regard to the post-mission disposal of objects passing through the LEO region, the IADC Space Debris Mitigation Guidelines provide that: "Retrieval is also a disposal option."[119] The *Support to the IADC Space Debris Mitigation Guidelines* sheds further light on the feasibility of this option.[120] This document explains that with the current technology, the option of on-orbit retrieval is not feasible for most spacecraft owners and/or operators.[121] Therefore, "until such time that direct retrieval is a more commonly available option (perhaps by robotic means), this is not a practical solution".[122] As noted by the US FCC, direct retrieval means "the use of one spacecraft to retrieve another from orbit", which includes ADR activities.[123] Therefore, while at the current stage, ADR technologies might not be sufficiently mature to be employed as a commonly accessible post-mission disposal strategy at a large scale, ADR may likely become an available option for the removal of end-of-mission spacecraft out of congested orbital areas with technological advances in the future. To support future direct retrieval operations, it

118 Ibid.
119 Sec. 5.3.2, IADC Space Debris Mitigation Guidelines.
120 Support to the IADC Space Debris Mitigation Guidelines, *supra* note 32.
121 Ibid, p. 32.
122 Ibid.
123 FCC 20-54 (2020), *supra* note 15, para. 106.

would be helpful if newly launched spacecraft and launch vehicle orbital stages could be more ADR-ready, e.g., to equip these objects with interfaces that may facilitate their removal from orbit after the termination of their operational phases.

In addition to the consideration of ADR as a potential post-mission disposal option for objects passing through the LEO region, the space debris mitigation guidelines are also relevant to ADR activities when it comes to the limitation of the generation of space debris as a result of ADR operations per se. As noted earlier, ADR is needed to control the growth of space debris because the current number of debris in Earth orbit is large enough to trigger the self-sustaining collisional cascading process of space debris. Therefore, it would run afoul of the purpose of ADR activities if these activities generate even more amount of space debris. Hence, ADR activities should also comply with the space debris mitigation guidelines like other space activities, and arguably even more so because ADR is intended to clean up rather than adding to the mess that has already been created in space. In fact, the FCC affirms expressly that its orbital debris mitigation rules apply to all spacecraft operators seeking licenses from the FCC, including operators of In-Space Servicing, Assembly, and Manufacturing (ISAM) systems such as ADR spacecraft.[124]

The application of the space debris mitigation guidelines to ADR activities can be assessed from all four categories of debris mitigation measures contained in the IADC Space Debris Mitigation Guidelines.[125] As to the limitation of debris released during normal operations, it is important to recall once again that ADR activities are intended to ameliorate rather than deteriorate the space debris situation. Therefore, if by mission design, it can be expected that a certain amount of space debris is planned to be released in an ADR operation, the State engaging in such operation would need to assess whether it is worthy to proceed with the operation from an environmental protection perspective.

With regard to the minimisation of on-orbit break-ups, a potential risk is the accidental explosion of the target object. The existing debris objects in space are mostly not designed for removal, and their physical states may be unknown after years in space. In fact, the harsh space environment can degrade the materials and structures of debris objects, making them fragile

124 According to the FCC, "[a] specific sub-category of ISAM missions are those performing a remediation or removal function for preexisting space debris". See FCC. (8 August 2022). *Facilitating Capabilities for In-space Servicing, Assembly, and Manufacturing*. FCC 22-66, para. 29. <https://docs.fcc.gov/public/attachments/FCC-22-66A1.pdf>.

125 See Section 4.1.1.1 *supra*.

to physical contact or sudden manipulation.[126] Objects such as defunct orbital stages and derelict spacecraft failing to be fully passivated may have residual fuel or stored energies onboard which could possibly trigger the explosion of these objects if disturbed.[127] This kind of risk should be duly taken into account by ADR operators when selecting removal targets and designing mission profiles.

With regard to post-mission disposal, NASA Standard 8719.14C points out that the use of atmospheric re-entry to limit the orbital lifetime of space structures in compliance with post-mission disposal requirements "results in the transfer of an orbital environment risk to a potential human casualty risk".[128] Similarly, when an ADR operation is performed to de-orbit from LEO a target object with a very long orbital lifetime, such operation also shifts on-orbit collision risks to human casualty risks on Earth.[129] Therefore, the casualty risks resulting from ADR operations should be limited, following the same rationale to limit the re-entry risks associated with the end-of-mission disposal of LEO objects.[130] When it comes to GEO objects, the post-mission disposal strategy is to re-orbit these objects to a graveyard orbit in order to avoid their long-term interference with the GEO region. China's Shijian-21 mission has proven the technical feasibility of using ADR to clean up defunct spacecraft in GEO.[131] Remarkably, the mission relocated the target debris object to an orbit 3,000 km above the GEO belt, an altitude far higher than the usual graveyard orbit around 300 km above GEO, which has effectively moved it out of harm's way.[132]

Finally, as ADR activities may involve close proximity operations and physical contact between the removal spacecraft and the target debris object, limiting the probability of accidental collision between them is a key consideration in mission design and operations.[133] Therefore, it is essential for ADR operators to develop and employ reliable strategies to safely de-spin, capture and control their target debris objects. In addition, ADR operators should take reasonable measures to estimate and limit the risk of accidental collision with space objects of third parties during mission operations.

126 Weeden, B. (2011). Overview of the Legal and Policy Challenges of Orbital Debris Removal. *Space Policy*, *27*(1), p. 41.

127 Ibid.

128 Sec. 4.7.1.1, NASA Standard 8719.14C, "*Process for Limiting Orbital Debris*", approved 5 November 2021.

129 Liou, J.-C., Kieffer, M., Drew, A., & Sweet, A. (2020). Project Review: The 2019 U.S. Government Orbital Debris Mitigation Standard Practices. In *Orbital Debris Quarterly News*, *24*(1), p. 7.

130 Ibid.

131 See Chapter 2 Section 2.3.1.

132 Andrew, J. (27 January 2022). China's Shijian-21 towed dead satellite to a high graveyard orbit. *SpaceNews*. <https://spacenews.com/chinas-shijian-21-spacecraft-docked-with-and-towed-a-dead-satellite/>.

133 Liou *et al.* (2020), *supra* note 129, p. 7.

4.1.1.5 Implementation of the Space Debris Mitigation Guidelines and Standards at the National Level

As Martinez submits, "although soft law instruments are *non-binding*, this does not mean they are *non-legal*", for States may choose to implement the norms contained in these instruments in their national regulatory frameworks for space activities.[134] In other words, while the international space debris mitigation guidelines do not have binding force under international law, States may decide to make them binding in their national legal order and require private entities to comply with these guidelines as a licensing condition. Reference can be made to the UN General Assembly resolution 68/74 of 11 December 2013, which provides a set of recommendations on the development of national legislation applicable to the peaceful exploration and use of outer space.[135] The resolution refers explicitly to space debris by noting "the need to maintain the sustainable use of outer space, in particular by mitigating space debris, and to ensure the safety of space activities and minimize the potential harm to the environment".[136] The resolution further recommends that licensing conditions should help to ascertain that space activities are carried out in a safe manner and do not lead to harmful interference with other space activities.[137] To this end, States should verify the experience, expertise and technical qualifications of the applicants and may include in the licensing conditions safety and technical standards that are in line, in particular, with the COPUOS Space Debris Mitigation Guidelines.[138]

In fact, as COPUOS notes, many States and international intergovernmental organisations are implementing space debris mitigation measures in line with the COPUOS Space Debris Mitigation Guidelines, and a number of States have harmonised their national space debris mitigation standards with these guidelines.[139] COPUOS also notes that some States are using the COPUOS Space Debris Mitigation Guidelines as well as the guidelines and standards developed by the IADC, ISO and ITU as reference points in their regulatory frameworks for national space activities.[140] COPUOS further urges those countries that have not yet done so to consider implementing the COPUOS Space Debris Mitigation Guidelines on a voluntary basis.[141] With the continuous growth of private space activities, the implementation

134 Martinez, P. (2020). The Role of Soft Law in Promoting the Sustainability and Security of Space Activities. *Journal of Space Law*, *44*(2), p. 530.
135 UN Doc. A/RES/68/74 (2013), *supra* note 13.
136 Preamble, ibid.
137 Recommendation 4, ibid.
138 Ibid.
139 A/77/20 (2022). Report of the Committee on the Peaceful Uses of Outer Space on its sixty-fifth session, para. 97.
140 Ibid, para. 98.
141 Ibid, para. 96.

of international mechanisms at the national level will play an increasingly important role in their regulation. Reference can be made to the Space Debris Compendium, where many States have affirmed their support and adherence to the international space debris mitigation guidelines and standards, especially those of the IADC and COPUOS.[142]

While the incorporation of the international space debris mitigation guidelines into national legal order by many States shows a wide acceptance within the international community of these guidelines, an examination of the rate of practical compliance indicates that more efforts are needed to ensure effective adherence to these guidelines. Reference can be made to the *IADC Report on the Status of the Space Debris Environment* published in January 2023 ("IADC Report of 2023"), which aims to verify the effect of IADC Space Debris Mitigation Guidelines in practice and to monitor their level of implementation.[143] The key finding of this IADC Report is that:

> "The widespread adoption of the IADC space debris mitigation guidelines […] continue to remain the most effective method to reduce the long-term environmental impacts of global space activity by slowing the rate of growth of the space debris population observed. However, the adoption of the IADC space debris mitigation guidelines is not yet at a level that is sufficient to induce substantial benefits or slowing of the population growth."[144]

A similar observation is made in the *ESA's Annual Space Environment Report* published in September 2023 ("ESA Report of 2023"), which aims to provide a transparent overview of the ongoing global debris mitigation efforts.[145] According to the ESA Report:

> "Whereas adoption of, and compliance to, space debris mitigation practices at a global level is noted as slowly increasing, it is of importance to note that the successful implementation is still at a too low level to ensure a sustainable environment in the long-run."[146]

In particular, one of the core principles of the space debris mitigation guidelines is to remove end-of-mission objects from the LEO and GEO protected regions with a probability of success of at least 90% for those orbits where a natural disposal mechanism is absent.[147] Naturally compliant means that "[s]pace objects that operate in an orbit such that they naturally re-enter

142 Space Debris Compendium, *supra* note 30.
143 IADC. (2023). *IADC Report on the Status of the Space Debris Environment*. IADC-23-01.
144 Ibid, p. 6.
145 ESA. (12 September 2023). *ESA's Space Environment Report 2023*, p. 3. The document is available at: <https://www.esa.int/Space_Safety/ESA_s_Space_Environment_Report_2023>.
146 Ibid, p. 8.
147 IADC Report of 2023, *supra* note 143, p. 6.

within 25 years (i.e., without requiring any manoeuvre)".[148] Most objects deployed below the altitude of 600 km will generally decay within 25 years at the end of their mission.[149] According to the IADC Report of 2023, the general "[p]ost mission disposal compliance remains low".[150] This is problematic because unsuccessfully disposed spacecraft and launch vehicle orbital stages provide the mass to trigger and sustain a collisional cascade of objects in orbit.[151]

According to the IADC Report of 2023, between 45% and 90% of all spacecraft reaching end-of-life for any given year in the last decade in LEO are in compliance with the post-mission disposal measures, with the compliance trend increasing.[152] However, this increase is mainly due to the growth of spacecraft placed in naturally compliant orbits.[153] When it comes to non-naturally compliant spacecraft, the compliance rate is only between 10% to 40%.[154] As to end-of-mission rocket bodies in the LEO region, the IADC Report finds that between 30% and 90% of them are in compliance with the recommended post-mission disposal measures during the last decade, with an increasing compliance trend mainly due to an increasing number of spacecraft delivered to naturally compliant orbits.[155] Similar figures are provided in the ESA Report of 2023.[156] The finding in a Report published by the NASA OIG in 2021 seems even more concerning.[157] According to this Report, over the last decade, the global compliance rate for spacecraft and rocket bodies with the 25-year post-mission disposal rule has only averaged between 20% to 30%, much lower than the 90% success rate set in the international space debris mitigation guidelines.[158] The Report further notes that compliance with post-mission disposal guidelines "will have greater impact on mitigating the risks of orbital debris than pursuing the development of costly remediation technologies".[159] Hence, to stabilise the orbital environment, space operators should significantly increase their compliance with the 25-year rule.

With regard to the situation in GEO, the IADC Report of 2023 finds that between 85% and 100% of all spacecraft in the GEO region reaching end-of-

148 Ibid, p. 4.
149 Lewis, H. G. (2020). Evaluation of Post-Mission Disposal Options for a Large Constellation. *Journal of Space Safety Engineering*, *7*(3), p. 192.
150 IADC Report of 2023, *supra* note 143, p. 6.
151 Support to the IADC Space Debris Mitigation Guidelines, *supra* note 32, p. 30.
152 IADC Report of 2023, *supra* note 143, p. 6.
153 Ibid.
154 Ibid.
155 Ibid.
156 ESA Report of 2023, *supra* note 145, p. 7.
157 NASA OIG. (2021). *NASA's Efforts to Mitigate the Risks Posed by Orbital Debris*. Report No. IG-21-011.
158 Ibid, p. 17.
159 Ibid.

life during the last decade attempt to comply with the disposal guidelines and between 60% and 90% do so successfully, with the compliance trend asymptotically increasing.[160] The same figures can also be found in the ESA Report of 2023.[161] Meanwhile, the compliance rate of rocket bodies in GEO appears less satisfactory. According to the IADC Report of 2023, between 20% and 70% of the orbital stages delivering spacecraft in or near the GEO region during the last decade are in compliance with the recommended disposal measures, with the compliance trend also increasing.[162] Similarly, the compliance rate for the post-mission disposal of GEO orbital stages found in the ESA Report is between 40% and 50%.[163]

The above figures show that more ambitious efforts are needed to ensure the proper disposal of spacecraft and launch vehicles at the end of their missions. As well summarised by ESA: "The adoption of space debris mitigation measures is improving, but, given the sheer number of new satellites and amount of existing debris, the rate is still not enough and our behaviour in space appears to be unsustainable in the long term."[164] Hence, it is important for States to ensure that their space activities are carried out in compliance with the space debris mitigation guidelines and to make stronger commitments to preserve the outer space environment.

4.1.2 The LTS Guidelines

An issue closely connected to space debris mitigation is the long-term sustainability of outer space activities. While the UN has addressed the concept of sustainable development on Earth for over four decades, the extension of this concept to outer space is a more recent development.[165] With the increasing dependence of humankind on space assets and applications, the issue of long-term sustainability for outer space activities has attracted growing attention within the international community.[166] This culminated in the adoption by COPUOS of twenty-one LTS Guidelines in 2019, which provide insights into the practical steps that can be taken to enhance the

160 IADC Report of 2023, *supra* note 143, p. 6.
161 ESA Report of 2023, *supra* note 145, p. 7.
162 IADC Report of 2023, *supra* note 143, p. 6.
163 ESA Report of 2023, *supra* note 145, p. 7.
164 ESA (2023), *supra* note 145.
165 Martinez (2020), *supra* note 134, p. 537. The first commonly recognised definition of "sustainable development" was provided in the 1987 Brundtland Report: "Sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future". See Brundtland, G. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. UN Doc. A/42/427 (4 August 1987).
166 Preamble of the LTS Guidelines, para. 5.

sustainability of outer space activities.[167] Space sustainability is closely related to ADR because, as mentioned in Chapter 2, ADR operations are needed to stabilise the amount of space debris, which is a critical threat to the long-term sustainability of outer space activities. Section 4.1.2.1 will introduce the development of the LTS Guidelines, including how the issue of ADR was addressed in this process. Section 4.1.2.2 will analyse the relevance of the adopted LTS Guidelines to ADR, and Section 4.1.2.3 will discuss the implementation of the LTS Guidelines.

4.1.2.1 Development of the LTS Guidelines

At its forty-seventh session in February 2010, the COPUOS STSC established the Working Group on the Long-term Sustainability of Outer Space Activities ("LTS Working Group").[168] The Working Group was tasked with producing a report on the long-term sustainability of outer space activities and a consolidated set of voluntary and non-legally binding guidelines to enhance the long-term sustainability of outer space activities for all space actors and all beneficiaries of space activities.[169] To expedite its work, the LTS Working Group established four expert groups:

Expert Group A: "Sustainable space utilization supporting sustainable development on Earth";
Expert Group B: "Space debris, space operations and tools to support collaborative space situational awareness";
Expert Group C "Space Weather"; and
Expert Group D: "Regulatory regimes and guidance for actors in the space arena".[170]

The task of the expert groups was to provide inputs for the consideration of the LTS Working Group, which would then take necessary decisions.[171] This approach established a clear separation "between the expert groups as technical deliberative fora and the Working Group as a diplomatic negotiation

167 UN Doc. A/AC.105/C.1/2023/CRP.31/Rev.2 (16 February 2023). A practical and inclusive approach to identifying and studying challenges and considering possible new guidelines: Conference room paper submitted by Canada, Italy, Japan, Luxembourg, New Zealand, the United Kingdom of Great Britain and Northern Ireland and the United States of America, para. 2.

168 UN Doc. A/AC.105/958 (11 March 2020). Report of the COPUOS Scientific and Technical Subcommittee on its forty-seventh session, para. 181. For a detailed overview of the early phase of the discussions on the concept of space sustainability in COPUOS see Brachet, G. (2012). The Origins of the "Long-term Sustainability of Outer Space Activities" Initiative at UN COPUOS. *Space Policy*, *28*(3), pp. 161-165.

169 UN Doc. A/AC.105/2018/CRP.22/Rev.1 (28 June 2018), Report of the Working Group on the Long-term Sustainability of Outer Space Activities: Working paper by the Chair of the Working Group, para. 7.

170 Ibid, para. 15.

171 Martinez, P. (2021). The UN COPUOS Guidelines for the Long-Term Sustainability of Outer Space Activities. *Journal of Space Safety Engineering*, *8*(1), p. 99.

forum within COPUOS".[172] The four expert groups delivered their reports in 2014, providing proposed candidate guidelines and issues for further consideration. The finalisation of these reports marked the transfer of the discussion of the guidelines from the expert groups to the LTS Working Group.[173]

The issue of space debris was expressly addressed by *Expert Group B*. In its final report, Export Group B noted that "[c]oncepts for removing large debris from low earth orbit have been proposed since the early 1980s".[174] However, "reviews by panels of international experts have repeatedly failed to identify a single [removal] plan which is both technically feasible in the near-term and economically viable", and thus additional studies on this issue were needed.[175] Hence, Expert Group B concluded that "there is currently no established practice for space debris removal that can serve as the basis for a recommended guideline".[176] Expert Group B also pointed out that space debris mitigation measures alone might not be sufficient to limit the growth of the future space debris population and suggested States to move forward with concepts for ADR.[177] In addition to the draft guidelines proposed by the expert groups, a number of COPUOS member States also proposed draft guidelines for consideration by the LTS Working Group.[178] In particular, while Expert Group B did not propose any ADR-specific guidelines, Russia proposed draft guidelines addressing the issue of ADR, which provide recommendations regarding the safety of ADR operations.[179]

At its fifty-ninth session in 2016, COPUOS agreed on the first set of LTS Guidelines and extended the mandate of the LTS Working Group to June 2018.[180] The Working Group concluded its work by the end of this mandate, reaching consensus on nine additional guidelines and a preambular text. At its sixty-second session in 2019, COPUOS adopted the preamble and a

172 Ibid.
173 UN Doc. A/AC.105/1088 (27 February 2015), Report of the Scientific and Technical Subcommittee on its fifty-second session, Annex III, para. 7.
174 UN Doc. A/AC.105/2014/CRP.14 (16 June 2014), Working Report of Expert Group B: Space Debris, Space Operations and Tools to Support Collaborative Space Situational Awareness, p. 27.
175 Ibid.
176 Ibid.
177 Ibid.
178 Martinez (2020), *supra* note 134, p. 538.
179 UN Doc. A/AC.105/L.290 (4 March 2014). Long-term sustainability of outer space activities – Working paper submitted by the Russian Federation, pp. 6-7. UN Doc. A/AC.105/L.296 (30 April 2015), Additional considerations and proposals for building up understanding of the priority aspects, comprehensive meaning and functions of the concept and practices of ensuring the long-term sustainability of outer space activities – Working paper submitted by the Russian Federation, p. 11.
180 UN Doc. A/71/20 (2016). Report of the COPUOS on its fifty-ninth session, para. 130 & Annex.

comprehensive set of twenty-one LTS Guidelines, and "encouraged States and international intergovernmental organizations to voluntarily take measures to ensure that the guidelines are implemented to the greatest extent feasible and practicable".[181] Besides these twenty-one adopted guidelines, there are another seven draft guidelines for which consensus could not be reached by the LTS Working Group within the term of its mandate. These remaining guidelines, including the draft guideline regarding ADR originally proposed by Russia, are contained in a separate document.[182] As political tensions marked the discussions throughout the mandate of the LTS Working Group, it was more difficult to achieve consensus on the draft guidelines addressing more sensitive topics such as ADR.[183]

At the same session where the twenty-one LTS Guidelines were adopted, COPUOS decided to establish, under a five-year workplan, a new working group under the agenda item of the long-term sustainability of outer space activities of its Scientific and Technical Subcommittee ("LTS 2.0 Working Group").[184] COPUOS further decided that the Working Group would be guided by the following framework:

(a) Identifying and studying challenges and considering possible new guidelines for the long-term sustainability of outer space activities. This could be done by taking into consideration existing documents including, inter alia, documents A/AC.105/C.1/L.367 and A/AC.105/2019/CRP.16;
(b) Sharing experiences, practices and lessons learned from voluntary national implementation of the adopted guidelines;
(c) Raising awareness and building capacity, in particular among emerging space nations and developing countries.[185]

The explicit inclusion of UN document A/AC.105/C.1/L.367 into the guiding framework for the LTS 2.0 Working Group indicates that the draft guideline regarding ADR would be considered by this new working group in its future work. This draft guideline will be discussed in more detail in Chapter 5 in the context of the future development of international guidelines to address ADR activities.

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181 UN Doc. A/74/20 (2019). Report of the COPUOS on its sixty-second session, para. 163.

182 UN Doc. A/AC.105/C.1/L.367 (16 July 2018), Draft Guidelines for the Long-term Sustainability of Outer Space Activities: Working paper by the Chair of the Working Group on the Long-term Sustainability of Outer Space Activities.

183 Masson-Zwaan & Hofmann (2019), *supra* note 2, p. 117. See also Martinez, P. (2018). Development of an International Compendium of Guidelines for the Long-Term Sustainability of Outer Space Activities. *Space Policy*, *43*, p. 16.

184 UN Doc. A/74/20 (2019), *supra* note 181, para. 165.

185 Ibid, para. 167.

4.1.2.2 Relevance of the LTS Guidelines to ADR

The twenty-one LTS guidelines address the policy, regulatory, operational, safety, scientific, technical, international cooperation and capacity-building aspects of space activities.[186] They are grouped into four categories: (A) Policy and regulatory framework for space activities; (B) Safety of space operations; (C) International cooperation, capacity-building and awareness; and (D) Scientific and technical research and development. These guidelines are not legally binding under international law, and States and international intergovernmental organisations are encouraged to voluntarily take measures to ensure their implementation to the greatest extent feasible and practicable, in accordance with their respective needs, conditions and capabilities.[187] Each guideline is composed of "a short action-oriented title text that summarizes the main intent of a given guideline, followed by several paragraphs of more detailed recommendatory text to support the implementation of the guideline".[188]

The adoption of the LTS Guidelines can be seen as "an important milestone" in the work of COPUOS to ensure that all nations can continue to benefit from the exploration and use of outer space over the long term.[189] The issue of space debris is expressly addressed in the LTS Guidelines. For example, Guideline A.2 recommends States to implement debris mitigation measures, such as those contained in the COPUOS Space Debris Mitigation Guidelines, when developing and revising national regulatory frameworks for outer space activities. However, the LTS Guidelines do not directly address the issue of ADR, though several guidelines are relevant to this issue to varying degrees. The following sections will assess four LTS Guidelines of close relevance in this regard to illustrate how the current long-term sustainability guidelines may support debris removal activities.

4.1.2.2.1 LTS Guideline D.2

Guideline D.2 "*Investigate and consider new measures to manage the space debris population in the long term*" may be seen as the guideline most relevant to ADR activities. It recommends States and international organisations to investigate new measures, including technological solutions, and consider the implementation thereof, in order to manage the space debris population in the long term.[190] Investigation of new measures could include, among others, methods for the extension of operational lifetime, novel techniques to prevent collisions with and among non-manoeuvrable objects, advanced

186 Preamble of the LTS Guidelines, para. 11.
187 Ibid, paras. 15-16.
188 Martinez (2021), *supra* note 171, p. 102.
189 UN Doc. A/AC.105/C.1/2023/CRP.31/Rev.2 (2023), *supra* note 167, para. 2.
190 LTS Guideline D.2, para. 1.

measures for spacecraft passivation and post-mission disposal, and designs to enhance the disintegration of space objects during re-entry.[191]

In reporting its implementation of this guideline, ESA refers to its ADR mission Clearspace-1 to de-orbit an ESA-owned space debris, which will, according to ESA, "pave the way to more ADR missions as well as commercial services for in-orbit servicing including management of end of life of future constellations".[192] Similarly, when sharing its implementation practices regarding this guideline, Japan notes that JAXA carries out research and development on space debris mitigation and removal.[193] It further proposes to form "a forward-looking international consensus on transparency and safety assurance to encourage private sectors to implement space debris removal activities".[194] The sharing of debris removal practices in the context of Guideline D.2 indicates that ADR can be regarded as an advanced measure to address the problem of space debris.[195]

Guideline D.2 also recommends that the "new measures aimed at ensuring the sustainability of space activities and involving either controlled or uncontrolled re-entries should not pose an undue risk to people or property". While not explicitly referring to ADR, this guideline stresses the need to limit the risk to the ground in the design and implementation of de-orbiting operations. Hence, ADR operators should duly assess and mitigate the risk to the ground when de-orbiting objects from the LEO region.

4.1.2.2.2 LTS Guideline B.8

Guideline B.8 "*Design and operation of space objects regardless of their physical and operational characteristics*" provides two key recommendations relevant to space debris and ADR. Firstly, it recommends States and international organisations to encourage manufacturers and operators of space objects "to design such objects to implement applicable international and national space debris mitigation standards and/or guidelines in order to limit the long-term presence of space objects in protected regions of outer space after the end of their mission".[196] It also encourages the sharing of "experiences and information on the operation and end-of-life disposal of space objects,

191 Ibid, para. 2.

192 UN Doc. A/AC.105/C.1/2022/CRP.14/Rev.1 (7 February 2022), Report on the implementation of the Guidelines for the Long-term Sustainability of Outer Space Activities in the European Space Agency, p. 13.

193 UN Doc. A/AC.105/C.1/2023/CRP.28 (8 February 2023). Report on the implementation of the Guidelines for the Long-term Sustainability of Outer Space Activities in Japan, p. 17.

194 Ibid.

195 Weeden, C., Blackerby, C., Forshaw, J., Martin, C., Lopez, R., Yamamoto, E., & Okada, N. (2019). Development of Global Policy for Active Debris Removal Services. *First International Orbital Debris Conference*, p. 4.

196 LTS Guideline B.8, para. 2.

in furtherance of the long-term sustainability of space activities".[197] The explicit reference to the international space debris mitigation guidelines, especially the post-mission disposal measures, underlines the importance of these guidelines and measures to space sustainability.

Secondly, Guideline B.8 encourages States and international intergovernmental organisations to "promote design approaches that increase the trackability of space objects, regardless of their physical and operational characteristics, including small-size space objects, and those that are difficult to track throughout their orbital lifetime, as well as facilitate the accurate and precise determination of their position in orbit".[198] Similar recommendations to enhance the trackability of space objects can also be found in the *IADC Statement on Large Constellations of Satellites in Low Earth Orbit* updated in 2021, which recommends constellation operators to enhance the trackability of their satellites by adding on-board components that can improve the orbit determination and prediction.[199] According to the IADC Statement, this would have a positive impact on conjunction analysis.[200]

The recommendation to increase the trackability of space objects is relevant to ADR because this could enhance the safety and effectiveness of missions to locate and capture these objects.[201] The ability to be tracked can be improved by incorporating cooperative servicing interfaces such as optical fiducial markers and beacons.[202] Hence, satellite operators may consider increasing the trackability of their satellites by installing these interfaces to their satellites. As a practice to implement Guideline B.8, ESA is developing technologies "targeting add-ons for small spacecraft to improve the capability of ground surveillance systems to track them ('design to track') and to provide identification means".[203]

4.1.2.2.3 LTS Guideline B.1

Guideline B.1 "*Provide updated contact information and share information on space objects and orbital events*" focuses on the exchange of orbital information to enhance space safety. More specifically, it recommends States and international intergovernmental organisations to voluntarily exchange the contact information on their designated entities authorised to engage in information exchange and conjunction assessment, through UNOOSA or

197 Ibid.
198 Ibid, para. 1.
199 IADC. (2021). *IADC Statement on Large Constellations of Satellites in Low Earth Orbit*. IADC-15-03. Initially published 10 November 2017, updated 6 July 2021.
200 Sec. 4.3.5, ibid.
201 Sec. 2, *CONFERS Recommended Design and Operational Practices* ("CONFERS Recommended Practices"), last revised in October 2022. <https://www.satelliteconfers.org/publications/>.
202 Ibid.
203 UN Doc. A/AC.105/C.1/2022/CRP.14/Rev.1 (2022), *supra* note 192, p. 8.

directly with other States and international intergovernmental organisations.[204] In addition, it recommends the establishment of appropriate means to enable timely coordination to mitigate orbital collision and to exchange information on space objects and information related to orbital events that may affect the safety of space operations.[205]

As noted by Weeden *et al.*, information sharing is essential to enhance the transparency and the understanding of space activities.[206] A good example in this regard is set by the CNES Space Situational Awareness Center, which makes use of existing platforms to widely communicate its contact details as well as the contact details of space operators in order to assist the coordination among operators to avoid on-orbit collisions.[207] Specific to ADR operations, Astroscale's command segment of the ELSA-d mission has been designed to include a round-the-clock point of contact to monitor conjunctions and provide an open line of communication with other orbital "neighbours".[208] Since ADR operations "may inadvertently generate more debris or increase the probability of collision",[209] the sharing of contact details and other relevant information could enable other space actors to coordinate with the ADR operators to reduce potential risks and concerns in a timely manner. In this sense, Guideline B.1 can be relevant to the safety and transparency of ADR operations.

4.1.2.2.4 LTS Guideline B.2

Guideline B.2 "*Improve accuracy of orbital data on space objects and enhance the practice and utility of information sharing*" recognises that "spaceflight safety strongly depends upon the accuracy of orbital and other relevant data".[210] As such, the guideline recommends States and international organisations to "promote the development and use of techniques and methods to improve the accuracy of orbital data".[211] While data accuracy is important for the safety of space missions in general, accurate and ongoing SSA data is particularly essential for ADR operations, especially in the rendezvous and

204 LTS Guideline B.1, para. 1.
205 Ibid, para. 2.
206 Weeden *et al*. (2019), *supra* note 195, p. 3.
207 UN Doc. A/AC.105/C.1/2022/CRP.20 (7 February 2022). General presentation of French activities and views concerning the long-term sustainability of outer space activities, in relation with the implementation of the 21 Guidelines, paras. 23&40.
208 FCC. *FCC Report: ELSA-d CONOPS and Debris Mitigation Overview* ("ELSA-d CONOPS Report"), p. 11. <https://fcc.report/IBFS/SES-STA-INTR2020-00086/2166969.pdf>.
209 US. (January 2021). *US National Orbital Debris Research and Development Plan*, p. 11. <https://www.space.commerce.gov/white-house-releases-orbital-debris-rd-plan/>.
210 LTS Guideline B.2, para. 2.
211 Ibid, para. 1.

capture phases of the mission, which requires a thorough assessment of the location of the target object.[212]

In view of the importance of data accuracy, the *CONFERS Recommended Design and Operational Practices* recommend that operators should use external resources to provide independent and coordinated data and information to plan and inform their on-orbit servicing activities, including the removal of debris objects.[213] These external sources can include external SSA and modelling or simulation capabilities.[214] As a practical example, in its ELSA-d mission, Astroscale has signed an agreement with ESA for the provision of data on the environmental monitoring of space debris and conjunction assessment.[215] Considering the high demand for data accuracy in ADR activities, it would also be beneficial for States with SSA capabilities to enter into cooperation to increase the accuracy and reliability of their data for the safety of ADR operations.

4.1.2.3 Implementation of the LTS Guidelines at the National Level

The twenty-one LTS guidelines "are intended to support States in engaging in activities aimed at preserving the space environment".[216] As Martinez comments, these guidelines are "not at all prescriptive about the manner of implementation, recognizing the wide variety of ways in which States organize, conduct and regulate their space activities", and they "will only achieve their intended purpose if they are implemented as widely as possible".[217] Therefore, it would be helpful to provide guidance to States on the possible ways of implementation.

To promote the implementation of the LTS Guidelines, UNOOSA has established, with the support of the UK, the project "*Awareness-raising and capacity-building related to the implementation of the Guidelines for the Long-term Sustainability of Outer Space Activities*" ("UNOOSA LTS Project") on 26 January 2021.[218] The Project aims to showcase how the LTS Guidelines "can be implemented in a multi-stakeholder perspective in order to protect the

212 Weeden *et al.* (2019), *supra* note 195, p. 3. See also 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. 7.

213 Sec. 1.4.5., *CONFERS Recommended Design and Operational Practices* ("CONFERS Recommended Practices"), last revised October 2022. <https://www.satelliteconfers.org/publications/>. This document will be further discussed in Chapter 4 Section 4.2.2.

