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Právnická fakulta

Alice Lepesantová

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Faculty of Law

Alice Lepesantová

Legal issues of space debris remediation

Diploma thesis

Thesis Advisor: prof. JUDr. Mahulena Hofmannová, CSc.

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Poděkování

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Contents

Introduction

It has been 66 years since the first artificial satellite, the USSR's Sputnik 1, was launched into outer space and started an era later called the Space Race. Shortly after, a dog named Laika was sent to outer space in Sputnik 2, being the first mammal in outer space. Not to be left behind, the United States launched their first satellite, Explorer 1, a year later in 1958.[1] These successes were quickly followed by others, such as the first weather satellite in space, the first photograph of Earth taken, and eventually, in 1961, the first human spaceflight orbiting the Earth with Yuri Gagarin on board of Vostok 1, followed by the first woman, Valentina Tereshkova, to travel to space and first humans, Neil Armstrong and Edwin Aldrin to land and walk on the Moon during the Apollo 11 mission.[2] Since then, the world has witnessed unprecedented growth in space activities on which our society is dependent for everyday life. Weather satellites, internet connectivity satellites, and navigation systems are only a few examples of such services. However, with growing space activities, the number of space debris in outer space also grows. At first, the population of space debris was negligible. At present, it poses a significant threat to activities in space.

Research has shown that even without new launches of space objects to outer space, the space debris population will continue to grow and, with it, the risk of collision. Potentially, a collision between objects in outer space will occur and it will cause other collisions to follow, leading to a phenomenon described as collisional cascading[3] and later named the Kessler syndrome.[4] Such an event could hinder future space exploration. Fortunately, the international community has recognised the issue of space debris. The first to bring the space debris problem before the United Nations in the 1970s was Luboš Perek, a Czech astronomer and professor, pioneer of space law and the space debris issue.[5] Further recognition of the problem of space debris mitigation and remediation has been brought by another significant Czech space law expert, Vladimír Kopal, who considered space debris mitigation as *"the most pressing issue in this field"*.[6] Guidelines on space debris mitigation were adopted as an effort to mitigate the space debris problem. However, according to recent studies, only mitigation of space debris does not suffice to

[1] NATIONAL GEOGRAPHIC. The history of space exploration.
[2] *Ibid*.
[3] KESSLER, D.J., Collisional cascading: The limits of population growth in lower Earth orbit, p. 12(63).
[4] POPOVA, R. and SCHAUS, V., The legal framework for space debris remediation as a tool for sustainability in outer space, p. 2.
[5] IROZHLAS. Ve věku 101 let Zemřel Významný Astronom Perek. Jeho jméno nese největší český dalekohled.
[6] KOPAL, V., The Progressive Development of International Space Law by the United Nations and its present system., p. 244.

prevent collisional cascading and therefore, active debris removal is needed.[7] The space treaties were negotiated during the Cold War, in a time of race for military and overall superiority of the two world powers. It is, therefore, no surprise that the intentions behind drafting such treaties do not fit today's needs. In addition, at the time the space treaties were drafted, space debris did not even exist.[8] Hence, the space treaties do not specifically deal with space debris. Consequently, the current legal framework rather presents a burden to space debris remediation as it poses legal issues for conducting active debris removal or on-orbit servicing operations. These issues include the absolute character of ownership rights in space, transfer of ownership and unclear liability relations between States during such operations. In addition, the general character of the provisions of the Convention on Registration of Objects Launched into Outer Space present further complications for space debris remediation, along with non-compliance of States with obligations posed in the Convention.

Space activities are rapidly growing and will continue to grow in the future. While active debris removal technologies are still in the development stage, they are on the brink of becoming an imminent reality. With technology advancements driving more launches, drawing attention to these issues and trying to understand and offer possible solutions is necessary. Hence, the author of this thesis will try to answer whether the current international space law provides a suitable legal framework for space debris remediation. This thesis aims to describe the current legal framework and its lacunas, identify and analyse the legal issues surrounding space debris remediation. The thesis also aims to overview possible solutions to these issues with special focus on the International Organisation for Standardisation international standards.

The author uses the following methodology to attain the goals outlined in this thesis. First and foremost, descriptive methods are used to describe and explain space debris remediation and connected issues and establish a foundation for a deeper analysis. Interpretation of space treaties is used to understand the current legal framework governing space activities, including grammatical, systematic, logical, comparative, historical and teleological methods of interpretation of law. Preparatory documents and drafts of space treaties were examined for this purpose. In addition, analogy with different legal departments is used. Current international space law, notably international multilateral treaties, namely the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, the Convention on International Liability for Damage Caused by Space Objects,

[7] LIOU, J., ANILKUMAR, A., BASTIDA VIRGILI, B., HANADA, T., KRAG, H., LEWIS, H., RAJ, M., RAO, M., ROSSI, A., SHARMA, R., Stability of the future LEO environment – An IADC Comparison Study, p. 6.
[8] FORCE, M.K. Active Space Debris Removal: When Consent Is Not an Option, p. 10.

and the Convention on Registration of Objects Launched into Outer Space and non-binding guidelines are the base resources that were used for writing this thesis. The author also used many academic papers and books to discover and understand the legal issues and the solutions connected to space debris remediation. Data were primarily drawn from research papers and reports of international organisations and space agencies such as the National Aeronautics and Space Administration and the European Space Agency.

The first chapter of this thesis is dedicated to defining space debris and its characterisation as a hazard to a safe and sustainable outer space exploration. The gravity of the space debris issue is demonstrated by presenting research which offers predictions on the future development of the space debris population. The second chapter presents space debris remediation as a solution to the space debris problem. It also highlights the importance of space debris mitigation, as one cannot exist without the other for the solutions to be efficient. In the third chapter of this thesis, the individual legal issues of space debris remediation are analysed. The first discussed issue is perpetual ownership and the need for permission of the owner of the space object to conduct a space debris remediation operation. Secondly, liability issues such as the complexity of liability relations in remediation operations and the lack of vital regulation for an effective liability regime are explained. Furthermore, this chapter analyses issues related to the registration of space objects. Lastly, the transfer of ownership of space objects is explained with regard to space debris remediation. Additionally, the chapter offers solutions to the specific legal issues. Chapter four presents some solutions overcoming the lack of binding regulation, namely customary law, space traffic management and international standards issued by the International Organisation for Standardisation. Finally, the conclusion summarises the results and outcomes of the analysis of legal issues described in this thesis.

1. The notion of "Space debris"

Defining space debris properly is crucial for the understanding and application of space law regarding space debris. The first chapter presents several definitions of space debris and their subtle nuances. Furthermore, to provide a broader context, the chapter explains the risks posed by space debris demonstrated on examples of collisions. It also analyses the consequences of further growth of the space debris population. Finally, this chapter provides a brief overview of studies and analyses on the space debris problem and predictions about the future space environment.

1.1. The definition of space debris

There is no unified definition of space debris in space law. However, experts agree on the main characteristics of what constitutes space debris. The text accompanying the United Nations Office For Outer Space Affairs (UNCOPUOS) Space Debris Mitigation Guidelines defines space debris as *"all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional"*.[9] The Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines define space debris almost identically.[10,11] The Technical report on Space debris adopted by the UNCOPUOS provides a more detailed definition of space debris. It defines it as *"Space debris are all man-made objects, including their fragments and parts, whether their owners can be identified or not, in Earth orbit or re-entering the dense layers of the atmosphere that are non-functional with no reasonable expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be authorized"*.[12] Mahulena Hofmann and Tanja Masson-Zwaan define space debris as *"man-made objects in orbit around the Earth that no longer serve a useful function"*.[13] Armel Kerrest offers a more concise definition of space debris, as he defines it as *"a useless man-launched object in outer space"*.[14] Although definitions vary, mainly in their wording, the main aspects stay the same. Luboš Perek shows that even generally agreed-upon characteristics are not always reliable. For instance, a definition of space debris strictly distinguishing between active and inactive objects is not suitable. At least not without knowing who declares such an object

[9] United Nations Office for Outer Space Affairs Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (2010) UN Doc. A/RES/62/217 (hereafter UNCOPUOS Space Debris Mitigation Guidelines).
[10] The IADC Space Debris Mitigation Guidelines define space debris as *"all human made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional"*.
[11] Inter-agency Debris Coordination Committee, IADC Space Debris Mitigation Guidelines, rev. 3, IADC-02-01 (hereafter IADC Space Debris Mitigation Guidelines).
[12] United Nations General Assembly, Committee on the Peaceful Uses of Outer Space. Technical report on space debris: text of the report adopted by the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space. New York 1999 UN Doc. A/AC.105/720.
[13] MASSON-ZWAAN, T., HOFMANN, M., Introduction to space law, p. 109.
[14] KERREST, A. Space debris, remarks on current legal issues, p. 2.

inactive. Perek suggests it would be more suitable to consider the value of an object to the launching State as a factor when deciding whether a space object is debris or not. For instance, active spacecraft are certainly valuable space objects. However, he explains that even inactive military satellites can be valuable to the launching State as they can carry classified information.[15] Thus, only a technical definition of space debris *"as inactive objects with no hope of restoring activities"*[16] does not suffice as multiple factors are critical to the definition of space debris.[17] Many factors come into consideration when defining space debris. Kerrest, for instance, approaches the definition of space debris from different perspectives, considering the consequences on the legal status of the object.[18] Kerrest states that space debris can be defined with respect to three instances: for the purpose of mitigation, for the purpose of liability and for the purpose of remediation. The object's utility should be considered for mitigation purposes as space objects become debris when no longer functional. Because the Convention on International Liability for Damage Caused by Space Objects accounts for space objects in general, according to Kerrest, it is essential to define space debris as a space object for liability purposes. For remediation, the potential value of the debris should be considered.[19] However, it is necessary to analyse whether space debris can be recognised as a space object, which is essential for the purposes of liability. This is further developed in Chapter three.