214 Ibid.

215 ELSA-d CONOPS Report, *supra* note 208, p. 11.

216 Preamble of the LTS Guidelines, para. 7.

217 Martinez (2021), *supra* note 171, p. 103.

218 Information on the UNOOSA LTS Project is available on a dedicated UNOOSA webpage: <https://spacesustainability.unoosa.org/>.

Earth's limited orbital space environment and relevant space activities".[219] The first phase of the Project led to the publication of the LTS Guidelines in all six official languages of the UN and the production of over forty operational case studies of implementation practices.[220] In the second phase of the Project, UNOOSA conducted a series of interviews with States and international organisations to identify their experiences and challenges associated with the implementation of the LTS Guidelines.[221] The information gathered in the interviews is contained in a report published by UNOOSA in May 2022.[222] According to this report, ADR missions were flagged by some interviewees in the context of scientific and technical research and development under Section D of the LTS Guidelines.[223] This affirms the relevance of the LTS Guidelines to ADR activities. The UNOOSA LTS Project is currently in its third phase, where UNOOSA will create an open access e-learning tool to help improve understanding about the LTS Guidelines and enhance their implementation.[224]

As COPUOS serves as "the principal forum for continued institutionalized dialogue on issues related to the implementation and review of the guidelines",[225] many States and international organisations have reported their implementation practices at COPUOS.[226] An increasing number of such reporting can be observed over the years, probably because the LTS Guidelines were adopted several years ago and there are already some practices and experiences gathered with the passing of time. As noted by France, sharing and reviewing best practices on the implementation of the LTS Guidelines will enhance communication, international cooperation and capacity building towards the preservation of space sustainability.[227] To coordinate the reporting, the UK has proposed a template for States and international organisations to document their progress on and challenges of implementation.[228] The template contains four categories of information: (i) Thoughts or approach to implementation; (ii) Current progress and/or

219 Ibid.

220 UN Doc. A/AC.105/C.1/L.409 (14 September 2022), Information and views for consideration by the Working Group on the Long-term Sustainability of Outer Space Activities, p. 5.

221 UNOOSA LTS Project, *supra* note 218.

222 UNOOSA. (May 2022). *Awareness-raising and capacity-building related to the implementation of the Guidelines for the Long-Term Sustainability of Outer Space Activities (LTS Guidelines): Stakeholder Study Report*.

223 Ibid, pp. 30-31.

224 UNOOSA LTS Project, *supra* note 218.

225 UN Doc. A/74/20 (2019), *supra* note 181, para. 164.

226 The submissions of States and international organisations on their implementation of the LTS Guidelines can be found on the UNOOSA website: <https://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html>.

227 UN Doc. A/AC.105/C.1/2022/CRP.20 (2022), *supra* note 207, para. 4.

228 UN Doc. A/AC.105/C.1/2022/CRP.22 (14 February 2022). United Kingdom Update on its Reporting Approach for the Voluntary Implementation of the Guidelines for the Long-Term Sustainability of Outer Space Activities, para. 2 & Annex 1.

proposed future activities; (iii) Experiences, challenges and lessons learnt; (iv) Comments on specific needs for capacity building necessary to support implementation.[229] Some brief guidance is provided to explain the meaning of each category.[230] As the UK notes, understanding the challenges surrounding the implementation of the LTS guidelines is critical to identifying the form of future capacity-building activities.[231] Moreover, significant participation in the sharing of implementation practices will allow States to uncover the various approaches that could be adopted to implement the LTS Guidelines, which would form a basis for States to work towards potential coherency in their approaches to implementation.[232] Some States such as Austria[233] and Canada[234] have already used this template to report their implementation practices.

The importance of the sharing of implementation practices can be viewed from the concept of "regulatory impact assessment", which refers to the procedure to evaluate the practical effectiveness and identify the possible deficits of the non-binding norms.[235] As submitted by Brünner and Königsberger, such an evaluation may inform future efforts to further promote compliance and strengthen the public awareness of the norms as well as their power to steer behaviour.[236] From this perspective, both the UNOOSA LTS Project and the reporting of implementation practices by States and international organisations represent effective tools for them to understand the methods of implementation, the progress achieved, and the challenges and experiences identified. In particular, as the template proposed by the UK addresses various aspects of the implementation, which could help to reveal the potential areas for improvement, it is advisable for States to consider using the template to report their implementation practices.

The sharing of implementation practices regarding the LTS Guidelines may serve as a model of regulatory impact assessment to enhance the compliance and effectiveness of other soft law instruments. As noted earlier, efforts are needed to increase compliance with the space debris mitigation guidelines. Modelling after the UK-proposed template, States may also

229 Ibid.

230 Ibid.

231 UN Doc. A/AC.105/C.1/L.409 (2022), *supra* note 220, p. 6.

232 Ibid.

233 UN Doc. A/AC.105/C.1/2023/CRP.19 (6 February 2023). Austria: Report on the voluntary implementation of the Guidelines for the Long-term Sustainability of Outer Space Activities.

234 UN Doc. A/AC.105/C.1/2023/CRP.8 (6 February 2023). Canada – Annex to update on its reporting approach for the voluntary implementation of the Guidelines for the Long-term Sustainability of Outer Space Activities.

235 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, pp. 96-97.

236 Ibid.

report their implementation practices in a more systematic manner including their progress, challenges and lessons learnt in the implementation of each of the seven space debris mitigation guidelines endorsed by COPUOS. This evaluation process may contribute to assessing the effectiveness of implementation and enhancing compliance with the space debris mitigation guidelines. As both the LTS Guidelines and the COPUOS Space Debris Mitigation Guidelines are intended as living documents, the review of their implementation practices could help to inform their future update.

4.1.3 Section Conclusion

The international instruments providing space debris mitigation guidelines and standards constitute a significant step forward towards tackling the space debris problem. They focus on limiting the generation of new debris and not the remediation of existing debris from orbit. This does not mean that they are irrelevant to ADR. Rather, the IADC Space Debris Mitigation Guidelines touch upon the issue of ADR by recognising direct retrieval as a potential post-mission disposal option. In addition, the space debris mitigation guidelines and standards are applicable to ADR operations in the aspect of limiting the number of debris created as a result of these operations. However, while these instruments encourage their addressees to limit the generation of space debris as a result of their space activities, they neither call upon States to actively remediate previously created debris from orbit, nor provide clear recommendations on how ADR activities should be carried out in a manner to reduce the risk of creating more debris. In other words, while these guidelines set out general debris mitigation measures that apply to ADR like other space activities, these measures are not specifically designed for ADR and they need to be translated into more specific technical or operational practices to guide ADR operators towards complying with these measures.

The issue of protecting the orbital environment from the continuous growth of space debris is also considered within the context of the long-term sustainability of outer space activities. The adoption by COPUOS of the twenty-one LTS Guidelines is another positive step forward towards preserving the outer space environment. Space debris, which is recognised as a critical threat to space sustainability, is also addressed in the COPUOS LTS Guidelines. Several LTS Guidelines are of close relevance to ADR in the sense that faithful compliance with these guidelines may contribute to promoting the advances in ADR technologies and enhancing the safety of ADR operations. However, the issue of ADR is not sufficiently addressed in the COPUOS Guidelines. Firstly, the term ADR is not expressly mentioned in any of the twenty-one LTS Guidelines. Secondly, even Guideline D.2, which is understood as being of direct relevance to active remediation of space debris, only recommends States and international organisations to invest new measures to manage the space debris population in the long term, without more outrightly encouraging them to clean up their existing debris from congested orbital areas. Thirdly, although some draft guidelines regarding the safety of ADR operations were proposed during the negotiation of the 21 COPUOS LTS Guidelines, consensus could not be reached on these guidelines. In view of the intimate relation between ADR and space sustainability, i.e., ADR activities are necessary to maintain orbital sustainability while these activities, if not undertaken properly, may cause more harm than good to the space environment, it is important to ensure that ADR operations are carried out in a manner furthering the long-term sustainability of the orbital environment. In this regard, the commercial space industry is already moving ahead of the COPUOS LTS Guidelines and has developed principles and recommended practices that are directly applicable to ADR missions. The initiatives taken by the commercial space sector will be discussed in the next section.

4.2 *Issue 2*: The Role of Soft Law for the Clarification of "Fault" and the Industry-Led Initiatives in Developing ADR Guidelines

This section will discuss how soft law instruments can contribute to the clarification of the notion of "fault" and underline the need to develop safety guidelines and standards for ADR missions from a legal perspective. As mentioned in Chapter 2, the ambiguity of the concept of "fault" regarding the determination of liability for damage caused in outer space may create legal uncertainty and thus disincentivise States from undertaking ADR activities. To overcome this hurdle, an ideal solution would be for States Parties to the Liability Convention to develop a protocol specifying what "fault" means for the attribution of liability for damage caused by space objects in space. However, considering that the last of the five UN space treaties was adopted over four decades ago, it appears that the adoption of new space treaties is not a feasible option in the near future. Therefore, the most plausible method to clarify the notion of "fault" lies in the adoption of soft law instruments. The previous section has addressed several environmentally relevant instruments for outer space activities, and Section 2.1 will use these instruments as examples to discuss how soft law instruments may contribute to the clarification of the notion of "fault".

The previous section also notes that while the space debris mitigation guidelines and the COPUOS LTS Guidelines are relevant to ADR activities, they do not provide clear guidance on how ADR activities should be carried out safely in furthering the long-term sustainability of outer space activities. In the absence of clear guidance, the determination of "fault" may be difficult when an ADR operation causes damage to space objects of third parties. Therefore, it would be useful for the international community to develop specific guidelines and standards for the design and operation of ADR missions. This standardisation would not only contribute to enhancing the safety of ADR operations but also specify a standard of care against which fault could be assessed when, for instance, a removal spacecraft accidentally causes damage in outer space. Currently, States have not yet adopted international guidelines for ADR operations like the COPUOS Space Debris Mitigation Guidelines and COPUSO LTS Guidelines. In the meantime, the commercial space industry has formed associations and working groups that are developing best practices and recommended standards to ensure the safety of ADR activities.[237] Sections 2.2 to 2.5 will examine several industry-led initiatives expressly addressing ADR and discuss their relevance to the undertaking of ADR activities. More specifically, Section 2.2 will discuss the guiding principles and best practices published by CONFERS, which are directly applicable to commercial ADR operations. The publications of CONFERS were used as a foundation for the development of ISO 24330: 2022, the first-ever thorough set of international standards regarding ADR and other satellite servicing operations, which will be discussed in Section 2.3. Section 2.4 will assess another industry-led initiative that could contribute to ensuring safe ADR operations, which is the *Best Practices for the Sustainability of Space Operations* published by the Space Safety Coalition. Section 2.5 will discuss the Space Sustainability Rating, which is not a new set of guidelines but a rating system to evaluate the compliance with existing guidelines and promote more sustainable behaviours in outer space. Section 2.6 will summarise this section and point out the areas where future development of space law is needed in order to clarify "fault" for the attribution of liability for damage caused by ADR operations in space.

4.2.1 The Role of Soft Law for Clarifying the Notion of "Fault"

As discussed in Chapter 3, while the UN space treaties and general international law lay down the general legal framework for space activities, which sets forth fundamental rules and principles relevant to the governance of space debris and ADR, the issue of space debris is neither mentioned nor specifically addressed in these legally binding rules and principles. Therefore, clarification is needed to understand the specific meaning and requirements of these rules and principles. In particular, since the Liability Convention does neither define "fault" nor provide a standard of care for the determination of "fault", it is difficult to understand what "fault" means for the attribution of liability when damage is caused in outer space. However, the development of a binding agreement to define "fault" does not seem a possible option in the near term, as there has been no new space treaty adopted within the UN after the conclusion of the Moon Agreement. Rather, a trend can be observed where recourse has been made to the soft

237 Weeden *et al*. (2019), *supra* note 195, p. 6.

law instruments for the further development of space law. Therefore, a question is whether soft law can contribute to the clarification of "fault".

In general, fault denotes "the failure to adhere to, or breach of, an obligation imposed by law".[238] Reference can be made to the most environmentally relevant provision in the Outer Space Treaty, i.e., Article IX of the OST, which requires States to carry out their space activities with due regard to the corresponding rights and interests of other States. As the rights and interests of States to freely and safely explore and use outer space are hindered by the growth of space debris, a duty to take appropriate measures to reduce space debris when carrying out space activities can be inferred from the due regard principle. However, Article IX itself does not provide clear guidance to States on how to fulfil this requirement. In the context of the law of the sea, the Seabed Dispute Chamber of the ITLOS has highlighted the inter-linkage between the obligation of due diligence and the obligation to apply best environmental practices:

> "[I]n light of the advancement in scientific knowledge, member States of the [International Seabed] Authority have become convinced of the need for sponsoring States to apply "best environmental practices" in general terms so that they may be seen to have become enshrined in the sponsoring States' obligation of due diligence."[239]

In transposing this reasoning to the space law context, it can be likewise argued that the best practices for the protection of the space environment should be duly applied in order to fulfil the due regard requirement. In this regard, the internationally accepted space debris mitigation guidelines, as embodying best practices for limiting the creation of space debris, can be seen as instruments "giving concrete shape to the substantive requirements that States have to fulfil for meeting the obligations under Art. IX OST".[240] In fact, as Masson-Zwaan observes, "Article IX of the Outer Space Treaty is often considered as the main basis for further rules on space debris mitigation and remediation, even if the article itself does not seem to impose a very strong legal obligation on States Parties".[241] Therefore, conformity with soft law addressing space debris may be considered by judges in assessing the degree of due diligence exercised by States in the course of space activities. In addition, as argued in Chapter 3, space debris can be regarded as a form of "contamination" in the context of Article IX of the OST. Following this understanding, the space debris mitigation measures

238 Smith, L. J. & Kerrest, A. (2013). Article III (Fault Liability) LIAB. In *CoCoSL Vol. 2*, p. 132.

239 *Responsibilities and obligations of States with respect to activities in the Area, Advisory Opinion, 1 February 2011, ITLOS Reports 2011*, para. 136.

240 Stubbe, P. & Schrogl, K.-U. (2015). The Legal Significance of the COPUOS SDM Guidelines. In *CoCoSL Vol. 3*, p. 647.

241 Masson-Zwaan, T. L. (2023). Widening the Horizons of Outer Space Law. Doctoral Thesis at Leiden University, *Meijers-reeks*, p. 44.

contained in the non-binding instruments can also be seen as specification of the "appropriate measures" to be taken to avoid harmful contamination in outer space.[242] As space debris mitigation guidelines can be viewed as specifying the general requirements under Article IX of the OST, they may be used by judges in determining the existence of "fault" by virtue of Article IX.[243]

Meanwhile, the meaning of "fault" is not limited to the violation of an international legal rule.[244] As noted by Stubbe, by the time the Liability Convention was adopted, the concept of "internationally wrongful act" was already accepted as a prerequisite for State responsibility.[245] Hence, the deliberate reference to "fault" instead of "a breach of an international obligation" as a precondition for establishing liability for damage caused in outer space indicates that these concepts address different instances.[246] An understanding otherwise would make the fault-based liability regime of the Liability Convention rather redundant, as the victim State could in any event claim compensation against the wrongdoing State under general international law when the wrongdoing State breaches its international obligation and thereby causes damage.[247]

Through a comparative analysis of various jurisdictions, Marboe submits that the general understanding of the notion of "fault" is "a violation of required standard of behaviour of a reasonable person in the circumstances".[248] In this sense, non-binding instruments become once again relevant for the determination of "fault", for these instruments embody what is commonly regarded as reasonable behaviour in outer space. In fact, when endorsing the COPUOS Space Debris Mitigation Guidelines, the UN General Assembly recognised that these voluntary guidelines "reflect the existing practices as developed by a number of national and international organizations".[249] In addition, the COPUOS Guidelines state that "[t]he implementation of space debris mitigation measures is recommended since some space debris" can endanger space missions and that "[t]he prompt implementation of appropriate debris mitigation measures is therefore considered a prudent and necessary step towards preserving the outer space environment for future generations".[250] Similar statements can be found in the IADC Space Debris Mitigation Guide-

242 Stubbe & Schrogl (2015), *supra* note 240, pp. 644-646.
243 Smith & Kerrest (2013), *supra* note 238, p. 133.
244 Stubbe & Schrogl (2015), *supra* note 240, p. 648. Marboe (2012), *supra* note 36, p. 122.
245 Stubbe & Schrogl, ibid.
246 Ibid.
247 Marboe (2012), *supra* note 36, p. 122.
248 Ibid, pp. 125-135.
249 UN Doc. A/RES/62/217 (22 December 2007). International cooperation in the peaceful uses of outer space, para. 27.
250 Secs. 1&2, COPUOS Space Debris Mitigation Guidelines.

lines.[251] This indicates the common understanding of the international community that adherence to the space debris mitigation guidelines is essential to avoid posing risks to others and to safeguard the sustainability of outer space for future use. Therefore, these guidelines can be considered as "objective standards and practices that define the reasonable conduct with respect to the avoidance of space debris".[252] For instance, "[n]ot de-orbiting an object after its useful life could be considered an element of fault, just as de-orbiting it could be seen as a factor mitigating fault".[253] This understanding could incentivise States to strengthen their adherence to the space debris mitigation guidelines, for this could be used by them as a basis to claim "no-fault".[254]

Besides the space debris mitigation guidelines, the LTS Guidelines can also be considered in the assessment of "due diligence" and "fault". For instance, the recommendations addressing information sharing and conjunction assessment contained in the LTS Guidelines can be used to determine whether a satellite operator has taken reasonable measures to prevent collisions in space.[255] As such, these and other relevant guidelines concerning expected behaviours in outer space could become highly relevant for the determination of fault after a collision or some other events causing damage, when the issue of liability arises.[256]

Admittedly, soft law instruments have their limits for the clarification of concepts contained in the UN space treaties due to their non-binding status, which makes it unclear with regard to the exact level of relevance of these instruments for specifying the concepts of "due regard" and "fault" in the space treaties. Although this non-binding character can be regarded as an inherent shortcoming of soft law instruments as they do not create legal duties and cannot be enforced, it should be noted that it is precisely this character that enables States to reach consensus on the adoption of these instruments.[257] If the connection between soft law instruments and the space treaties can be clearly established from the beginning, then States would likely be hesitant to adopt these instruments in the first place to avoid subjecting themselves to binding obligations. Therefore, the non-binding character of soft law should be regarded as an opportunity which allows States to move forward when the adoption of a treaty does not seem a realistic option. Without these soft law instruments, States may have to conduct their space activities with an even greater degree of uncertainty.

251 IADC Space Debris Mitigation Guidelines, p. 6.
252 Stubbe & Schrogl (2015), *supra* note 240, p. 648.
253 Masson-Zwaan (2023), *supra* note 241, p. 224.
254 Smith & Kerrest (2013), *supra* note 238, p. 133.
255 Byers & Boley (2023), *supra* note 1, p. 83.
256 Ibid.
257 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. 29.

It should also be noted that non-binding instruments can have normative impacts in their own right.[258] According to the constructivist theories of international relations, ideational factors including normative beliefs can influence how States think of and pursue their interests.[259] As observed by Slaughter and Hale, constructivism is attentive to the role of social norms in international politics, which distinguishes between a "logic of consequences" — rational actions aimed at maximising the interests of a State — and "logic of appropriateness", where rationality is heavily mediated by social norms.[260] This "logic of appropriateness" constitutes a basis for decision-making that is influenced by social norms rather than pure cost-benefit considerations.[261] From this perspective, non-binding guidelines containing shared views on the necessary measures to take for preserving the outer space environment are of normative values to influence State behaviour. Finally, guidelines and recommended measures contained in soft law instruments may be later incorporated into treaties or may evolve into customary international law with sufficient State practice and *opinio juris*.[262] Once that happens, the Liability Convention would operate more effectively as the notion of "fault" can by then be measured against clear, legally binding standards of required behaviour.[263]

Like other space activities, ADR activities should also be carried out in accordance with the due regard principle under Article IX of the OST, which thus imposes a general obligation upon States engaging in ADR activities to avoid interfering with the space activities of other States. As such, the COPUOS Space Debris Mitigation Guidelines and LTS Guidelines are also relevant in determining whether States are acting reasonably in carrying out ADR activities. What is special about these activities is the complexity of ADR operations and the inherent risks of collision involved in these operations. To mitigate such risks and enhance mission safety, specific guidelines on how ADR activities should be performed need to be developed. In this regard, industry-led initiatives have taken one step ahead of State-centered efforts as the industry sector has already published guidelines, principles

258 Rose, C. (2022). Chapter 2: Sources of International Law. In Rose, C. et al. *An Introduction to Public International Law*. Cambridge University Press, p. 33.

259 Grieco, J. M., Ikenberry, G. J., & Mastanduno, M. (2019). *Introduction to International Relations: Perspectives, Connections, and Enduring Questions*. 2nd ed., Red Globe Press, p. 102. For a general overview of the theories of international relations see Walt, S. M. (1998). International Relations: One World, Many Theories. *Foreign Policy*, No. 110, pp. 29-46.

260 Slaughter, A. M. & Hale, T. (2011). International Relations, Principal Theories. *Max Planck Encyclopedia of Public International Law*, para. 22.

261 Balsiger, J. (2014), Logic of Appropriateness, *Encyclopedia Britannica*. <https://www.britannica.com/topic/logic-of-appropriateness>.

262 Masson-Zwaan (2023), *supra* note 241, p. 47.

263 Von der Dunk, F. G. (2010). Too-Close Encounters of the Third Party Kind: Will the Liability Convention Stand the Test of the Cosmos 2251-Iridium 33 Collision?. *Proceedings of the International Institute of Space Law 2009*, *52*, p. 206.

and best practices for the performance of ADR activities. These industry-led initiatives will be discussed in the sections below.

4.2.2 CONFERS Guiding Principles and Recommended Practices

Founded by the US Defense Advanced Research Projects Agency (DARPA) in October 2017, CONFERS is an industry-led initiative that identifies and leverages best practices from government and industry to establish non-binding technical and operational standards for RPO, OOS and In-Space Assembly, Servicing, and Manufacturing (ISAM).[264] The members of CONFERS include space companies, academic research institutions, and other private sector participants in the commercial satellite servicing industry.[265] Government agencies may also join CONFERS in the role of observer.[266] CONFERS has published a series of documents for the design and operations of RPO and OOS. Among these documents, the *CONFERS Lexicon* contains definitions of the relevant terminology, which aims to provide consistency within CONFERS and other international organisations for the discussion of OOS and RPO.[267]

The relation between OOS and ADR is outlined in *CONFERS On-Orbit Satellite Servicing Mission Phases.*[268] This document "establishes a baseline of mission phases that is intended to describe the functions of all OOS missions".[269] What deserves specific attention in the context of ADR is its Section 9 entitled "Service", which describes a series of on-orbit services. Subsection 9.7 entitled "'Debris' Collection and Removal" reads as follows:

> "This service includes the collection of debris, including non-functioning Client Space Objects. In this case, the RPOC functions are with uncontrolled debris objects (note that these objects may be tumbling, which creates a new technical challenge for the servicer, especially during final approach and capture.) Functions during the service include operation and control of the mated stack, *Orbit Transfer (9.3)* of the debris, and disposal of the debris in a specific orbit (graveyard or reentry)."[270]

Subsection 9.3 "Orbit Transfer" refers to the use of a servicer spacecraft to transfer a client space object "to a new orbit instead of using the Client's

264 For more information see CONFERS website <https://satelliteconfers.org/>.
265 Ibid.
266 Ibid.
267 CONFERS. *CONFERS Lexicon Terms and Definitions*. Released in April 2022, updated in March 2023.
268 CONFERS. *CONFERS On-Orbit Satellite Servicing Mission Phases*, updated 1 October 2019.
269 Ibid.
270 Sec. 9.7, ibid, emphasis added. The document does not provide a definition of the acronym "RPOC" and it is used only once in the document. According to correspondence with a member of the CONFERS Secretariat dated 21 April 2022, CONFERS currently just uses the acronym "RPO" (Rendezvous and Proximity Operations) and no longer "RPOC".

on-board propulsion (if it has any)". This service "may be used to assist with decommissioning" the client space object, which will be transferred to "either a graveyard orbit or a re-entry orbit".[271] A conjunct reading of Subsections 9.7 and 9.3 indicates that in the context of the CONFERS documents, ADR is categorised as a subset of OOS, which is therefore covered under these documents.

CONFERS has published two other documents that provide guidance for the performance of RPO and OOS activities, namely the *CONFERS Guiding Principles for Commercial RPO and OOS* and the *CONFERS Recommended Design and Operational Practices*.[272] The CONFERS Guiding Principles provide for a set of principles that CONFERS members believe will help establish responsible norms of behaviour for RPO and OOS.[273] The CONFERS members commit to endeavour to comply with these principles and to promote them throughout the global industry.[274] The four basic principles contained in the CONFERS Guiding Principles are:

I. Consensual Operations: OOS should be conducted via commercial agreements between consenting parties.
II. Compliance with Relevant Laws and Regulations: OOS should be carried out in compliance with appropriate national laws and the Outer Space Treaty.
III. Responsible Operations: commercial OOS operator should ensure that their activities are planned and conducted in a responsible manner to promote safety and mission success.
IV. Transparent Operations: OOS should be conducted in accordance with the principle of transparency to promote safety and trust.[275]

Principles III and IV entail several more specific recommendations. For instance, as to responsible operations, Principle III contains a recommendation that reasonable provisions should be made in mission planning to mitigate the adverse consequences of close approaches and to avoid the generation of space debris. As to transparent operations addressed in Principle IV, the recommendations concern mainly the notification, communication and information sharing regarding the servicing operation.

The CONFERS Recommended Practices were developed to implement the CONFERS Guiding Principles.[276] The recommended design and

271 Sec. 9.3, ibid.
272 *CONFERS Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS)* ("CONFERS Guiding Principles"), revised in October 2022. *CONFERS Recommended Design and Operational Practices* ("CONFERS Recommended Practices"), revised October 2022.
273 CONFERS Guiding Principles, p. 1.
274 Ibid.
275 Ibid, pp. 1-2.
276 CONFERS Recommended Practices, p. 1.

operational practices contained in the document represent lessons learned from prior servicing and RPO operations and are intended to evolve on the basis of experience gained through future commercial and government servicing operations.[277] The adoption of these practices is considered by the document as "an effective way to enhance operational safety and mission success".[278] The recommended practices are grouped into four categories:

1. "Design servicer vehicles and operations for mission success by taking into account a layered risk mitigation and operational safety approach";
2. "Design future satellites, including both servicer and client vehicles, to facilitate safe and effective satellite servicing";
3. "Share information, to the extent permissible, on success and resolution of spacecraft anomalies";
4. "Promote the long-term sustainability of space".

The *first* category recommends that OOS providers "should develop a holistic approach to the design and operations of their servicing system to enhance flight safety and mission success".[279] This approach can be divided into five layers: spacecraft hardware, spacecraft software, ground segment, mission operations, and security. The first layer provides that spacecraft hardware design is "fundamental to ensuring flight safety" and it addresses aspects with regard to the design of the servicer spacecraft including reliability, redundancy and compatibility.[280] The second layer provides that spacecraft software "should provide adequate levels of autonomy to ensure safe operations when ground control is limited", which includes autonomous on-board systems to identify faults and perform appropriate recovery actions.[281] The third layer addresses the ground segment, which "consists of the hardware and software systems located on earth to allow mission operations to interface with the spacecraft".[282] The fourth layer sets out a series of practices and processes "to ensure that RPO and OOS missions are performed in a safe and responsible manner", including to avoid causing harmful interference to other space objects.[283] The fifth layer addresses the issue of cyber security and provides that access to telemetry and commanding systems should be protected from cyber-attacks.[284]

The *second* category of recommended practices provides that servicer spacecraft "should be designed in such a way as to facilitate the safety and effectiveness of commercial satellite servicing activities".[285] In particular,

277 Ibid.
278 Ibid.
279 Sec. 1, CONFERS Recommended Practices.
280 Sec. 1.1, ibid.
281 Sec. 1.2, ibid.
282 Sec. 1.3, ibid.
283 Sec. 1.4, ibid.
284 Sec. 1.4.6, ibid.
285 Sec. 2, ibid.

one practice is to design and install grappling fixtures on client spacecraft in a location where the spacecraft "can be safely grappled even in an uncontrolled or tumbling condition".[286] As one operational challenge in ADR missions is for the removal spacecraft to capture and relocate uncooperative and tumbling target objects, the equipment of spacecraft with relevant interfaces would facilitate their future removal.

The *third* category encourages OOS providers to share best practices and information on the detection, resolution, recovery and attribution of spacecraft anomalies, to the extent practicable and allowed by applicable law.[287] It is pointed out by practitioners that anomaly sharing can help to "reinforce safe practices for on-orbit servicing, including debris removal".[288] Hence, as the CONFERS Best Practices notes, while competition is essential to a healthy satellite servicing sector, it is also in the best interest of the servicing community to share relevant information to help prevent anomalies and failures that could undermine trust in the servicing community.[289]

The *fourth* category recognises the importance of a well-maintained space environment to the success of the industry and recommends that CONFERS members should strive to "[c]omply with relevant internationally recognized guidelines and standards for the long-term sustainability of space activities".[290] It also encourages members to "identify emerging space sustainability challenges and participate in the development of future guidelines and standards that enhance space sustainability".[291] Reference can be made to the Method of Work of the LTS 2.0 Working Group, which provides that the Working Group may decide "to invite contributions of information from international organizations and non-governmental entities, including from academia, industry and private sector".[292] Therefore, contributions of the industry sector, such as those of CONFERS, can constitute an important source of inputs for the development of future guidelines on space sustainability.

The development by CONFERS of guiding principles and recommended practices for satellite servicing is ground-breaking because they constitute the first-ever comprehensive set of standards for this nascent field. As the removal of space debris is regarded as a category of on-orbit services in the context of CONFERS, these CONFERS standards also provide guidance for the design and operations of ADR missions. In fact, the CONFERS members

286 Sec. 2.2, ibid.
287 Sec. 3, ibid.
288 Weeden *et al*. (2019), *supra* note 195, p. 3.
289 Sec. 3, CONFERS Recommended Practices.
290 Sec. 4.1, ibid.
291 Sec. 4.2, ibid.
292 UN Doc. A/AC.105/1258 (23 February 2022), Report of the COPUOS Scientific and Technical Subcommittee on its fifty-ninth session, Appendix, para. 16.

include leading commercial ADR companies such as Astroscale and ClearSpace, which may not only provide inputs into the development of the relevant standards but can also be expected to adhere to these standards in their missions.[293] In addition to the values of their own, the CONFERS publications were used as a foundation for the development of ISO Standard 24330, which will be discussed below.

4.2.3 ISO Standard 24330: From Industry-Led Initiative to International Standard

After the publication of the first version of CONFERS Recommended Practices in February 2019, CONFERS submitted a formal request to the ISO TC20/SC14 to add a new work item on satellite servicing and to begin discussions of an initial draft standard on the basis of the CONFERS principles and practices.[294] In April 2019, CONFERS provided a draft standard developed from its guiding principles and recommended practices to the ISO.[295] In June 2019, the new work item proposed by CONFERS was approved within the SC14. [296]

The initial draft produced by the CONFERS team formed the basis for the development of ISO 24330: 2022 "*Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices*", which was published by ISO in July 2022.[297] ISO 24330:2022 is the first international satellite servicing standard of its kind.[298] The document establishes guiding principles and best practices at the programmatic level for all participants in the RPO and OOS industry, with the aim to ensure safe operations and promote the development of a healthy RPO and OOS industry.[299] It is intended to be the highest-level standard for the design and operation of RPO and OOS missions, and the principles and practices contained therein establish the broadest boundary of behaviours and precede more detailed standards.[300] Therefore, similar to ISO 24113 which constitutes the top-level standard in a family of standards addressing space debris mitigation, ISO 24330 may in the future also be elaborated by

293 CONFERS. Current Members. <https://satelliteconfers.org/members/>.
294 CONFERS Newsletter. (2nd Quarter 2019). From the Desk of the Executive Director, p. 1. <https://www.satelliteconfers.org/wp-content/uploads/2021/11/CONFERS-Q2-2019-Newsletterfinal.pdf>.
295 CONFERS Newsletter. (1st Quarter 2020). Updates on ISO Draft Standard on Commercial Satellite Servicing.
<https://www.satelliteconfers.org/newsletter-first-quarter-2020-edition/>.
296 Ibid.
297 The text of ISO 24330:2022 is available at: <https://www.iso.org/standard/78463.html>.
298 SWF. (2022). *Insight - Satellite Servicing Standards and Policy: A Progress Report*. <https://swfound.org/news/all-news/2022/09/insight-satellite-servicing-standards-and-policy-a-progress-report>.
299 Sec. 1, ISO 24330:2022.
300 Introduction & Sec. 1, ibid.

low-level standards and implementation measures on RPO and OOS, when more experiences regarding these operations are gathered.

Like the CONFERS publications, a critical issue is the applicability of ISO 24330:2022 to ADR activities. ISO 24330 provides definitions of the key terms for the purposes of the document. The term "servicing operation" is defined as "action provided by servicer spacecraft to the client space object, including but not limited to inspection, capture, docking, *relocation*, refuelling, repair, upgrade, assembly and release".[301] Relocation means "operation to change the orbit of the client space object".[302] Since in an ADR operation, the removal spacecraft either re-orbits the target debris object to a graveyard orbit or de-orbits it to a re-entry orbit, ADR operations could be covered within the ambit of "relocation". Reference can further be made to Annex B of ISO 24330, which outlines the mission phases of RPO and OOS operations. According to Section B.9 of Annex B, the scope of "Service" includes "'Debris' collection and removal", and the latter is defined as follows:

> "This service includes the collection of debris, including non-functioning client space objects. In this case, the RPO functions are with uncontrolled debris objects (note that these objects may be tumbling, which creates a new technical challenge for the servicer, especially during final approach and capture). Functions during the service include operation and control of the mated stack, orbit transfer (B.9.4) of the debris, and disposal of the debris in a specific orbit (graveyard or re-entry)."