1.2. Space debris as a threat to the safety of space activities

While space exploration began in the late 1950s, the issue of space debris started gaining attention only in the 1990s.[20] This success is owed also to Luboš Perek, a Czech astronomer and professor, pioneer in the space debris field, who was the first to bring the space debris problem before the United Nations (UN) in the 1970s.[21] Although some of the non-functioning or useless space objects are destroyed by natural decay processes or in controlled re-entries, most of the defunct objects stay in orbit for a long time even after they stop being operational.[22] According to the European Space Agency's (ESA) Space Environment Report 2023,[23] space surveillance networks have detected more than 30 000 trackable pieces of space debris orbiting around the Earth. However, only debris of the size of 5 cm in the Low Earth orbit (LEO) and 1 m in the

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[15] PEREK, L., Space Debris Mitigation and Prevention: How to Build a Stronger International Regime, p. 220.
[16] PEREK, L., Management Issues Concerning Space Debris, p. 2.
[17] *Ibid,* p.2.
[18] KERREST, *supra* note 14, p. 1.
[19] *Ibid,* p. 1.
[20] FORCE, *supra* note 8, p. 9.
[21] IROZHLAS, *supra* note 5.
[22] MASSON-ZWAAN, HOFMANN, *supra* note 13, pp. 110, 111.
[23] ESA, ESA's Annual Space Environment Report 2023, p. 19.

Geostationary Equatorial orbit (GEO) and larger can be detected.[24] The American Air Force's Space Surveillance Network (SSN) can track objects of a size of a softball or larger if they are on the LEO and objects of the size of a basketball and larger if located in higher orbits.[25] The number of small debris pieces can thus only be determined by statistical models. It is worth noting that the numbers may vary as it is impossible to determine the exact number of space debris in outer space due to its size, in fact, the smallest fragments can be smaller than 1 mm. According to ESA's latest statistics[26] the number of debris estimated is 36 500 for space debris larger than 10 cm, one million objects from 1 cm to 10 cm in size, and 130 million objects from 1 mm to 1 cm. [27] Average velocity of objects in space is 10 km/s, which is why even a collision with a small piece of debris can lead to catastrophic consequences.[28] ESA registers over 640 instances of collisions, break-ups or explosions.[29]

Space debris is not the only issue. There have been more satellite and commercial launches in the last few years than ever before. Since 2019 the number of launches quadrupled and 80 % of the launches were commercial.[30] According to ESA's report, the LEO is getting crowded, increasing the risk of conjunctions, i.e., close encounters of objects.[31] In addition, mega-constellations of thousands of satellites have been launched into space in the last few years, with many similar projects planned.[32]

The peril posed by space debris stems from its capacity to inflict damage to operational space objects both in outer space, on Earth, and, most critically, to human lives. Currently, two space stations carry people in space, the International Space Station[33] (ISS) and the Chinese Tiangong Space Station[34] (TSS). To illustrate the threat space debris poses, a few instances of collisions with space debris can be named. In 2016, a small paint chip or metal fragment damaged one of the windows on the International Space Station. The ISS did not suffer any serious damage, but the consequences of such a collision with a bigger piece of space debris would have been tragic.[35] The collision of the Iridium 33 satellite and the defunct Cosmos 2251 satellite in 2009 contributed to the creation of 2 296 catalogued space debris pieces and hundreds of thousands of

[24] NASA, Space debris and human spacecraft.
[25] AEROSPACE CORPORATION, Space debris 101.
[26] Last updated on 12 September 2023.
[27] ESA, Space debris by the numbers.
[28] KESSLER, D.J., *supra* note 3, p. 12(63).
[29] ESA, *supra* note 27.
[30] ESA, We're launching more than ever.
[31] ESA, *supra* note 23.
[32] *Ibid*.
[33] NASA, International Space Station.
[34] LUTZ, E. a Tour of China's Tiangong Space.
[35] PEAKE, T., Impact chip.

pieces of space debris impossible to track.[36] Space debris can cause damage not only in outer space but also on Earth. There have been cases of space debris falling from outer space to Earth's surface. For instance, in 1991, the 39-ton Soviet Slayut-7 space station crashed on the territory of Argentina after an uncontrolled re-entry.[37] In 2001, a 70 kg piece of debris from the Payload Assist Module-Delta crashed onto Saudi Arabian territory.[38] In 1997, a woman from Oklahoma was hit by a piece of metal that had fallen from space.[39] Astronauts are protected by their space suits when on spacewalks and by the protective shielding of the ISS when inside of the space station. However, shielding can only handle debris of 1 cm in diameter.[40] As outer space gets more populated, close encounters resulting in complicated avoidance manoeuvres become more frequent.

As the population of space debris continues to grow, collisions are inevitable. In 1978, Donald J. Kessler came up with a theory future known as the Kessler syndrome.[41] This theory notes that as orbits sometimes cross, collisions of objects orbiting on them are likely, more so when orbits are congested. Collisions of objects in space produce fragments which, according to Kessler, would then continue colliding with other objects resulting in an exponential increase of space debris and the formation of a dense belt of debris around the Earth, making further exploration of outer space impossible.[42] On top of that, destructive collisions could cause disruption in services provided by satellites in space for example the global positioning system (GPS) and navigation services, climate and weather monitoring, radio, internet connection, cell phones or banking transactions.[43]

Kessler also stated that the available data is sufficient to predict that even if there is no or very little increase in the population of LEO, collisional cascading will happen in the future.[44] In 1991, Kessler deemed that the LEO environment is unstable, and a collision may occur every 10 or 20 years. Nonetheless, with new additions to already unstable orbits the collision rate would be much higher.[45] Kessler emphasised that once the critical density of objects in outer space is reached, the number of space debris will increase on its own due to collisions even without any new launches. In such a case, the only remedy would be active debris removal (ADR). According

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[36] LE MAY, S., GEHLY, S., CARTER, B.A. and FLEGEL, S., Space debris collision probability analysis for proposed global broadband constellations, p. 445.
[37] MCQUISTON, John T. Salyut 7, Soviet station in space, falls to Earth after 9-year orbit.
[38] NASA Orbital Debris Program Office, Orbital Debris Qarterly News.
[39] BORENSTEIN, Seth. Space junk hits Earth often, not people.
[40] AEROSPACE CORPORATION, *supra* note 25.
[41] KESSLER, D. J. and COUR-PALAIS, B. G. Collision frequency of artificial satellites: The creation of a debris belt, p. 2645.
[42] KESSLER, COUR-PALAIS, *supra* note 41, p. 2634.
[43] ANZALDÚA, A. A Pragmatic, Evolutionary Path to Orbital Debris Removal via Customary International Law, p.9.
[44] KESSLER, COUR-PALAIS, *supra* note 41, p. 2642.
[45] KESSLER, *supra* note 3, p. 12(65).

to Kessler, critical density is reached when collisions produce space debris at a higher rate than the rate of space debris removal by natural processes.[46]

Research by Liou et al. from 2009 shows that even if 90% of space activities complied with space debris mitigation measures such as the 25-year lifespan rule, if there were no new launches, the LEO space debris population would still grow by 30% in the next 200 years.[47] The estimated number of collisions was one major collision (such as the Iridium 33 and Cosmos collision) every five to nine years. The studies showed that the highest increase in collisions would occur above 800 km of altitude.[48] As these studies were conducted in 2006-2009, the results can already be confronted with reality. As predicted, the population is increasing the most in the LEO.[49] With mitigation measures compliance around 60% in the 2000-2013 period,[50] and the launches of several mega-constellations, it seems safe to conclude that the population of the LEO will continue to grow. The authors mention two key elements to achieve long-term space sustainability: total compliance with mitigation measures such as post-mission disposal and active debris removal.[51] According to latest ESA report, the compliance with mitigation guidelines increased in the last decade.[52]

1.3. Legal framework

Before analysing the legal issues of debris remediation, it is appropriate to summarise the current legal framework. Space activities are governed by five fundamental binding space treaties concluded by the United Nations Committee on the Peaceful Uses of Outer Space, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty), the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue Agreement), the Convention on International Liability for Damage Caused by Space Objects (Liability Convention), the Convention on Registration of Objects Launched into Outer Space (Registration Convention), and the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement).

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[46] KESSLER, *supra* note 3, p. 12(63).
[47] LIOU, J., ANILKUMAR, A., BASTIDA VIRGILI, B., HANADA, T., KRAG, H., LEWIS, H., RAJ, M., RAO, M., ROSSI, A., SHARMA, R., *supra* note 7, p. 1.
[48] *Ibid*, p. 5.
[49] ESA, *supra* note 23.
[50] MORAND, V., DOLADO-PEREZ, J.-C., PHILIPPE, T., HANDSCHUH, D.-A., Mitigation rules compliance in low Earth Orbit, p. 91.
[51] LIOU, J., ANILKUMAR, A., BASTIDA VIRGILI, B., HANADA, T., KRAG, H., LEWIS, H., RAJ, M., RAO, M., ROSSI, A., SHARMA, R., *supra* note 7, p. 6.
[52] ESA, *supra* note 23.

The Outer Space Treaty (OST) entered into force in October 1967 and is mainly based on the 1963 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space[53]. The Outer Space Treaty contains the fundamental principles of space law such as the free exploration of outer space conducted for the benefit and in the interest of all countries. It also designates outer space as province of mankind and astronauts as envoys of mankind. The Outer Space Treaty provides that outer space cannot be subject to national appropriation, that the Moon and other celestial bodies should be used only for peaceful purposes. It also established the responsibility of States for national activities and their liability for damage caused by their space objects. The Outer Space Treaty also prohibits harmful contamination of outer space. [54] As the provisions of the Outer Space Treaty are rather general, the need for more specific rules occurred. The 1968 Rescue Agreement on the rescue of astronauts develops the principles set out in Article V and VIII of the OST and provides rules on the assistance and rescue for astronauts in distress. Specifically, the Rescue Agreement provides that astronauts should be returned to their launching State. It also provides on assistance of States when recovering space objects fallen to Earth outside the territory of the launching State.[55] The Liability Convention entered into force in 1972, and it develops Article VII of the OST on the liability of launching States and provides rules on the compensation of claims for damage caused by a space object.[56] In 1976, another international agreement, the Registration Convention, entered into force. The Registration Convention contains provisions on the registration of space objects in the United Nations Register of Object Launched into Outer Space.[57] Finally, in 1984 the Moon Agreement entered into force. It governs space activities of States on the Moon and other celestial bodies stating that activities on the Moon should be carried out only for peaceful purposes, prohibits militarisation of the Moon and describes the Moon and its natural resources as *"common heritage of mankind"* [58].