According to Section B.9.4 of Annex B, the orbital transfer service may be used to transfer a client space object or debris to either a graveyard orbit or a re-entry orbit. Like the aforementioned *CONFERS On-Orbit Satellite Servicing Mission Phases*, Annex B of ISO 24330 makes it clear that the principles, practices and standards contained in the document are applicable to ADR missions.

The heart of ISO 24330 lies in its Clauses 4 and 5. Clause 4 reflects largely Principles III and IV of the CONFERS Guiding Principles, which sets out two programmatic principles for RPO and OOS. The first principle concerns "Responsible design and operations", which requires OOS operators to ensure that "their activities are planned and conducted to promote safety and mission success".[303] In particular, the principle requires OOS operators to ensure conformity to ISO 24113 and to avoid generating debris during servicing operations.[304] This underlines the application of space debris miti-

301 Clause 3.16, ibid, emphasis added.
302 Clause 3.11, ibid.
303 Clause 4.1.1, ibid.
304 Clause 4.1.2, ibid.

gation guidelines to OOS operations. The second programmatic principle concerns "Transparent operations", which requires the servicing operations to be conducted in accordance with "the principle of transparency to promote safety and trust".[305] It includes measures such as the sharing of mission-related information and lessons learned. Clause 5 of 24330 entails a series of programmatic practices for RPO and OOS missions, many of which reflect the practices contained in CONFERS Recommended Practices. The practices are grouped into the following four categories:
1. Design for mission success;
2. Design servicing operations to minimise the risk and consequences of mishaps;
3. Avoidance of interference;
4. Information sharing.

In sum, ISO 24330 was developed on the basis of and reflects in many aspects the guiding principles and recommended practices published by CONFERS.[306] Like the CONFERS publications, ISO 24330 also provides useful guidance for ADR operators to promote safety and mission success. The document establishes norms of expected behaviours that participants in the RPO and OOS industry are advised to perform. Therefore, when an ADR operation causes damage to other space objects, ISO 24330 may be used as a point of reference for determining whether such operation is conducted in a reasonable manner and can thus be relevant for the attribution of "fault".

4.2.4 Space Safety Coalition Best Practices for Space Sustainability

Besides CONFERS, the Space Safety Coalition (SSC) is another industrial association which has developed best practices that may support ADR activities. Founded in 2019, the SSC is "an *ad hoc* coalition of companies, organizations, and other government and industry stakeholders that actively promotes responsible space safety through the adoption of relevant international standards, guidelines and practices, and the development of more effective space safety guidelines and best practices".[307] The SSC published in September 2019 and updated in April 2023 the "*Best Practices for the Sustainability of Space Operations*" ("SSC Best Practices") to "address gaps in current space governance and promote better spacecraft design, operations and disposal practices aligned with long-term space operations sustainability".[308]

305 Clause 4.2.1, ibid.

306 An additional example is that Annex B of the ISO 24330:2022, which describes the functions of RPO and OOS mission phases, reflects the *CONFERS On-Orbit Servicing Mission Phases*.

307 SSC. Home. <https://spacesafety.org/>.

308 Ibid. The document is available at: <https://spacesafety.org/best-practices/>.

The endorsees of the SSC Best Practices include space industry stakeholders ranging from satellite operators to manufacturers and launch providers.[309] They commit to "promote and strive to implement within their respective organizations the best practices identified and described [therein] as a valuable advancement towards the sustainability of space operations".[310] They also make similar commitments to the implementation of the space debris mitigation guidelines and standards published by the IADC, COPUOS and ISO.[311] In addition, according to the preambular text of the SSC document, the best practices "directly address many aspects of the twenty-one" LTS Guidelines.[312] Hence, the SSC document is closely linked to the guidelines and standards developed within the framework of international mechanisms.

The best practices identified and described in the SSC document are divided into nine sections. The most innovative part of the updated SSC Best Practices is the creation of "rules of the road" to avoid collisions in orbit, as provided in Section 8 of the document. Section 8 categorises five classes of objects in space according to their manoeuvrability: non-manoeuvrable, minimally manoeuvrable, manoeuvrable, objects with automated collision avoidance manoeuvring capability, and crewed spacecraft (presumed manoeuvrable).[313] The Section then sets out the general rules of CAMs that should be followed in the event of high-risk conjunctions. Another section that deserves particular attention in the context of space debris is Section 7, which provides for a number of best practices to limit debris generation and enhance space sustainability.

Section 6 is of direct relevance to ADR and other on-orbit services, which recommends spacecraft designers and operators to consider mission- and component-level design and operations to prepare spacecraft for on-orbit services such as inspection, refuelling, and timely post-mission disposal. More specifically, the SSC document recommends the consideration of the following elements:

a) Interfaces and physical features to enable RPO navigation operations and docking, such as features for grappling;
b) Features to improve the ability for spacecraft to be uniquely identified and tracked;
c) Modular spacecraft design features that facilitate the replacement or upgrade of failed or degraded components;

309 SSC. Endorsees. <https://spacesafety.org/endorsees/>.
310 SSC Best Practices, p. 4.
311 Ibid, p. 8.
312 Ibid.
313 Foust, J. (5 April 2023). Updated Space Safety Document Outlines Rules of the Road for Avoiding Collisions. *SpaceNews*. <https://spacenews.com/updated-space-safety-document-outlines-rules-of-the-road-for-avoiding-collisions/>.

d) The creation and preservation of detailed and up-to-date internal documentation of both spacecraft designs and status to the greatest extent practicable.

These recommendations on design improvement and information documentation could increase the readiness of spacecraft for ADR and other on-orbit services and thereby help to enhance the safety of these operations. In sum, as Victoria Samson comments, the publication of the updated SSC Best Practices, especially the development of the rules of the road for close conjunctions in space, shows that commercial space companies are "trying to get out ahead of governments making regulations for them".[314] Like CONFERS, the SSC is pushing forward the boundary of space law by developing new rules for space operations, including norms relating to the tracking and grappling of the target objects which may facilitate future ADR missions.

4.2.5 Space Sustainability Rating

The Space Sustainability Rating (SSR) is a rating system to assess the level of sustainability of space missions and operations. It is not a new set of guidelines but a system to evaluate the compliance with existing guidelines and to promote better-than-required behaviours in outer space.[315] The SSR was initiated by the World Economic Forum in 2016 and developed by a consortium involving ESA, the Massachusetts Institute of Technology (MIT), BryceTech and the University of Texas at Austin.[316] The Swiss Federal Institute of Technology Lausanne (EPFL) Space Center – eSpace has been selected in 2021 to drive the implementation of the SSR, which is managed by an independent association as of 2023.[317]

The SSR assesses the level of sustainability of space missions based on the evaluation of six modules covering different aspects of space sustainability.[318] Space operators participating in the SSR will receive one of the four tiers of rating badges according to the outcome of the assessment, which are Bronze, Silver, Gold or Platinum.[319] The rated entity may also earn additional credits for going over and above the baseline rating towards

314 Kramer, M. (11 April 2023). As Space Fills with Satellites, Operators Want to Create Rules of the Road. *Axios Space*. <https://www.axios.com/2023/04/11/satellite-rules-in-orbit>.
315 SSR. (15 April 2021). Space Sustainability Rating Virtual Workshop, p. 7. <https://www3.weforum.org/docs/WEF_Space_Sustainability_Rating_2021.pdf>.
316 SSR. Home. <https://spacesustainabilityrating.org/>.
317 Ibid.
318 SSR. The Rating. <https://spacesustainabilityrating.org/the-rating/>. The six SSR modules are: (1) Mission Index; (4) Detectability, Identification and Trackability; (3) Collision Avoidance Capabilities; (4) Data Sharing; (5) Application of Design and Operation Standards; and (6) External Services.
319 Ibid.

space sustainability, which are represented by stars on the side of the rating badge.[320] The first official SSR rating was launched in 2022 at the 4th Space Sustainability Summit in London, UK, where Stellar, a telecommunications company and founding member of the SSR, received a bronze badge with one star.[321]

Among the six SSR Modules, the "Application of Design and Operation Standards" Module is of particular relevance here for it concerns the compliance with international guidelines and standards for the design and operations of space missions.[322] The guidelines mentioned in this module include, *inter alia*, the space debris mitigation guidelines and standards published by COPUOS, the IADC and the ISO, as well as the LTS Guidelines.[323] Indeed, as pointed out by David and Saada, the SSR system uses many aspects of the LTS Guidelines and defines measures that can be directly implemented by space operators.[324] With regard to RPO, the module refers to the CONFERS Guiding Principles and CONFERS Recommended Practices.[325] Hence, for an ADR mission, compliance with these principles and recommended practices may be considered in the assessment of its sustainability level. By incorporating the relevant guidelines as a criterion of evaluation, SSR can serve as a tool to incentivise space operators to comply with these guidelines.[326]

Another SSR module with close relevance to ADR is the "External Services" Module, which addresses the activities and actions taken by space operators to make their missions more amenable to receiving external services and to increase the probability of successful external services.[327] The SSR does not assume that all operators will invest in external services, which in some cases are not deemed necessary, such as for low-altitude missions.[328] As a result, the "External Service" Module aims at providing a bonus rating for missions where the investment in external services capabilities is appropriate.[329] This Module includes three categories of actions by operators:

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320 Ibid.

321 Parker, S. (12 September 2022). A New Rating for Space Sustainability. *SSR News*. <https://spacesustainabilityrating.org/news/>.

322 SSR. Application of the Design and Operation Standards. <https://spacesustainabilityrating.org/the-rating/modules-standard-regulations/>.

323 Ibid.

324 David, E., & Saada, A. (8 February 2022). Space Sustainability Rating: a Voluntary Exercise to Incentivize Operators Towards Sustainable Behaviours in Space. *Presentation on 8 February 2022 at the 59th session of COPUOS Scientific and Technical Subcommittee*, p. 14. <https://www.unoosa.org/oosa/en/ourwork/copuos/stsc/technical-presentations.html>.

325 Ibid.

326 David & Saada (2022), *supra* note 324, p. 14.

327 SSR. External Services. <https://spacesustainabilityrating.org/the-rating/modules-external-services/>.

328 Ibid.

329 Ibid.

1. Actions during the design and pre-launch phase to make it easier for spacecraft to be serviced in the future, such as the installation of grapple fixtures;
2. Commitment to use or demonstration of use of OOS, such as external ADR services.
3. Utilising external services in line with current standards, such as those developed by CONFERS.[330]

Similar to the SSC Best Practices, the "External Service" Module of the SSR may encourage the improvement of spacecraft design to facilitate future ADR operations. The explicit reference to the standards developed and proposed by CONFERS could also provide an impetus for operators to procure external services from providers that adhere to these guidelines.

Through the SSR, space operators can get a clear picture of where their missions stand in terms of space sustainability, and they can publicly share the rating's outcome demonstrated by the badge awarded without the need to disclose sensitive mission data or proprietary information.[331] According to ESA, the rating may act as a differentiator among operators and a favourable score for a particular rated operator might lead to advantageous results including the reduction of insurance costs or improved funding conditions from financial backers.[332] As such, the SSR could contribute to incentivising safe and sustainable behaviours in outer space. In particular, by factoring the compliance with the CONFERS standards and the actions related to external services into the assessment of sustainability level, the SSR could help to promote the orderly development of the ADR industry.

4.2.6 Section Conclusion

The value of soft law for the governance of space activities lies not only in its capability to influence and steer the behaviours of States in outer space but also in its connection with hard law. In particular, non-binding instruments like the COPUOS Space Debris Mitigation Guidelines and the COPUOS LTS Guidelines can be used to specify the requirements under Article IX of the Outer Space Treaty, such as the due regard principle. In addition, these instruments could be used by judges in determining fault for the establishment of liability for damage caused in outer space. This can be argued in the context of Article IX of the OST, as well as from the perspective that these instruments embody the general understanding of States on

330 Ibid.
331 Micco, F. (23 June 2022). Space Sustainability Rating is Now Live. *SSR News*. <https://spacesustainabilityrating.org/space-sustainability-rating-now-live/>.
332 ESA. (17 June 2021). Space Sustainability Rating to Shine Light on Debris Problem. <https://www.esa.int/Safety_Security/Space_Debris/Space_sustainability_rating_to_shine_light_on_debris_problem>.

reasonable and responsible behaviours in the conduct of space activities. Therefore, the development of internationally accepted guidelines and standards for ADR could provide clarity to States engaging in these activities on how their missions should be conducted in compliance with the due regard principle and how they can reduce the risk of being held at fault if damage occurs to other space objects as a result of these missions. This is especially important in view of the technical complexity and challenges involved in ADR activities. Therefore, guidelines and standards on how ADR missions are to be designed and operated should be developed.

The commercial space industry has taken the first step to develop technical and safety standards for ADR. More specifically, CONFERS has published several documents setting out guiding principles and recommended practices on the design and operations of ADR missions. The compliance with these principles and practices could be used as an index in the SSR system to assess the level of sustainability of ADR missions. The publications of CONFERS were used as a basis for the development of ISO Standard 24330, which contributes to enhancing the universalisation of these publications across the globe. The SSC has also produced best practices that could facilitate ADR missions such as the installation of grappling and docking mechanisms in future satellites.

In terms of the determination of "fault", the abovementioned standards could be used as a yardstick in this regard as they reflect practical operational experience accumulated in the space industry. This is especially so for ISO 24330, which constitutes the first set of international standards for satellite servicing and could be implemented nationally by its national standard bodies. However, as the ISO is a non-governmental organisation, even ISO 24330 has a weak status from a formal point of view. Therefore, it would be desirable to develop international guidelines and standards regarding ADR with the direct involvement of States like the space debris mitigation guidelines adopted by the IADC and COPUOS. As Pronto submits, considering that States are the principal law-makers in the international legal field, "nonbinding tests adopted by states are inherently more authoritative than those negotiated under the auspices of non-state entities".[333] Non-binding instruments adopted by States can embody their political commitments, which can thus be politically binding upon States to act in a certain manner.[334] As such, the future development and adoption by States of ADR guidelines can not only reflect their endorsement of how ADR activities are to be carried out safely but also represent their political commitment to perform ADR operations in compliance with these guidelines to the greatest extent feasible. In addition, as discussed in Chapter 3, Article VI of the OST

333 Pronto, A. N. (2015). Understanding the Hard/Soft Distinction in International Law. *Vanderbilt Journal of Transnational Law*, *48*, p. 946.

334 Rose (2022), *supra* note 258, p. 31. Martinez (2020), *supra* note 134, p. 557.

requires States to authorise and continuously supervise space activities conducted by private entities, and many States have developed national space legislation to implement this obligation. To reduce the risk of a patchwork of different national standards and practices on ADR activities, it would be beneficial for States to develop commonly agreed guidelines on how these activities are to be carried out.

4.3 *Issue 3*: Recommendations Regarding Registration and the Need for Legal Development to Facilitate Consensual ADR

As was discussed in Chapter 3, Article VIII of the Outer Space Treaty has been elaborated in the Registration Convention, which sets out specific rules of how registration over space objects is to be made. However, the information required to be furnished to the UN Secretary-General under Article IV(1) of the Registration Convention is deemed as vague and general, which does not effectively enable States to identify objects in space after their launch into orbit.

Article IV(2) of the Registration Convention provides that each State of registry may, from time to time, provide the UN Secretary-General with additional information concerning a space object carried on its registry. While this provision is contained in a legally binding instrument, it is a recommended practice rather than a strong obligation, and the Registration Convention itself does not specify the nature and possible content of such information. Further clarification regarding "additional information" is provided in UN General Assembly 62/101 of 17 December 2007, which is adopted with an aim to increase the efficiency of the registration process.[335] In particular, the Resolution recommends that consideration should be given to the furnishing of additional appropriate information to the UN Secretary-General on any change of status in operations, for instance when a space object is no longer functional, on the approximate date of decay or re-entry, and on the date and physical conditions of moving a space object to a disposal orbit.[336] In other words, a State of registry could notify UNOOSA that its operational satellite has become space debris. The UNGA Resolution 62/101 also requests UNOOSA to prepare a model registration form to assist in the submission of registration information.[337] Pursuant to this request, UNOOSA presented in 2010 a template which provides guidance on the furnishing of such additional information.[338]

335 UN Doc. A/RES/62/101 (2007), *supra* note 12.
336 Sec. 2(b), ibid.
337 Sec. 5(a), ibid.
338 The model registration form is available on the UNOOSA webpage: <https://www.unoosa.org/oosa/spaceobjectregister/resources/index.html>.

The notification to the UN Secretary-General regarding the change of operational status of a space object can provide useful information on whether and when such object has become space debris. Yet, as discussed in Chapter 3, space debris should be considered as a subset of space objects under the current international space law. It follows that the change of functional status of a space object does not affect the jurisdiction and control retained by the State of registry over such object. Therefore, the provision of additional information that a space object is no longer functional does not grant other States the right to remove such object from orbit. Furthermore, it should be noted that the functionality-based definition of space debris under the IADC and COPUOS Space Debris Guidelines is made for the purpose of debris mitigation, i.e., to provide recommendations to limit the generation of artificial non-functional objects in earth orbit. It is a non-binding definition and it is thus not intended to create legal rights or obligations. Therefore, a State is not entitled to remove a space object of another State even after the operational status of such object changes, e.g., when it no longer serves a useful function.

In sum, even in cases where the State of registry of a space object provides additional information to the UN Secretary-General that such object is no longer functional, the prior consent of such State is still needed for the removal of this object. Admittedly, it can be said that the provision of this kind of information would facilitate the request for removal by other States, as it can be presumed that States would generally not allow others to remove their operational spacecraft from orbit. Yet, a non-functional object is not devoid of legal value, and it is subject to the discretion of its State of registry to decide whether or not to grant approval for the removal of such object. There is currently no known international mechanism facilitating the requesting and granting of approval for the removal of space objects under the jurisdiction of another State. To promote cooperative ADR programs on a consensual basis, it would be advisable for States to establish such mechanisms in future legal development.

4.4 *Issue 4*: Relevance of Transparency and Confidence-Building Measures for Addressing Dual-Use Concerns over ADR

As discussed in Section 4.1.2.2, although the LTS Guidelines do not specifically address the issue of ADR, some of these guidelines are of close relevance to ADR activities. For instance, Guideline B.1, which addresses the sharing of orbital information and the coordination among space actors in a timely manner, can help to enhance both the safety and the transparency of ADR missions. In fact, the preambular text of the LTS Guidelines states expressly that:

> "The guidelines duly take into account the relevant recommendations contained in the report of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities (A/68/189) and could be considered as potential transparency and confidence-building measures."[339]

The above statement indicates the link between transparency and sustainability in outer space activities. As analysed in Chapter 3, the deployment and use of removal spacecraft in orbit for peaceful purposes do not contravene international law. Rather, in view of the necessity to remove around five to ten large debris objects from space per year in order to control the growth of space debris, ADR activities should be encouraged and enlarged to preserve the sustainability of the outer space environment. However, even when carried out lawfully, an ADR activity could still raise misperceptions and dual-use concerns. Therefore, the question is how to ensure that a peaceful ADR mission is not mistaken as a threatening action.

According to the Secure World Foundation (SWF), ADR operations may be perceived as threats to space security if not conducted transparently.[340] As a result, Transparency and Confidence-Building Measures (TCBMs) could serve as a useful tool to reduce mistrust and misperceptions in the conduct of ADR operations.[341] In 1993, the UN General Assembly convened a Group of Governmental Experts (GGE) to undertake a study on the application of TCBMs in outer space. The 1993 GGE adopted a report which emphasised the importance of appropriate TCBMs for ensuring space security and put forward a number of recommendations on this matter.[342] In particular, the 1993 GGE agreed that:

> "[T]he application of space technologies is ambivalent in nature and that dual-purpose aspects of sensitive technologies should not be defined as harmful *per se*. It is the way in which they are utilized that determines whether they are harmful or not."[343]

While the above observation was made in the context of space systems that can collect and use data for both civil and military purposes,[344] it appears equally applicable to other dual-use technologies such as ADR. Following this understanding, removal spacecraft should not be perceived as "harm-

339 Preamble of the LTS Guidelines, para. 13.

340 SWF. Debris Removal/Rendezvous and Proximity Operations: Looking at Policy Implications. <https://swfound.org/media/167942/openingremarks_hitchens.pdf>.

341 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, p. 38.

342 UN Doc. A/48/305 (15 October 1993). Study on the application of confidence-building measures in outer space: Report by the Secretary-General.

343 Ibid, para. 304.

344 Ibid, paras. 51-54.

ful" simply because of their dual-use nature, but what matters is the way in which such spacecraft is used and operated.

In 2013, another GGE established by the UN General Assembly adopted a consensus report containing conclusions and recommendations on TCBMs for outer space activities.[345] The Report builds on the recommendations of the previous GGE and on proposals for outer space TCBMs submitted to the UN by Member States.[346] The GGE Report of 2013 describes TCBMs as "a means by which Governments can share information with the aim of creating mutual understanding and trust, reducing misperceptions and miscalculations and thereby helping both to prevent military confrontation and to foster regional and global stability".[347] TCBMs for outer space activities are part of a broader context of such measures, which can "augment the safety, sustainability and security of day-to-day space operations.[348]

The GGE Report of 2013 contains a set of non-legally binding TCBMs for outer space activities for consideration and implementation by States on a voluntary basis.[349] In the context of the establishment of norms and principles of responsible behaviours for space activities, a number of States refer to the GGE Report and describe the recommendations contained therein "as a foundation which should be re-examined, made better use of and implemented" for further legal development.[350] Specifically, five elements are highlighted in relation to the further elaboration, strengthening, agreement and implementation of TCBMs in outer space activities:[351]

i. Information exchange on national space policies and military expenditures;
ii. Information exchanges on space objects and activities;
iii. Risk reduction notifications;
iv. Policy and operational communication channels and consultative mechanisms;
v. Familiarisation visits.

The following sub-sections will assess the above five elements and discuss how these measures may contribute to enhancing the transparency of ADR activities.

345 UN Doc. A/68/189 (2013), *supra* note 14.
346 Ibid, p. 4.
347 Ibid, p. 12, para. 20.
348 Ibid, p. 13, paras. 25-26.
349 Ibid.
350 UN Doc. A/76/77 (13 July 2021), Report of the UN Secretary-General on Reducing space threats through norms, rules and principles of responsible behaviours, p. 10, para. 21. The establishment of norms of responsible behaviours in outer space will be taken up in Chapter 5 Section 5.4.
351 Ibid, pp. 15-16, para. 38.

4.4.1 Information Exchange on Space Policies

This element recommends States to exchange information and pursue dialogue on national space doctrines, goals, policies and strategies.[352] To implement this recommendation, States contemplating or preparing ADR activities may consider notifying other States of their future ambitions in this regard through the publication of national space policies. In practice, many States have explicitly addressed their ADR plans and activities in their national space policies. The policy document titled *China's Space Program: A 2021 Perspective* published in 2022 states that China will carry out technology verification in a number of areas including, *inter alia*, space debris cleaning.[353] It also states that China will foster and develop new space economy sectors such as debris removal.[354] Japan's 4th *Basic Plan on Space Policy* published in 2020 outlines its plans to develop technologies for removing and mitigating space debris and lead international rulemaking in this regard.[355] The UK's *National Space Strategy* published in 2021 states that the UK "will work to establish early leadership in potential and emerging markets" including ADR.[356] It refers to ADR as one of the emerging sectors in space, and recognises that ADR "will be increasingly required to keep orbits safe".[357] The US also highlights in a series of policy documents its plan to pursue ADR as a necessary long-term approach to ensure the operational safety in key orbital areas.[358] In particular, the 2020 US *National Space Policy* states that to preserve the space environment, the US shall "[e]valuate and pursue, in coordination with allies and partners, active debris removal as a potential long-term approach to ensure the safety of flight in key orbital regimes".[359]

The above national policies not only outline the ambitions, visions, strategies and plans of States pertaining to ADR but also demonstrate their political will to develop ADR technologies and lead ADR efforts, which may encourage other States to follow suit. Besides national space policies,

352 Ibid, p. 15, para. 38(a). See also UN Doc. A/68/189 (2013), *supra* note 14, p. 16, para. 37.

353 The full text of the *China's Space Program: A 2021 Perspective* is available at: <http://www.scio.gov.cn/zfbps/32832/Document/1719693/1719693.htm>.

354 Ibid.

355 See *Outline of the 2020 Basic Plan on Space Policy (Provision Translation)*, published by the National Space Policy Secretariat of the Cabinet Office of Japan on 30 June 2020. <https://www8.cao.go.jp/space/english/basicplan/basicplan.html>.

356 UK *National Space Strategy*, published on 27 September 2021, last updated 1 February 2022, p. 7. <https://www.gov.uk/government/publications/national-space-strategy>.

357 Ibid, p. 16.

358 US Statement – Agenda Item 7 – Space Debris – 60th Session of the STSC of COPUOS (9 February 2023). <https://vienna.usmission.gov/u-s-statement-agenda-item-7-space-debris-60th-session-of-the-stsc-of-copuos/>.

359 *National Space Policy of the United States of America*, issued on 9 December 2020, p. 15. <https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf>.

States may also provide more detailed information regarding their planned, ongoing and completed ADR missions through other channels such as governmental websites. For instance, the UK updates periodically information regarding its space programmes and missions, including the progress of its planned ADR project.[360] This kind of information sharing can contribute to the avoidance of unwanted surprises and to the clarification of peaceful intentions.

4.4.2 Information Exchange on Space Objects and Activities

This element concerns the exchange of information on the basic orbital parameters, general function and mission objective of objects in Earth orbit.[361] It also includes notification of planned spacecraft launches, including data on the generic class of the space launch vehicle, the planned launch window, the planned launch area and the planned direction.[362] As the US notes:

> "Exchanging appropriate information about spacecraft operations in orbit may facilitate effective responses to orbital collisions, orbital break-ups and other events that may ultimately pose a risk to human lives, property and/or the environment. Such communications could contribute to risk reduction by helping to avoid misunderstandings and miscalculations."[363]

Similar recommendations on information exchange can be found in the LTS Guidelines, such as the aforementioned LTS Guidelines B.1, which reflect the character of the LTS Guidelines as TCBMs. To enhance mission safety and transparency, it is advisable for States engaging in ADR activities to provide other States with relevant information on their removal spacecraft and planned missions. According to the "*Guidelines on a License to Operate a Spacecraft Performing On-Orbit Servicing*" published by Japan in 2021 ("Japanese OOS Guidelines"), the relevant information to be shared could include, *inter alia*, the basic orbital parameters, the period of the sequence from rendezvous to separation between the removal spacecraft and target debris object, and the information disclosure policy in the event of emergencies.[364] Information exchange could facilitate other States to assess the conjunction risks posed to their space objects and to request appropriate international consultation where necessary.

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360 The UK government has a dedicated webpage to publish information on its space science and technology. <https://www.gov.uk/business-and-industry/space>.

361 UN Doc. A/76/77 (2021), *supra* note 350, p. 15, para. 38(c). See also UN Doc. A/68/189 (2013), *supra* note 14, p. 16, para. 39.

362 UN Doc. A/76/77 (2021), ibid, p. 15, para. 38(e).

363 Ibid, p. 99.

364 Sec. 4.3.1, Japanese OOS Guidelines. This document will be discussed in more detail in Chapter 5 Section 5.2.3.

4.4.3 Risk Reduction Notifications

The GGE Report of 2013 recommends States to "notify, in a timely manner and to the greatest extent practicable, potentially affected States of scheduled manoeuvres that may result in risk to the flight safety of the space objects of other States".[365] It also recommends States to notify other potentially affected States in a timely manner of events linked to natural and man-made threats to the flight safety of space objects, such as risks caused by the malfunctioning of space objects or loss of control that could result in a significantly increased probability of collisions.[366]

On the basis of the recommendations of the GGE Report of 2013, the UNSG Report of 2021 enumerates a series of manoeuvres calling for prior notifications including, *inter alia*, ADR operations.[367] As ADR activities entail an inherent risk of collision, notification of potentially dangerous events and operations could enable better preparation to respond to such risk. Reference can be further made to the CONFERS Guiding Principles, which recommend entities conducting on-orbit servicing operations to "develop and implement a protocol that provides timely public notification of anomalies or mishaps that could have an adverse impact on other entities or the space environment".[368] In sum, ADR operators should notify and coordinate with potentially affected entities when there are anomalies or other potential risks.

4.4.4 Communication Channels and Consultative Mechanisms

According to the GGE Report of 2013, timely and routine consultations among States through various mechanisms can contribute to preventing mishaps, misperceptions and mistrust, which may also be useful in clarifying information and ambiguous situations.[369] The UNSG Report of 2021 further recommends the establishment of national points of contact for the exchange of information and consultations on policy matters, as well as for round-the-clock operational communications.[370]

As stated by the US, the way space mechanisms with dual-use capabilities are operated will be an important factor of consideration when determining whether these mechanisms are to be considered as a threat.[371] More specifically, there will likely be less concern about such operations if the pattern

365 UN Doc. A/68/189 (2013), *supra* note 14, p. 17, para. 42.
366 Ibid, para. 44.
367 UN Doc. A/76/77 (2021), *supra* note 350, pp. 15-16, para. 38(g).
368 Principle IV(c), CONFERS Guiding Principles.
369 UN Doc. A/68/189 (2013), *supra* note 14, p. 19-20, para. 57.
370 UN Doc. A/76/77 (2021), *supra* note 350, p. 16.
371 Ibid, p. 98.

of life of a satellite is consistent with that of its stated intent.[372] In other words, concerns may arise as to the true intention of an ADR mission if the actual operation of the removal spacecraft deviates from the previously announced mission plan. In the case of deviation, notification and consultation in a timely manner can be useful for the avoidance of miscalculation and the clarification of ambiguity.

In addition, RPO conducted without advance notification, coordination or consent can be regarded as a threatening act, as the State whose satellite is approached is unable to know the intent of the manoeuvring satellite.[373] As Germany notes, in the absence of consent, explanation or consultation, the affected State cannot exclude the possibility that the approaching satellite is intended to cause interference or conduct hostile actions.[374] The situation could be even more concerning when a spacecraft equipped with a capture mechanism, such as a robotic arm, somehow approaches a satellite of strategic importance to another State. To reduce the risk of unintended tensions, States should establish appropriate communication channels to exchange views regarding ambiguous behaviours.

4.4.5 Familiarisation Visits

According to the GGE Report of 2013, "[v]oluntary familiarisation visits can provide opportunities to improve international understanding of a State's processes and procedures for space activities, including *dual-use* and military activities, and can provide context for the development and implementation of notifications and consultations".[375] This is the only time when the term "dual-use" is referred to in the Report. As ADR technologies are of an inherent dual-use nature, familiarisation visits may help to build trust among States.

The GGE Report further recommends that the demonstrations of rockets and other space-related technologies could be conducted on a voluntary basis and in line with existing multilateral commitments and national export control regulations.[376] As ADR items and technologies may be subject to national export control regulations, familiarisation visits to ADR facilities have to be carried out in compliance with these regulations. Given the sensitivity of ADR technologies, a possible way to initiate familiarisa-

372 Ibid.
373 Ibid, p. 7.
374 Ibid, p. 48.
375 UN Doc. A/68/189 (2013), *supra* note 14, p. 18, para. 46, emphasis added. As an example of familiarisation visits, in April 2017, the Director of UNOOSA and other UN officials participated in a familiarisation visit to the Wenchang Space Launch Centre in Hainan province, China. See UN Doc. A/AC.105/2017/CRP.11 (9 June 2017). Information on the official visit to China of the Director of the United Nations Office for Outer Space Affairs.
376 Ibid, para. 48.

tion visits may start with "observations of space object launches".[377] For instance, States may invite other States to observe the launch of removal spacecraft and arrange such visits on a reciprocal basis. Like information sharing, States may demonstrate publicly their peaceful intentions through familiarisation visits.

4.4.6 Section Conclusion

Due to their dual-use potential, ADR activities may raise security concerns. To respond to these potential concerns, States engaging in ADR activities should enhance the transparency of their missions through the sharing of relevant information in a timely manner to clarify their intentions, especially in ambiguous situations. While not explicitly addressing ADR, the GGE Report of 2013 contains a series of recommendations that could be useful for reducing the risk of concerns over ADR activities. On the basis of these recommendations, the relevant measures that could be adopted by States conducting ADR activities to reduce the risk of misperceptions can be summarised as below:

1. Publication of national policies relating to the development and use of ADR technologies;
2. Exchange of information on ADR activities such as the publication of mission plans;
3. Provision of risk reduction notifications to other States, especially before potentially dangerous operations and in the event of anomalies in the course of ADR activities;
4. Designation of a contact point and establishment of appropriate channels for effective communication, consultation, and coordination regarding ADR activities;
5. Organisation of familiarisation visits to ADR launches, on an equitable and mutually acceptable basis and in compliance with relevant export control laws and regulations.

ADR activities are not only a necessity for space sustainability but are becoming a reality, as some States and private entities are developing and planning their missions to remove defunct objects from orbit. Hence, it is essential for the potential dual-use concerns over these activities to be properly addressed to ensure that these activities would not become destabilising factors to international peace and security in outer space. The international discussion on the future legal development to address the security concerns over ADR activities is addressed by the OEWG convened under the UN General Assembly Resolution 76/231.[378] This will be taken

377 UN Doc. A/76/77 (2021), *supra* note 350, pp. 15-16, para. 38(i).

378 UN Doc. A/RES/76/231 (30 December 2021). Reducing space threats through norms, rules and principles of responsible behaviours, para. 5.

up in Chapter 5 Section 5.4 to assess the relevance of the initiatives on the development of norms of responsible behaviours for ADR operations.

4.5 Chapter Conclusion

As noted in Chapter 3, gaps can be found in the hard law pillar of international space law for the regulation of all four issues relating to the governance of ADR, viz., (1) the lack of a clear legal obligation to not create space debris and to clean up existing debris; (2) the ambiguity of "fault" in the current liability regime that may disincentivise ADR; (3) the jurisdiction and control over space objects that may constitute a legal hurdle for ADR; and (4) the absence of specific rules to address the dual-use concerns over ADR. The question of this chapter is how the soft law pillar contributes to filling these regulatory gaps in the hard law pillar. To answer this question, the current chapter examined a number of relevant soft law instruments to assess how the four issues are addressed by them.

As to the *first* issue, States and international organisations have developed several international guidelines and standards for the mitigation of space debris. These instruments recognise the need to implement space debris mitigation measures for the safety of space operations and they reflect the current practices regarding debris mitigation. They have been incorporated by States into their national legal order to varying degrees, and a growing trend of compliance in practice can be observed. However, the current rate of their compliance is insufficient to effectively control the growth of space debris. The adoption of the LTS Guidelines constitutes another remarkable milestone for the preservation of the long-term sustainability of outer space activities, and some guidelines are of close relevance to ADR, including the guideline recommending the investigation of new measures to manage the space debris population in the long term. However, the LTS Guidelines do not explicitly address ADR, and currently no international guidelines are found that encourage States to remove previously created debris, in spite of the general understanding of the space community that the removal of five to ten massive objects per year is necessary to preserve the sustainability of the orbital environment. This may be explained by the fact that ADR operations are in the nascent phase and it still takes time for ADR to develop into routine practices. Meanwhile, with the growth of the space debris population and increasing congestion in the orbital environment, it would be advisable to shape international commitments on space debris mitigation and remediation sooner rather than later.

As to the *second* issue, the ambiguity of the notion of "fault" under the current liability regime of international space law can be remediated by the adoption of soft law instruments governing space activities. In particular, the guidelines and standards regarding debris mitigation and space sustainability provide guidance on how space activities are to be carried out in a reasonable manner with due regard to the rights and interests of other States. Hence, the compliance with these soft law instruments can be an element of consideration in the determination of fault. Currently, States have not yet adopted specific guidelines for the performance of ADR activities. The commercial space industry has already taken some initiatives in this regard, including the guidelines and standards developed by industry associations such as CONFERS and the SSC to support ADR missions. In particular, CONFERS has published a set of guiding principles and recommended practices that can enhance the safety and mission success of ADR. These CONFERS publications served as a foundation for the development of ISO 24330, which contributes to the standardisation of ADR operations at the international level. The inclusion of the compliance with current standards such as those published by CONFERS in the SSR assessment of ADR missions could provide an additional incentive for operators to adhere to these standards. A further step that can be taken is to develop international guidelines for ADR that are adopted by States, which can not only represent the common understanding of States on the way to conduct ADR activities but also embody their political commitment that they will perform ADR operations in a manner that contributes to the long-term sustainability of outer space activities.

As to the *third* issue, UNGA Resolution 62/101 provides useful recommendations on the provision of additional information to the UN Secretary-General on the change of status in operations of objects launched into outer space. Yet, as space debris is still included in the scope of "space object" in the context of the UN space treaties, the information that a space object becomes no longer functional does not mean other States are entitled to remove such object. Therefore, prior approval of the State of registry is still needed for the removal of a debris object under its jurisdiction. Currently, there is no known international mechanism facilitating the requesting and granting of such approval. To promote cooperative ADR programs on a consensual basis, it would be desirable for the international community to develop such mechanisms in the future.

As to the *fourth* issue, the GGE Report of 2013 provides some general recommendations that could be considered by States to enhance the transparency of their ADR missions. These measures include, for instance, the publication of national policies on the development and use of ADR technologies as well as the notification and coordination regarding ADR activities in a timely manner. In view of the potential dual-use concerns over ADR activities, it would be advisable for States to develop more specific principles and norms for ADR to ensure that these activities are carried out in a transparent and responsible manner in order to reduce the risks of security concerns.

In sum, it can be concluded that the soft law pillar fills, to some extent, the regulatory gaps in the hard law pillar, but there are also areas where further development of space law is needed. For future legal development to address these gaps, an important question to consider is whether soft law is an appropriate vehicle for space law to move forward. As noted in Chapter 1, no new space treaty has been adopted within the UN ever since the adoption of the Moon Agreement in 1979. As COPUOS makes decisions by consensus, the expanding range of States taking part in space activities and becoming members of COPUOS makes the negotiation and adoption of an international space treaty within COPUOS increasingly challenging.[379] This does not necessarily mean that the development of a legally binding agreement for the regulation of space debris is completely out of reach, especially when considering that all space actors, whether governmental or private, whether large or small, have a common interest in safeguarding the sustainability of outer space for future use.[380] Meanwhile, in view of the fact that even the non-binding COPUOS LTS Guidelines took almost a decade to develop, it can be reasonably expected that developing a binding agreement for the governance of space debris will be a lengthy process marked with intensive discussions and negotiations among States. Moreover, as observed by Zannoni, within COPUOS, there is currently no consensus among States on whether legally binding rules should be established for the regulation of space debris.[381] Therefore, from where we stand, the most plausible path forward is to strengthen the compliance with the existing space law and to continue using soft law for furthering legal development to more effectively regulate issues relating to space debris and ADR.

When reflecting on the role of soft law for the further development of space law, it is important to note that the developments of soft law and hard law are not two mutually exclusive paths. Rather, the adoption of soft law instruments may later lead to the conclusion of new treaties for the governance of space activities. As one example in space law, the basic principles contained in the 1963 Declaration of Legal Principles were incorporated almost verbatim into the Outer Space Treaty.[382] As von der Dunk observes,

379 Ibid.

380 Masson-Zwaan & Hofmann (2019), *supra* note 2, p. 119.

381 Zannoni, D. (2022). Out of Sight, Out of Mind? The Proliferation of Space Debris and International Law. *Leiden Journal of International Law*, *35*(2), p. 296.

382 Similarly, in the context of human right law, the Universal Declaration on Human Rights (UDHR) is a non-legally binding instrument adopted by the UN General Assembly in 1948. The UDHR served as a foundation for the development of two binding treaties regarding human rights which elaborate upon the norms contained in the declaration. See UDHR (adopted 10 December 1948) UNGA Res 217 A(III). See also Rose (2022), *supra* note 258, p. 32. The two treaties are: International Covenant on Civil and Political Rights, entered into force 23 March 1976, 999 UNTS 171; International Covenant on Economic, Social and Cultural Rights, entered into force 3 January 1976, 993 UNTS 3.

the adoption of soft law allows States, hesitant at the outset to subject themselves to clear-cut treaty obligations, "to start out accepting merely political 'obligations' which are not yet fully elaborated and/or not legally binding […] [and] to gradually lose their cold feet in getting acquainted with the way such obligations turn out to affect their interests".[383] In this sense, soft law can serve as a stepping stone in the process towards the goal of concluding a legally binding agreement.[384] In addition, soft law instruments could be more easily revised compared to the amendment of treaties, a character allowing them to keep in step with technological developments.[385] This character makes soft-law instruments particularly suitable to govern areas involving rapid technological advances such as the space domain. Specifically, as ADR activities are currently at a nascent stage, the understanding of the international community regarding how these activities should be carried out safely and responsibly in order not to cause harmful interference with the space activities of others may evolve over time.

Finally, being non-legally binding does not mean being completely toothless. Since many international instruments reflect best practices and expected behaviours, non-conformity with them may cause reputational damage, lead to international condemnation, or result in other forms of backlash such as the loss of opportunities for international cooperation.[386] These factors can exert political pressure on States to ensure compliance with these instruments in spite of their lack of binding force. The importance attached to soft law can be observed in the process of their development. As Freeland submits, it is often the case that the negotiation and finalisation of the texts of a space-related soft law instrument has been a complex and time-consuming endeavour, making it difficult to argue that such instrument "is not intended to have *any* legal consequence whatsoever".[387] A similar observation is made by Dupuy that in some instances, State delegations approach the negotiation of soft law provisions "with extreme care, just as if they were negotiating treaty provisions".[388] The seriousness taken by States in the development of soft law instruments indicates that they do not view these instruments "as devoid of at least some political significance, if not, in the long term, any legal significance".[389] In practice, legal and political con-

383 Von der Dunk, F. G. (2012). Contradictio in Terminis or Realpolitik? A Qualified Plea for a Role of 'Soft Law' in the Context of Space Activities. In Marboe, I. (Ed.), *Soft Law in Outer Space: The Function of Non-binding Norms in International Space Law*. Böhlau Verlag, pp. 53-54.
384 Masson-Zwaan (2023), *supra* note 241, p. 4.
385 Wessel, B. (2012). The Rule of Law in Outer Space: The Effects of Treaties and Nonbinding Agreements on International Space Law. *Hastings International and Comparative Law Review*, *35*, p. 315.
386 Martinez (2020), *supra* note 134, p. 557.
387 Freeland (2012), *supra* note 257, p. 28.
388 Dupuy (1991), *supra* note 117, p. 429.
389 Ibid.

siderations often combine to influence the behaviours of States.[390] Hence, as articulated by Jennings, "recommendations may not make law, but you would hesitate to advise a government that it may, therefore, ignore them, even in a legal argument".[391]

In light of the above considerations, the adoption of soft law instruments, especially those embodying political commitments of States, represents the most feasible way forward to fill the remaining regulatory gaps regarding the governance of the four issues relating to ADR. How these gaps are to be filled in future legal development will be discussed in the next chapter.

390 Abbott, K. W., Keohane, R. O., Moravcsik, A., Slaughter, A. M., & Snidal, D. (2000). The Concept of Legalization. *International Organization*, *54*(3), p. 419.

391 Jennings, R. Y. (1980). What is International Law and How Do We Tell It When We See It?. *The Cambridge-Tilburg Law Lectures*, 3rd series, p. 14. Quoted from Freeland (2012), *supra* note 257, p. 28.

5 Further Development of International Space Law for ADR Activities

The previous discussion assesses the two pillars of space law – the hard law pillar in Chapter 3 and the soft law pillar in Chapter 4 – in order to understand to what extent the four issues identified in Chapter 2 are addressed in these two pillars. In general, these two pillars have provided, to varying degrees, answers to all these four issues, but some gaps remain for the regulation of these issues. Therefore, the main question of Chapter 5 is how international space law should move forward to fill these gaps and better regulate the four issues relating to the governance of ADR.

The *first* gap is that there is no clear legal obligation upon States to mitigate and remove space debris. While the UN space treaties and international law provide some general requirements relevant to the protection of the space environment, they do not specifically address the issue of space debris. Soft law partly fills this gap by providing some guidelines on debris mitigation and space sustainability, but these guidelines are not legally enforceable due to their non-binding character. In view of the continuous growth of space debris, more efforts are needed from the international community to tackle the space debris problem. Section 5.1 will discuss how the lack of an explicit obligation can be filled through the shaping of unilateral, multilateral and global commitments of States, as well as commitments made by all stakeholders of the space industry from over the world.

The *second* gap is that the concept of "fault" for the establishment of liability for damage caused in outer space is not clearly defined in the space treaties. This may create legal uncertainty and disincentivise operators from engaging in ADR activities. The development of non-legally binding instruments such as the space debris mitigation guidelines can contribute to the specification of this concept, but more specific guidelines for the safety of ADR operations are needed due to the complexity and inherent risk of these operations. CONFERS and ISO have both published standards and practices applicable to ADR operations, but it would be beneficial for States to adopt commonly accepted guidelines regarding how ADR activities are to be conducted in a safe and sustainable manner, which could provide a more authoritative yardstick for the determination of "fault" when an ADR operation causes damage to other space objects. Section 5.2 will discuss the development of ADR guidelines in the context of space sustainability, assess some recent developments in national legal order specifically addressing ADR, and analyse the way forward for the development of safety guidelines for ADR activities.

The *third* gap is that the jurisdiction and control retained by the State of registry over its space object may constitute a legal hurdle to the removal of space debris under foreign jurisdiction. Circumventing this obstacle does not appear a viable option, for this may be perceived by the State of registry as threatening or even hostile actions, which could undermine international peace and security in outer space. Hence, the feasible path forward is to establish international mechanisms that could facilitate consensual ADR operations. Section 5.3 will provide several recommendations that could be incorporated into a UN General Assembly resolution to promote the implementation of ADR missions on a consensual basis.

The *fourth* gap arises from the fact that the inherent dual-use nature of ADR technologies may raise security concerns. The space treaties and general international law impose restrictions on the use of ADR systems for forcible actions, but the hard law pillar does not specifically address how peaceful ADR activities should be carried out in a way to reduce the risks of misperceptions and misunderstandings. The GGE Report of 2013 provides some general recommendations that could be helpful in mitigating such risks, but more specific norms are needed to ensure that ADR activities are carried out in a transparent and responsible manner in order to alleviate potential security concerns. This will be discussed in Section 5.4.

5.1 *Issue 1*: Commitments to Tackle the Space Debris Problem

One possible way to overcome the legal gap regarding the lack of a clear obligation to mitigate and remove debris is for those more forward-looking States to make commitments and lead international efforts to solve the space debris problem. As to the form of commitments, reference can be made to the GGE Report of 2013, which states that:

> "The Group endorses efforts to pursue political commitments, for example, in the form of unilateral declarations, bilateral commitments or a multilateral code of conduct, to encourage responsible actions in, and the peaceful use of, outer space. The Group concludes that voluntary political measures can form the basis for consideration of concepts and proposals for legally binding obligations."[1]

In other words, political commitments can take a variety of forms, and these commitments may contribute to the further development of international law for the governance of space activities. Accordingly, States could make unilateral, multilateral and global commitments to address the space debris problem. These three forms of commitments will be discussed in Sections 5.1.1 to 5.1.3 below. Besides the State-oriented commitments addressed in

1 UN Doc. A/68/189 (29 July 2013). Report of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities, para. 69.

these three sections, Section 5.1.4 will discuss the "Net Zero Space" initiative launched in November 2021 at the Paris Peace Forum which calls upon all stakeholders over the world, ranging from governmental agencies to private actors, to make commitments to debris mitigation and remediation.[2]

5.1.1 Unilateral Commitment to Debris Mitigation and Remediation

At the unilateral level, States could issue unilateral statements to express their determination and commitment to mitigate and remove space debris. In fact, some States have explicitly expressed in their national space policies their political will to promote the development and implementation of ADR programs. For instance, the UK National Space Strategy states that the UK aims to "[l]ead the global effort to make space more sustainable".[3] More specifically, the UK "will explore advanced *in-orbit debris removal*, servicing, refuelling and assembly technologies, bringing together industry, academia, and government to ensure the UK is ready to grasp the opportunities of the future space economy".[4]

With regard to the US, the Orbital Sustainability Act ("ORBITS Act") passed unanimously by the Senate on 31 October 2023 finds that an increasing amount of space debris endangers the safety and sustainability of operations in LEO and nearby orbits.[5] To respond to this growing problem, the Act provides that the US should develop and carry out programs to minimise space debris, including initiatives to demonstrate active remediation of space debris generated by the US government.[6] Moreover, the Act would direct the US to lead international efforts to encourage other spacefaring nations to mitigate and remediate space debris under their jurisdiction and control.[7] Therefore, political will is taking shape that could serve as a basis

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2 Net Zero Space initiative. (November 2022). <https://parispeaceforum.org/en/initiatives/net-zero-space/>.

3 UK National Space Strategy, published on 27 September 2021, last updated 1 February 2022, p. 42. <https://www.gov.uk/government/publications/national-space-strategy>.

4 Ibid, emphasis added.

5 US Senate Committee on Commerce, Science & Transportation. (1 November 2023). Cantwell, Hickenlooper Bill to Clean Up Space Junk Passes Senate Unanimously. <https://www.commerce.senate.gov/2023/11/cantwell-hickenlooper-bill-to-clean-up-space-junk-passes-senate-unanimously>. The ORBITS Act was first introduced in September 2022 and it passed the Senate by unanimous consent in December 2022, but was not taken up by the US House of Representatives. After the unanimous pass of the bill by the Senate in October 2023, the ORBITS Act now heads to the House for the second time. For more details see Foust, J. (1 November 2023). Senate Passes Orbital Debris Bill. *SpaceNews*. <https://spacenews.com/senate-passes-orbital-debris-bill/>. See also US National Space Society (NSS). (14 September 2022). NSS Statement on the Orbital Sustainability Act of 2022 (ORBITS Act). <https://space.nss.org/nss-statement-on-the-orbital-sustainability-act-of-2022-orbits-act/>.

6 Sec. 2(b)(1), ibid.

7 Sec. 2(b)(2), ibid.

for forward-looking States to lead by example through the declaration of commitments to mitigate and remediate space debris.

The following two examples indicate that some States are pioneering efforts in developing new rules for the governance of outer space activities beyond the current requirements towards a safer and more sustainable space environment. The first example is the ban on destructive direct-ascent anti-satellite missile testing and the second example is the shortening of the FCC post-mission disposal rule for satellites in LEO from 25 years to 5 years. These two examples will be addressed respectively in Sections 5.1.1.1 and 5.1.1.2. They illustrate the feasibility of the unilateral approach for space law to move forward. Section 5.1.1.3 will discuss the substance of the potential unilateral commitment to mitigate and remove space debris.

5.1.1.1 Moratorium on Destructive Direct-Ascent Anti-Satellite Missile Testing

On 18 April 2022, US Vice President Kamala Harris announced in a speech at Vandenberg Space Force Base in California:

> "[T]he United States commits not to conduct destructive direct-ascent anti-satellite missile testing.
> Simply put: These tests are dangerous, and we will not conduct them.
> We are the first nation to make such a commitment. And today, on behalf of the United States of America, I call on all nations to join us."[8]

Despite being a unilateral commitment, it is intended as a starting point for further international norm-setting to ban direct-ascent ASAT tests. As Harris stated, "we will lead by example. […] We are the first nation to make such a commitment. And today, on behalf of the United States of America, I call on all nations to join us. In the days and months ahead, we will work with other nations to establish this as a new international norm for responsible behavior in space".[9] In other words, unilateral commitment may be intended to serve as a means towards the shaping of broader commitments within the international community. According to *SpaceNews*, the timing of the commitment was not accidental, as it was made just a few weeks before the first meeting of the OEWG on Reducing Space Threats established by the UN General Assembly in 2021.[10] As pointed out by US official Eric

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8 US White House. Remarks by Vice President Harris on the Ongoing Work to Establish Norms in Space. 18 April 2022. <https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/04/18/remarks-by-vice-president-harris-on-the-ongoing-work-to-establish-norms-in-space/>.

9 Ibid.

10 Foust J. (25 April 2022). A Small Ban of ASATs, A Giant Leap for Space Security? *The Space Review*. <https://www.thespacereview.com/article/4374/1>. UN Doc. A/RES/76/231 (30 December 2021), Reducing space threats through norms, rules and principles of responsible behaviours, para. 5.

Desautels, this timing “is meant to spur a meaningful discussion in the Open-Ended Working Group, as we view this as an important tool in our efforts to multilateralize this commitment”.[11]

The US-initiated moratorium on destructive direct-ascent anti-satellite missile tests has been joined by a considerable number of other States.[12] According to a US statement, while many States “do not intend to develop direct-ascent anti-satellite missile capabilities”, their supports “contribute their voices to identifying this in the international community as an emerging norm of responsible behavior”.[13] In September 2022, the US announced that it would propose a UNGA resolution banning the conduct of such tests.[14] On 1 November 2022, the First Committee of the UN General Assembly approved the US-proposed draft resolution entitled “Destructive direct-ascent anti-satellite missile testing” (A/C.1/77/L.62).[15] On 7 December 2022, the UN General Assembly adopted this draft resolution (A/RES/77/41), calling upon all States to commit not to conduct destructive direct-ascent anti-satellite missile tests.[16]

As Chen points out, the US-initiated moratorium is limited in scope as it addresses only the testing but not the use of direct-ascent ASAT missiles, and it does not address weapons other than direct-ascent ASAT weapons.[17] According to a Working Paper submitted by Germany and the Philippines at the OEWG in September 2022, on top of direct-ascent anti-satellite mis-

11 Ibid.

12 These include Canada, New Zealand, Japan, *Germany*, the UK, South Korea, Switzerland, Australia, and *France*, *The Netherlands*, *Austria*, and *Italy*, as well as the 27 Member States of the EU which made their commitments in a joint statement. It should be noted that before the EU joint commitment, 5 EU members had already made their commitments earlier, which are emphasised in italics. See Foust, J. (24 August 2023). European Union nations join ASAT testing ban. *SpaceNews*. <https://spacenews.com/european-union-nations-join-asat-testing-ban/>.

13 US Mission Geneva. (13 September 2022). U.S. Statement to the Open-Ended Working Group on Reducing Space Threats. <https://geneva.usmission.gov/2022/09/13/u-s-statement-to-the-open-ended-working-group-on-reducing-space-threats-2/>.

14 U.S. Mission Geneva. (21 September 2022). Aide-Memoire on Proposed UN General Assembly Resolution on Destructive Direct-Ascent Anti-Satellite Missile Testing Submitted by the United States of America. <https://geneva.usmission.gov/2022/09/21/proposed-un-general-assembly-resolution-on-destructive-direct-ascent-anti-satellite-missile-testing/>.

15 UN. (1 November 2022). Approving 21 Drafts, First Committee Asks General Assembly to Halt Destructive Direct-Ascent Anti-Satellite Missile Tests in Outer Space. <https://press.un.org/en/2022/gadis3703.doc.htm>.

16 UN. (7 December 2022). General Assembly Adopts over 100 Texts of First, Sixth Committees Tackling Threats from Nuclear Weapons, International Security, Global Law, Transitional Justice. <https://press.un.org/en/2022/ga12478.doc.htm>.

17 Chen, K.-W. (21 April 2022). Commentary on the US Commitment Not to Conduct Direct-Ascent Anti-Satellite Testing. <https://www.mcgill.ca/iasl/US%20commitment%20not%20to%20conduct%20ASAT%20testing>.

siles, co-orbital anti-satellite capabilities are equally concerning in terms of space security, i.e., the kinetic destruction of satellites via other satellites that can close in on the target.[18] In its statement to the OEWG, the US describes the moratorium as an important first step "to rein in the destructive testing of direct-ascent anti-satellite missiles" and states that ongoing collective work in bodies like the OEWG "will make progress on developing further solutions to address other challenges resulting from State behavior that threaten the security of space systems".[19] Therefore, while limited in scope, the moratorium may serve as a starting point for a progressive approach towards further development.

This progressive approach is reflected in the aforementioned UN General Assembly resolution 77/41.[20] The preamble of the resolution not only expresses concerns over the impact of destructive direct-ascent anti-satellite missiles on the space environment but also recognises the similar negative impact that other types of anti-satellite systems might have. Therefore, besides calling for a halt to destructive direct-ascent anti-satellite missile testing, the resolution also calls upon all States to continue discussions to develop further practical steps and contribute to legally binding instruments on the prevention of an arms race in outer space.[21]

The above moratorium illustrates how a unliteral commitment could attract support from other States and provoke international discussions. Similarly, a unilateral commitment made by one State to mitigate and remove space debris may gain momentum towards a more sustainable and stable space environment, with other like-minded and interested States joining the initiative. In addition, a commitment need not be comprehensive from the outset but could focus on one specific problem and broaden its scope at a later stage. A similar path can be followed for States to make their commitments to debris mitigation and remediation.

5.1.1.2 Shortening the Post-Mission Disposal Rule to 5 Years

On 29 September 2022, the US FCC adopted the Report and Order (FCC 22-74) which sets out new rules requiring satellites ending their mission in or passing through LEO to de-orbit as soon as practicable but no more than five years following mission completion.[22] The new rule, which will apply

18 UN Doc. A/AC.294/2022/WP.17 (6 September 2022). Security risks, threats, and irresponsible behaviors undermining stability in outer space: Submitted by the Federal Republic of Germany and the Republic of the Philippines, para. 9(b).

19 US Mission Geneva. (2022), *supra* note 13.

20 UN Doc. A/RES/77/41 (7 December 2022). Destructive direct-ascent anti-satellite missile testing.

21 Ibid, paras. 1&3.

22 FCC. (29 September 2022). FCC Adopts New '5-Year Rule' for Deorbiting Satellites. <https://www.fcc.gov/document/fcc-adopts-new-5-year-rule-deorbiting-satellites>.

to US-licensed satellites as well as foreign-licensed satellites seeking access to the US market, is largely shorter than the 25-year post-mission disposal rule as generally contained in international instruments on space debris mitigation, such as the IADC Space Debris Mitigation Guidelines.[23]

As explained by Jessica Rosenworcel, chairwoman of the FCC, the proliferation of defunct satellites in orbit raises the risk of collisions to operational satellites, making it harder to launch new objects into higher orbits.[24] Therefore, the shortening of post-mission disposal period for satellites in LEO from 25 years to 5 years "will mean more accountability and less risk of collisions that increase orbital debris and the likelihood of space communication failures".[25] FCC commissioner Geoffrey Starks adds that compliance with the new five-year rule will help to bend the curve of space debris proliferation.[26] The study of the CNES also supports the view that the 25-year rule can no longer accommodate the current need for a sustainable orbital environment. Based on the analysis performed by the French space debris evolutionary models, the CNES concludes that "existing post-mission disposal guidelines (e.g. 90% post-mission disposal success rate as well as the 25-year rule) are not sufficient to guarantee the sustainable use of space in the presence of large constellations."[27]

As the population of space debris grows continuously, the current international guidelines and standards addressing this issue might not be sufficiently effective for ensuring the safety and the long-term sustainability of space operations, and more ambitious efforts would be needed. The update made by the FCC illustrates that it is possible for national initiatives to move ahead of international efforts to tackle the space debris problem and preserve the orbital environment. In a similar vein, with the development of ADR technologies and the growing need for ADR operations to stabilise the orbital environment, one could expect that some States may lead international efforts to remediate space debris.

5.1.1.3 Substance of Unilateral Commitments

With regard to the substance of unilateral commitments to tackle the space debris problem, reference can be first made to the IADC ADR Statement which puts forward three recommendations for space operators:

23 FCC. (September 2022). Mitigation of Orbital Debris in the New Space Age. FCC 22-74, p. 8, para. 18.
24 Ibid, p. 23.
25 Ibid.
26 Ibid, p. 24.
27 UN Doc. A/AC.105/C.1/2022/CRP.20 (7 February 2022). General presentation of French activities and views concerning the long-term sustainability of outer space activities, in relation with the implementation of the 21 Guidelines, para. 81.

i. Adhere to the existing space debris mitigation guidelines with a post-mission reliability as high as practicable but no less than 90%;
ii. Conduct further research and cost-benefit analysis on ADR and develop concepts and technologies that can satisfy technical, economic and safety considerations for the stabilisation of debris population;
iii. Newly launched spacecraft and upper stages are encouraged to be ADR ready.[28]

Further reference can be made to the two white papers developed within the Net Zero Space initiative which provide, respectively, legal and technical recommendations for the achievement of the sustainable use of outer space. The Net Zero Space WG1 White Paper aims to enhance regulations and public policies with regard to debris mitigation and remediation.[29] Specific to debris remediation, it provides two recommendations. One recommendation is that States should adopt stricter regulations concerning debris remediation, including requiring LEO satellite operators to engage with credible on-orbit servicing providers to perform viable ADR and end-of-life services to de-orbit their inactive satellites.[30] This issue is also addressed in the 2018 US *Space Policy Directive-3* ("SPD-3"), which enumerates a number of factors that should be considered by satellite and constellation owners in their pre-launch certification process.[31] These factors include, *inter alia*: "Self-disposal upon the conclusion of operational lifetime, or owner-operator provision for disposal using active debris removal methods."[32] If ADR can be included as a disposal strategy in the licensing process, this may create more commercial opportunities for the ADR market. Another recommendation proposed in the WG1 White Paper is that States should collaborate towards ADR solutions.[33] This could start from the discussion and development of a list of the most concerning derelict objects in space, followed by the establishment and maintenance of international dialogue to pursue opportunities for the collaborative de-orbiting of these objects.[34] The Net Zero Space initiative Working Group 2 White Paper provides recommendations "focusing on advancing international efforts towards a more interoperable way of stipulating the existence of a risk of collision in orbit".[35] The recommendations contained in these two White Papers can be incorporated by States into their commitments to debris mitigation and remediation.

28 IADC. (2022). IADC ADR Statement, IADC-22-02, p. 1.
29 Net Zero Space WG1. (November 2022). White Paper on "*Fostering Better and More Interoperable Norms: Comparing Existing Binding National Requirements Relating to Space Debris*".
30 Ibid, p. 17.
31 US. (18 June 2018). *Space Policy Directive-3*, *National Space Traffic Management Policy*. <https://trumpwhitehouse.archives.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/>.
32 Ibid.
33 WG1 White Paper 2022, *supra* note 29, pp. 17-18.
34 Ibid.
35 Net Zero Space Working Group 2 (WG2). (November 2022). White Paper on "*Developing Reference Modelling to Assess Risks of Collision in Orbit*" ("WG2 White Paper"), p. 2. <https://www.netzerospaceinitiative.org/activities/2022-working-group-2>.

In addition, regulatory certainty is key for investors to be willing to invest in expensive ventures, including the development of ADR technologies and the execution of ADR missions.[36] Therefore, States should, where appropriate, adopt and revise their national regulations to provide legal assurance to space operators. This issue is addressed in the *United States Space Priority Framework* released by the White House in December 2021, which states that US regulations "must provide clarity and certainty for the authorization and continuing supervision of non-governmental space activities, including for novel activities such as on-orbit servicing, orbital debris removal…".[37] In particular, States may consider whether specific licensing conditions should be made for ADR operations due to their higher risks than conventional space activities, while also ensuring that this fledgling industry would not be overburdened by the additional regulatory requirements. In this regard, the US and Japan have already adopted some national rules and standards specifically addressing ADR operations, which will be discussed in more detail later.

In the future, when ADR technologies become more mature and economically viable, States could make commitments that they will execute ADR missions in a responsible and transparent manner to ensure mission safety and avoid generating additional space debris during mission operations. States with strong willingness can even commit to actively removing large defunct objects at a certain rate, i.e., on average one object per year, which would likely be plausible when technologies allowing the removal of multiple debris objects in a single mission become applicable. States could also coordinate their efforts by setting a common goal for ADR and allocating among them the responsibilities to achieve this goal.

In sum, at the current stage, the commitments could be to enhance the compliance with space debris mitigation guidelines, advance ADR technologies, and develop national law to provide legal certainty to ADR operators and promote the development of the commercial ADR sector. When ADR technologies become more mature and reliable in the future, States could commit to removing a certain number of their debris objects per year. As stressed by Mazlan Othman, "the prompt implementation of appropriate space debris mitigation measures is in humanity's common interest, particularly if we are to preserve the outer space environment for future generations".[38] Specifically, the implication of increased debris

36 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. 186.

37 US. (December 2021). *United States Space Priorities Framework*. <https://www.whitehouse.gov/wp-content/uploads/2021/12/United-States-Space-Priorities-Framework-_-December-1-2021.pdf>.

38 UN. (13 February 2009). UN Reiterates the Importance of the Implementation of the Space Debris Guidelines to Curtail Space Debris in Future. UNIS/OS/376. <https://unis.unvienna.org/unis/en/pressrels/2009/unisos376.html>.

population in space will be more severe for those States and international organisations that rely heavily on their space assets and infrastructure for economic and strategic purposes.[39] As such, these States and organisations may have a strong motivation to tackle the space debris problem. Moreover, they are usually more technologically capable of developing viable methods to actively remove space debris. Initiatives taken by them could pave the way for broader international efforts within the international community to collectively solve the space debris problem.

5.1.2 Multilateral Commitment to Debris Mitigation and Remediation

While a unilateral commitment could potentially be 'multilateralised' at a later stage, States sharing common goals could also make joint commitments straightforwardly. One example of this approach is the joint statement of the Group of Seven (G7) nations on the safe and sustainable use of space, which was made in June 2021 at the G7 Leader's Summit in Cornwall, the UK ("G7 Statement of 2021").[40] The statement, recognising the growing hazard of space debris and increasing congestion in Earth's orbit, aims to support humanity's ambitions to use space now and in the future.[41] Considering that the orbit around the Earth is "a fragile and valuable environment", the G7 nations agree to strengthen their efforts to "ensure the sustainable use of space for the benefit and in the interests of all countries".[42] In particular, the statement makes explicit reference to ADR:

> "We welcome all efforts, public and commercial, in debris removal and on-orbit servicing activities and undertake to encourage further institutional or industrial research and development of these services."[43]

Similar to a unilateral commitment, a multilateral commitment could also be further multilateralised and globalised. The G7 Statement calls upon all nations to work together, through international bodies like COPUOS, the IADC and the ISO, to preserve the space environment for future generations.[44] Simonetta Di Pippo, then Director of UNOOSA, welcomed this joint commitment and commented that "[o]nly through such leadership, with all nations working together, will we preserve the space environment for future generations".[45] In other words, multilateral commitment can be used

39 Jakhu, R. S. & Ahmad, M. T. (13 November 2017). The Outer Space Treaty and States' Obligation to Remove Space Debris: A US Perspective. *The Space Review*. <https://thespacereview.com/article/3370/1>.
40 UK Space Agency. (June 2021). G7 Nations Commit to the Safe and Sustainable Use of Space. <https://www.gov.uk/government/news/g7-nations-commit-to-the-safe-and-sustainable-use-of-space>.
41 Ibid.
42 Ibid.
43 Ibid.
44 Ibid.
45 Ibid.

as a step-wise approach towards a global effort to solve the space debris problem.