[53] United Nations General Assembly, Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space (1963) UN Doc. A/RES/1962(XVIII).

[54] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, London/Moscow/Washington, entered into force 10 October 1967. (hereafter as Outer Space Treaty)

[55] Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, London/ Moscow/Washington, entered into force 3 December 1968. (hereafter as Rescue Agreement)

[56] Convention on International Liability for Damage Caused by Space Objects, London/Moscow/Washington, entered into force 1 September 1972. (hereafter as Liability Convention)

[57] Convention on Registration of Objects Launched into Outer Space, New York, entered into force 15 September 1976. (hereafter as Registration Convention)

[58] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, New York, entered into force 11 July 1984. (hereafter as Moon Agreement)

In addition, five documents on principles of space activities have been adopted: Declaration of Legal Principles (1963)[59], Broadcasting Principles (1982)[60], Remote Sensing Principles (1986)[61], Nuclear Power Sources Principles (1992)[62], Benefits Declaration (1996)[63]. The United Nations General Assembly also adopts non-binding resolutions on different issues concerning outer space. Such resolutions include for instance recommendations on national legislation relevant for peaceful exploration of outer space, and recommendations on enhancing States' practice of registering their space objects.[64] In addition, many bilateral and multilateral agreements were concluded between the spacefaring States. In 2010, the UN adopted the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space.[65] The Inter-Agency Space Debris Coordination Committee adopted its own set of guidelines, the IADC Space Debris Mitigation Guidelines.[66] These guidelines contain rules and recommendations on post-mission disposal and prevention of space debris generation. In addition, this thesis discusses standards issued by the International Organisation for Standardisation (ISO) in Chapter four. For the purposes of this thesis, the Outer Space Treaty, the Liability Convention, and the Registration Convention are the most relevant.

2. Space debris remediation and mitigation

This chapter explains the concepts of space debris remediation and mitigation, including measures and strategies to address the space debris problem. This chapter also provides an overview of the latest technologies and examples of current active debris removal and on-orbit servicing (OOS) projects. Although the topic of this thesis is centred around the legal issues of space debris remediation, mitigation must also be presented as the legal issues of debris remediation and mitigation are closely intertwined.

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[59] United Nations General Assembly, *supra* note 53.
[60] United Nations General Assembly, The Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting (1982) UN Doc. A/RES/37/92.
[61] United Nations General Assembly, Principles Relating to Remote Sensing of the Earth from Outer Space (1986) UN Doc. A/RES/41/65.
[62] United Nations General Assembly, The Principles Relevant to the Use of Nuclear Power Sources in Outer Space (1992) UN Doc A/RES/47/68.
[63] United Nations General Assembly, The 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 (1996) UN Doc A/RES/51/122.
[64] United Nations Office for Outer Space Affairs. Space Law: Resolutions.
[65] UNCOPUOS Space Debris Mitigation Guidelines, *supra* note 9.
[66] IADC Space debris mitigation guidelines, *supra* note 11.

2.1. Space debris remediation

Space debris remediation is the process of removing non-operational space objects from outer space or otherwise reducing the number of space debris in space.[67] It has been stated in relating research that mitigation measures only will not suffice to prevent collisional cascading and that the only way to prevent it is through space debris remediation which includes active debris removal.[68] There are multiple methods of active debris removal depending on the location of debris.

Objects situated in the LEO naturally decay due to the atmospheric drag. When space objects do not decay fast enough by natural processes, they can be forced to burn up in a controlled re-entry by entering Earth's atmosphere, a process that would naturally last up to years.[69] There are various ADR techniques that are currently under development. Space debris can be captured and then de-orbited by using harpoons, nets, glue, robotic manipulators, or tentacles.[70] These operations are called rendezvous operations as they require another space object conducting the removal operation to physically approach the targeted space debris, in order to capture it and depose it in a lower orbit, detach and repeat the operation with another target.[71] Other currently developed methods include using an ion beam or laser to move the space object or change its velocity to change the objects orbit[72] or spraying on foam or clouds of particles to increase the mass of the space object and make it re-enter the atmosphere faster.[73] Most of these technologies are still under development or in the testing phase. The challenging part of these operations is ensuring that the controlled re-entry of the targeted space object or the remediation operation itself do not cause damage to other space objects in outer space, aircrafts in flight, infrastructure, or persons on Earth. Rendezvous operations are hazardous as the space debris in space might be fragile and may break upon contact or manipulation or explode from remaining fuel and consequently cause damage or create even more space debris during the ADR operation.[74]

Space objects in higher orbits cannot be de-orbited, such as space objects in the GEO, where there is almost no atmospheric drag, meaning that natural decay is impossible. Space objects in the GEO can be boosted by using remaining fuel into a disposal orbit or so-called graveyard

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[67] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 113.
[68] LIOU, J., ANILKUMAR, A., BASTIDA VIRGILI, B., HANADA, T., KRAG, H., LEWIS, H., RAJ, M., RAO, M., ROSSI, A., SHARMA, R., *supra* note 7, p. 6.
[69] NATURE ASTRONOMY, Time to clean up low Earth orbit., p. 1099.
[70] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 118.
[71] WEEDEN, B., Overview of the legal and policy challenges of orbital debris removal. p. 39.
[72] *Ibid*.
[73] USOVIK, I.V. Review of Perspective Space Debris Mitigation Solutions., p. 57.
[74] WEEDEN, *supra* note 71*,* p. 40.

orbit, which is situated far from operational orbits,[75] and used by States for gathering defunct space objects.[76] The space objects should be manoeuvred in a sufficiently high altitude above the GEO to ensure that the space object does not re-enter the GEO region within the next 100 years.[77] The first one to move its satellites from the GEO into a disposal orbit was the International Telecommunications Satellite Organisation (INTELSAT) that re-orbited three of its Intelsat III satellites in 1977. However, some are not incentivised to perform re-orbiting as fuel needed for successful re-orbiting into a graveyard orbit could be used to prolong the operational life of the space object[78] without stopping its activities earlier. Another possibility for space objects with no remaining fuel or objects that cannot be controlled is performing re-orbiting operations. There are two options. The space object could be re-orbited by placing a thruster re-orbiting kit on the defunct space object. The other option consists of the active space object performing the removal mission pushing the targeted space debris into the disposal orbit.[79]

Several active debris removal projects have already been designed, and some have even been tested.[80] Clear space-1 from the Swiss start-up Clear space SA in cooperation with the European Space Agency (ESA) will remove space debris from orbit. The launch is planned to take place in 2026, and its goal is to capture a derelict rocket part weighting 112 kg[81] and de-orbit together and burn up in the atmosphere[82]. Astroscale is a project that can remove multiple satellites in one mission through a magnetic spacecraft capture system that can capture and then release a targeted space debris.[83] RemoveDEBRIS is another ADR project that already conducted an experimental space debris removal operation. The mechanism used a net to capture a target space object deployed for the purposes of the experiment and it completed the first successful demonstration of an ADR technology in outer space.[84]

Another instrument of space debris remediation is on-orbit servicing, which are technologies used for the repair, refuelling, upgrade, or other forms of maintenance of space objects in orbit to prolong their operability.[85] OOS still faces many technical challenges such as

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[75] ESA, *supra* note 23, p. 109.
[76] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 118.
[77] ESA, *supra* note 23, p. 109.
[78] PEREK, L., Safety in the Geostationary orbit after 1988, p.86.
[79] BARANOV, A.A., GRISHKO, D.A., KHUKHRINA, O.I. and CHEN, D. Optimal transfer schemes between space debris objects in geostationary orbit. p. 24.
[80] University of Surrey, Net successfully snares space debris.
[81] ESA, ClearSpace-1.
[82] ESA. ESA Commissions World's first space debris removal.
[83] NATURE ASTRONOMY, Time to clean up low Earth orbit.
[84] University of Surrey, *supra* note 80.
[85] MIFSUD, G., Recycling the Outer Space Treaties: Analysing the Potential for On-Orbit Servicing Agreements, p. 602.

safely approaching and docking with spacecraft to execute the on-orbit servicing operation effectively.[86] Astroscale, Northrop Grunmman, Maxar Technologies,[87] Airbus[88], Thales Alenia Space,[89] Rogue Space Systems[90], and Atilus Space Machines[91] are only few examples of companies planning on providing OOS services and developing projects on in-orbit manufacturing.

Even though remediation is not a quotidian task and ADR and OOS technologies are still in the testing and experimental phases, they will soon need to be conducted regularly, especially in the LEO where the space debris population density is becoming dangerous. [92] Furthermore, these operations are hazardous and expensive, and thus, States are not incentivised to perform them. Concerning the GEO, the downfall of re-orbiting is the shortened active phase and the economic loss connected to it.[93] In addition, every operation carries the risk of being unsuccessful, and creating more space debris, even causing damage to other States' space objects. In the next chapter, the thesis analyses the legal issues that may arise once such operations are in practice.