The *G7 Science and Technology Ministers' Communiqué* published in May 2023 in Sendai, Japan ("Sendai Communiqué of 2023") addresses the space debris problem in more detail in its section titled "Promoting Safe and Sustainable Use of Outer Space".[46] In this section, the G7 nations recall the G7 Statement of 2021 and share the view that space debris constitutes an urgent issue.[47] To promote space debris mitigation efforts, the G7 nations commit to:[48]

- Follow the relevant guidelines adopted by international bodies such as COPUOS and the IADC.
- Share experiences and best practices on space debris mitigation.
- When appropriate, support the development of new guidelines.

In addition, the Sendai Communiqué reiterates the respective commitments that have already been made by the G7 members on the ban of destructive direct-ascent anti-satellite missile tests and encourages other countries to follow suit.[49] This shows the interaction between unilateral and multilateral commitments and the intention of these commitments to be further globalised. The importance of addressing the issue of space debris is reiterated in the *G7 Hiroshima Leaders' Communiqué* published on 20 May 2023 ("Hiroshima Communiqué").[50] The Hiroshima Communiqué reaffirms the key commitments made in the Sendai Communiqué, including:[51]

- The implementation of international guidelines adopted at COPUOS;
- Further development of solutions and technologies for space debris mitigation and remediation;
- Commitment not to conducting destructive direct-ascent anti-satellite missile testing.

Another way to initiate multilateral commitment is to start at the regional level. During a panel session at the World Economic Forum in Switzerland in January 2023, ESA Director General Josef Aschbacher said he was in discussions with the ESA Member States about a "zero debris" policy that would require spacecraft to be de-orbited immediately after end-of-mission.[52] In June 2023, ESA, with the support of several European space

46 The text of the Sendai Communiqué is available on the website of the Cabinet Office of Japan: <https://www8.cao.go.jp/cstp/english/others/2023/g7_2023_en.html>.
47 Sendai Communiqué (2023), p. 5.
48 Ibid.
49 Ibid, p. 6.
50 The text of the Hiroshima Communiqué is available on the website of the Ministry of Foreign Affairs of Japan: <https://www.mofa.go.jp/ms/g7hs_s/page1e_000690.html>.
51 Hiroshima Communiqué (2023), para. 41.
52 Foust J. (20 January 2023). ESA Seeks Global Adoption of "Zero Debris" Policy. *SpaceNews*. <https://spacenews.com/esa-seeks-global-adoption-of-zero-debris-policy/>.

companies, announced the Zero Debris Charter initiative.[53] The Charter aims to bridge previous ESA initiatives aiming to shape global consensus on space sustainability and the Agency's technical work on the technologies and solutions enabling safe and sustainable space operations.[54] As Aschbacher said: "We are calling upon all stakeholders from across the European space ecosystem, including new space actors, to display a strong commitment towards achieving global leadership in space debris mitigation and remediation, through the Zero Debris Charter initiative".[55] In November 2023, the Zero Debris Charter was released at the European Space Summit in Seville, setting out both high-level guiding principles and specific, jointly defined targets towards a zero debris future.[56] The aim of the Charter is to shape consensus on space safety and sustainability at European and global levels.[57]

Multilateral commitments can also be program-oriented, i.e., States participating in cooperative space projects can incorporate commitments of space debris mitigation and remediation into their international agreements. For instance, the issue of space debris and spacecraft disposal is addressed in the Artemis Accords signed between NASA and the participating agencies to the Artemis Program.[58] According to Section 12 of the Artemis Accords, NASA and partner agencies commit to plan for the mitigation of orbital debris, including the safe, timely, and efficient passivation and disposal of spacecraft at the end of their missions.[59] They also commit to limit, to the extent practicable, the generation of new, long-lived harmful debris by taking appropriate measures to this end.[60] Similar commitments could be incorporated into other international agreements to mitigate the creation of space debris in cooperative space missions.

In sum, States can pursue multilateral dialogue and make joint commitments to preserve the long-term sustainability of the outer space environment. The substance of such commitments could be similar to those made in unilateral commitments, with appropriate adjustments made to reflect the common will of the endorsees or to accommodate the specific needs of

53 ESA. (22 June 2023). ESA Announces the Zero Debris Charter Initiative. <https://esoc.esa.int/esa-announces-zero-debris-charter-initiative>.
54 Ibid.
55 Ibid.
56 ESA. The Zero Debris Charter. <https://www.esa.int/Space_Safety/Clean_Space/The_Zero_Debris_Charter>.
57 ESA. (6 November 2023). World-First Zero Debris Charter Open for Registration. <https://esoc.esa.int/zero-debris-community-update>.
58 *Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes* ("Artemis Accords"), available at: <https://www.nasa.gov/specials/artemis-accords/index.html>.
59 Sec. 12(1), ibid.
60 Sec. 12(2), ibid.

a certain cooperative program. As a multilateral commitment represents a concerted voice of a group of States, it could be more politically powerful and influential than a unilateral one, and could also be used to reinforce unilateral commitments.

5.1.3 Global Commitment to Debris Mitigation and Remediation

As mentioned in the previous two sections, both unilateral and multilateral commitments may be oriented towards a global commitment. As stated by the UK, politically and legally binding approaches are not mutually exclusive but reinforcing.[61] When there is sufficiently strong political will in place, as a next step, the international community may consider establishing an international agreement to systemise the process of commitment-making. The 2015 Paris Agreement on climate change may provide a relevant model in this regard, which will be assessed in this section.[62]

The Paris Agreement is a legally binding international treaty on climate change adopted at the twenty-first session of the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) in December 2015. It has currently 195 parties (including 194 States plus the EU).[63] This universal acceptance is also needed for a future space debris agreement through which States can make and review their commitments to address this issue. Like the issue of climate change, the problem of space debris also constitutes a challenge of a global dimension, where the activities of a single State could affect the common interests of the whole international community. Under the Paris Agreement, the Parties aim to reach global peaking of greenhouse gas (GHG) emissions as soon as possible and to undertake rapid reductions thereafter in accordance with the best available science, "so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of this century".[64] Similarly, the stabilisation of the space debris population entails a balance of sources and sinks: the former focuses on mitigating the generation of new debris and the latter on removing existing debris from orbit.[65] In light of the comparability between the issue of climate change and that of space debris, lessons can be learned from the Paris Agreement to control the growth of space debris.

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61 The UK. (1 February 2023). Statement by the United Kingdom at the 3rd Session of the OEWG, pp. 1-2. <https://meetings.unoda.org/meeting/57866>.

62 United Nations Framework Convention on Climate Change (UNFCCC). Adoption of the Paris Agreement. Report No. FCCC/CP/2015/L.9/Rev.1, December 2015. <http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf>

63 UN Climate Change. The Paris Agreement. <https://www.un.org/en/climatechange/paris-agreement>.

64 Art. 4(1), Paris Agreement, ibid.

65 Bonnal, C., & McKnight, D. S. (Eds.). (2017). *IAA Situation Report on Space Debris – 2016*. International Academy of Astronautics, p. 19.

The Paris Agreement sets a long-term goal to guide the global response to the threat of climate change:

> "Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."[66]

In space, a widely shared long-term goal is to maintain outer space as an operationally stable and safe environment that is suitable for exploration and use by current and future generations.[67] For the quantification of this goal, reference can be made to the concept of "space environment capacity", also called "orbital capacity", which is understood as the full capacity of the orbital region that can be safely used by operators without leading to irreversible consequences for the space environment.[68] According to the Net Zero Space initiative WG2 White Paper, although there is currently no commonly accepted definition of what carrying capacity is, "the state of the art does allow a numerical approximation of the aggregate risk posed by each new system to the total [orbital] environment (based on elements like the reliability of satellites, the number of them, their lifetime or the debris background, to name a few)".[69] Knowing the maximum carrying capacity of an orbit would allow strategic decisions to be made accordingly on the efficient and sustainable use of such orbit.[70] As the IADC has already published some studies on the projected growth of space debris and its impact on the orbital environment, it appears as an appropriate forum to assess the full and remaining capacity of the orbital environment.

At the heart of the Paris Agreement are the nationally determined contributions (NDCs) which are the climate actions outlined by each State to reduce national emissions and adapt to the impacts of climate change.[71] Article 4(2) of the Paris Agreement requires each Party to prepare, communicate and maintain successive NDCs that it intends to achieve, and to pursue domestic mitigation measures with the aim of achieving the objectives contained in the NDCs. The NDCs are to be submitted every five years to the UNFCCC secretariat.[72] In order to enhance the ambition over time, the Paris

66 Art. 2(1)(a), Paris Agreement.

67 Preamble of the LTS Guidelines, para. 4.

68 European Space Policy Institute (ESPI). (April 2022). *ESPI Report 82 – Space Environment Capacity*, pp. 39-41. See also 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.

69 Net Zero Space WG2 (2022), *supra* note 35, p. 22.

70 Ibid.

71 UN Climate Change. Nationally Determined Contributions (NDCs). <https://unfccc.int/ndc-information/nationally-determined-contributions-ndcs>.

72 Ibid.

Agreement provides that each Party's successive NDC will represent a progression beyond its current NDC and reflect its highest possible ambition.[73] Modelling after this mechanism, the future legal framework governing space debris should require States to periodically submit their self-defined space debris removal action plans.

As national actions set out in the NDCs are not legally binding under the Paris Agreement, the Agreement creates three different review mechanisms to ensure their effectiveness.[74] The first mechanism is the "enhanced transparency framework (ETF)" provided for in Article 13 of the Paris Agreement, which is designed to build trust and confidence that all countries are contributing their share to the global effort.[75] According to the ETF, starting in 2024, Parties will report transparently on their actions and progress in the implementation of their individual NDCs.[76] The submitted reports will be subject to a technical expert review and a multilateral consideration of progress.[77] As Dupuy and Viñuales note, the ETF functions as "a form of 'naming and shaming' mechanism designed to nudge States into complying with their NDCs".[78]

The information gathered through the ETF will feed into a global stocktake process, which is the second review mechanism in the Paris Agreement.[79] Starting in 2023 and then every five years thereafter, Parties will take stock of the implementation of the Paris Agreement with the aim to assess the world's collective progress towards achieving the purpose of the Agreement and its long-term goals and identify the gaps.[80] The outcome of the global stocktake will inform Parties in setting more ambitious goals in their subsequent NDCs and in enhancing international cooperation for climate action.[81]

The third mechanism is the Paris Agreement Implementation and Compliance Committee (PAICC) established pursuant to Article 15 of the Paris Agreement, which serves to facilitate implementation of and promote

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73 Art. 4(3), 2015 Paris Agreement.

74 Sands, P., Peel, J., Fabra, A., & MacKenzie, R. (2018). *Principles of International Environmental Law*. 4th ed., Cambridge University Press, p. 328.

75 UN Climate Change. Reporting and Review under the Paris Agreement. <https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-paris-agreement>.

76 UN Climate Change. The Paris Agreement. <https://unfccc.int/process-and-meetings/the-paris-agreement>.

77 Dupuy, P.-M., & Viñuales, J. E. (2018). *International Environmental Law.* 2nd ed., Cambridge University Press, p. 194. Art. 13(11), the Paris Agreement.

78 Ibid, p. 193.

79 UN Climate Change, *supra* note 76.

80 Art. 14, 2015 Paris Agreement. See also UN Climate Change. Global Stocktake | UNFCCC. <https://unfccc.int/topics/global-stocktake>.

81 Ibid.

compliance with the provisions of the Paris Agreement.[82] The PAICC is "expert-based and facilitative in nature" and it is to "function in a manner that is transparent, non-adversarial and non-punitive".[83] The Committee can take various measures to achieve its aim, such as "helping countries engage with relevant bodies or arrangements on finance, technology and capacity building or assist in the development of an action plan".[84] As such, the PAICC is designed to play a supportive role, helping parties figure out how to comply with the Agreement, and not enforcing compliance or sanctioning non-compliance.[85]

The future legal framework addressing debris mitigation and remediation could incorporate review mechanisms akin to those of the Paris Agreement to assess the individual and collective progress towards achieving the pre-defined long-term goal and inform future actions. Specifically, an ETF process may assess whether individual States have complied with their respective self-determined commitments, and the global stocktake could enable the global community to jointly evaluate the remaining orbital capacity that is able to host space activities in a sustainable manner. In addition, an expert-based committee with a facilitative role could be established to support implementation and promote compliance.

In brief, the Paris Agreement provides a model for the development of an international agreement to regulate the mitigation and remediation of space debris. The new treaty could be negotiated under the auspices of COPUOS, the place where the five UN space treaties were developed. This development of a legal regime is contingent upon the existence of political will, which could be built and shaped by unilateral and multilateral commitments made by States willing to take the lead in tackling the space debris problem. While currently only a few States have the technological potential to remove space debris, the development of the commercial ADR sector could, in the future, become a mature market that provides viable options for States to procure ADR services at a large scale. This is indeed happening, for space agencies such as ESA and JAXA are purchasing services from commercial space companies for their debris removal programs.

Admittedly, even with the wide ratification of the Paris Agreement, the situation of climate change is still concerning. The NDC Synthesis Report published on 26 October 2022 analyses 166 NDCs representing 193 Parties

82 UN Climate Change. Paris Agreement Implementation and Compliance Committee (PAICC). <https://unfccc.int/PAICC>.

83 Ibid. Art. 15(2), Paris Agreement.

84 UN Climate Change. (30 March 2022). Paris Agreement Implementation and Compliance Committee Meets to Assess Challenges. <https://unfccc.int/news/paris-agreement-implementation-and-compliance-committee-meets-to-assess-challenges>.

85 Owley, J., Ibrahim, I. A., & Maljean-Dubois, S. (2021). The Paris Agreement Compliance Mechanism: Beyond COP 26. *Wake Forest Law Review Online*, *11*, p. 153.

to the Paris Agreement recorded in the NDC registry as of 23 September 2022.[86] The Report "shows countries are bending the curve of global greenhouse gas emissions downward but underlines that these efforts remain insufficient to limit global temperature rise to 1.5 degrees Celsius by the end of the century".[87] Meanwhile, the report finds that "[m]ost of the Parties that submitted new or updated NDCs have strengthened their commitment to reducing or limiting greenhouse gas emissions by 2025 and/or 2030, demonstrating increased ambition in addressing climate change".[88] These findings indicate that the Paris Agreement is functioning, though more ambitious commitments and actions are urgently needed to achieve the goal set in the Agreement.

In the space context, it could be likewise questionable whether self-defined commitments would be able to effectively solve the space debris problem. This doubt is reasonable and the question cannot be answered until such a pledge and review system is established to test the effectiveness of these commitments. However, it should be noted that the COPUOS Space Debris Mitigation Guidelines remain voluntary even fifteen years after adoption and the development of LTS Guidelines took almost a decade of negotiation marked with political tensions. Therefore, it does not seem likely that States are ready to accept specific legal obligations on debris mitigation and remediation. Rather, allowing States the discretion to make their own commitments appears the most realistic way forward. As pointed out by Hobe, "[t]he best space law cannot help improve the situation if the space-faring states do not want to help".[89] The shaping of political will would be the most challenging part, and a step-wise approach through unilateral and multilateral commitments could hopefully trigger a snowball effect and prompt the whole international community to follow suit. In any event, the increasing imminence of the space debris problem will likely propel States to contribute their efforts and make commitments to mitigate and remove space debris.

5.1.4 Involvement of All Stakeholders: The Net Zero Space Initiative

The proposals for unilateral, multilateral and global commitments as discussed in the previous sections are centred on States. State commitments can be transformed into national legal order as licensing requirements and

86 The text of the 2022 NDC Synthesis Report is available at: <https://unfccc.int/ndc-synthesis-report-2022>.

87 UN Climate Change. (26 October 2022). Climate Plans Remain Insufficient: More Ambitious Action Needed Now. *UN Climate Press Release*. <https://unfccc.int/news/climate-plans-remain-insufficient-more-ambitious-action-needed-now>.

88 Ibid.

89 Hobe, S. (2012). Environmental Protection in Outer Space: Where We Stand and What is Needed to Make Progress with regard to the Problem of Space Debris. *Indian Journal of Law and Technology*, *8*, p. 10.

become binding requirements for the regulation of private space activities at the domestic level. Meanwhile, private entities are not merely regulatees and they are playing an ever-increasing role in the promotion of responsible behaviour in outer space. The SSC and CONFERS are good examples showing that the commercial industry can also contribute to broadening the boundaries of space law.

In view of the growing importance of the private sector, a global commitment to space sustainability would not be complete without the active involvement of private entities. In this regard, the "Net Zero Space" initiative launched at the 4th edition of the Paris Peace Forum in November 2021 can complement State-centered commitments to debris mitigation and remediation as it is targeted at all stakeholders involved in space activities.[90] The overall goal of the Net Zero Space initiative is to "ensure safe space operations and the long-term sustainability of outer space activities".[91] To this end, it calls for "a global commitment to achieving sustainable use of outer space for the benefit of all humankind by 2030".[92] In addition, the initiative recommends "urgent action from 2021 onwards to rapidly contain and then reduce the ongoing pollution of Earth's orbital environment:

- by avoiding further generation of hazardous space debris, and
- by remediating existing hazardous space debris."[93]

The Net Zero Space initiative is "a global, multistakeholder platform gathering actors from across the space value chain and beyond the industry to raise awareness on the pressing need to better protect Earth's orbital environment."[94] Up to December 2023, the initiative has 65 supporters from 24 countries, which covers a wide range of stakeholders including OOS and SSA providers, satellite operators, civil society and academic actors, space agencies and public authorities, and other stakeholders in the space sector.[95] This all-inclusive approach can leverage the potential of the space community across the globe consisting of both public and private actors to contribute to space safety and sustainability.

With regard to the merits of the Net Zero Space initiative, reference can be further made to the concept of the "polycentric approach" proposed by Elinor Ostrom, 2009 Nobel Laureate in Economic Sciences, to address the cli-

90 Net Zero Space. (November 2022). The Launch of Net Zero Space Initiative. <https://parispeaceforum.org/en/initiatives/net-zero-space/>.
91 Net Zero Space. The Net Zero Space Declaration. <https://www.netzerospaceinitiative.org/declaration>.
92 Ibid.
93 Ibid.
94 Net Zero Space. Sustainable Use of Outer Space by 2030. <https://www.netzerospaceinitiative.org/>.
95 Net Zero Space. Key Facts & Figures. <https://www.netzerospaceinitiative.org/supporters>.

mate change problem.[96] As submitted by Ostrom, it would take a long time to resolve many of the conflicts at high-level international negotiations over "who caused global [climate] change in the first place and who is responsible for correcting [it]".[97] However, without sufficient action undertaken, the climate change problem can only get more serious.[98] Therefore, while States should endeavour to reach international agreements on the reduction of greenhouse gas emissions, "the capabilities of people to organize at a local level" should not be overlooked.[99] To leverage such capabilities, fostering mutual trust among individuals that "others are also going to contribute to their solution" is crucial, and therefore successful efforts at a local scale should be advertised and made well known on a larger scale.[100]

A similar bottom-up approach can be achieved through the Net Zero Space initiative, calling for commitments by all stakeholders instead of relying solely on the commitments of States. This allows forward-looking stakeholders to take the lead and like-minded ones to join the initiative. In addition, the initiators of the Net Zero Space initiative have asked the Paris Peace Forum to host the secretariat of the initiative, "to report annually on the status of the initiative and promote subsequent steps towards the realization of the 'Net Zero Space' goal".[101] This annual review approach could facilitate information exchange among supporters of the initiative and demonstrate to the international space community the positive results that have been achieved by these supporters. This could help enhance mutual trust among supporters and propel other space operators to follow suit by declaring their commitments to space sustainability.

5.2 *Issue 2*: Establishment of Safety Guidelines and Standards for ADR

As observed by Freeland, while the fundamental rules and principles contained in the UN space treaties and general international law remain relevant and applicable to new activities and challenges in outer space, "they do not necessarily provide the specific standards or direction to provide clarity as to every aspect of the conduct of many such activities".[102] ADR

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96 The New Humanitarian. (25 April 2012). Interview with Nobel Prize Winner Elinor Ostrom on Climate Change. <https://www.thenewhumanitarian.org/feature/2012/04/25/interview-nobel-prize-winner-elinor-ostrom-climate-change>.

97 Ibid.

98 Ibid.

99 Ibid.

100 Ibid.

101 Net Zero Space (2022), *supra* note 90.

102 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. 18.

is one such novel activity that is subject to the general requirements and limitations set forth in international space law, whereas more specific norms as to how ADR activities are to be carried out in a safe and sustainable manner are missing.

In particular, as discussed in Chapter 3, Article IX of the Outer Space Treaty requires States Parties to conduct all their activities in outer space with due regard to the corresponding rights and interests of other States and to adopt appropriate measures to avoid harmful contamination of outer space. Since the generation of space debris would adversely affect the safety and sustainability of space operations, it can be inferred from this principle a requirement that States engaging in ADR activities should enhance the safety of their operations and minimise the generation of space debris. As noted in Chapter 4, soft law instruments can contribute to the clarification of concepts such as "due regard" and "appropriate measures", and thus the adoption of UN General Assembly resolutions and sets of guidelines for the governance of space activities may specify the general requirements under the UN space treaties and provide guidance to States regarding the way to comply with these requirements.

Meanwhile, the lack of a standard of fault for the establishment of liability in outer space may create legal uncertainty for entities engaging in ADR activities. As suggested in the *Report of the International Interdisciplinary Congress on Space Debris Remediation and On-Orbit Satellite Servicing*, it may be useful to establish a rule that "if someone does the right thing (e.g., by removing a non-functional object from orbit), then fault could be mitigated in some way".[103] This suggestion can be read in conjunction with the aim to maintain the long-term sustainability of outer space activities, as expressed in the LTS Guidelines.[104] As mentioned in Chapter 4, LTS Guideline D.2 recommends the investigation of new measures to manage the space debris population in the long term, which can include the development of ADR technologies. Therefore, ADR operators may well argue that their efforts to maintain the long-term sustainability of outer space activities should be duly considered for the determination of fault. As ADR operations aim to remove hazardous debris objects from orbit and can thereby reduce collision risks in outer space, it can be regarded as the "right thing" to do for the benefit and in the interests of all countries.

Meanwhile, in view of the complexity of and risks involved in ADR operations, it is essential for such "right thing" to be done in the "right way",

103 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, p. 32.

104 Preamble of the LTS Guidelines, para. 5.

i.e., to avoid causing harmful interference with the space activities of other States. As discussed in Chapter 4, soft law instruments may be considered in assessing whether a launching State should be held at fault for damage caused in space. Hence, if an internationally recognised instrument setting out guidelines and standards for safe ADR operations can be established, ADR operators will have more certainty to assess their risks of liability exposure. The commercial space sector has already published some guiding principles and recommended practices in this regard, which were used as the foundation for the development of ISO Standard 24330. To enhance the authoritativeness of these guidelines and standards, it would be desirable for States to adopt international guidelines for ADR activities, which can reflect the general consensus of States on the way to conduct ADR operations and be implemented by them in the licensing process. As these guidelines would generally reflect best practices, compliance with these guidelines can provide a basis for States engaging in ADR activities to argue that they are acting diligently within the current legal framework. Moreover, as these guidelines are designed to enhance mission safety, compliance with them can reduce the likelihood and consequences of mishaps, which thereby reduces the risks of liability exposure.

This section will discuss the development of guidelines with regard to ADR activities by States and international bodies. Section 5.2.1 will examine the draft guideline on the measures of precaution for preparing and conducting ADR operations, which was proposed during the development of the LTS Guidelines. Sections 5.2.2 and 5.2.3 will discuss some recent regulatory developments in the US and Japan which specifically address the governance of ADR activities. National guidelines and standards on space debris mitigation served as the foundation for the development of international guidelines on this matter, such as those produced by the IADC and COPUOS. Therefore, the development of national guidelines and practices addressing ADR can not only provide legal certainty to operators at the domestic level, but they can also be used as a basis for the establishment of international guidelines. Section 5.2.4 will discuss the path forward for the development of international guidelines for ADR operations.

5.2.1 Draft ADR Guideline Proposed in the Development of the LTS Guidelines

As discussed in Chapter 4, at its sixty-second session in 2019, COPUOS decided to establish the LTS 2.0 Working Group under a five-year plan.[105] COPUOS also defined a guiding framework for the Working Group, including to identify and study challenges and consider possible new guidelines for the long-term sustainability of outer space activities.[106] This could be

105 UN Doc. A/74/20 (2019). Report of the COPUOS on its sixty-second session, para. 165.
106 Ibid, para. 167.

done by taking into consideration existing documents including, *inter alia*, document A/AC.105/C.1/L.367, which contains seven draft guidelines for space sustainability on which consensus could not be reached and were therefore not included in the set of twenty-one LTS Guidelines adopted by COPUOS in 2019. Among these seven guidelines, *Guideline 20+21+part of 22* ("draft ADR Guideline") is particularly relevant to ADR for it provides measures of precaution for preparing and conducting ADR.

At the sixty-fifth session of COPUOS in 2022, the view was expressed that the plans of the LTS 2.0 Working Group to identify challenges and consider possible new guidelines were of relevance due, among other things, to the interests of States and commercial entities in ADR projects.[107] In addition, Italy underlined some of the outstanding new challenges for the consideration of the LTS 2.0 Working Group including, *inter alia*, "the active debris removal missions and their implications for the long-term sustainability of outer space activities".[108] In fact, ADR activities could affect the long-term sustainability of the space environment in two aspects. On the one hand, the removal of existing space debris is indispensable to the stabilisation of the space debris in Earth's orbits. On the other hand, ADR activities are inherently risky in that a collision between the ADR spacecraft and the target debris object may generate more space debris that deteriorates the outer space environment. Therefore, ADR operators should enhance mission safety to ensure that their missions contribute to solving, instead of worsening, the space debris problem.

In a conference room paper submitted at the sixtieth session of COPUOS STSC, Canada expresses the view that in light of the increasing congestion in outer space, one area that the LTS 2.0 Working Group could consider is ADR.[109] This could include "the development of recommended procedures for effective communication and notification of active debris removal activities; means to conduct these activities in a transparent manner, and techniques for these operations that promote spaceflight safety".[110] As submitted by Canada, the publications of CONFERS and the ISO Standard 24330 could provide a starting point for international discussion, which would help ensure that ADR is conducted in a manner that contributes to the long-term sustainability of outer space activities.[111]

107 UN Doc. A/77/20 (2022). Report of the COPUOS on its sixty-fifth session, para. 155.
108 UN Doc. A/AC.105/C.1/L.409/Add.4 (1 December 2022). Information and views for consideration by the Working Group on the Long-term Sustainability of Outer Space Activities, p. 13.
109 UN Doc. A/AC.105/C.1/2023/CRP.17 (6 February 2023), Consideration of areas for possible new guidelines concerning the long-term sustainability of outer space activities: Conference room paper by Canada, para. 3(c).
110 Ibid.
111 Ibid.

Since the LTS 2.0 Working Group will be guided by UN Document A/AC.105/C.1/L.367, the draft ADR Guideline may be considered by the Working Group in the development of new guidelines for space sustainability. This draft Guideline has two alternative formulations for the consideration of delegations. The two formulations share many commonalities.[112] They both recommend that when considering and conducting ADR operations, States and international intergovernmental organisations should ensure that such operations are "carried out in a manner that is consistent with the aim of ensuring the long-term sustainability of outer space activities".[113] To this end, they should identify, evaluate and mitigate the risks involved in these operations, including the risks posed to space objects of other parties.[114]

Both alternatives also encourage States and international intergovernmental organisations contemplating ADR operations to provide information on such operations at the international level in advance, such as through UNOOSA or other appropriate channels.[115] The first alternative is more specific in this regard as it adds a recommendation that "the greater the probability of side effects from such an operation, the more detailed should be the information made available at different stages of the operation's preparation and implementation".[116] In addition, the first alternative encourages "the provision of information in an expeditious reactive mode or in a near-real-time mode" where practicable.[117] Since information sharing in a timely manner is essential for coordination among operators to avoid collision, such recommendations can help to enhance mission safety and reduce harmful interference.

Another issue that is addressed in both alternatives is the positive identification of the space object to be removed.[118] More specifically, they both underline the need to secure legitimate grounds for ADR operations, which depends on whether the specific space object planned for active removal, "and a specific physical object in orbit that is presumed to be or is associated with that space object, are in fact one and the same physical body".[119] In other words, entities engaging in ADR operations should ensure that no "wrong" space object, i.e., a space object that is not the intended removal target, will be mistakenly removed. This guideline could help avoid the

112 UN Doc. A/AC.105/C.1/L.367 (16 July 2018), Draft Guidelines for the Long-term Sustainability of Outer Space Activities: Working paper by the Chair of the Working Group on the Long-term Sustainability of Outer Space Activities, pp. 4-5.
113 Ibid.
114 Ibid.
115 Ibid.
116 Ibid, p. 4.
117 Ibid.
118 Ibid, pp. 4-5.
119 Ibid.

provocation of potential tensions and conflicts resulting from the removal of an object under the jurisdiction of a third State, especially in light of the inherent dual-use capabilities of ADR technologies which could easily raise security concerns.

On top of the above common recommendations, each alternative addresses one additional issue. Alternative 1 addresses the issue of intentional destruction of space objects. It states that "States and international intergovernmental organizations should avoid any intentional destruction operations that could generate [long-lived] [long-term] debris, with the understanding that, under certain exceptional circumstances, such operations may need to be considered because the alternatives would have far more negative consequences".[120] Examples of these exceptional circumstances include "the need to avert an immediate or potential serious [threat] [risks] to human life, the environment or property in outer space or on the ground, in the air or at sea in the case of re-entry of the space object".[121] The topic of intentional destruction is also addressed in the aforementioned moratorium on direct-ascent anti-satellite testing, but this only bans one specific kind of intentional destruction. The exceptional circumstance may be discussed by States in the context of the circumstances precluding wrongfulness as discussed in Chapter 3, as the circumstances of distress and necessity also address situations where human life and other essential interests are at risk. In any event, it should be borne in mind that the intentional destruction of space objects may significantly deteriorate the orbital space environment and should in principle be prevented.

Alternative 2 addresses expressly the issue of prior consent. It provides that ADR operations "should be agreed to in advance by the authorities exercising jurisdiction and/or control over those space objects" to be removed, as well as in consultation with "the holders of proprietary or other legal rights with respect to those objects".[122] In other words, the non-consensual removal of space objects controlled, owned, or operated by other States or entities should be avoided.

In sum, the draft ADR Guideline provides a number of recommendations that should be considered by States and international organisations engaging in ADR activities. First, the Guideline sets forth a fundamental principle for ADR activities, namely that these activities should be carried out in a way that contributes to the long-term sustainability of outer space. In fact, as stated in another document that is also mentioned in the guiding framework for the LTS 2.0 Working Group, the safety issues related to ADR activities constitute the main concern of States, as such activities may in the

120 Ibid, p. 4.
121 Ibid.
122 Ibid, p. 5.

worst case lead to the production of new debris.[123] Hence, while ADR is necessary to stabilise the orbital environment, it should also be taken as a cautious move, so as not to let an activity with benign intent lead to a result worse than the *status quo* of the space debris situation.

To achieve the above aim, the Guideline provides more specific recommended measures. States and international organisations should assess and mitigate the risks involved in ADR activities. They are also encouraged to provide relevant information on such operations at the international level, which can facilitate consultation and coordination with the potentially affected entities and contribute to mission safety. In addition, States and international organisations should ensure that they do not mistakenly remove objects of other States, and obtain prior consent if they contemplate the removal of objects under foreign jurisdiction. This can help avoid provoking tensions and conflicts as a result of the non-consensual removal of space objects under the jurisdiction of other States. Finally, intentional destruction of space objects should be avoided unless in exceptional circumstances. These measures outline issues that should be considered by States and international organisations when engaging in ADR operations, but they are not sufficiently prescriptive about the way of implementation. From this perspective, they are more guiding principles for ADR activities than detailed design and operational standards specifying how ADR activities should be carried out. Therefore, while the adoption of the draft ADR Guideline in the future would be beneficial to enhance the safety of ADR activities, it is also advisable for the spacefaring nations to establish more specific guidelines for debris removal like the IADC Space Debris Mitigation Guidelines for debris mitigation. The recent regulatory development taking place in the US and Japan may inform future legal development in this regard.

5.2.2 Legal Developments in the US Relating to the Governance of ADR

The US has recently updated some of its national laws and standards to address the issue of ADR. The 2018 US Space Policy Directive-3 directed NASA to lead efforts to update the US *Orbital Debris Mitigation Standard Practices* (ODMSP) and establish new guidelines for satellite design and operation.[124] The revised ODMSP was published in November 2019, which is the first update to the ODMSP since its original publication in 2001.[125]

123 UN Doc. A/AC.105/2019/CRP.16 (18 June 2019). Meeting hosted by Switzerland on possible further work on the long-term sustainability of outer space activities: Background and Chair's Summary, p. 4.

124 Sec. 6(b)(i), US SPD-3, *supra* note 31.

125 U.S. Government Orbital Debris Mitigation Standard Practices, updated in November 2019 ("2019 ODMSP"). <https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf>. See also NASA Orbital Debris Program Office. *Orbital Debris Quarterly News*, *24*(1), January 2021, p. 1.

This 2019 update "incorporates new sections to clarify and address operating practices for" certain classes of space operations such as RPO, satellite servicing, and ADR.[126] The revised ODMSP focuses on the debris mitigation aspect of ADR by providing that ADR operations should follow the debris mitigation objectives like other space operations.

Also relevant to ADR is the reference to direct retrieval as one of the post-mission disposal methods. Objective 4-1.f of the 2019 ODMSP reads: "Direct retrieval: Retrieve the structure and remove it from orbit preferably at completion of mission, but no more than 5 years after completion of mission." As direct retrieval includes ADR activities, this means that ADR could be considered as a potential post-mission disposal measure.[127] To align its requirements with the 2019 ODMSP, NASA has updated its Standard 8719.14 in November 2021.[128] Reflecting the aforementioned Objective 4-1.f of the 2019 ODMSP, Requirement 4.6-1 of the NASA Standard lists direct retrieval as one of the options to accomplish post-mission disposal of space structures used for NASA space programs and projects.

Like NASA, the FCC has also updated in 2020 its rules regarding space debris mitigation to incorporate the technical guidance of the 2019 ODMSP and to address the developments in space technologies and activities. Among other issues, the FCC adopted in this update a requirement that in the licensing process of space stations, the applicant should disclose whether its spacecraft is capable of, or will be, performing proximity operations.[129] If so, the applicant should submit a statement "addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks".[130] According to the FCC, this disclosure requirement "follows the general approach in the revised ODMSP of analyzing such operations within the framework of standard debris mitigation objectives" and "provide[s] a vehicle for further review of those operations".[131] At the time, the FCC took note of the "evolving and developing nature" of RPO and considered it premature to adopt "more specific technical or operational requirements".[132]

In a *Notice of Proposed Rulemaking* (NPRM) published in 2018, the FCC observed that there are a number of specific technologies under development for direct spacecraft retrieval such as nets and harpoons, and sought

126 Preamble of the 2019 ODMSP.
127 FCC. (24 April 2020). *Mitigation of Orbital Debris in the New Space Age: Report and Order and Further Notice of Proposed Rulemaking*. FCC 20-54, para. 106.
128 NASA Standard 8719.14C, *Process for Limiting Orbital Debris*, approved 5 November 2021.
129 FCC 20-54 (2020), *supra* note 127, para. 123 & Appendix A.
130 Ibid, Appendix A.
131 Ibid, para. 123.
132 Ibid.

comments on "what weight, if any, the Commission should give to post-mission disposal proposals relying on direct spacecraft retrieval".[133] Similar to the case of RPO, the FCC concluded that "it would be premature to establish more detailed regulations in this area".[134] To the extent that applicants seek to rely on direct retrieval as a means of post-mission disposal, the plan may be considered by the FCC on a case-by-case basis.[135]

The issue of ADR is also addressed by the FCC in the context of in-space servicing, assembly, and manufacturing (ISAM) activities. As a first step towards the development of new rules to govern ISAM activities, the FCC issued in August 2022 a *Notice of Inquiry* (NOI) on ISAM.[136] The NOI stated that the FCC's orbital debris mitigation rules apply to all spacecraft operators seeking licenses from the FCC, including operators of ISAM missions.[137] Like the 2019 ODMSP, this affirms the application of space debris mitigation rules to ADR activities. The FCC is supportive of the continued advancement of technologies that would enable ADR and is interested in identifying how it can facilitate the advancement of these technologies.[138] To this end, the NOI sought comments on whether and how the FCC should consider ADR as a potential post-mission disposal strategy.[139]

In sum, current US space law specifically addresses two aspects of ADR activities. The first aspect is space debris mitigation. Both the 2019 ODMSP and the FCC affirm that ADR operations are subject to the relevant space debris mitigation requirements like other space activities. In addition, the 2019 ODMSP and NASA Standard 8719.14C provide that direct retrieval, which includes ADR, may be used as a means of post-mission disposal. The FCC is contemplating the weight it should give to direct retrieval as a debris mitigation strategy and how it may support the advancement of ADR technologies. The second aspect is the disclosure requirement. The FCC requires applicants to disclose the capability and plan of their spacecraft to perform proximity operations. As ADR involves proximity operations, the requirement applies *a priori* also to ADR operators. Meanwhile, the FCC finds that at the moment, more detailed technical and operational requirements for RPO and ADR operations would be premature due to the evolving and developing nature of these activities.

133 Ibid.
134 Ibid, para. 107.
135 Ibid.
136 FCC. (August 2022). Facilitating Capabilities for In-space Servicing, Assembly, and Manufacturing. FCC 22-66. <https://docs.fcc.gov/public/attachments/FCC-22-66A1.pdf>.
137 Ibid, para. 27.
138 Ibid, para. 29.
139 Ibid, para. 30.

5.2.3 The Japanese Guidelines and Standards Relevant to ADR

While the FCC considers it premature to develop specific rules for ADR, Japan has established two sets of guidelines applicable to the design and operations of ADR activities. The reason for the rapid steps taken by Japan to establish these guidelines may be explained by Japan's active engagement in ADR activities at both private and governmental levels. As mentioned in Chapter 2, the Japan-headquartered commercial company Astroscale is advancing and demonstrating key technologies for ADR operations. In addition, JAXA is in the process of developing its CRD2 program to remove a large debris object of Japanese origin in cooperation with private companies. In comparison, while the 2010 US National Space Policy directs NASA and the Department of Defense to "[p]ursue research and development of technologies and techniques […] to mitigate and remove on-orbit debris […]", no US governmental entity has currently been assigned the task of removing existing on-orbit debris.[140]

On 10 November 2021, the National Space Policy Secretariat (NSPS) of the Cabinet Office of Japan published the *Guidelines on a License to Operate a Spacecraft Performing On-Orbit Servicing* (Japanese OOS Guidelines).[141] This set of guidelines is applicable to the licensing of the operation of spacecraft designed to perform OOS missions.[142] Through the implementation of these guidelines, Japan aims to ensure that Japanese OOS missions are conducted in a safe and transparent manner and in compliance with international law.[143] The Japanese OOS Guidelines are designed to provide supplementary requirements for the licensing of OOS missions on top of the general licensing requirements for the operation of conventional spacecraft.[144] The instrument also provides some tips and sample measures on how to conform to these requirements.[145]

140 NASA Orbital Debris Program Office. Debris Remediation. <https://orbitaldebris.jsc.nasa.gov/remediation/>. The situation would likely change if the US ORBITS Act could be enacted as law, which would direct NASA to establish an Active Orbital Debris Remediation Demonstration Program to partner with industry in developing technology for remediating debris objects. The establishment of this program may motivate the US to develop more specific rules and regulations for ADR activities.

141 Japanese *Guidelines on a License to Operate a Spacecraft Performing On-Orbit Servicing*, published on 10 November 2021. A tentative English translation for reference purpose only is available on the website of the Cabinet Office of Japan. <https://www8.cao.go.jp/space/english/stm/index.html>.

142 Japan. (2022). *Japan Item 7 – "Report of the Scientific and Technical Subcommittee on its fifty-ninth session"*. <https://www.unoosa.org/documents/pdf/copuos/2022/Statements/7_Japan_r1.pdf>.

143 Ibid.

144 Sec. 1.1, Japanese OOS Guidelines.

145 Ibid.

The term "Active debris removal (ADR)" is defined in the Japanese OOS Guidelines as:

> "On-orbit servicing that removes either a spacecraft whose mission is terminating[146] or space debris from the current orbit to an orbit for disposal (including orbits for the Earth's atmospheric reentry)."[147]

According to the above definition, the Japanese OOS Guidelines categorise ADR as a subset of OOS and are therefore applicable to the licensing of ADR operations. As summarised by the NSPS, the guidelines contain the following four major requirements:[148]

1. Justifiability of purposes as a lawful business conduct
   The applicant for license should obtain consent from the entity which holds the proprietary and other legitimate rights to the client object.[149]

2. Reliability of subsystems of the servicer spacecraft to ensure mission safety
   Each subsystem of the servicer spacecraft must have the functions and capabilities to safely execute their associated operations.[150]

3. Establishment and enforcement of operations and management plan for the safe performance of OOS
   This includes a set of operational requirements for safe mission performance.[151] Specifically, for relocation or ADR missions, the client object should be transferred to an appropriate orbit in order not to interfere with the operation of third-party spacecraft.[152]

4. Information disclosure to enhance mission safety and transparency
   This concerns the disclosure of the main features of the mission and other associated information before the commencement of the mission as well as information on anomalies in the case of malfunction and other emergencies.[153]

As the SWF notes, a conundrum for the development of satellite servicing standards is "the interdependent nature of the government and industry efforts: industry is looking for regulatory certainty to be able to plan their

146 Thus, the definition of 'ADR' here includes end of life servicing. [Original footnote]
147 Sec. 3(4), Japanese OOS Guidelines.
148 NSPS. (November 2021). Japan's Guidelines on a License to Operate a Spacecraft Performing On-Orbit Servicing, p. 2. <https://qzss.go.jp/en/events/khp0mf0000001l2j-att/0-2-2_CAO.pdf>.
149 Sec. 4.1, Japanese OOS Guidelines.
150 Sec. 5.2, ibid.
151 Sec. 5.3, ibid.
152 Sec. 4.2, ibid.
153 Sec. 4.3, ibid.

future missions, while governments need to know about future missions to establish regulatory frameworks".[154] In light of this conundrum, the Japanese OOS Guidelines represent a significant step forward, as the guidelines provide useful guidance for Japanese companies in the OOS and ADR industry to prepare and conduct their operations. In addition, regulatory uncertainty could affect private capital investment, for "investors are reluctant to invest in ventures that are mere 'not illegal' through silence in the law".[155] Therefore, the Japanese OOS Guidelines could help promote the development of the commercial OOS and ADR industry in Japan by providing certainty to these activities.

In addition to the Japanese OOS Guidelines, there is another Japanese document relevant to the safety of OOS missions, namely the *Safety Standard for On-Orbit Servicing Missions* ("JAXA OOS Standard") published by JAXA on 30 March 2020.[156] The Standard applies to "on-orbit servicing to be operated under liability" of JAXA.[157] Like the Japanese OOS Guidelines, the JAXA OOS Standard also includes ADR as a part of OOS.[158] Therefore, the document is applicable to JAXA's CRD2 program, which clarifies the safety and security requirements for the mission design and operations.[159]

The JAXA OOS Standard consists of basic requirements and specific requirements for OOS.[160] The basic requirements contain three measures:[161]
(1) Avoid unintended generation of space debris and loss of major functions that are required for the servicing spacecraft and client spacecraft to mitigate debris generation;
(2) Conduct a hazard analysis of the entire system involved in OOS and take appropriate safety measures to address the identified hazards;
(3) Consider adding fault tolerance or equivalent measures if due to the size, orbit or properties of the payload, a collision could lead to a catastrophic consequence.

The specific requirements are provided to deal with different categories of hazards such as collision caused by improper orbit and attitude control, structural failure, and failure caused by thermal incompatibility.[162]

154 SWF. (12 September 2022). Insight - Satellite Servicing Standards and Policy: A Progress Report. <https://swfound.org/news/all-news/2022/09/insight-satellite-servicing-standards-and-policy-a-progress-report>.
155 Blount (2019), *supra* note 36, p. 187.
156 JAXA. Safety Standard for On-Orbit Servicing Missions. JERG-2-026, 30 March 2020. <https://sma.jaxa.jp/en/TechDoc/index.html>.
157 Sec. 1, JAXA OOS Standard.
158 Sec. 3, ibid.
159 Yamamoto, T., Matsumoto, J., Okamoto, H., Yoshida, R., Hoshino, C., & Yamanaka, K. (2021). Pave the Way for Active Debris Removal Realization: JAXA Commercial Removal of Debris Demonstration (CRD2). *Proceedings of 8th European Conference on Space Debris*, p. 4.
160 Sec. 5, JAXA OOS Standards.
161 Sec. 5.1, ibid.
162 Sec. 5.2, ibid.

The guidelines and standards developed by Japan may serve as a basis for the development of international guidelines addressing ADR. In fact, the *Mid-to Long-term Policy on Efforts for Rule-Making on the Use of Earth Orbit* released by Japan in 2022 expresses the will of Japan to "take the initiative in making rules for the use of orbit ahead of other countries in order to promote discussions on STCM (space traffic coordination and management) and responsible behavior in outer space, and to help formulate rules and norms thereon".[163] Among other issues, this 2022 Policy states that Japan will study and develop mechanisms to promote the advancement of debris reduction and removal technologies by satellite manufacturers and operators, and then promote these mechanisms internationally so as to make them become international rules.[164]

5.2.4 The Way Forward for the Development of Safety Norms for ADR Activities

The above discussion on the national mechanisms of the US and Japan shows that some States are already taking initiatives to develop rules and guidelines for ADR operations. With the advancement of ADR technologies and the engagement of more States and private entities in ADR activities, it can be expected that more national regulations and standards will be developed to govern ADR. To enhance the harmonisation among the national mechanisms, it would be advisable for States to establish some internationally accepted guidelines and standards for ADR activities. Reference can be made to the aforementioned Sendai Communiqué of 2023, which expresses the commitment of the G7 nations to promote the technological and legal development for debris mitigation and remediation:

> "We strongly encourage further research and development of orbital debris mitigation and remediation technologies. We also strongly encourage development of national guidelines and regulatory frameworks for remediation that align with *guidelines developed within UN COPUOS*. We call for international cooperation, including through appropriate international bodies, that could encourage transparency and responsible remediation practices and foster the future development of international guidelines in this area."[165]

The above statement demonstrates the political will of the G7 nations to establish national and international guidelines for space debris remediation. In the Sendai Communiqué of 2023, the G7 nations commit to promoting debris mitigation efforts by continuing to act consistently with the COPUOS Space Debris Mitigation Guidelines and the LTS Guidelines.[166] The express

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163 Sec. 1, *Mid- to Long-term Policy on Efforts for Rule-Making on the Use of Earth Orbit*, published on 28 March 2022. The English version of this policy is available on the website of the Cabinet Office of Japan: <https://www8.cao.go.jp/space/english/index-e.html>.

164 Sec. 3.3, ibid.

165 Sendai Communiqué of 2023, *supra* note 46, p. 5, emphasis added.

166 Ibid.

reference to "guidelines developed within UN COPUOS" in the above statement implies that future guidelines may be developed to provide design and operational guidance on how ADR activities should be conducted in accordance with the existing COPUOS guidelines, i.e., in a way to prevent the generation of space debris and contribute to the long-term sustainability of outer space activities.

As Japan has already developed national guidelines for ADR activities, the dissemination of these guidelines could "socialise" them and provide a basis for the development of technical standards and best practices at the international level.[167] As Martinez observes:

> "A number of soft law instruments are bottom-up technically-based instruments drawn from technical standards and best-practice guidelines based on the experiences of States in the safe conduct of space operations. Other States may use these soft law instruments as a basis for enhancing their own national regulatory frameworks and associated administrative procedures."[168]

An example of this bottom-up process is the development of international space debris mitigation guidelines and standards, which were formed on the basis of national guidelines and best practices in this area. In 1995, NASA published NASA Safety Standard (NSS) 1740.14 and became the first space agency in the world to issue a comprehensive set of space debris mitigation guidelines.[169] The NSS 1740.14 (1995) provided the baseline for the development of the 2001 ODMSP, which "served as one of the primary sources" for the development of the IADC Space Debris Mitigation Guidelines and later the COPUOS Space Debris Mitigation Guidelines".[170] Very soon after the publication of NSS 1740.14, other space agencies began to follow suit, including the NASDA (now JAXA), the CNES, ESA, and the RSA (now Roscosmos).[171] Like the NSS 1740.14, these space guidelines also informed the development of the IADC Space Debris Mitigation Guidelines,[172] which reflected "the fundamental mitigation elements of

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167 Martinez, P. (2020). The Role of Soft Law in Promoting the Sustainability and Security of Space Activities. *Journal of Space Law*, *44*(2), p. 530.

168 Ibid.

169 Reynolds, R., Eichler, P., & Johnson, N. (1997). An Overview of Revised NASA Safety Standard 1740.14. *Proceedings of 2nd European Conference on Space Debris*, *393*, p. 721. See also NASA Orbital Debris Program Office. Debris Mitigation. <https://orbitaldebris.jsc.nasa.gov/mitigation/>.

170 Compendium of Space Debris Mitigation Standards Adopted by States and International Organizations (15 May 2023), p. 88. <https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html>.

171 Mudge, A. G. (2022). Incentivizing 'Active Debris Removal' Following the Failure of Mitigation Measures to Solve the Space Debris Problem: Current Challenges and Future Strategies. *Air Force Law Review*, *82*(1), p. 105.

172 See the original version of the IADC Space Debris Mitigation Guidelines published in 2002, as contained in UN Doc. A/AC.105/C.1/L.260 (29 November 2002), which listed a series of documents and study reports published by States and international organisations from which the IADC obtained information in the process of producing the IADC Guidelines.

a series of existing practices, standards, codes and handbooks developed by a number of national and international organizations".[173] The IADC Space Debris Mitigation Guidelines were then used as a foundation for the development of other international guidelines and standards on space debris mitigation. These international instruments could be implemented by States in their national regulatory frameworks for the licensing of private space activities. Hence, the development of national and international mechanisms can be regarded as a two-way traffic, i.e., the development of national and international guidelines is mutually supportive. As observed by Vedda, the current space debris mitigation guidelines and standards "are the results of a gradual evolution on both domestic and international fronts".[174]

As Japan and the US have developed some national guidelines and standards to govern ADR activities, these national initiatives could provide useful models for other interested States to develop their own national mechanisms in this area. Since the draft LTS ADR guideline for which consensus could not be reached is contained in a document that forms part of the guiding framework for the future work of the LTS 2.0 Working Group, it could be used as a basis for further negotiations. In the meantime, States, especially those with ADR capabilities, could contribute their insights and opinions for the consideration of the Working Group. In fact, according to the *Draft terms of reference, methods of work and workplan* of the LTS 2.0 Working Group, the Working Group will invite contributions from COPUOS States members for further discussion at its meetings.[175] Hence, some basic principles to ensure the safety of ADR activities can be developed in the context of space sustainability within COPUOS. These basic principles would be essential because although only a few spacefaring nations are technologically capable of conducting ADR activities, such activities could adversely affect all other States if carried out in a reckless and irresponsible manner. At the same time, as the issue of ADR is but one topic of space sustainability, the LTS 2.0 Working Group may not be an ideal forum to develop a comprehensive set of detailed ADR guidelines and standards. For instance, while the draft ADR Guideline recommends States to assess and mitigate risks in planning and conducting ADR activities, it does not provide specific implementation guidance. Considering the technical complexity of ADR activities, it would be useful to adopt an international instrument providing more detailed technical and operational guidelines for these activities.

173 Sec. 2, COPUOS Space Debris Mitigation Guidelines.

174 Vedda, J. A. (March 2017). Orbital Debris Remediation Through International Engagement. *The Aerospace Corporation*, p. 2.

175 UN Doc. A/AC.105/C.1/2022/CRP.13 (7 February 2022). Draft terms of reference, methods of work and workplan of the Working Group on the Long-term Sustainability of Outer Space Activities: Conference room paper by the Chair of the Working Group on the Long-term Sustainability of Outer Space Activities, para. 14.

As discussed in Chapter 4, there are already some principles, standards and best practices developed for OOS and RPO, including those published by the CONFERS and the ISO. These documents can provide a basis for spacefaring nations to develop and adopt a set of commonly accepted guidelines for ADR activities. The IADC could serve as a forum for the future negotiation and development of a set of guidelines for the design and operations of ADR, for two main reasons. Firstly, the technologies to enable ADR operations are mastered by only a few leading space agencies, and thus only these agencies have relevant experience and insights on how ADR operations should be planned and executed in a safe manner. Since the members of the IADC represent virtually all the leading space agencies in the world, the IADC can be seen as an appropriate international body with relevant expertise to develop ADR guidelines. It should be recalled that the primary purposes of the IADC include "to exchange information on space debris research activities between member space agencies" and "to facilitate opportunities for cooperation in space debris research".[176] As ADR activities are still at a nascent stage, it would be helpful for States actively engaging in ADR to share their experiences and safety concerns regarding these activities, which can inform the future development of guidelines for ADR.

Secondly, the IADC has already touched upon the issue of ADR. While the IADC Space Debris Mitigation Guidelines focus on debris mitigation, Section 5.3.2 of the instrument provides that "[r]etrieval is also a disposal option" for the post-mission disposal of objects passing through the LEO region. As mentioned earlier, ADR can be considered as a means of direct retrieval. More importantly, the IADC ADR Statement provides some useful recommendations on ADR activities including, *inter alia*: "Debris removal activities must be conducted in accordance with both, national and international law, and in a manner that does not unduly impose hazards to space systems in orbit or to people and property on Earth from reentering debris."[177] On the basis of this general principle for ADR activities, it would be helpful for the IADC to provide specific guidance on the measures that should be taken to implement this principle.

In short, since the IADC consists of all the major spacefaring agencies and has already started to address ADR, it appears as an appropriate international forum where the leading space agencies in the world could discuss and develop safety guidelines for ADR activities. This can be achieved by drawing upon the existing standards and practices as developed by national and international entities, like how the IADC did to develop and revise its space debris mitigation guidelines. Once established, these ADR guidelines should be kept as a living document to be periodically reviewed and updated so that they can keep in step with technological advances

176 IADC. About. <https://www.iadc-home.org/what_iadc>.
177 IADC ADR Statement (2022), *supra* note 28, p. 1.

and continue to ensure that ADR activities are conducted in a manner that contributes to the long-term sustainability of outer space activities and does not unduly pose hazards to others.

5.3 *Issue 3*: Recommendations to Promote Consensual ADR Operations

As discussed in Chapter 3, the jurisdiction and control retained by the State of registry over its space object is not affected by the functionality of such object. Therefore, an ADR operation targeting a debris object under foreign jurisdiction can only be conducted with the formal consent of its State of registry, otherwise this would constitute an infringement of Article VIII of the OST. Therefore, a debris object can only be removed either by the State of registry itself or with its explicit permission.[178]

Considering that non-consensual ADR may be regarded as a threatening and hostile act by the State of registry, which could potentially disturb international peace and security, this in principle does not appear a feasible option. Therefore, this section will discuss how the obstacle posed by Article VIII of the Outer Space Treaty could be tackled on a consensual basis. Section 5.3.1 will assess two key legal issues that may need to be addressed by States when entering into international arrangements or agreements for cooperative ADR projects. Section 5.3.2 will propose the provision of additional information about the removability of space objects to the UN to facilitate the seeking of approval for removal by other States. Section 5.3.3 will discuss the legal issues related to the removal of space debris of unknown origin and suggest States to conclude an agreement to generally consent to the removal of small debris fragments under their jurisdiction. Section 5.3.4 will propose the adoption of a UN General Assembly resolution to incorporate the recommendations made in this section.

5.3.1 Consultation and International Cooperation for ADR

Even though space debris is by definition non-functional, it might still serve some practical purposes and/or represent some real value to its owner and State of registry.[179] For instance, defunct satellites and rocket stages in orbit may contain materials that may be collected for re-utilisation.[180] Also, some

178 Popova, R., & Schaus, V. (2018). The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space. *Aerospace*, *5*(2), p. 9.

179 Von der Dunk, F. G. (2010). Too-Close Encounters of the Third Party Kind: Will the Liability Convention Stand the Test of the Cosmos 2251-Iridium 33 Collision?. *Proceedings of International Institute of Space Law*, p. 203.

180 Koch, F. (2021). The Value of Space Debris. *Proceedings of 8th European Conference on Space Debris*, pp. 1-5.

defunct spacecraft of special status can represent a symbol of national prestige and thus have cultural and historical significance, such as the "Dong Fang Hong" satellite, China's first artificial satellite launched on 24 April 1970, which currently remains in orbit around the Earth.[181] Therefore, it is still for the State of registry of a space object to make a determination of its residual value after mission completion.[182]

As the removal target may contain sensitive data, to determine whether to grant or refuse approval, the State of registry would need to know the details of the planned ADR operations in order to assess whether there are risks of information divulgence that could threaten its national security interests. Therefore, the seeking of approval would likely start from information sharing. Reference can be made to a draft principle for responsible behaviour in space proposed by Germany titled "*Considerations in relation to rendezvous operations*":

> "States should not conduct or knowingly support rendezvous operations unless a State has reasonable grounds for the rendezvous operation and the affected other State has given consent. States should notify such rendezvous operations to affected States and should submit a request for consent to these States in advance of the manoeuvre. Notifications leading to consultations should include at least the planned timing, trajectory and objective of the manoeuvre".[183]

The above proposed principle addresses two categories of information, namely the rationale for removal and the basic information of the planned mission. As to the former, the State of registry may want to know the reasons for selecting its space object as a removal target. One possible reason could be that such debris object poses a significant threat to the operational safety of the State requesting approval. As to the latter, the sharing of information on the nature of the activity would enable the State of registry to estimate the relevant risks of such activity.

As an ADR operation may involve complex technical and legal issues, if the requesting State and the State of registry are interested in proceeding with the removal following the stage of information exchange, they may need to conclude a bilateral agreement to address these issues. There are two essential issues that would need to be considered by States in their cooperative arrangement, namely liability apportionment and export control. These issues will be discussed in the following two sub-sections.

181 For more details see the State-owned Assets Supervision and Administration Commission of the State Council (SASAC) of China. (Updated 24 April 2020). Dongfanghong 1, China's First Independently Developed Satellite, is Launched Successfully on April 24, 1970. <http://en.sasac.gov.cn/2020/04/24/c_1360.htm>.

182 Von der Dunk (2010), *supra* note 179, p. 203.

183 UN Doc. A/76/77 (13 July 2021). Report of the UN Secretary-General on Reducing space threats through norms, rules and principles of responsible behaviours, p. 49.

5.3.1.1 Apportionment of Liability for Damage Caused

The first issue is the apportionment of liability for damage caused to space objects of third parties. As ADR operations entail greater risks than conventional space activities, especially during the rendezvous, capture and relocation phases, there is accordingly a higher probability of liability exposure. Therefore, States involved in the ADR operations may enter into prior agreements to determine which State should bear what liability and to what extent.[184] The Liability Convention provides that the participants in a joint launching may conclude agreements regarding the apportioning among themselves of the financial obligation to compensate third parties for the damage caused.[185] When the State of registry of a debris object purchases removal services from another State, it can be regarded as the State which "procures" the launching of the removal spacecraft, and can thus be qualified as a "launching State" of such spacecraft.[186] Therefore, the Liability Convention can serve as a basis for the conclusion of an agreement to apportion liability among the States concerned.

Reference can further be made to UN General Assembly resolution 59/115 of 2004 which recommends States to "consider the conclusion of agreements in accordance with the Liability Convention with respect to joint launches or cooperation programmes".[187] The ADR program is beyond doubt also a "cooperation program" as States need to work closely, including in data sharing, to ensure the success and safety of the mission. Therefore, this resolution could also be seen as a basis for States to conclude agreements for the apportioning of liability for damage caused. In any event, each State possesses the capacity to conclude treaties, and there is no law prohibiting States involved in an ADR project from apportioning among themselves the ultimate burden of compensation through agreements.[188]

In an ADR operation, damage to a third party in outer space could be caused either by the removal spacecraft or the target debris object, and their respective launching States could be held liable if "fault" can be established. Obviously, before the removal spacecraft conducts any operation in relation to the target debris object that alters its trajectory, the launching State of the removal spacecraft should not be held liable for damage caused by the debris object. Meanwhile, since the capturing and detumbling phases when the removal spacecraft exerts some physical impacts on the target debris

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184 Way, T. & Koller, J. (22 April 2021). Active Debris Removal: Policy and Legal Feasibility. *The Aerospace Corporation*, p. 4.

185 Art. V(2), Liability Convention.

186 Way & Koller (2021), *supra* note 184, p. 4.

187 UN Doc. A/RES/59/115 (10 December 2004), UNGA resolution on Application of the concept of the "launching State".

188 Art. 6, Vienna Convention on the Law of Treaties, adopted 22 May 1969, entered into force 27 January 1980, 1155 UNTS 331: "Every State possesses capacity to conclude treaties."

object which subsequently causes damage to a third party, a causal link can arguably be established between the removal spacecraft and the damage caused. For instance, this could be a scenario where a removal spacecraft accidentally "bumps" the debris object out of its original orbit which, as a consequence, causes damage to a third party's spacecraft.[189]

During the RPO when the removal spacecraft approaches the target debris object, there is a risk that these two objects may collide, and the debris fragments thereby generated cause damage to other spacecraft. Under the Liability Convention, the launching States of the former two spacecraft, if proven at fault, would be held jointly and severally liable for the damage caused. Following the grappling phase, the removal spacecraft and the target debris object might become one combined stack which moves towards a graveyard or re-entry orbit for the purpose of disposal. Damage may be caused by the combined stack to other space objects during the orbit transfer. In light of their involvement in the ADR operation, both the removal spacecraft and the target debris object seem to have some causal links with the damage.[190] However, the operator of the removal spacecraft appears more likely to be blamed as it is executing actual control over the combined stack.

Fault-based liability applies in the above scenarios, as damage is caused to objects in outer space. Meanwhile, damage may also be caused to the ground, e.g., the removal spacecraft accidentally causes the uncontrolled reentry of the target debris object which survives the re-entering process and inflicts damage to persons or property on Earth. In this case, the launching States of the target debris object would be absolutely liable for compensation. The States involved in an ADR operation may conclude agreements to specify how the burden of compensation for the damage is to be apportioned among them if damage occurs.

For the harmonisation of practices on liability apportionment, an analogy could be drawn from the International Commercial Terms (Incoterms) rules published by the International Chamber of Commerce (ICC), which define a series of standardised trade terms for the sale of goods.[191] For example, the transaction parties may choose to agree that risks of loss of or damage to the goods transfer from the seller to the buyer from the point when the goods are loaded on the vessel nominated by the buyer at the named port of shipment. Similarly, for an ADR operation, the States involved may agree, for instance, that the State operating the removal spacecraft bears

189 Blount (2019), *supra* note 36, p. 184.

190 In spite of their combination into one "stack", these two spacecrafts should still be considered distinct space objects as they are registered by different States.

191 The latest edition of the Incoterms rules is Incoterms 2020. The previous edition, Incoterms 2010, remains in effect for those using them. See ICC. Incoterms 2020. <https://iccwbo.org/resources-for-business/incoterms-rules/incoterms-2020/>.

the ultimate burden of compensation for any third-party liability from the moment when the removal spacecraft or its components parts contact the target debris object.

5.3.1.2 Legal Arrangements for Export Control

A critical challenge for international cooperation in ADR programs is export control. To safely rendezvous with, grapple and remove a debris object, the State of registry may need to share potentially sensitive data of such object to the engaging State.[192] These data may involve essential interests such as national security and intellectual property rights.[193] Therefore, the removal by one State of an object under the jurisdiction of another State may trigger the application of export control laws and regulations of the latter State.[194] As a result, cooperative ADR missions are more likely to occur among mutually trusted or allied States.[195]

The export control restrictions do not necessarily rule out the possibility of the removal of objects under foreign jurisdiction. For instance, the US ORBITS Act expressly addresses international cooperation in ADR program.[196] The Act, which would direct NASA to establish an ADR demonstration program, provides that in carrying out such program, "it is critical that the Administrator [of NASA], in coordination with the Secretary of State and in consultation with the National Space Council, cooperate with one or more partner countries to enable the remediation of orbital debris that is under their respective jurisdictions".[197] Therefore, should this bill be passed as law, the US may consider removing space debris under the jurisdiction of other States through international cooperation.

To alleviate export control concerns, the State of registry could conclude an agreement with the engaging State to limit the use and dissemination of sensitive technical data. Reference can be made to the 1998 ISS Intergovernmental Agreement (IGA), which sets forth restrictions for the transfer of technical data and goods under the Agreement.[198] Under the ISS IGA, tech-

192 Way & Koller (2021), *supra* note 184, p. 10.
193 NRC. (2011). *Limiting Future Collision Risk to Spacecraft: An Assessment of NASA's Meteoroid and Orbital Debris Programs*. The National Academies Press, p. 84. <https://doi.org/10.17226/13244>.
194 Way & Koller (2021), *supra* note 184, p. 10.
195 Ibid.
196 Sec. 4(b)(7), US ORBITS Act, *supra* note 5.
197 Ibid.
198 Agreement among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America concerning Cooperation on the Civil International Space Station ("ISS-IGA"), Washington, done 29 January 1998, entered into force 27 March 2001. The text of the ISS-IGA is available at: <https://www.state.gov/wp-content/uploads/2019/02/12927-Multilateral-Space-Space-Station-1.29.1998.pdf>.

nical data or goods that are to be protected for export control purposes shall be marked by the furnishing Cooperating Agency with a notice or specific identification, which shall indicate any specific conditions regarding the use of such technical data or goods.[199] The conditions include: (1) such technical data shall be used only for the purposes of fulfilling the responsibilities of the receiving Cooperating Agency under the IGA or relevant Memorandums of Understanding (MOUs), and (2) such technical data or goods shall not be used by any third parties or for any other purposes without the prior written permission of the furnishing Cooperating Agency.[200] Similar restrictions are made for technical data to be protected for proprietary rights purposes as well as for classified technical data and goods.[201] Modelling after these provisions, should the States involved in an ADR operation consider it necessary, they could make similar legal arrangements for data management and protection.