2.2. Space debris mitigation

Space debris mitigation aims at minimising the quantity of new debris in space. One fundamental aspect of space debris mitigation is designing spacecraft and launch vehicles using materials and components that minimise the generation of debris during their operational lifetimes. At the end of their operational life, satellites and rocket stages should be disposed of to reduce the risk of long-term space debris. Debris mitigation methods and measures include collision avoidance, end-of-mission disposal, passive protection, and protective shielding.[94] Space agencies and international organisations try to engage in space traffic management, actively monitoring and manoeuvring their missions to avoid potential collisions with other objects in orbit. International cooperation and data sharing are essential in this effort to ensure the long-term sustainability of outer space.[95] Mitigation consists of measures to prevent collisions, but also other types of material interference. Such material interference among object in outer space can also be a close encounter that adversely affects the functions of a satellite or other space object. For example, by disturbing

[86] FLORES-ABAD, Angel, MA, Ou, PHAM, Khanh and ULRICH, Steve. A review of Space Robotics Technologies for on-orbit servicing. p. 20.
[87] MIFSUD, *supra* note 85, p. 602.
[88] AIRBUS. Airbus pioneers first satellite factory in space.
[89] THALES GROUP. Space to explore.
[90] ROGUE SPACE SYSTEMS CORPORATION. Orbital Robotics.
[91] ALTIUS SPACE MACHINES. Engineering. Innovation. Agility.
[92] PEREK, L., Early Concepts for Space Traffic, p. 3.
[93] PEREK, *supra* note 78, p. 86.
[94] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 113.
[95] PEREK, L., Management of Outer Space. p. 192.

the electromagnetic field of such object or by creating a shadow and preventing solar radiation from getting to an object that is powered by solar energy. Even these interferences can be harmful and lead to damage of such object and the creation of new space debris as stated by Perek.[96]

Mitigation also consists of creating an appropriate legal framework for those measures. The main documents on space debris mitigation are the IADC Space Debris Mitigation Guidelines (2002)[97] and the UNCOPUOS Space Debris Mitigation Guidelines (2010).[98] Both mitigation guidelines provide recommendations on measures that should be taken to limit the creation of debris through the lifetime of a space object, starting from the launch through its operational phase to the end-of-life disposal. The IADC Space Debris Mitigation Guidelines (IADC Mitigation Guidelines) state that for each project, the operator should design a Space Debris Mitigation Plan to efficiently apply mitigation measures outlined in the IADC Mitigation Guidelines.[99] The first stipulated mitigation rule is the need to minimise the release of space debris during operations by design of spacecraft and orbital stages.[100] In addition, space objects should be designed to minimise the risk of on-orbit break-ups and accidental explosions during the operational phase and in the post-mission stage. The IADC Mitigation Guidelines also set forth that States and other operators in outer space should avoid harmful activities.[101] Space objects in the GEO should perform post-mission disposal manoeuvres to be removed into a disposal orbit away from the GEO. Space objects launched into the LEO should remain in orbit for a maximum of 25 years after their operational phase ended.[102] To reduce the risk of on-orbit collisions, space objects should perform collision avoidance manoeuvres and each launch should be well planned and coordinated.[103]

The UNCOPUOS Space Debris Mitigation Guidelines (UN Mitigation Guidelines) follow a similar structure of guidelines. They contain seven guidelines, which set forth the basic principles of space debris mitigation. First, the UN Mitigation Guidelines set out the requirement to limit the discharge of space debris during operations. Minimising break-up risks during operations and post-mission, limiting collision risks in orbit, avoiding the intentional destruction of space objects in outer space are other important guidelines.[104] The UN Mitigation Guidelines state that the presence of non-functional objects in the LEO and GEO regions should be limited by either removing space objects from the lower orbits or by leaving them in disposal orbits where space debris cannot

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[96] PEREK, *supra* note 95, p. 192.
[97] IADC Space Debris Mitigation Guidelines, *supra* note 11.
[98] UNCOPUOS Space Debris Mitigation Guidelines, *supra* note 9.
[99] IADC Space Debris Mitigation Guidelines, Art. 4, *supra* note 11.
[100] *Ibid*., Art. 5.1.
[101] *Ibid*., Art 5.2.
[102] *Ibid*., Art 5.3.
[103] *Ibid*., Art. 5.4.
[104] UNCOPUOS Space Debris Mitigation Guidelines, *supra* note 9.

interfere with ongoing activities in the GEO region.[105] As space activities continue to expand, space debris mitigation remains a critical focus to ensure long term sustainability of outer space.

The next chapter explains legal aspects of space debris remediation. The chapter provides an analysis of most pressing legal issues connected to space debris remediation that complicate active debris removal and on-orbit servicing operations as described above.

3. Legal aspects of space debris remediation

Space debris remediation is complicated by many issues, not only legal but also economical, technical, political, and practical. This chapter focuses on the legal aspects of space debris remediation. The chapter further analyses legal issues related to the active debris removal of space debris from outer space and on-orbit servicing. Shedding light on these legal issues is key for the realisation of space debris remediation activities.

A recurring issue of space debris remediation is the lack of binding rules and an incomplete legal framework. The Space Treaties were negotiated during the Cold War, in a time of race for military and overall superiority of two world powers.[106] It is, therefore, no surprise that the intentions behind drafting such treaties do not fit today's situation anymore as the space environment has changed drastically, with commercial launches massively overtaking over the governmental ones.[107] It is under those Cold War circumstances that rules such as the perpetual ownership of space objects and the prohibition to interfere with another State's space object were created without taking into account the possible issues it would cause in the future.[108] The lack of detailed legal rules proves to be an issue in the context of ownership as the implications of ownership must be interpreted on the basis of a few provisions in the original space treaties. In addition, the lack of precise and detailed binding rules on registration hinders an effective utilisation of the Registration Convention and complicates the remediation of space debris. As active debris removal missions are dangerous and expensive, States are not incentivised to perform them. In addition, every mission carries the risk of being unsuccessful, and of creating more debris, even cause damage to other States' space objects. An effective legal framework is needed in order to facilitate the conduct of space debris remediation from a legal perspective. The resolution of these issues is crucial for efficient conduct of debris removal or on-orbit service operations.

Firstly, this chapter explains the issue of ownership and permission. Liability for damage and the liability regimes under the existing legal framework are explained next, as well as the

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[105] UNCOPUOS Space Debris Mitigation Guidelines, *supra* note 9.
[106] FORCE, *supra* note 7, p. 10.
[107] ESA, *supra* note 30.
[108] FORCE, *supra* note 7, p. 10.

issues liability poses for debris remediation. Furthermore, this chapter explains issues posed by the general character of the Registration Convention and the absence of obedience to the obligation to register space objects. Lastly, transfer of ownership is often referred to as a possible way to facilitate the conduct of active debris removal or on-orbit servicing, however, it also entails legal problems.

3.1. Ownership and permission

In space law, every space object remains the property of its owner, even if it explodes into thousands of pieces.[109] Ownership of a space object is one of the main issues of space debris remediation and it entails other issues with permission, transfer of ownership, and liability. The space treaties do not deal with the question of ownership of space objects extensively, and some do not mention it at all. Article VIII of the Outer Space Treaty only refers to ownership in the sense that *"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."*[110] Ownership is also referred to in Article 12 of the Moon Agreement. However, it only provides that it is not affected by the presence of the space object on the Moon.[111] The Registration Convention, the Liability Convention and the Rescue Agreement do not provide any information on ownership. Von der Dunk believes it is not surprising as ownership is a private law concept and space law falls within the domain of public international law.[112]

In the context of space debris remediation, certain scenarios can arise. Either the State is inclined to performing an ADR or OOS operation when needed and conducts it by itself, or a private entity conducts it with the States' permission under a bilateral agreement. In such a case, no legal problems under international law should arise. However, there is an issue when an ADR or OOS operation is needed, and the owner of the space debris is unknown or does not provide permission for the operation.[113] In such a case, conducting such operation by a third party is not possible under the current legal framework. This is because of the requirement of parties to avoid harmful interference with each other's space activities as interpreted from Article IX of the OST.[114] Force interprets that perpetual ownership is absolute and can only be interfered with when space activities are contrary to the requirement of peaceful use and exploration of outer space as set forth

[109] TALLIS, J., Remediating Space Debris: Legal and Technical Barriers, p. 83.
[110] Outer Space Treaty, *supra* note 54, Art. VIII.
[111] Moon Agreement, *supra* note 58, Art. XII.
[112] VON DER DUNK, F. Transfer of ownership in orbit: From fiction to problem, p. 6.
[113] FORCE, *supra* note 8, p. 2.
[114] NSS, Orbital Debris: Overcoming challenges, p. 24.

in the OST. According to Force, a case of extremely dangerous activities could justify the interference in the ownership rights in accordance with space law. However, the reasons for interference are not specified, which poses future problems, especially for space debris removal.[115] According to some authors, these activities do not cover space debris remediation.[116] Conversely, Wang argues that the interpretation of Article IX of the OST as a prohibition of harmful interference between States is false. Article IX of the OST only states that in case a State deems that its space activity or activities of its nationals could harmfully interfere with the peaceful use and exploration of outer space by other States, the State has an obligation of international consultation before it carries out such space activities.[117] Nevertheless, Navalgund states that no State can intervene and take control over another State's space object without its prior permission, including space debris.[118] According to Perek, without the launching State's consent, it cannot be assumed that a space object is space debris and even if it poses a threat to another State's satellite, it cannot be destroyed.[119] This is an example of rigid rules set by the space treaties that prevent active debris removal and pose an issue to space debris remediation. Force states that the idea that consent must be obtained, even in case of risk posed by dangerous space debris, must be overcome.[120]

Current space treaties do not take into consideration situations of serious danger posed by space objects and space debris, neither do they contain exceptions to the need for permission such as the institute of necessity. For necessity to be established under international law, there must be an imminent threat to life of persons, the impossibility or unwillingness of the sovereign State to protect such persons and the interference must be limited by duration and by the means used.[121] Perhaps this could be used for the purposes of space debris remediation as a scenario where space debris endangers, for example, the ISS with astronauts on board, therefore creating an imminent threat to their lives, is easily imagined. The UN adopted Articles on Responsibility of States for Internationally Wrongful Acts.[122] Article 25 provides for necessity and states that necessity can be

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[115] FORCE, *supra* note 8, p. 3.
[116] NAVALGUND, R., Reduce, Reuse and recycle: An environmental law approach to long-term sustainability of Outer Space, p. 285.
[117] WANG, G., NASA's Artemis Accords: The Path to a united space law or a divided one?
[118] NAVALGUND, *supra* note 116, p. 300.
[119] PEREK, *supra* note 15, p. 219.
[120] FORCE, *supra* note 8, p. 2.
[121] POTOČNÝ, M., ONDŘEJ, J., Mezinárodní právo veřejné Zvláštní část, 5. doplněné a přepracované vydání, p. 8.
[122] General Assembly, Articles on Responsibility of States for Internationally Wrongful Acts, International Law Commission, (2002) U.N. Doc. A/RES/56/83.