Due to the strategic sensitivity of ADR technologies, export control issues may also constitute a hurdle for States to pool their resources to jointly develop ADR technologies and programs.[202] Under US law, technologies involved in ADR operations can likely match several descriptions on the United States Munitions List (USML), a list identifying defence and space-related articles, services, and technical data subject to the US International Traffic in Arms Regulations (ITAR).[203] In particular, paragraph (a)(12) of Category XV of USML entitled "Spacecraft and Related Articles" applies to spacecraft that "[a]re specially designed to provide inspection or surveillance of another spacecraft, or service another spacecraft via grappling or docking". Therefore, the export of many ADR technologies is regulated under the ITAR, and a license has to be obtained from the US Directorate of Defense Trade Controls (DDTC). Besides ITAR, dual-use space products and technologies listed on the Commercial Control List (CCL) are subject to export control under the Export Administration Regulations (EAR), which may apply to some less-sensitive items and technologies used for ADR operations.[204]

In addition to export control regulations, there may be other legal and political restrictions that could hinder international cooperation. For instance, in

199 Art. 19(3)(a), ISS-IGA.
200 Ibid.
201 Art. 19(3)(b) & Art. 19(3)(c), ibid.
202 Popova & Schaus (2018), *supra* note 178, p. 10.
203 For a discussion on the application of US export control regulations to ADR and OOS technologies see Rivière, A. (2020). Potential Export Control Challenges and Constraints for Emerging Space Debris Detection and Removal Technologies: The Case of On-Orbit Collision. *Advances in Astronautics Science and Technology*, *3*(2), pp. 105-114.
204 US Department of Commerce and Federal Aviation Administration. (November 2017). *Introduction to U.S. Export Controls for the Commercial Space Industry*. 2nd ed., p. 5. <https://www.space.commerce.gov/regulations/satellite-export-control-regulations/>.

2011, the US Congress included a passage, known as the Wolf Amendment, in the annual Commerce, Justice, and Science (CJS) appropriations bill.[205] This bill restricts NASA, the Office of Science and Technology Policy (OSTP) and the NSC from cooperating with China and Chinese-owned companies.[206] The Wolf Amendment constitutes a hurdle for the US and China, the two major spacefaring nations in the world, to enter into cooperation in the space field.[207]

In light of these legal restrictions, together with the dual-use sensitivity of ADR technologies, although it would be desirable for the international space community to pool technical and financial resources into the advancement of ADR technologies and the execution of ADR programs, global-scale cooperation does not seem practicable at least in the near future. Meanwhile, States and international organisations, such as those that have established traditions of cooperation in the space field, may collaborate among themselves at a smaller scale through bilateral or multilateral agreements to jointly develop ADR technologies and perform ADR missions. ESA's Sunrise project, which has been financially backed by the UK Space Agency and includes the development of ADR technologies, illustrates the feasibility of international cooperation in ADR activities.[208]

5.3.2 Provision of Information on the Removability of Space Debris

As discussed in Chapter 4, although UNGA Resolution 62/101 recommends States to provide the UN Secretary-General with additional information regarding the change of operational status of their space objects, pursuant to Article VIII of the OST, the valid consent of the State of registry is still needed for the removal of its non-functional objects, i.e., space debris. Since even a defunct space object may still involve strategic and national security interests, States would need to determine the grant of permission for removal according to the sensitivity of the target concerned. The higher the sensitivity level, the more defensive the State of registry could be to avoid the divulgence of classified information entailed in the space object

205 The passage is commonly referred to as the "Wolf Amendment" because it was introduced by Representative Frank Wolf of Virginia. See e.g., Marshall, W., & Hadfield, C. (15 April 2021). Why the U.S. and China Should Collaborate in Space. *Time*. <https://time.com/5954941/u-s-china-should-collaborate-in-space/>

206 Ibid.

207 This hurdle is not unsurmountable. A recent instance is that NASA-funded researchers have been granted permission from the Congress, in an exception to the prohibition on bilateral activities according to the Wolf Amendment, to apply for access to portions of samples collected by China's Chang'e-5 mission. See Jones, A. (1 December 2023). NASA Researchers Get Permission to Apply for China's Moon Samples. *SpaceNews*. <https://spacenews.com/nasa-researchers-get-permission-to-apply-for-chinas-moon-samples/>.

208 ESA. (24 May 2021). First Leap for Beam-Hopping Constellation. <https://www.esa.int/Applications/Telecommunications_Integrated_Applications/First_leap_for_beam-hopping_constellation>.

as a result of removal by others. Therefore, it is ultimately at the discretion of the State of registry to determine whether and how its space objects are to be removed.

Following an evaluation of the sensitivity of its space objects, the State of registry may decide that some of its debris objects are closely associated with its national security interests for which no permission for removal would be granted in any event, while some do not contain any sensitive information. There could also be objects in between these two cases for which the grant of removal permission is possible but further negotiations are needed according to the circumstances. For instance, from an export control perspective, it is more likely for the US to grant permission to its allies such as Japan and the UK than to other countries.[209]

To facilitate the removal of space objects under foreign jurisdiction, this dissertation proposes that the UN General Assembly could recommend its member States to furnish "additional information" on the removable status of their space objects to UNOOSA. For instance, States may categorise their non-functional objects in orbit as non-removable, negotiable, and free for removal, or as appropriate into more specific classifications. The State of registry may impose conditions on the removal operations, such as restrictions on the removal methods to reduce the need to share sensitive data.[210] If it so wishes, the State of registry may also include in the notification the reward it is willing to pay for the removal, motivated by, for instance, its desire to live up to the commitment it has made to remove space debris. This provision of additional information can be regarded as an invitation to tender to the international community, and a State interested in the removal may enter into consultation with the State of registry to determine the technical and legal issues involved in the ADR operation. Through the consultation process, the State of registry could exercise necessary control over the planning and conducting of the operation to ensure that its interests would not be adversely affected.

As noted in Chapter 2, to preserve the long-term sustainability of the outer space environment, priority of debris removal should be given to massive space objects with a high risk of collision, as they are potential sources of fragmentation debris. Therefore, States may individually or jointly establish a list of the most dangerous space debris objects under their jurisdiction and provide, to the greatest extent feasible, information on the removable status of the top-ranking objects. The list of the top 50 statistically-most-concerning objects in LEO produced by a global consortium of experts could serve

209 Way & Koller (2021), *supra* note 184, p. 10.

210 As submitted by Way and Koller, "a debris-capturing net would not necessarily require many technical details of the internals of the satellite" compared to the use of other more sophisticated docking mechanisms. See ibid.

as a basis for international discussion.[211] A step towards this direction may be taken by the US if its ORBITS Act can be passed as law, which would direct the Secretary of Commerce to lead the efforts in publishing a list of identified space debris that "may be remediated to improve the safety and sustainability of orbiting satellites and on-orbit activities".[212] If the major spacefaring nations could provide in good faith information on the removability of their most dangerous debris objects, then the international community could have a good list of removal targets for ADR operations.

5.3.3 Removal of Space Objects of Unknown Origin

As the current space surveillance systems only allow the tracking and cataloguing of objects larger than 5-10 cm in LEO and larger than 0.3-1.0 m in GEO, the origin of most debris objects cannot be identified. Therefore, a question arises as to whether objects of unknown origin can be targeted for removal, if in the future the removal of small-sized debris objects becomes a feasible option. Pursuant to Article VIII of the OST, the State of registry retains jurisdiction and control over its space object after its useful life, and even after such object has been fragmented into pieces. In addition, the owner retains perpetual ownership of its space object, whether such object remains in outer space or returns to Earth. Therefore, the break of identity link between the State of registry and its space object does not affect the sovereign and ownership link between them from a legal perspective.

Reference can be made to Article X(2) of the Liability Convention, which provides that if "a State does not know of the occurrence of the damage or has not been able to identify the launching State which is liable, it may present a claim within one year following the date on which it learned", or should have learned through the exercise of due diligence, of the aforementioned facts. This provision indicates that the unidentifiability of a space object causing damage does not exonerate its launching States from liability of compensation, which can be subsequently claimed by the injured State following the establishment of the identity within the one-year time limit. As the liability link is not cut off even when the identity of a space object cannot be ascertained, so should the sovereignty link between the State of registry and its space object. An understanding otherwise would render the allocation of responsibility and liability under international space law asymmetric.[213]

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211 McKnight, D. S., Witner, R., Letizia, F., Lemmens, S., Anselmo, L., Pardini, C., Rossi, A., Kunstadter, C., Kawamoto, S., Aslanov, V., Dolado Perez, J.-C., Ruch, V., Lewis, H., Nicolls, M., Liu, J., Shen, D., Wang, D., Baranov, A., & Grishko, D. (2021). Identifying the 50 Statistically-Most-Concerning Derelict Objects in LEO. *Acta Astronautica*, *181*, pp. 282-291.

212 Sec. 4(a), US ORBITS Act, *supra* note 5.

213 Su, J. (2016). Active Debris Removal: Potential Legal Barriers and Possible Ways Forward. *Journal of East Asia and International Law*, *9*, p. 408.

In addition, an attempt to argue that a space object becomes *res nullius* when its identity cannot be ascertained can create complexities in practice, for there is no global unitary SSA data centre. The leading spacefaring nations and agencies in the world have developed their own SSA capabilities, and there are also private entities such as the Space Data Association (SDA), which is an organisation of satellite operators that collect and share SSA data.[214] Therefore, if the existence of sovereignty rights and ownership is contingent on the identifiability of space objects, a question may arise as to how to deal with the information inconsistency among different SSA systems. This approach would also render the legal status of unidentifiable objects unstable, for with the advancement of SSA technologies, a space object of unknown origin today may be able to be associated with a certain launching State tomorrow.

Still, it is impossible for a State planning an ADR mission to request consent for the removal of an unidentifiable object, for the launching State of such object is unknown. As submitted by Larsen, uncertainty about ownership of unidentifiable space debris creates "legal difficulty as to the right of third party states to remove such debris".[215] As a result, States would be hesitant to select this kind of object as their removal target.[216] In this regard, the CONFERS Recommended Practices provide a solution for servicing space objects with no known owner:

> "For cases where no owner of the space object can be identified (e.g., space debris objects) provide adequate public notice and communication of intent with all States agencies which may have reasonably been the source of the object. If the source is identified during/following the [on-orbit] service, notify the relevant States."[217]

Similar recommendations can be found in ISO 24330.[218] As noted in Chapter 4, both the CONFERS Recommended Practices and ISO 24330 apply to ADR, which is considered in these instruments as a category of OOS. Hence, the above recommendations are applicable to the removal of space debris of unknown origin. Admittedly, prior notification and timely communication of intent to States that are possibly the source of the object can increase the transparency of the removal missions and solve some problems

214 Blount, P. J. (2019). Space Traffic Management: Standardizing On-Orbit Behavior. *American Journal of International Law*, *113*, p. 122.In addition, private companies such as LeoLabs and NorthStar also collect SSA data and provide commercial SSA services. See e.g., Rainbow, J. (17 June 2022). Getting SSA off the Ground. *SpaceNews*. <https://spacenews.com/getting-ssa-off-the-ground/>.

215 Larsen, P. B. (2018). Solving the Space Debris Crisis. *Journal of Air Law and Commerce*, *83*(3), p. 486.

216 Ibid.

217 Sec. 1.4.1.2., CONFERS Recommended Practices.

218 Secs. 5.2.1.2. & 5.2.1.3., ISO 24330:2022.

by allowing the potential State of registry to claim identity. Yet, there remain several legal issues to be considered.

Firstly, there are issues relating to compensation and payment. On the one hand, if the origin of a de-orbited object is identified after the mission, can the State of registry claim compensation from the ADR operator by contending that the de-orbited object still has value? Or can the State of registry be asked to pay because a hazard has been removed from space? On the other hand, if the target debris object causes damage to third parties during the ADR operation, who is liable? The launching States of the ADR spacecraft could be liable if such spacecraft collides with the target debris object and thereby causes damage to others as per Article IV(1) of the Liability Convention. However, what if the debris object is accidentally and uncontrollably knocked out of orbit by the ADR spacecraft and thereby causes damage to a third State?[219] If the launching State of the target debris object is identified after the operation, should it be held at fault and liable for the damage caused?

Secondly, if the State of registry of the target debris object is identified and notified during the ADR operation, and such State requires the cessation of such operation, is the ADR operator obliged to cease the operation? If the operation is ceased, should the State of registry compensate the ADR operator for the expenses incurred for planning and conducting the ADR operation? What if the State of registry demands the ADR operator to relocate the removed object to its original position?

Thirdly, since there are many identifiable objects that could be selected as removal targets, especially many massive objects that are potentially a long-term source of space debris, selecting an object with no known owner as the removal target could raise doubts of other States as to the real intention underlying the ADR operation. In particular, knowledge of the physical state of the debris object, including its physical and orbital properties, is a critical factor relating to mission success.[220] In this sense, it would be presumably safer to select objects of known origin as removal targets since their owners may provide useful information to facilitate the removal operation. Therefore, to avoid unnecessary misunderstandings, the State planning the removal of an unidentifiable space debris object may need to explain the rationale for target selection in a public notice.

Until consensus can be reached among States on the above matters, the removal of objects of unknown origin may bring about many legal risks and uncertainties. In addition, there may also be political implications if

219 Blount (2019), *supra* note 36, p. 184.
220 May, C. R. (25 January 2021). Game Changer: Triggers and Effects of an Active Debris Removal Market. *The Aerospace Corporation*. <https://csps.aerospace.org/papers>.

the removed object is considered as entailing strategic values for its State of origin, which may be identified during or after the mission. Therefore, unless in exceptional circumstances where inaction would have far greater negative consequences, it is preferable for ADR operators to focus on objects of known origin.

As mentioned earlier, most unidentifiable debris objects are small fragments that cannot be tracked or catalogued by current SSA systems. While the removal of large and massive objects is generally considered to be a more practical and cost-effective option as these objects are the potential sources of small debris,[221] the removal of small-size debris can help to reduce the risk to the current fleet of operational spacecraft.[222] Therefore, when it becomes technically and economically feasible, entities possessing a vast amount of space assets in orbit would also have the motivation to remove small debris.[223] These entities may include spacefaring nations such as the US and mega-constellation operators such as SpaceX, which can have strong interests in ensuring the safety of their spacecraft.

Reference can be made to the "*Satellite Orbital Safety Best Practices*" jointly released by the American Institute of Aeronautics and Astronautics (AIAA) and the major constellation operators Iridium, OneWeb, and SpaceX in September 2022.[224] Among other things, the document recommends operators to "[i]nvestigate the active satellite populations and *known debris object densities* at the injection orbit and along the trajectory to the final orbit if needed" [italics added].[225] This indicates that space debris densities are something within the safety considerations of constellation operators. Therefore, if such densities substantially obstruct orbital accessibility in the future, these operators would likely initiate the clearance of the orbital space they need for the deployment of their constellations. With regard to governmental actors, the US ORBITS Act recognises that "[e]xploration and scientific research missions and commercial space services of critical importance to the United States rely on continued and secure access to outer space".[226] Similarly, China's national space policy states that "[t]he space industry is

221 UN Doc. A/AC.105/C.1/2012/CRP.16 (2012), *supra* note 103, p. 24.
222 NASA Orbital Debris Program Office. Debris Remediation. <https://orbitaldebris.jsc.nasa.gov/remediation/>.
223 For instance, small debris pieces may be removed through laser technology. See Dumestier, D., Scheidel, D., Rousset, H., Thiry, N., Peltoniemi, J., & Di, A. Space Debris Deflection by Space Based Laser Study. *Proceedings of 8th European Conference on Space Debris*, p. 1.
224 *Satellite Orbital Safety Best Practices Guide*, published 8 September 2022, updated 24 October 2022. <https://www.ascend.events/outcomes/satelittle-orbital-safety-best-practices-by-iridium-oneweb-spacex-aiaa/>.
225 Practice A-1, ibid.
226 Sec. 2(a), US ORBITS Act, *supra* note 5.

a critical element of the overall national strategy".[227] Therefore, it would be in the interest of the spacefaring nations to remove debris pieces in order to protect their space assets. In that case, the jurisdiction over small debris fragments would present a hurdle when with technological development, safe and affordable solutions for the removal of small debris pieces become available.

To overcome this obstacle, States may consider concluding an international agreement to jointly consent to the removal of small debris fragments under their jurisdiction in order to facilitate the removal of these fragments. In the agreement, the States Parties may define what "small debris fragments" means, e.g., space debris pieces below the size threshold of 5 cm. Since it is less likely for debris fragments to contain sensitive data compared to large intact space objects, there would be fewer strategic and national security concerns and thus easier for States to reach consensus. Reference can be made to draft guideline 22 proposed in the development of the LTS Guidelines.[228] This draft guideline recommends the establishment of a shared vision which allows States, consistent with their authority and responsibilities under international space law, to adjust the "status of space objects under their jurisdiction and control (including objects originally part of such space objects)" that have become non-functional, "so as to provide definitive eligibility with regard to potential international efforts" to remediate space debris.[229] This is particularly relevant to space debris fragments when "it is convincingly established that such fragments have irretrievably lost the ability to function or sustain functionality and that lifting constraints on their removal could be the best solution".[230] International bodies like COPUOS could promote this process by encouraging States to pursue negotiation in good faith on issues relating to the effective removal of debris fragments such as the determination of a commonly accepted size threshold and the investigation of reliable removal methods.

5.3.4 Adoption of a UNGA Resolution to Promote International Cooperation on ADR

The recommendations proposed in this section may be adopted by States in the form of a UN General Assembly resolution. Specifically, to facilitate international cooperation for debris removal, it would be beneficial for States to harmonise their practices, as this could provide more legal certainty and streamline the process of negotiation. An analogy can be drawn

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227 State Council Information Office of China. (January 2022). *China's Space Program: A 2021 Perspective*. The text of the policy is available at: <https://www.cnsa.gov.cn/english/n6465645/n6465648/c6813088/content.html>.

228 UN Doc. A/AC.105/C.1/L.367 (2018), *supra* note 112, pp. 6-7.

229 Ibid, p. 7.

230 Ibid.

to UN General Resolution 59/115 of 2004, which recommends COPUOS to invite its Member States to "submit information on a voluntary basis on their current practices regarding on-orbit transfer of ownership of space objects".[231] The resolution further recommends States to "consider, on the basis of that information, the possibility of harmonizing such practices as appropriate with a view to increasing the consistency of national space legislation with international law".[232] Similarly, the UN General Assembly could adopt a resolution recommending States to share their experiences and standardise their practices regarding international cooperation in ADR.

The resolution can also recommend States to submit additional information to UNOOSA about the removability of their space objects, to establish a priority list of candidate debris targets for removal, and to pursue negotiations on the possible solutions for the remediation of small debris fragments. These recommendations could either be adopted as a distinct resolution dedicated to the enhancement of the practices of States in international cooperation regarding ADR, or be incorporated in the annual UN General Assembly resolution on international cooperation in the peaceful uses of outer space. If implemented by States in good faith, these recommendations could facilitate the seeking and granting of approval among States for the removal of existing debris objects in orbit that pose significant threats to space safety and sustainability. In addition, the recommendations may help to surmount the legal hurdle for the removal of debris objects of unknown origin, in particular small debris fragments.

5.4 *Issue 4*: Norms of Responsible Behaviours to Address Dual-Use Concerns over ADR

As mentioned in Chapter 3, when a removal spacecraft is used for peaceful purposes, such spacecraft should not be considered as a "weapon" or "weapon of mass destruction". Therefore, States are not prohibited from deploying and using ADR mechanisms in outer space. However, while being lawful is a *conditio sine qua non* for being responsible, a responsible behaviour requires more than acting in compliance with international law. As noted by Canada, an action that is lawful under international law does not necessarily mean that such action can be viewed as responsible, and Canada encourages States to act both lawfully and responsibly in outer

231 UN Doc. A/RES/59/115 (2004), *supra* note 187, para. 3. As noted by Way and Koller, transfer of ownership of the target debris object is not needed for ADR, just like the owner of a defunct car does not need to transfer ownership to a towing company for removing such car. See Way & Koller (2021), *supra* note 184, p. 8.

232 Ibid, para. 4.

space.[233] In particular, as Norway submits, [s]ome legitimate operations in space, such as close proximity or inspection operations, can easily be mistaken for dangerous or even hostile operations".[234] Since ADR technologies and capabilities may raise security concerns due to their dual-use nature, norms of responsible behaviours should be developed to reduce the risks of misperceptions and unwanted tensions associated with ADR operations. Section 5.4.1 will assess the approach and form to be taken for the development of norms and principles on reducing space threats within the OEWG. Section 5.4.2 will analyse the views of States and international organisations regarding the possible norms of responsible behaviours for ADR.

5.4.1 The Way Forward for Normative Development to Reduce Space Threats

There are essentially two approaches for normative development to govern issues relating to space security: a behaviour-based approach and a capabilities-based approach.[235] The former approach is adopted in the UNGA Resolution 76/231 of 2021, where the General Assembly decides to convene, beginning in 2022, an Open-Ended Working Group (OEWG):[236]

(a) To take stock of the existing legal and other normative frameworks concerning threats arising from States' space-related behaviours;
(b) To consider current and future threats by States to space systems and actions, activities and omissions that could be regarded as irresponsible;
(c) To make recommendations on possible norms, rules and principles of responsible behaviours in outer space including, as appropriate, how they would contribute to the negotiation of legally binding instruments; and
(d) To submit a report to the General Assembly at its seventy-eighth session in 2023.

The mandate of the OEWG shows that it will focus on behaviours, actions and activities for future normative development. As noted in an Executive Brief published by the European Space Policy Institute (ESPI), this represents "a shift in approach to consider and value behaviours – instead of technological hardware and capabilities – as the basis for international norm-setting".[237] Many States and international organisations have underlined the advantages of a behaviour-based approach. In France's view, a behaviour-based approach obviates the need for distinguishing between

233 UN Doc. A/AC.294/2022/WP.7 (6 May 2022). Canada's Views on Reducing Space Threats through norms, rules and principles of Responsible Behaviour, para. 9.
234 UN Doc. A/76/77 (2021), *supra* note 183, p. 75.
235 Ibid, pp. 11-12.
236 UN Doc. A/RES/76/231 (2021), *supra* note 10.
237 ESPI. (November 2021). UN Resolution on Norms of Responsible Behaviours in Space – a Step Forward to Preserve Stability in Space? *ESPI Briefs No. 54*, p. 1.

aggressive and peaceful capabilities and ultimately, to decide which capabilities to prohibit.[238] France further adds that a behaviour-based approach "is more suitable [than a capability-based approach] as it cannot be rendered obsolete by future technological development".[239] Similarly, Japan submits that the inherently dual-use nature of space technologies "brings complexity to verification".[240] Therefore, Japan considers it more feasible for States to reach "a common understanding on patterns of behaviors that are regarded as either responsible or irresponsible", which can serve as measurable criteria for the verification of compliance.[241] The behaviour-based approach is also advocated by the EU and its Member States as "the most pragmatic and immediate way forward to improve space security today", for it "will help to reduce the risks of misunderstanding, misinterpretation and miscalculation, and therefore decrease the risks of conflicts and escalation in outer space."[242] Since ADR systems have inherent dual-use potential, a behaviour-based approach constitutes a feasible path forward for their governance by specifying the measures that ADR operators should take to ensure mission transparency.

UNGA resolution 76/231 also states in its preamble that the further development and implementation of norms, rules and principles of responsible behaviours in space might "contribute to further consideration of legally binding instruments on the prevention of an arms race in outer space".[243] This is also reflected in the mandate of the OEWG, which, as mentioned earlier, is to make recommendations on how possible norms, rules and principles of responsible behaviours "would contribute to the negotiation of legally binding instruments".[244]

In fact, many States and international organisations consider the development of non-legally binding norms and principles as a pragmatic first step towards the establishment of international legally binding agreements. In particular, as noted in an EU contribution, most of the provisions contained in legally binding treaties governing outer space activities were inspired from principles contained in previous UN General Assembly resolutions.[245]

238 UN Doc. A/76/77 (2021), *supra* note 183, pp. 38-39.
239 Ibid, p. 39.
240 Ibid, p. 56.
241 Ibid.
242 The EU. (13 September 2022). Open Ended Working Group on reducing space threats through norms, rules and principles of responsible behaviours - EU Statement. <https://www.eeas.europa.eu/delegations/un-geneva/open-ended-working-group-reducing-space-threats-through-norms-rules-and_en?s=62>.
243 UN Doc. A/RES/76/231 (2021), *supra* note 10, p. 3.
244 Ibid, p. 3, para. 5(c).
245 UN Doc. A/AC.294/2022/WP.5 (5 May 2022), EU joint contribution to the works of the Open-Ended Working Group on reducing space threats through norms, rules and principles of responsible behaviours: second part: existing international legal and other normative frameworks concerning threats arising from State behaviours with respect to outer space, p. 4.

In this context, the EU considers voluntary norms as "useful tools to shape international consensus and to build trust to take more ambitious steps potentially leading to a comprehensive, effective and verifiable legally binding instrument".[246] It follows that non-binding instruments and legally binding treaties should not be seen as mutually exclusive, for both of them are useful in contributing to the preservation of a safe, secure and sustainable space environment.[247] In a similar vein, the UK states that the development of voluntary norms on responsible behaviours in space "is not an alternative to but a first step towards legally binding agreements".[248] To take this first step, the UK suggests the international community to adopt "a holistic, inclusive, and iterative approach, beginning with dialogue and promoting common understanding".[249] The view is also shared by Canada that "pragmatic, non-binding standards of responsible behaviours should be applied as soon as possible which, if accepted by a majority of spacefaring nations, could become legally binding international law in the future".[250]

The above statements show that the discussion within the OEWG for the development of norms and principles to reduce space threats will focus on behaviours. In this sense, what matters most is how States behave and act when carrying out space activities, as distinct from the potential capabilities of their space systems. In addition, this will start from the development of voluntary norms, principles and standards, which are expected to pave the way for the future development of legally binding agreements. In view of the dual-use nature of ADR capabilities, the question is how an ADR operation should be conducted in a way that is perceived as responsible rather than threatening.

5.4.2 Development of Norms of Responsible Behaviours for ADR

At the sessions of the OEWG, States have shared their views and perspectives on the further development and implementation of norms and principles of responsible behaviours in outer space to reduce the risks of misperceptions and misunderstandings. In Canada's view, responsible behaviours in space are "those behaviours that promote the safety, security, and sustainability of outer space activities and the space environment", which can "increase the predictability and general transparency of operations and therefore reduce the potential for hostilities in, from, or through space".[251] These include actions such as the exchange of information and communication with other parties in a timely manner in order to reduce

246 Ibid.
247 Ibid.
248 The UK (2022), *supra* note 255.
249 Ibid.
250 UN Doc. A/AC.294/2022/WP.7 (2022), *supra* note 233, para. 8.
251 Ibid.

adverse impacts to space operations and to avoid misunderstandings of the intent.[252] According to the EU, "the characterisation of what constitutes an irresponsible behaviour should consider the consequences on safety, sustainability and security in outer space as well as international peace, security and stability".[253] In the view of Switzerland, acting responsibly requires States to refrain from "actions that are likely to lead to misperceptions and, therefore, to the risk of escalation".[254]

It can be seen from the above views that the overall objective of promoting responsible behaviours is to ensure the safety, security and sustainability in outer space. To achieve this aim, States should enhance the transparency of their missions in order to clarify intentions and avoid misunderstandings. Specifically, many States and international organisations have shared their views on how RPO are to be conducted responsibly. As RPO can be part of ADR, these views are also relevant to how ADR activities are to be conducted in a responsible manner.

In view of the dual-use nature of RPO, the UK submits that to build trust, it is important that "the development and testing of such technologies is done as transparently as possible and that there are clear and agreed procedures for the conduct of such activity".[255] In addition, as suggested by the Philippines, when a satellite of one State approaches a satellite of another State and leads to a risk of collision, "immediate communication with the potentially affected State is an urgent exigency".[256] Such communication could include "clarification whether the proximity operation arises from a deliberate action, and if so, what is the rationale for such action".[257] This is particularly relevant for satellites with RPO capabilities, for these satellites are more likely to raise security concerns. Therefore, if such satellites accidentally approach other satellites, timely communication would be essential to avoid unwanted tensions.

On the other side of the coin, being responsible means refraining from conducting actions and activities that are considered as irresponsible. The EU

252 Ibid.

253 UN Doc. A/AC.294/2022/WP.18 (15 September 2022). EU joint contribution to the Open Ended Working Group on reducing space threats, Third part: current and future threats by States to space systems, and actions, activities and omissions that could be considered irresponsible: submitted by the European Union, p. 1.

254 UN Doc. A/76/77 (2021), *supra* note 183, p. 91.

255 The UK. (14 September 2022). Statement by the United Kingdom at the 2nd session of OEWG. <https://documents.unoda.org/wp-content/uploads/2022/09/UK-Statement-Topic-3-Current-and-future-space-to-space-threats-by-States-to-space-systems.pdf>.

256 Philippines. (12 September 2022). Statement by the Philippines at the 2nd session of OEWG. <https://documents.unoda.org/wp-content/uploads/2022/09/TOPIC-3-PHL-STATEMENT.pdf>.

257 Ibid.

is of the view that non-transparent RPO may be perceived as a threatening or hostile action.[258] More specifically, "[t]he omission to inform, notify or communicate about a proximity operation that affects another State's space system" is considered by the EU as an irresponsible behaviour.[259] According to Canada, to reduce the potential for a peaceful-use system to be mistaken for a weapon, a responsible behaviour could require States to disclose the mission plan of their ADR and OOS operations.[260] Again, effective communication is considered as a key element to ensure that ADR activities are carried in a responsible manner.

Moreover, Switzerland views that unfriendly RPO in orbit represent a threat to the safety and security of space systems.[261] As RPO technologies can be used to disable the satellite of another State, "[u]nexpected close approaches to foreign satellites without notification, coordination and consent may be interpreted as a hostile act".[262] The threat of hostile RPO may lead countries to equip their satellites with defensive capabilities, which may further jeopardise the stability of space security.[263] Similarly, in Canada's view, the conduct of non-cooperative RPO could be seen as irresponsible or even threatening, such as approaching or following another satellite.[264] In this context, Canada proposes that responsible behaviour could include notification of RPO to potentially affected States in order to coordinate operations and avoid misinterpretation.[265] In brief, RPO should not be conducted in an ambiguous or even threatening manner.

The examination of the views of the States and international organisations indicates that effective and timely notification, consultation, coordination and consent are essential elements for a responsible ADR operation. All these can be considered as TCBMs, which can contribute to reducing or even eliminating the risks of misperceptions and misunderstandings with regard to space activities. In fact, TCBMs constituted one key issue of consideration at the sessions of OEWG. In particular, in his statement at the first session of the OEWG in 2022, Victor Vasiliev, Chair of the GGE, expressed his belief that the GGE Report of 2013 will be helpful for the considerations

258 UN Doc. A/AC.294/2022/WP.2 (13 April 2022). EU Joint Contributions to the Works of the Open-Ended Working Group on Reducing Space Threats through Norms, Rules and Principles of Responsible Behaviours – Part One: Scoping, para. 8.

259 The EU (2022), *supra* note 242.

260 UN Doc. A/AC.294/2022/WP.7 (2022), *supra* note 233, para. 14.

261 Switzerland. (12 September 2022). Remarks by the Swiss delegation at the 2nd session of the OEWG, p. 2. <https://documents.unoda.org/wp-content/uploads/2022/09/2022-09-OEWG-Space-2ndSession-CH-Statement-GenExOfViews-v2.pdf>.

262 Ibid.

263 Ibid.

264 UN Doc. A/AC.294/2022/WP.7 (2022), *supra* note 233, para. 14.

265 Ibid.

of delegates to the OEWG.[266] At the third session of the OEWG held in early 2023, topics 7 and 8 were directly related to TCBMs.[267] Specifically, the UK stated under these two topics that "[i]f States are as transparent as possible about their intentions, capabilities, doctrine and policies it can all help to improve mutual understanding, build trust and reduce risks of conflict".[268] To enhance transparency, the UK referred expressly to the GGE Report of 2013 and encouraged States to implement the measures recommended therein.[269] As discussed in Chapter 4, while the GGE Report of 2013 does not specifically address ADR, many of the recommendations contained in this Report are relevant to ADR and their implementation can help to enhance the transparency of ADR missions.

Although the final session of the OEWG failed to achieve the adoption of a formal report due to the lack of consensus among the participating States, the process has provided a forum for States to share and discuss their views on the nature of threats related to space security and the possible measures to address the potential risk of misperceptions.[270] In particular, many States considered that the dual-use nature of certain types of capabilities and operations such as OOS and ADR makes it difficult to distinguish between threatening and benign capabilities and operations.[271] In addition, many States stressed the importance of effective and timely communication in building transparency and trust, and considered it advisable to elaborate further TCBMs with the goal of preventing an arms race in outer space.[272] On 4 December 2023, the UN General Assembly adopted resolution 78/20, which decides to convene, in Geneva, a new open-ended working group ("OEWG 2.0"), building on the work of the 2022-2023 OEWG and other relevant bodies and the existing international legal framework, "to further elaborate the concept, and to make recommendations on the prevention of an arms race in outer space through the development of norms, rules and principles of responsible behaviours" in areas including, among others, "[r]endezvous operations and proximity operations that could increase the risk

266 Vasiliev, V. (9 May 2022). Statement by the Chair of the GGE on Transparency and Confidence-Building Measures in Outer Space Activities, p. 3. <https://meetings.unoda.org/meeting/57866/statements>.

267 See UN Doc. A/AC.294/2023/INF.1/Rev.2 (31 January 2023). Indicative timetable for the 3rd Session of the OEWG. Topic 7 is entitled "Norms, rules and principles relating to information exchange on space policies". Topic 8 is entitled "Norms, rules and principles relating to information exchange and risk reduction notifications related to outer space activities as well as to consultative mechanisms".

268 The UK. (2 February 2023). Statement by the United Kingdom at the 3rd Session of the OEWG, p. 1. <https://meetings.unoda.org/meeting/57866/statements>.

269 Ibid.

270 The UK. (1 September 2023). Statement by the United Kingdom at the 4th session of the OEWG, p. 2. <https://meetings.unoda.org/meeting/57866/statements>.