invoked only if it is the only means to protect *"an essential interest against a grave and imminent peril."*[123] If this condition is fulfilled, the interference does not constitute a wrongful act.[124]

Force suggested that absolute protection of property rights should not be granted in cases where the space object is no longer functional, or the activities of an object are contrary to the principle of due regard[125] as stated in Article IX of the OST. Some authors, such as Dunstan, propose that after a certain period of time, non-functional space objects should be deemed abandoned.[126] Abandonment can facilitate active debris removal operations as if the space debris is deemed abandoned, there is no need for transfer of ownership or permission to avoid interference with ownership rights.[127] Nevala develops the idea of abandonment following the example of United States' (US) laws and points out some application issues. For abandonment to be established under US law, three requirements must be fulfilled. The act of abandonment of the space object, the intent to abandon the space object, these two must be simultaneous. In addition, abandonment must be voluntary.[128] Intent can be ascertained by checking the United Nations Registry or the United Nations Space Object Index or the national registry of the launching State if it has changed the status of the space object. Abandonment can be shown on the example of satellites boosted to a graveyard orbit. When a satellite from the GEO is boosted into a disposal orbit at the end of its mission, the first requirement being the action of abandoning an object is fulfilled. The requirement of intent and concurrence is also satisfied by intentionally leaving remaining fuel specifically for re-orbiting. However, as most often the re-orbiting is motivated by the adherence to mitigation guidelines, the requirement of voluntariness cannot be met. Thus, in this scenario the satellite would not be abandoned according to Nevala.[129] If a satellite remains in the GEO even after it stopped being functional, all requirements for abandonment are fulfilled according to Nevala as abandonment by omission is also possible and the unwillingness to remove the satellite to a disposal orbit shows intent. Thus, the abandoned space object is up for disposition of any other State or private entity.[130] The 25-year rule for stay of satellites after the end of their mission in the LEO could be a decisive factor for determining abandonment in the LEO. After 25-year post mission, the scenario is similar to the one described for GEO. Either the owner leaves the defunct satellite in orbit or tries to remove it from the LEO but is not successful and the space

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[123] General Assembly, *supra* note 122, Art. 25.
[124] *Ibid.*
[125] FORCE, *supra* note 8, p. 3.
[126] DUNSTEN, *J. E.* "Space trash": Lessons learned (and ignored) from Space Law and Government, p. 70.
[127] NEVALA, E. M. Waste in Space: Remediating Space Debris Through the Doctrine of Abandonment and the Law of Capture, p. 1521.
[128] *Ibid.*, p. 1516.
[129] *Ibid.*, p. 1522.
[130] *Ibid.*, p. 1523.

object is still present there.[131] Abandonment is more complicated in case of space debris such as fragments, which cannot always be attributed to an owner. In such case, abandonment criteria would probably not be met as the owner has no practical control over the space debris, and therefore, cannot perform any action of abandonment.[132] Perek suggests that abandonment of space objects that have become space debris or the renunciation of their protection by the space legal framework will become a necessity. However, only under the condition that launching States remain liable for abandoned objects.[133]

The author of this thesis agrees that abandonment could facilitate and accelerate active debris removal. However, to prevent the misuse of abandonment and to ensure that States have righteous motivation to abandon their space debris, it is crucial to establish strict rules. The author of this thesis therefore agrees with Perek that abandonment may be allowed only under certain circumstances. Otherwise, abandonment of non-functional space objects seems hazardous as it would entail more legal and other issues. This thesis argues that making abandonment possible for all inactive space objects according to its owner could potentially have negative consequences. First, if the object is abandoned, there would be no State with liability, jurisdiction, and control over it. Hence, for ADR purposes, permission would not be needed, and States could not be opposed the removal as they would not run the risk of liability and paying compensation in case damage is caused to another space object during such mission. However, the lack of liability is exactly the problem. After the active operational phase of the space object, States would simply abandon it with no one liable for its existence in orbit. With the vision that their space object would be considered abandoned, States or private companies would not be motivated to include end-of-mission disposal mechanisms to their operations, unless it is mandatory or beneficial. For these reasons, the scenario described by Nevala where space objects orbiting in the GEO could be deemed abandoned after a certain time elapsed is dangerous. Although a counter argument must be noted that States are rather protective of their space objects as they do contain technologies, designs protected by patents or restricted information which States do not want to disclose.[134] Therefore, they would only carefully choose those that are no longer valuable and their possession or study by other entities would not disclose any patents or technologies.

Therefore, to conduct space debris remediation in compliance with current space law, the operator must either remove an object of its own or when removing another state's object, obtain

[131] NEVALA, *supra* note 127, p. 1525.
[132] *Ibid*., p. 1528.
[133] PEREK, L., What Future for Space Debris? p. 2.
[134] WEEDEN, *supra* note 71, p. 42.

prior permission and agree on the terms in a separate agreement or agree on a transfer of ownership which poses separate issues discussed in the subchapter below. If the owner does not want to provide permission or is unknown, many legal issues arise, and the performance of a removal operation can even be impossible.

3.2. Liability

Liability poses yet another legal difficulty for space debris remediation. Liability for damage caused by a space object is a type of international liability that requires compensation even if rules of international law were not violated.[135] According to Kopal, this is due to the hazardous nature of space activities.[136] Debris remediation missions can be hazardous in terms of elevated collision risk and causing damage in outer space or on Earth because both active debris removal and on-orbit servicing operations require close contact with space objects.[137] The Liability convention of 1972 provides definitions relevant for further analysis. Damage is defined as *"loss of life, personal injury or other impairment of health; or loss or damage to property of States or of persons, natural o juridical, or property of international intergovernmental organizations"*.[138] The term launching State is also defined. A launching State is a state that *"launches and procures the launching of a space object and a state from whose territory or facility a space object is launched"*.[139] In practice, if these States are different, all four can be launching States. The Liability Convention provides that launch means also attempted launching.[140] This is important as a failed launch is often a significant source of damage-causing debris.[141] The main problem is that liability is linked to the launching State.[142,143] Compensation for any damage caused to a third-party object during a debris remediation operation could, therefore, be claimed from the launching State. States do not want to take on the responsibility of being liable for damage caused during an active debris removal or on-orbit servicing operation. Complicated legal relations arise as a consequence as they can only be solved by concluding bilateral or multilateral agreements on liability between the launching State and the ADR or OOS mission operator and through national

135 ONDŘEJ, J., Právní režimy mezinárodních prostorů, p. 224.
136 KOPAL, *supra* note 6, p. 237.
137 MIFSUD, *supra* note 85, p. 605.
138 Liability Convention, *supra* note 56, Art. I(a).
139 *Ibid*., Art. I(c).
140 *Ibid*., Art. I(b).
141 MOROZOVA, E., LAURENAVA, A., International Liability for commercial space activities and related issues of debris, p. 8.
142 Outer Space Treaty, *supra* note 54, Art. VII.
143 Liability Convention, *supra* note 56, Art. II, Art. III.

legislation and authorisation.[144] In this subchapter, the current legal framework for liability is summarised. This subchapter explains the different types of liability in space law and specifies why liability can be an issue for space debris remediation.

Liability for damage is covered by both the OST and the Liability Convention. Pursuant to Article VII of the Outer Space Treaty and to Article II and Article III of the Liability Convention*,* a launching State of a space object is liable for damage it may cause.[145,146] It is important to note that both OST and the Lability Convention lay liability on launching States, liability for damage caused by space objects owned by private entities is not excluded as States are liable for damage caused by persons they are responsible for.[147] According to Article VI of the OST, States are responsible for national activities whether conducted by governmental or non-governmental entities.[148] It should be noticed that the treaties refer to damage caused by space objects in general, not mentioning space debris. Therefore, an important question must be answered. Are space debris considered space objects?

Kerrest suggests that for liability purposes, the definition of a space object is more useful than the notion of space debris. He stresses that every space debris should be considered a space object according to the Liability Convention.[149] Hofmann and Masson-Zwaan analyse the same question. The qualification of space debris as a space object is crucial as it decides whether the Liability Convention applies or not.[150] Hofmann and Masson-Zwaan search for the answer in Article I (d) of the Liability Convention which states that a space object includes *"component parts of a space object as well as its launch vehicle and parts thereof"*[151]. The authors conclude that it means that an inactive satellite or its parts are still considered a space object or its component parts.[152] According to Kerrest, some authors doubt that space debris can be qualified as space objects, this misconception stems out of a restrictive interpretation of the definition of a space object and its understanding in the sense of spacecraft.[153] In fact, the definition of a space object is not straightforward as none of the Space Treaties expressly define it. The Travaux Préparatoires to the Liability Convention shed light on what is meant by space object. A draft liability agreement proposed by Hungary stated in draft Article I that space object *"means spaceships, satellites,*

144 CHATZIPANAGIOTIS, M., Using Space Objects in Orbit as Transaction Objects: Issues of Liability and Registration de lege lata and de lege ferenda., p. 87.
145 Outer Space Treaty, *supra* note 54, Art. VII.
146 Liability Convention, *supra* note 56, Art. II, Art. III.
147 *Ibid*., Art. III.
148 Outer Space Treaty, *supra* note 54, Art. VI.
149 KERREST, *supra* note 14, p. 1.
150 MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 112.
151 Liability Convention, *supra* note 56, Art. I.
152 MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 112.
153 KERREST, *supra* note 14, p. 1.

orbital laboratories, containers, and any other devices designed for movement in outer space and sustained there otherwise than by the reaction of air, as well as the means of launching such objects".[154] Belgium proposed to use the term space device defined as *"any device intended to move in space and sustained there by means other than the reaction of air, as well as any constituent element of such device or the equipment used for its launching or propulsion"*.[155] The Italian draft of the Convention defined a Space Object as *"any man-made object designed to reach outer space and to move there (either naturally or by means of radio-electric signals or the control exercised by pilots on board)."*[156] *"For the purposes of this Convention, the component parts of space objects which became detached or were made to detach during transit, and objects which have fallen or are launched from space objects, shall also be deemed to be space objects."*[157] Neither of the definitions contain the term space debris, nor expressly provide on functionality, neither on operability as pointed out by Morozova and Laurenava.[158] The definition provided in the Italian draft includes component parts that became detached and object, which have fallen, which could encompass space debris.[159] Consequently, the points made by Hofmann and Masson-Zwaan and Kerrest hold. Space debris are therefore considered space objects, and states are liable for damage caused by space debris as the Liability Convention applies. Although experts agree that space debris are space objects, not all authors, such as Perek, agree that the same rules should apply to both. The fact that certain rules, such as perpetual ownership and the need for permission to interfere, apply to all objects, both functional and non-functional, are the main cause making space debris remediation difficult. Perek states that the protection of space debris should be reconsidered and changed as space debris profits from the same protection regarding ownership rights as all space objects, which is an important obstacle to space debris removal.[160]

As already mentioned, both the OST and the Liability Convention contain rules on liability. The rules in each treaty differ slightly and while the OST rules are of a more general character, the Liability Convention offers a more detailed regulation. Concerning the relation between the two

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[154] United Nations General Assembly Committee on Peaceful Uses of Outer Space Hungary: Proposed draft agreement concerning liability for damage caused by the launching of objects into outer space (1964) A/AC.105/C.2/L.10.
[155] United Nations General Assembly Committee on Peaceful Uses of Outer Space Belgium: Proposed for a convention on the unification on certain rules governing liability for damage caused by space devices (1964) A/AC.105/C.2/L.7/Rev.1.
[156] United Nations General Assembly Committee on Peaceful Uses of Outer Space, Working Paper submitted by the Italian delegation: Draft Convention concerning liability for damage caused by the launching state of objects into outer space, (1969) A/AC.105/C.2/L.40/Rev.1.
[157] *Ibid*.
[158] MOROZOVA, LAURENAVA, *supra* note 141, p. 5.
[159] United Nations General Assembly, *supra* note 156.
[160] PEREK, Luboš, The 1976 Registration Convention, p. 356.

treaties, the Liability Convention is considered *lex specialis* to the OST, [161] meaning that according to the general legal principle *lex specialis derogat legi generali,* the Liability Convention is applicable before the OST.[162] It is worth noting that not all States are parties to both the OST and to the Liability Convention. Thus, not all States fall within the same liability regime and the conditions for liability might vary as the treaties treat liability differently.[163]

Article VII of the OST lays out the basics of liability for damage which were later elaborated by the Liability Convention. Article VII of the OST accounts for absolute liability of the launching State.[164] Meaning that the State is liable and compensation for damages can be claimed even if damage results from fault-free behaviour. However, absolute liability under the OST is broader than absolute liability under the Liability Convention.[165,166] According to Article VII of the OST, the launching State is liable for damage caused to natural or juridical persons of another State Party of the OST by an object or its component parts if damage is caused on Earth, in air or in outer space as well as on the Moon and other celestial bodies.[167]

The Liability Convention distinguishes between liability according to two areas where damage may occur. Firstly, it regulates damage caused on Earth or to an aircraft in flight where absolute liability applies[168] and secondly, damage caused elsewhere, where fault liability is applicable.[169] Damage caused elsewhere means damage caused in outer space, to a space object of a launching State or to its persons or property on board of that space object.[170] Absolute liability means, that States can be held liable no matter the circumstances and not even *force majeure* is a reason for exoneration.[171] Although liability is absolute, Article VI (1) of the Liability Convention contains one exception to that rule. If a launching State can prove that damage has been caused wholly or partially because of gross negligence or from an act or omission done intentionally to cause damage on the claimant’s part or by its natural or juridical persons, the launching State will be exonerated form liability.[172] This applies only if the launching State’s behaviour was in compliance with international law, namely the Outer Space Treaty and the Charter of the United

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161 MOROZOVA, LAURENAVA, *supra* note 141, p.1.
162 *Ibid.*
163 *Ibid*. p.10.
164 Outer Space Treaty, *supra* note 54, Art. VII.
165 *Ibid*.
166 Liability Convention, *supra* note 56, Art. II.
167 Outer Space Treaty, *supra* note 54, Art. VII.
168 Liability Convention, *supra* note 56, Art. II.
169 *Ibid*., Art. III.
170 *Ibid*.
171 MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 27.
172 Liability Convention, *supra* note 56, Art.VI (1).

Nations.[173] For a launching State to be liable under the fault-based liability regime, damage needs to be caused due to fault of the launching State or the persons for which the state is responsible under Article III of the Liability Convention.[174] While the Liability convention introduces fault liability, it does not provide any standard of fault which complicates proof of fault.[175] Neither does the Liability Convention provide a definition of fault. Von der Dunk defines fault as the *"intent or negligence to cause damage in respect of someone else active in space"*.[176] Consequently, keeping this definition in mind, damage caused by omission is also considered due to fault. In case of absolute liability, fault does not need to be proven and attributability suffices. The conditions for liability are damage to life, health or property caused by a space object to persons or States.[177] It is also questionable whether the Liability Convention applies only to direct damage or also to indirect damage. According to Hofmann and Masson-Zwaan, only direct damage seems to be covered.[178] Morozova and Laurenava concur that direct material damage is undoubtedly a reason for compensation. The authors also assume that as damage according to the Liability Convention includes *"loss of life, personal injury or other impairment of health"*[179], which can include impairment of mental health, compensation for nonmaterial damage could also be claimed under the Liability Convention.[180] However, there is no clear consent on the answer to this question even between experts.[181]

Further issues may arise when a space activity is conducted by multiple launching States. Whenever two or more States launch a space object in a joint effort, they are jointly and severally liable as per Article IV (1) of the Liability Convention.[182] Again, if such damage occurs on the surface of Earth or to flying aircraft, the liability is absolute, if damage is caused in outer space, liability is determined based on fault.[183] In case of joint liability, the burden of compensation should be divided between the two States according to the extent of their fault. If the extent of fault cannot be determined, the burden of compensation will be shared equally. However, the victim can still seek full compensation from any one of the launching States.[184] Whenever one of the States pays compensation for damage, it has the right to claim indemnification from the other

[173] Liability Convention, *supra* note 56, Art. VI (2).
[174] *Ibid*., Art. III.
[175] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 28.
[176] VON DER DUNK, F. G., Liability versus Responsibility in Space Law Misconception or Misconstruction? p. 366.
[177] POPOVA, and SCHAUS, *supra* note 4, p. 9.
[178] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 29.
[179] Liability Convention, Art. IV.
[180] MOROZOVA, LAURENAVA, *supra* note 141, p. 14.
[181] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 29.
[182] Liability Convention, *supra* note 56, Art. IV.
[183] *Ibid*., Art. IV (1).
[184] *Ibid*., Art. IV (2).

launching State or States.[185] Provisions on joint liability are important for space debris remediation. In cases of joint and several liability, States need to conclude agreements on the allocation of compensation obligations because the Liability Convention does not provide enough precise rules for certain scenarios. Such agreements are applicable only between the parties, i.e., launching States, however, the Liability Convention still applies.

The precedent paragraphs explained how liability rules apply to launching States of a space object. However, how would that look in practice during an active debris removal mission? As already mentioned above, liability poses a legal challenge to space debris remediation. These example scenarios can illustrate what the specific downfalls of the current liability framework are. According to Morozova and Laurenava, the launching State of the targeted object being removed may be held liable for damage caused by the targeted object during the ADR operation. The launching State of the spacecraft conducting the removal operation will not be liable for damage caused by the targeted space object, as a launching State can only be liable for damage caused by its object and not by a space object of a third party.[186] However, this example is rather general and does not account for all possible scenarios and different circumstances. This thesis proposes other possible scenarios. First, the following situation can be imagined. A company conducts an ADR operation with State A as the launching State of the removal spacecraft. The target is a defunct satellite with State B as its launching State. If the removal spacecraft captures the target with a net and these two space objects become connected and on their trajectory through a lower orbit, they collide with a functioning satellite owned by State C, who will be liable? If the States are parties to the Liability Convention, the scenario falls under the fault-based liability regime as damage was caused to a space object in outer space. Liable should be who is at fault. As the target object is passive during an ADR operation and the removal is operated and supervised by the removal spacecraft, it seems that the launching State of the ADR operator would be liable in this situation. It is also unclear whether the space objects are considered as one space object or separate space objects during an active debris removal operation.[187] However, as there has not yet been such case, it cannot be said with certainty, and this remains only a speculation. These issues must be dealt with before such missions are conducted regularly. Let's imagine a different scenario where State A launches a spacecraft that only projects particles on the target owned by State B to accelerate its re-entry into the atmosphere and during its re-entry, said space object causes damage to State's C satellite. In such case, even if the ADR mission operator is supervising the operation, as it is not

[185] Liability Convention, *supra* note 56, Art. V.
[186] MOROZOVA, LAURENAVA, *supra* note 141, pp. 7,8.
[187] MIFSUD, *supra* note 85, p. 607.

the launching State of the target and damage was caused solely by the target, under international space law, the operator would likely not be liable. Weeden argues that it is not certain whether the launching State would have any recourse against State A under the current legal framework. Weeden also questions whether State A as the state that performs the removal operation is obliged to control the atmospheric re-entry of the targeted object and its trajectory to guarantee that no damage is caused.[188] This would most probably be dealt with in a bilateral agreement concluded prior to the ADR operation.