271 UN Doc. A/AC.294/2023/WP.22 (1 September 2023), OEWG Chairperson's Summary, para. 40.

272 Ibid, para. 26.

of misunderstanding and miscalculation".[273] Therefore, the discussions and interactions that took place at the four sessions of the OEWG between 2022 and 2023 can serve as a useful basis for future work to develop norms and principles of responsible behaviours for ADR activities to reduce the potential risk of security concerns over these activities.

5.5 Chapter Conclusion

The research question of this chapter is how should international space law move forward to better regulate the four issues relating to the governance of ADR. The potential path forward can be outlined in four words, which are commitment, safety, consent and transparency.

With regard to *Issue 1*, the keyword is "commitment". In view of the global dimension of the space debris problem, collective efforts of the international community are needed to tackle this challenge. However, the current international legal framework for space activities does not impose a clear obligation upon States to mitigate and remove space debris. Considering that the conclusion of a legally binding agreement does not appear a feasible near-term option, the international community has to consider other alternatives to deal with the ever-growing amount of space debris. The path forward may start with some States acting as trailblazers which take the lead in making unilateral and multilateral commitments on space debris mitigation and remediation, and other States may subsequently join the initiative. The US-led moratorium on direct-ascent anti-satellite testing illustrates how a unilateral commitment is joined by other States and leads to the adoption of a UN General Assembly resolution on this matter. The statement and communiqué made by the G7 nations and the ESA-initiated Zero Debris Charter represent examples of commitments at the multilateral and regional levels. This also indicates that some actors are already taking steps to shape global consensus on space sustainability.

The commitments and initiatives made by some forward-looking States and institutions would hopefully create a snowball effect and lead to the adoption of an international agreement systematising the process for the contracting parties to make and review their commitments. The Paris Agreement may serve as a relevant model, and the review mechanisms established in this Agreement could be modelled after for the development of an international agreement to mitigate and remove space debris. With the growing role of private actors in space activities, their involvement in the preservation of the outer space environment will become increasingly important. The Net Zero Space initiative represents an inclusive forum where all stakeholders

273 UN Doc. A/RES/78/20 (4 December 2023). Reducing space threats through norms, rules and principles of responsible behaviours, para. 4.

over the world, ranging from governmental agencies to actors from the commercial and civil sectors, may join the coalition and commit to the sustainable use of outer space. This process, beginning from unilateral and multilateral commitments, and ultimately leading to the commitments made at a global scale, can allow the international community to respond rapidly to the imminent need to tackle the space debris problem. With some States kicking start this process and other States following suit, this process may have already created considerable results in reducing space debris even before the conclusion of a legally binding agreement. It could also exert pressure on States that have not yet done so to commit and act.

With regard to *Issue 2*, the keyword is "safety". Although under the existing international framework for space activities, States are required to carry out their space activities with due regard to the rights and interests of others, which could mean to avoid harmful interference with other space activities and to limit the generation of space debris, the regime does not provide specific guidance on how ADR activities should be conducted in such a manner to comply with these requirements. Also, the ambiguity of the concept of "fault" may disincentivise States from engaging in ADR activities. As soft law can be used to specify the notions of "due regard" and "fault", the development of internationally accepted guidelines and standards for ADR would provide more clarity to ADR advocates. The development of new LTS guidelines may provide general principles for ADR activities, including the overall aim of these activities to contribute to the long-term sustainability of outer space activities. The adoption of this kind of guidelines can be useful in ensuring the safety of ADR, but considering the technical complexity of ADR missions, more specific guidelines on the design and operations of ADR missions are also needed. Some States are starting to develop national guidelines and standard practices expressly addressing ADR activities, and they may inform the future development of international ADR guidelines, which could follow a similar path where the first set of international space debris mitigation guidelines was developed. The contributions of the commercial space sector such as the guiding principles and recommended practices published by CONFERS, as well as the ISO 24330:2022 developed on the basis of the CONFERS publications, can also be used as a foundation for further legal development. The IADC appears an appropriate forum in this regard, because its members include the leading space agencies active in ADR, and the IADC has already addressed this matter to some extent.

With regard to *Issue 3*, the keyword is "consent". Under current international space law, no State can remove a debris object under the jurisdiction of another State without the express consent of the latter. In view of the potential strategic sensitivity of space assets, this regime contributes to the maintenance of international peace and security in outer space. Therefore, the direction of future legal development should be to contemplate the means to promote consensual ADR activities, where a State grants approval to another State to remove a debris object under its jurisdiction and control. To this end, it would be advisable for the UN General Assembly to adopt a resolution, which provides recommendations to facilitate the seeking and granting of approval for debris removal. Firstly, the resolution could recommend States to consider harmonising their practices in bilateral agreements for cooperative ADR programs, such as to establish some standard clauses for liability apportionment and export control. Secondly, the resolution could encourage States to notify the UN Secretary-General of the removability of their space debris objects and the conditions of their removal. This could be made on the basis of the provision of additional information under Article IV(2) of the Registration Convention. It may further encourage States to establish a list of the candidate removal targets that pose critical threats to the space environment. Thirdly, the resolution could recommend States to pursue negotiations on the way to lift the legal constraints on the removal of unidentifiable small debris fragments. One possible option would be for States to agree that they consent to the removal of debris fragments under their jurisdiction below a certain size threshold of, e.g., 5 cm.

With regard to *Issue 4*, the keyword is "transparency". Due to the dual-use nature of ADR technologies and mechanisms, ADR activities may raise security concerns, which should be properly addressed through transparency and confidence-building measures. The discussion took place within the OEWG adopted a behaviour-based approach for further normative development. This can start from the development of voluntary norms and principles of responsible behaviours, which may serve as a basis for the negotiation of legally binding instruments at a later stage. Many States and international organisations have contributed their views and inputs on enhancing the transparency of ADR operations, which can help to clarify the peaceful intention underlying these operations and reduce the risk of misunderstandings. Responsible behaviour may require the prior disclosure of mission plan, timely consultation with potentially affected actors, and effective coordination in the event of contingencies. As discussed in Chapter 4, many recommendations contained in the GGE Report of 2013 can be used to enhance the transparency of ADR missions. As such, the GGE Report could serve as a foundation for the further development of norms and principles of responsible behaviours for ADR to reduce the risk of security concerns over ADR activities. Therefore, the elaboration of specific norms of TCBMs to reduce potential dual-use concerns over ADR activities may represent an area of consideration by the OEWG 2.0 convened to address space threats.

In the end, the four keywords – commitment, safety, consent and transparency – can be boiled down to one word – *communication*:

– Precursors leading international efforts can communicate their commitments and determination to mitigate and remove space debris loudly

and broadly at the international level, calling upon other States and international organisations to follow suit.
- States can share their safety concerns over ADR activities at international forums and exchange opinions on the appropriate measures to address these concerns, which can lead to the development of international guidelines for ADR activities.
- A State contemplating the removal of a debris object under the jurisdiction of another State may clearly communicate the reasons and plans of the mission to the latter State, which could be followed by consultation and negotiation of the terms and conditions of the agreement between them regarding the removal. States may also consider communicating information on the removability of their space objects to the international community.
- Communication is also an essential tool to enhance mission transparency and reduce the risk of misperceptions and misunderstandings regarding ADR activities.

As Masson-Zwaan observes, to ensure the long-term sustainability of space activities, it is important to start actively removing objects from orbit.[274] To that end, it is time for constructive communications within the international community to fill the gaps for the governance of ADR.

274 Masson-Zwaan, T. L. (19 January 2021). Sustainability in Space. *Leiden Law Blog*. <https://www.leidenlawblog.nl/articles/sustainability-in-space>.

6 Concluding Remarks

The central research question addressed in this dissertation is whether the current international legal framework for space activities, consisting of hard and soft law pillars, adequately governs ADR and if not, what are the gaps and how the current legal framework can move forward to fill these gaps. This question is addressed in Chapters 2 to 5 of this dissertation, each seeks to answer a specific sub-question in order to ultimately answer the central question.

Chapter 2 discusses why space debris is problematic and what are the potential issues surrounding ADR to solve the debris problem. Space debris is a problem because it threatens both the safety of space operations and the long-term sustainability of outer space activities. Mitigating the generation of new debris is indispensable but alone insufficient to halt the growth of space debris, and the active removal of about five to ten large debris objects from outer space per year is needed to stabilise the orbital environment. The practical need for debris mitigation and remediation raises a question as to whether the current international legal framework imposes an obligation to mitigate and remove space debris. Due to their high velocity orbiting the Earth, space debris can cause damage to other objects in orbit and thus raise liability issues, which is relevant to ADR activities as these activities involve a high risk of collision and may lead to the creation of more debris if such risk materialises. Therefore, the current liability regime for damage caused by space objects and its implications to ADR activities need to be studied. Meanwhile, if one State cannot effectively remove its own dangerous space debris from orbit, other States may want to do it on its behalf for the sake of protecting their space assets or maintaining long-term space sustainability. Therefore, it is important to understand which State has what rights over space debris under the current legal framework. Finally, the dual-use potential of removal spacecraft may raise security concerns, and it is thus essential for the legal framework to regulate the use of these dual-use systems and the way to carry out ADR activities in a manner to reduce the risks of misperceptions and misunderstandings.

In light of the above issues, **Chapter 3** analyses how the hard law pillar of international space law applies to ADR and whether there are regulatory gaps. This pillar, with the UN space treaties being at its core, provides some basic answers to the regulation of the four issues relating to space debris and ADR, but these answers do not respond satisfactorily to the need for the effective governance of these issues.

Firstly, while the hard law pillar contains provisions that require States to conduct their space activities with due regard to the rights and interests of others and to avoid contaminating outer space, it fails to impose a clear obligation upon States to mitigate and remove space debris, which is problematic in view of the continuing growth of space debris. Secondly, the existing international legal framework for space activities does not provide a specific standard of care for the determination of fault to attribute liability for damage caused in outer space. This creates legal uncertainty for ADR operators in terms of liability exposure and may disincentivise them from conducting ADR operations. Thirdly, under the existing legal framework, the State of registry retains jurisdiction and control over its space object. The interpretation of this provision indicates that the jurisdiction and control over a space object remains after such object ceases to function, and even after such object has been disintegrated into pieces. Therefore, express consent of the State of registry must be obtained before the removal of a space debris object under its jurisdiction. Non-consensual removal may be excused by invoking the circumstances precluding wrongfulness such as necessity and distress under certain conditions. However, non-consensual removal should in general be avoided and should in any event be conducted with caution because this kind of operations can be considered as threatening actions and could thus adversely affect international peace and security in outer space. Therefore, the international community needs to find a way to promote ADR activities undertaken on a consensual basis, namely to facilitate the seeking and granting of permission for debris removal. Fourthly, due to the inherent dual-use nature of ADR systems, namely their capability to remove space debris and to degrade or damage another satellite according to the intention of their operators, the deployment and use of ADR systems can potentially raise security concerns. The hard law pillar imposes restrictions on the use of ADR mechanisms for hostile purposes, but it does not contain specific rules on how ADR operations should be conducted in a manner to assuage potential dual-use concerns.

Chapter 4 discusses whether and how the soft law pillar of international space law contributes to filling the regulatory gaps in the hard law pillar. The analysis shows that some of the gaps in the hard law pillar have been addressed in the soft law pillar of international space law, but there still remain some gaps to be filled in future legal development.

Firstly, the international community has taken some positive steps forward in the form of non-binding instruments on the mitigation of space debris and the preservation of long-term space sustainability. Despite their voluntary nature, these instruments can be implemented by States in their national legal order and become binding to private operators at the domestic level. However, in practice, these instruments are not complied with at a sufficient rate to effectively tackle the space debris problem. In addition, these instruments focus on the mitigation of space debris and the long-term sustainability of outer space activities, yet they do not specifically address ADR. Therefore, further efforts are needed from the international community to promote the mitigation and remediation of space debris. Secondly, soft law instruments, such as the COPUOS Space Debris Mitigation Guidelines and COPUOS LTS Guidelines, can contribute to clarifying the general concepts and provisions of the UN space treaties, including in particular the notions of "fault" and "due regard". Therefore, it would be advisable for the international community to develop specific guidelines and standards on the design and operations of ADR missions, which could be used as a benchmark for the determination of "fault" when an ADR mission causes damage to other space objects. The commercial space sector has stepped forward in this regard by publishing some guiding principles and recommended practices for ADR, and some of these publications served as the foundation for the development of ISO Standard 24330:2022. To enhance the authoritativeness of the relevant standards, States could adopt commonly accepted guidelines for ADR operations like the international space debris mitigation guidelines developed within the IADC and COPUOS, which can embody their political commitments and endorsement on the way to carry out ADR activities in a safe manner. Thirdly, although the UNGA resolution 62/101 provides some recommendations on the provision of additional information to the UN Secretary-General regarding the change of status in operations, this does not solve the legal obstacle of jurisdiction and control as the prior consent of the State of registry is still needed even for the removal of a non-functional object. Currently, an international mechanism facilitating the requesting and granting of approval for the removal of space objects under the jurisdiction of another State is not available, which thus represents a domain for improvement in the future development of space law. Fourthly, a critical manner to reduce dual-use concerns over ADR activities is to enhance the transparency of these activities. This makes the GGE Report of 2013 particularly relevant in this regard, which contains a series of recommendations to enhance the transparency of space activities and build confidence and trust among States. While these recommendations provide useful guidance on the way to carry out space activities, they do not explicitly address ADR and the development of more specific guidelines regarding the way to conduct ADR activities in a transparent manner would be beneficial to reducing the risk of misperceptions over these activities.

In sum, while soft law provides some answers to the legal gaps of hard law for the governance of the four issues relating to ADR identified in Chapter 2, there are still domains where the current international space law needs to move forward to better regulate these issues. In this regard, soft law represents a step-wise approach for the further development of space law, which may pave the way for the conclusion of a binding agreement to govern ADR in the future.

Therefore, when it comes to the central question as to whether the current international legal regime adequately regulates ADR, the answer of this study is no. Through its hard and soft law pillars, the existing regime provides for a basic legal framework applicable to the governance of ADR activities. Yet, there are regulatory gaps calling for further legal development. In this context, **Chapter 5** examines the current initiatives relevant to the governance of ADR activities and assesses how the current legal framework may move forward to accommodate the regulatory needs of these activities.

Firstly, to fill the gap of the lack of an explicit obligation under international law on debris mitigation and remediation, States with a strong intent to ensure the long-term sustainability of outer space activities may lead international efforts by making unilateral and multilateral commitments to mitigate and remove space debris. This process can contribute to the shaping of political will, and an example in this regard is the moratorium on the testing of destructive, direct-ascent anti-satellite missiles, which was initiated by the US and has been subsequently joined by other States, including all EU members. This process could hopefully lead to the conclusion of an international agreement to systematise the process of States to make and review their commitments regarding debris mitigation and remediation, modelling after the 2015 Paris Agreement. In the meantime, all sorts of stakeholders in the space sector, public and private, may commit to taking concrete actions to mitigate the creation of new debris and remediate existing debris within the Net Zero Space initiative.

Secondly, States can develop consensus general principles for ADR activities within the LTS 2.0 Working Group as these activities, due to their inherent risk of collision, can affect the safety of all actors in space. In addition, it is advisable for spacefaring nations, especially those engaging actively in the development of ADR technologies and missions, to develop more specific guidelines to guide the design and operations of ADR activities. IADC represents an appropriate forum in this regard because it has already started to address the issue of ADR and its members are the most technologically feasible ones to perform ADR missions in the near future. In the process of producing these guidelines, the IADC may obtain information from the contributions of the commercial space industry such as the publications of CONFERS, the ISO 24330:2022, and the legal development made by States for the governance of ADR activities.

Thirdly, as prior consent of the States of registry is needed, it would be advisable for States to develop an international mechanism to facilitate the seeking and granting of permission for the removal of debris under foreign jurisdiction. This could be achieved through the adoption of a UN General Assembly resolution providing recommendations on the following areas (i) the elements for consideration in bilateral arrangements for the granting of permission including liability apportionment and export control; (ii) the furnishing of information on the removable status of debris objects to UNOOSA; and (iii) the joint granting of consent to the removal of debris objects below a certain size threshold in order to provide definitive legitimacy for the lawful removal of these objects.

Fourthly, to ensure that peaceful ADR operations would not be mistaken as a threat, the international community could establish, on the basis of the GGE Report of 2013, specific norms and principles to enhance the transparency of ADR operations. As communication will be an important tool to enhance both mission safety and transparency, it would be beneficial for the OEWG 2.0 to work in coordination with the LTS 2.0 Working Group and other relevant initiatives to develop norms and principles for the notification, consultation and information sharing regarding ADR operations.

In sum, the current international space law establishes the fundamental legal framework for the governance of space activities, yet the existing regime is not sufficient to effectively govern ADR. This dissertation identifies the gaps in the existing legal regime and points out the way forward for further legal development to better regulate ADR activities. As stated at the beginning of the preamble of the Outer Space Treaty, the States Parties to the Treaty were "[i]spired by the great prospects opening up before mankind as a result of man's entry into outer space". To ensure that such great prospects would not be "closed down" by the continuous growth of space debris, it is now a time and a mission for space lawyers to demonstrate the contribution and significance of space law to clear up space debris and preserve the future use of outer space.

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Samenvatting (Dutch Summary)

Juridische Aspecten van *Active Debris Removal* (ADR): Regulering van ADR onder Internationaal Ruimterecht en de Weg Vooruit voor Juridische Ontwikkeling

De mensheid wordt steeds afhankelijker van ruimtevaarttechnologieën en -toepassingen, zoals navigatie, communicatie en aardobservatie. Deze diensten zijn essentieel voor een goed functioneren van de samenleving. Aangezien ruimtevaartactiviteiten toenemen in omvang en reikwijdte, wat weerspiegeld wordt in de snel groeiende ruimtevaarteconomie, lijkt de ruimte in de toekomst alleen nog maar belangrijker te worden. Niettemin wordt de bloeiende ruimtevaartsector nu geconfronteerd met een steeds grotere bedreiging: ruimtepuin (*space debris*). Dit bestaat uit niet-functionele, door mensen gemaakte objecten die in een baan om de aarde draaien. Ruimtepuin ontstaat als bijproduct van ruimtevaartactiviteiten en vormt een risico voor de veiligheid van huidige en toekomstige activiteiten in de ruimte.

Technisch gezien kan het probleem van ruimtepuin worden aangepakt door het verminderen en verwijderen van ruimtepuin. Bij het eerste gaat het om de vermindering van de hoeveelheid *nieuw* ruimtepuin als gevolg van ruimtevaartactiviteiten, en bij het tweede wordt *bestaand* puin uit de ruimte verwijderd. Dit laatste wordt ook aangeduid als *Active Debris Removal* (ADR). Uit onderzoek van vooraanstaande ruimtevaartorganisaties zoals het Europese Ruimtevaartagentschap (ESA) en de Amerikaanse *National Aeronautics and Space Administration* (NASA) blijkt dat alleen het verminderen van ruimtepuin niet voldoende is om de toename van ruimtepuin te voorkomen. Aangezien botsingen tussen bestaande objecten in de ruimte kunnen leiden tot voortdurende groei van het ruimtepuin, is ADR nodig om de omgeving in de omloopbaan te stabiliseren. Gezien dit vereiste gaat het huidige onderzoek over de juridische aspecten van ADR. De centrale onderzoeksvraag is:

> Is het huidige internationale juridische kader voor ruimtevaartactiviteiten toereikend voor de regulering van ADR-activiteiten? Zo niet, welke lacunes zijn er en hoe kunnen die worden aangevuld door juridische ontwikkeling?

Hoofdstuk 1 beschrijft de onderzoekscontext en -methode. Vervolgens wordt in hoofdstuk 2, 3, 4 en 5 ingegaan op de centrale onderzoeksvraag.

Hoofdstuk 2 biedt de achtergrond voor de daaropvolgende juridische analyse. Het begint met een algemeen overzicht van wat ruimtepuin is, de problemen die door ruimtepuin worden veroorzaakt en de noodzaak om de problemen aan te pakken met ADR. Vervolgens wordt een aantal toonaangevende ADR-missies beschreven. Tenslotte schetst het hoofdstuk vier belangrijke kwesties rond ADR-activiteiten waarvoor internationaal ruimterecht een oplossing op het gebied van de regelgeving moet vinden.

Ten eerste is er de voortdurende toename van ruimtepuin. Daarom betreft *Kwestie 1* de vraag of het huidige internationale juridische kader staten verplicht ruimtepuin te verminderen en te verwijderen. Ten tweede brengen ADR-activiteiten operationele risico's met zich mee. *Kwestie 2* betreft de internationale aansprakelijkheidsregeling voor schade als gevolg van ruimtevaartactiviteiten en de implicaties daarvan voor ADR. Ten derde moet worden vastgesteld welke staat het recht heeft ruimtepuin te verwijderen. *Kwestie 3* gaat daarom over de juridische status van ruimtepuin, en vooral over de vraag of het onder de huidige wettelijke regeling toegestaan is dat een staat ruimtepuin van een andere staat verwijdert. Ten vierde is ADR een dual-use-technologie. Daarom gaat het bij *Kwestie 4* om de vraag of en hoe in het bestaande internationale juridische kader rekening gehouden wordt met potentiële veiligheidsrisico's en zorgen die deze technologieën met zich meebrengen.

Hoofdstuk 3 gaat over de pijler van *hard law* in het internationaal ruimterecht. Die omvat de ruimteverdragen van de Verenigde Naties (VN) en andere toepasselijke regels van het algemeen internationaal recht. Beoogd wordt te beoordelen of en hoe de pijler van *hard law* een passend antwoord biedt op de regelgevingsbehoeften die worden geschetst in de genoemde vier kwesties. De term 'ruimtepuin' wordt niet expliciet genoemd in de VN-ruimteverdragen, aangezien deze zijn opgesteld in de jaren 1960 en 1970, lang voordat de internationale gemeenschap zich ging bezighouden met het probleem van ruimtepuin. Deze verdragen bevatten echter wel algemene regels en beginselen die kunnen worden toegepast op ruimtepuin en ADR. Toch bestaan er juridische lacunes in de regelgeving rond alle vier de kwesties.

Voor *Kwestie 1* geldt dat de pijler van *hard law* weliswaar bepalingen bevat die relevant zijn voor de bescherming van het milieu in de ruimte, maar geen duidelijke verplichting om ruimtepuin te verminderen en te verwijderen. Voor *Kwestie 2* geldt dat de term ruimteobject weliswaar zodanig kan worden geïnterpreteerd dat ruimtepuin eronder valt, maar dat staten door de bestaande aansprakelijkheidsregeling krachtens het internationaal ruimterecht onvoldoende worden aangespoord om ruimtepuin te beperken en te verwijderen. Dit ligt aan het ontbreken van een voorgeschreven schuldnorm. Dit gebrek aan juridische duidelijkheid kan ADR ook ontmoedigen, met name wanneer rekening wordt gehouden met het hoge risico op botsingen bij deze activiteiten. Voor *Kwestie 3* geldt dat een registratiestaat de jurisdictie en controle over zijn ruimteobject behoudt, zelfs wanneer het object niet meer functioneel is, aangezien ruimtepuin als een bepaalde categorie 'ruimteobject' (*space object*) kan worden beschouwd. De omstandigheden die onrechtmatigheid uitsluiten onder het algemeen internationaal recht bieden weliswaar een aantal juridische gronden voor verwijdering zonder uitdrukkelijke toestemming van de registratiestaat, voor zover aan de vooraf gedefinieerde voorwaarden voor het inroepen van deze omstandigheden is voldaan, maar verwijdering zonder toestemming kan worden opgevat als een vijandige handeling, hetgeen moet worden vermeden. Waar het aan schort is dus een internationaal mechanisme om het vragen en verlenen van toestemming te vergemakkelijken. Voor *Kwestie 4* geldt dat het bestaande internationale juridische kader staten weliswaar verbiedt ADR-systemen voor offensieve doeleinden te gebruiken, maar dat het gebruik van dergelijke systemen voor vreedzame doeleinden nog steeds vragen kan oproepen over de veiligheid, vanwege hun potentiële dual-use-aard. Met deze punten van zorg wordt onvoldoende rekening gehouden in het huidige kader.

Gezien de juridische lacunes in de pijler van *hard law* op het gebied van de regulering van ADR, wordt in hoofdstuk 4 gekeken of en hoe de pijler van *soft law* in het internationaal ruimterecht bijdraagt aan het opvullen van deze lacunes. Na de goedkeuring van de vijf VN-ruimteverdragen zijn er binnen de VN geen nieuwe ruimteverdragen gesloten. Dit betekent niet dat een verdere ontwikkeling van het ruimterecht is uitgebleven. De ontwikkeling van het ruimterecht heeft veeleer de vorm aangenomen van niet-juridisch bindende instrumenten waarin verwacht gedrag en aanbevolen werkwijzen in de ruimte worden aangegeven. Dit wordt gewoonlijk '*soft law*' genoemd. Uit onderzoek naar de pijler van *soft law* blijkt dat niet-bindende instrumenten, ondanks de vrijwillige aard ervan, in verschillende mate de juridische lacunes in de pijler van de harde wetgeving opvullen wat betreft bestuurlijke aspecten van de vier kwesties. Toch zijn er in de toekomstige juridische ontwikkeling nog enkele lacunes op te vullen om deze kwesties effectiever te reguleren.

Wat *Kwestie 1* betreft, betekent de ontwikkeling van internationale richtlijnen voor het verminderen van ruimtepuin en van de '*Guidelines for the Long-term Sustainability of Outer Space Activities*' (VN, 2019) een belangrijke stap voorwaarts in de aanpak van het probleem van ruimtepuin. Deze instrumenten worden echter niet voldoende toegepast om het ontstaan van ruimtepuin effectief te verminderen, noch worden staten hierdoor opgeroepen om ruimtepuin actief te verwijderen. Met betrekking tot *Kwestie 2* zijn instrumenten van *soft law* relevant voor de verduidelijking van de VN-ruimteverdragen, met inbegrip van het begrip 'schuld' (*fault*). Hoewel de commerciële ruimtevaartindustrie al initiatieven heeft genomen om uitgangspunten en aanbevolen werkwijzen voor veilige ADR-operaties te ontwikkelen, hebben staten wel internationale richtlijnen voor het verminderen van ruimtepuin aangenomen, maar nog geen internationale richtlijnen voor ADR. Dit is in de toekomst nodig om de politieke toezeggingen van staten concreet te maken en meer duidelijkheid te verschaffen aan uitvoerders van ADR. Wat betreft *Kwestie 3* bevat Resolutie 62/101 van de Algemene Vergadering van de VN van 17 december 2007, getiteld '*Recommendations on Enhancing the Practice of States and International Intergovernmental Organizations in Registering Space Objects*', nuttige aanbevelingen om de secretaris-generaal van de VN aanvullende informatie te verstrekken over de verandering van de operationele status van ruimteobjecten. Aangezien ruimtepuin echter nog steeds als ruimteobject wordt beschouwd, is verdere juridische ontwikkeling nodig om consensuele ADR-programma's te vergemakkelijken. Wat betreft *Kwestie 4* geldt het volgende voor de algemene aanbevelingen voor maatregelen ter bevordering van transparantie en vertrouwen (*transparency and confidence-building measures*, TCBM's) die zijn voorgesteld door de VN-*Governmental Group of Experts* (GGE) inzake TCBM's voor de ruimte. Hoewel deze aanbevelingen relevant zijn voor het vergroten van de transparantie van ADR, is het raadzaam dat staten specifiekere normen voor verantwoorde ADR-activiteiten ontwikkelen om de risico's van zorgen over dual-use-technologieën te verminderen.

Hoofdstuk 5 gaat over de vraag hoe het bestaande internationale juridische kader voor ruimtevaartactiviteiten de resterende lacunes kan opvullen en ADR-activiteiten beter kan inpassen. Daartoe wordt nauwkeurig gekeken naar verschillende initiatieven en discussies op nationaal en internationaal niveau die relevant zijn voor de ontwikkeling van richtlijnen en normen voor ADR. Op basis van deze initiatieven worden in hoofdstuk 5 aanbevelingen gedaan voor een betere regulering van de vier genoemde kwesties, die in vier sleutelwoorden kunnen worden samengevat: toezegging, veiligheid, toestemming en transparantie.

Het sleutelwoord voor *Kwestie 1* is 'toezegging'. In dit proefschrift wordt voorgesteld dat toekomstgerichte staten het voortouw kunnen nemen bij het doen van unilaterale en multilaterale toezeggingen voor het verminderen en verwijderen van ruimtepuin. Als andere staten dit voorbeeld later volgen, kan dit uiteindelijk leiden tot het aangaan van een internationale overeenkomst waarin systematisch wordt vastgelegd hoe de verdragsluitende partijen hun toezeggingen doen en herzien. De Overeenkomst van Parijs over klimaatverandering kan hierbij een relevant model zijn. Partijen uit de private sector spelen een steeds grotere rol in ruimtevaartactiviteiten. Daarom is het wenselijk om alle belanghebbenden, waar ook ter wereld, erbij te betrekken opdat ook zij zich kunnen verbinden aan duurzaamheid in de ruimte. Het sleutelwoord voor *Kwestie 2* is 'veiligheid'. In dit proefschrift wordt voorgesteld dat staten specifieke internationale richtlijnen ontwikkelen voor de opzet en uitvoering van veilige ADR-missies op basis van bestaande ontwikkelingen op sector-, nationaal en internationaal niveau.

Het *Interagency Debris Coordination Committee* (IADC), dat de kwestie van ADR al tot op zekere hoogte op de agenda heeft gezet, kan hiervoor als forum dienen. Het sleutelwoord voor *Kwestie 3* is 'toestemming'. Gezien de potentiële gevoeligheid van ruimteobjecten moet de verdere juridische ontwikkeling gericht zijn op het bevorderen van ADR-missies op basis van consensus. In dit verband is het raadzaam een resolutie van de Algemene Vergadering van de VN aan te nemen met daarin aanbevelingen om het vragen en verlenen van toestemming voor verwijdering te vergemakkelijken. Deze resolutie kan staten aanmoedigen om hun aanpak te harmoniseren in coöperatieve ADR-programma's, om aanvullende informatie te verstrekken over de verwijderbaarheid van hun ruimtepuin, en om te gaan onderhandelen over de manier waarop de wettelijke beperkingen op de verwijdering van niet-identificeerbare kleine brokstukken kunnen worden opgeheven. Het sleutelwoord voor *Kwestie 4* is 'transparantie'. Om de risico's van misverstanden te verminderen en de veiligheid te bevorderen, is het wenselijk om internationale normen en uitgangspunten voor verantwoorde ADR-activiteiten te ontwikkelen, waaronder bijvoorbeeld het vooraf bekendmaken van missieplannen, tijdig overleg met mogelijk betrokken actoren, en effectieve coördinatie in geval van onvoorziene omstandigheden.

In hoofdstuk 6 wordt de centrale onderzoeksvraag beantwoord. De conclusie is dat het bestaande internationale juridische kader ontoereikend is om ADR adequaat te reguleren. Het huidige kader, dat pijlers van *hard law* en *soft law* omvat, biedt weliswaar een basale juridische structuur die van toepassing is op ADR-activiteiten, maar er bestaan lacunes in de regelgeving voor het in goede banen leiden van deze activiteiten. De vier eerdergenoemde sleutelwoorden wijzen de weg naar verdere juridische ontwikkeling. Daarbij wordt benadrukt dat gezamenlijke toezeggingen, veiligheidsrichtlijnen, op toestemming gebaseerde benaderingen en transparantienormen van belang zijn om het huidige kader beter af te stemmen op ADR-activiteiten.

Curriculum Vitae

Zhuang 'Oliver' Tian was born in Guangdong Province, China on 29 July 1991. He obtained his Bachelor's degree in law from Sun Yat-sen University, China. During his undergraduate studies, Zhuang successfully passed the Chinese Bar Examination and collaborated with his supervisor to translate and publish legal articles from French to Chinese. Furthering his education, Zhuang pursued an LL.M. in Air and Space Law at the International Institute of Air and Space Law (IIASL) of Leiden University, the Netherlands. During the LL.M. program, Zhuang gained practical experience in air and space law through internships at HEAD Aerospace Netherlands in Noordwijk, the Netherlands, and China Southern Airlines in Guangzhou, China. After graduation, Zhuang worked at De Wolf Law Firm Shanghai, first as a legal intern and later as an Associate.

Zhuang commenced his PhD study at Leiden Law School in September 2018. During his time in Leiden, he specialised in the legal aspects of space debris and has published multiple articles in this field in journals and books. In addition to his research, Zhuang coached the IIASL space law moot court for four years and delivered guest lectures on Chinese space law. In 2021, Zhuang participated in the Space Studies Program (SSP) at the International Space University (ISU) in Strasbourg, France, where he enhanced his interdisciplinary skills through collaboration with space experts from diverse backgrounds on team projects.

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ONDERZOEK

The growth of space debris is becoming increasingly problematic for current and future space operations. Active debris removal (ADR) is needed to tackle this problem and stabilise the orbital environment. This research addresses the question as to whether the current international legal framework for space activities adequately regulates ADR and, if not, what the gaps are and how they can be filled.

To answer this question, this research identifies four issues relating to the governance of ADR that need legal answers, including whether an international obligation to mitigate and remove debris exists, what the implications of the international liability regime are for ADR activities, whether it is allowed to remove space debris of other States, and how to address the inherent dual-use nature of ADR technologies.

An examination of the hard and soft law pillars of international space law reveals that while the existing legal framework lays down fundamental rules and principles that apply to ADR activities, it falls short of adequately governing the identified issues associated with ADR. To address the legal gaps, this research analyses initiatives undertaken at national and international levels and provides recommendations for the further development of international space law to better accommodate ADR activities.

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