However, as stated in Article VII of the Liability Convention, the Convention does not apply to certain cases. When it comes to damage caused by an object of a launching State its nationals or to foreign nationals when they are participating in the operation of said object or its launch or when they are in the immediate vicinity of the planned launching or recovery of the object.[189] The reason for this exception is that these categories of persons are at a higher risk and are therefore not covered by the protection provided by the Liability Convention.[190]

Concerning compensation for damage, both the OST and the Liability Convention allow claims for compensation for damage caused by a space object. The launching State must be determined in order to claim compensation as private entities can only claim compensation through their launching State.[191] This is a problem in the context of space debris because if debris causes damage and the launching State cannot be determined, claiming compensation for damage and the application of the Liability Convention is practically impossible. Article VIII of the Liability Convention and the following provide basic principles for compensation for damage. The Liability Convention also regulates claims. According to the Convention the claim shall be presented through diplomatic channels and at latest one year following the date when damage occurred or the date of identification of the liable Launching state.[192] If States do not agree on the settlement, a claim must be then submitted to a Claims Commission established at the request of either party. The Claims Commission is established by the parties in question, and it has three members, two from each state and the third, Chairman, chosen and appointed jointly by both parties, otherwise, the UN Secretary appoints the Chairman.[193] Article XII provides that the compensation payable by the liable Launching state should be determined in compliance with international law and principles of justice and equity.[194] Compensation should be provided so that reparation restores

[188] WEEDEN, *supra* note 71, p. 42.
[189] Liability Convention, *supra* note 56, Art. VII.
[190] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 29.
[191] MOROZOVA, LAURENAVA, *supra* note 141, p. 14.
[192] Liability Convention, *supra* note 56, Art. X (1).
[193] *Ibid*., Art. XIV, Art. XV.
[194] *Ibid*., Art. XII.

the victim of damage who presented the claim to the condition in which the victim would be if the damage had not occurred.[195]

According to Tallis, articles VI and VII of the OST impose the liability for damage on States which is disproportionate[196] considering that most of the current activities in outer space are commercial and private corporations are currently predominant in the space business.[197] Popova and Schaus argue that it should be reconsidered whether the standard for fault liability should also be applied equally to space debris removal missions.[198] In addition, Kerrest notes that the Liability Convention only complicates things by linking liability to the determination of fault.[199] The determination of gross negligence as stated in Article VI of the Liability Convention is also a complicating factor as there are no precise and binding rules defining it. Also, the Liability Convention does not provide any clues for what constitutes causation.[200] The lack of rules and policies on what constitutes fault behaviour or what standard of behaviour must be followed in order to rule out fault or negligence is an impediment to efficient remediation. There are no binding rules on space traffic management that could help determine a good State behaviour.[201]

Inspiration for a solution of some of the liability issues could be drawn from the multilateral Agreement Concerning the Cooperation on the Civil International Space Station (ISS Agreement) which contains a cross-waiver of liability in Article 16.[202] Article 16 of the ISS Agreement states that Partner States and related entities to the ISS Agreement waived liability in order to encourage participation in exploration and use of outer space through the International Space Station.[203] Related entities are defined as contractors and subcontractors of a Partner State or its users or customers and their contractors. The ISS Agreement also applies to agencies. It also establishes *"Protected Space Operations"*, for instance, launch vehicle activities, Space Station activities, research, and all activities related to ground support which fall within the scope of this Agreement. State Partners consequently waive all claims against the other Partner States or entities that arise from damage caused during Protected Space Operations. Article 17 of the ISS Agreement states that except as provided in Article 16, the Liability Convention applies, and Partner States

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[195] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 29.
[196] TALLIS, *supra* note 109, p. 82.
[197] ESA, *supra* note 30.
[198] POPOVA, SCHAUS, *supra* note 4, p. 9.
[199] KERREST, *supra* note 14, p. 5.
[200] TALLIS, *supra* note 109, p. 83.
[201] KERREST, *supra* note 14, p. 1.
[202] 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, Washington, entered into force 2001. (hereafter as ISS Agreement)
[203] *Ibid.*, Art. 16.

concerned by a compensation claim can accordingly conclude separate agreements in case of joint and several liability.[204] Concluding such an agreement between the largest space faring nations which are the biggest producers of space debris could have a positive impact on space debris removal activities.

A similar regime to the regime of Protected Space Operations could be established for ADR operations which would consequently be exempt from the liability regime under the Liability Convention. This would render ADR operations more acceptable for launching States of the target space debris as they would not face such a risk of being held liable for damage caused during a removal operation to the parties involved in the operation. According to Anzaldúa,[205] such agreement would be in accordance with the obligation set out in Article IX of the OST that space activities shall be conducted in a manner to avoid the harmful contamination of space and *"where necessary, shall adopt appropriate measures for this purpose."*[206] Jakhu, Nyampong, and Sgobba also refer to a cross-waiver of liability as a good solution for facilitating ADR and OOS operations. They add that this cross-waiver should be agreed on within a newly created international organisation which would be established specifically for ADR and OOS purposes following the examples of INTELSAT and the International Maritime Satellite Organisation (INMARSAT).[207] The cross-waiver would apply to governments and non-governmental entities within that organisation. The member States would still be liable for damage caused to non-member third parties under the Liability Convention.[208] This solution would simplify the legal relationships between States and entities performing ADR and OOS mission regularly, as there would only be one agreement regulating these relationships and no need to conclude a multitude of complex bilateral agreements under national laws.

The provisions on liability are rather straightforward for normal nonproblematic operations, however, space debris removal presents a unique challenge to liability determination. The determination of liability in such situations is further complicated as the notion of fault is unclear under the space treaties and there are no binding standards of good behaviour and no specific rules on what constitutes negligence. It might be therefore hard to find the liable State. The only remedies to these issues are complicated bilateral agreements and arrangements under national laws between the parties involved. However, international space law needs to be adopted

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[204] ISS Agreement, *supra* note 202, Art 17.
[205] ANZALDÚA, *supra* note 43, p. 26.
[206] Outer Space Treaty, *supra* note 54, Art. IX.
[207] JAKHU, R. S., NYAMPONG, Y. O. and SGOBBA, T., Regulatory framework and organization for space debris removal and on orbit servicing of satellites, p. 136.
[208] *Ibid*.

on these issues to unify the practice. Namely a system of guidelines or principles on fault behaviour, negligence and what behaviour constitutes due regard therefore excluding negligence and fault should be adopted. Also, more precise international rules on the complex liability relationships would avoid the need for bilateral agreements. Some authors contemplate and propose the conclusion of an agreement on space debris remediation which would contain a cross-waiver of liability among the States.[209] Issues of liability are also relevant in transfer of ownership which this chapter discusses later. In the following subchapter, issues connected to registration are explained.

3.3. Registration

Article VIII OST states that the State that registers a space object is the State of registry and retains jurisdiction and control over such object.[210] Jurisdiction signifies the power of a State to legally enforce over its object, and control represents the factual element that makes technical control possible.[211] The Registration Convention defines a State of registry as a launching State on whose registry the space object is registered.[212] According to Article II of the Registration Convention, States shall register objects with their national registry and inform the Secretary-General of the UN of the establishment of a national registry.[213] As there can be multiple launching States to one space object, Article II (2) specifies that where there is more than one launching State, the States shall jointly determine which one of them will register the object. The Registration Convention anticipates that agreements regarding the allocation of jurisdiction and control between the launching States of the same objects will be concluded.[214] States are also obliged to register their space object with the Secretary-General of the UN. Accordingly with the Registration Convention, the UN established a central Register of Objects Launched into Outer Space.[215] It must be noted that in accordance with the qualification of space debris as space objects, jurisdiction and control of a space object is retained whether it is functional or not.[216] Article IV of the Registration Convention sets out the requirements for registration.[217]

As jurisdiction and control belongs to the State of registry, Hofmann and Masson-Zwaan pose an interesting question of who has jurisdiction and control over unregistered objects? The

[209] JAKHU, NYAMPONG, and SGOBBA, *supra* note 207, p. 136.
[210] Outer Space Treaty, Art. VIII.
[211] POPOVA, SCHAUS, *supra* note 4, p. 9.
[212] Registration Convention, *supra* note 57, Art. I.
[213] *Ibid.*, Art. II.
[214] *Ibid.*
[215] *Ibid.*, Art. III.
[216] JAKHU, NYAMPONG, SGOBBA, *supra* note 207, p. 131.
[217] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 32.

authors explain that the registration is not the act that confers jurisdiction and control to a State.[218] Therefore, in case there is only one launching State to a space object that has not registered the object, it still has jurisdiction and control. How would this apply when there are multiple launching States? This would imply that any of the launching States has jurisdiction and control over the space object if none of them register the object. In practice, States would probably determine which one has jurisdiction and control along the meaning of Article II of the Liability Convention, which states that in case of multiple launching States, they should decide on one that will register the space object. The absence of registration of space objects has negative consequences for space debris remediation as it may be unknown who the launching State is. This is connected to legal problems discussed above.

Another problem with the registration of space objects is the vaguely defined deadline in the Registration Convention. Article IV of the Registration Convention requires that States of registry provide the UN Secretary with information on the launched space object *"as soon as practicable"*.[219] Perek states the delays are sometimes months or years and rightfully criticises that instead States register information *"as soon as convenient"*.[220] Although according to more recent research the delays have shortened, still the median delay for registration in the period from December 2018 to March 2019 was up to 342 days.[221] This is an issue as timely registration of information on the launch and position of space objects is needed by all participant of space activities. Registration is also vital for space debris remediation operations to be conducted successfully as it is important to have good knowledge of the space environment around the possible target.

The format of registration and announcement of information poses another issue. As the Registration Convention itself provides little to no information on the format or the extent of information to register, the practices of States differ.[222] The Registration Convention calls for States to register information on the date and location of the launch, information of the general function of the object, a designator and the registration number of such object and information on the four basic orbital elements (nodal period, inclination, apogee, perigee),[223] these are not sufficient to determine the exact position of an object in orbit.[224] Perek concludes that practices of

[218] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 32.
[219] Registration Convention, *supra* note 57, Art. IV.
[220] PEREK, *supra* note 160, p. 354.
[221] LE MAY, S., CARTER, B.A., GEHLY, S., FLEGEL, S. and JAH, M. Representing and querying space object registration data using graph databases. p. 401.
[222] PEREK, *supra* note 160, p. 354.
[223] Registration Convention, *supra* note 57, Art. IV.
[224] PEREK, *supra* note 160, p. 353.

States such as incomplete registration of information, long and irregular delays in registering information, and different formats have a negative effect on the use and potential of the Registration Convention. He also notes that the number of unregistered objects is alarming.[225] ESA demonstrates that the number of unregistered space objects is still growing.[226]

The registration of space objects is not always straightforward. To illustrate this issue, Hofmann and Masson-Zwaan recall the example of Kicksat.[227] Kicksat was a small satellite launched in 2014 that, during its mission, deployed 104 very small computer-chip sized objects called Sprites with satellites functions and equipped with a radio, solar cells, and microcontroller.[228] The question is whether the Sprites possess the same legal status as Kicksat, whether they are space objects as per the definition in Article I(b) of the Registration Convention or component parts. This is relevant regarding the registration of the objects. Proper registration of space objects launched is a key step in debris mitigation and remediation especially for collision avoidance. In reality, neither Kicksat nor the individual Sprites were registered. Theoretically, registering each satellite separately makes more sense, as it would allow other operators to have more specific information on the satellites including their position. However, on a practical level, it seems improbable as States are more likely to register the constellation as a whole rather than each satellite individually.[229]

Article VI of the Registration Convention provides that States that have means for space object tracking shall provide assistance upon request in identifying a space object that caused damage and its launching State was not able to identify it. In addition, the State to which the space object had caused damage should provide all necessary information on the incident that led to this request.[230] This is an interesting provision that could be used even for remediation purposes.

If obediently followed, the Registration Convention has great potential and could be of assistance for space debris mitigation and remediation. For instance, if all States registered information on when an object becomes non-functional, it would be easier to determine which objects are space debris.[231] The UN has adopted Recommendation on enhancing the practice of States and international intergovernmental organisations in registering space objects.[232] In order to harmonise registration practices amongst State Parties, the UN recommends that specific

[225] PEREK, *supra* note 160, p. 355.
[226] ESA, *supra* note 30.
[227] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 152.
[228] KREBS, Gunter D. Kicksat 1, 2.
[229] MASSON-ZWAAN, HOFMANN, *supra* note 13, p. 153.
[230] Registration Convention, *supra* note 57, Art. VI.
[231] PEREK, *supra* note 160, p. 356.
[232] United Nations General Assembly, Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects A/RES/62/101.

parameters and units should be used to achieve uniformity in registering information.[233] In addition, the resolution recommends that more information should be provided such as the GEO orbit location, change of status in operations, information on functionality of the object including when the object becomes non-functional, the approximate date of decay or re-entry of such object or its move into a graveyard orbit.[234] The recommendations also state that in case of joint launches of multiple objects, such objects should be registered separately,[235] this is an important guideline in the context of mega-constellation of satellites. Ideally, satellites belonging to a mega-constellation, i.e., a large group of satellites would be registered individually to simplify the localisation of individual satellites within the constellation and to provide more information about them in general. This is key for ADR or OOS operations purposes. Often only one satellite from the group becomes non-functional and easier locating would help effectively conducting a remediation operation.

An improved registration system and more regular and systematic registration would present many advantages for space debris remediation and mitigation. First, better trackability of space objects and debris would allow for more precise trajectory planning and better collision avoidance. In addition, meticulous registration would allow for easier recognition of launching States of space objects. This would be significantly helpful for damage compensation purposes as without the knowledge of who is the launching state of an object that caused damage, compensation cannot be claimed. It would also be helpful for ADR and OOS operators that need to know the identity of the launching State in order to obtain its permission to conduct an operation.

3.4. Transfer of ownership

The space treaties do not contain any provisions on transfer of ownership. Nonetheless, some transfers of ownership have already occurred. To name a few examples, bSkyB sold a small satellite called Marcopolo-2 to Norwegian Telecom in 1992. BSkyB also sold its Marcopolo-1 satellite to the Swedish company Nordic Satellite AB[236] (now SES Astra[237]). In 1993, Telesat Canada sold two if its satellites to an Argentinian company Paracom. In 2014, Airbus Defence & Space sold a satellite to the Azerbaijani space agency. AsiaSat satellites were launched when Hong Kong was still a part of the UK, however, Hong Kong became Chinese again in 1997. Hence, the

[233] United Nations General Assembly, *supra* note 232, Art. 2 (a).
[234] *Ibid*. Art. 2 (b).
[235] *Ibid*. Art. 3 (c).
[236] POPOVA, SCHAUS, *supra* note 4, p. 10.
[237] VIA SATELLITE. SES Astra gains full ownership of SES Sirius.

nationality of these satellites changed. Another example is when the Canadian company Telesat Canada was bought by Loral, a US company.[238]

A space object may be sold and bought even if it is in outer space. Space law does not prohibit the transfer of ownership. The question of transfer of ownership of a space object entails questions of transfer of liability, registration, jurisdiction, and control.[239] As per article VII of the Outer Space Treaty, the liability lies on the launching State,[240] on the other hand, jurisdiction and control belong to the State of registry.[241] There are two different types or situations of transfer. Transfer of ownership between two launching States of the same space object and the transfer of ownership between a launching State and a non-launching State.[242] In the first case, the ownership of that space object can be transferred including jurisdiction and control connected to it. As the transferee is also an original launching State of the transferred object, it is also liable for damage as per the OST and the Liability Convention. However, the liability is not transferred from the transferor and the transferor remains liable together with the transferee. The liability relations between the two launching States can be sorted out in a bilateral agreement binding only on the two parties. As stated in Article I of the Registration Convention, only a launching State can register a space object.[243] Navalgund explains that if the transferee is a launching State, it can register the object and, therefore, have control and jurisdiction over it as per Article II of the Registration Convention. At the same time, the transferor can unregister the object and cease to have jurisdiction and control.[244]

This does not apply to a transfer of ownership between a launching and a non-launching State. When it comes to the transfer of ownership where the transferee is not a launching State, the transferor as the launching State retains liability over the transferred space object even though it cannot practically exercise any control over it. However, the transferee cannot register the space object in its name as it is not a launching State, nor can it gain jurisdiction and control over that object as these are connected to the registration.[245] To sum up, according to the Outer Space Treaty, the State of registry retains jurisdiction and control, and the case is the same in case of transfer as the State of registry *de jure* retains jurisdiction and control over the transferred space object. The State to whom the object is being transferred to, therefore, has only *de facto* control if it does not

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[238] VON DER DUNK, *supra* note 105. pp. 2,4.
[239] KERREST, A., Legal aspects of transfer of ownership and transfer of activites, p. 5.
[240] Outer Space Treaty, *supra* note 54, Art. VII.
[241] Registration Convention, *supra* note 57, Art. VIII.
[242] KERREST, *supra* note 239, pp. 5,6.
[243] Registration Convention, *supra* note 57, Art. I.
[244] NAVALGUND, *supra* note 116 p. 293.
[245] *Ibid*. p. 294.

register the space object itself.[246] As for liability, a bilateral agreement can be concluded between the two parties. Even though a bilateral agreement can be concluded between the transferor and the transferee, it is only binding to the parties of the agreement and does not apply to third parties. Kerrest suggests an ideal process of transfer of ownership under current space law. First, an agreement between the transferor and transferee must be concluded, including provisions on liability and the right of recourse of the transferor. Concerning liability, in case of such agreement, the victim is in a better position as both States are liable and the victim can demand compensation from both. On the other hand, the transferor is protected by the agreement as the final burden can be laid on the transferee.[247]

The evident legal issue with transfer of ownership is liability. In both cases, liability cannot be transferred and remains with the launching State who was the original owner. This is a great issue as without the transfer of liability, the transfer of ownership is incomplete, and the liability issue must be solved by separate agreements. The fact that the original launching State stays internationally liable is a deterrent to effecting ownership transfers. Von der Dunk also recognises that the issue of liability being connected to the launching State is troublesome in today's commercially driven use of space.[248] Chatzipanagiotis argues that instead of the State which has no jurisdiction or control over a space object, the State in control should be liable.[249] The author of this thesis agrees that liability rules should be revisited as they are not favourable for space debris remediation operations.

It should be noted that the UN takes transfer of ownership into consideration. The UN Res. 59/115 of 2004 recommends that States inform voluntarily about on-orbit transfers of ownership of space objects. The transferor and transferee are also recommended to provide relevant information about the transfer such as the orbital position of the object and its function, identification of the transferee and date of change in supervision of the object.[250] The resolution also recommends that States should harmonise the transfer of ownership practices based on the information provided to increase consistency within these practices and within national and international regulation.[251]

How is the transfer of ownership of space objects relevant for space debris remediation? Assume, for instance, that State A launched a satellite which has now reached the end-of-mission

[246] NAVALGUND, *supra* note 116, p. 294.
[247] KERREST, *supra* note 239, p.10.
[248] VON DER DUNK, *supra* note 105, p. 35.
[249] CHATZIPANAGIOTIS, *supra* note 144, p. 92.
[250] NAVALGUND, *supra* note 116, p. 296.
[251] United Nations General Assembly, Application of the concept of the "launching State" (2004) UN Doc. A/RES/59/115.

phase. State A would consider this satellite non-operational debris and has no interest in conducting active debris removal or on-orbit servicing itself as it has newer satellites with more advanced technology and this satellite has no value for State A anymore. State B has resources to conduct an on-orbit servicing operation and repair, refuel or repurpose State A's satellite and prolong its operational life and would also like to keep the satellite for its own space activities. State A and State B could agree on transferring the space object. However, as neither liability nor jurisdiction and control can be transferred when State B is not a launching State, States may be disincentivised to conduct the transfer. This problem will only gain importance in the future as space activities will continue to grow.[252]

The transfer of ownership of space objects in orbit could be a useful tool for active debris removal and on-orbit servicing as demonstrated on the example above. However, the current legal framework does not allow for transfer of liability neither for launching to launching State transfers, nor for launching to non-launching State transfers, which entails the need for bilateral agreements. However, these do not have effect on third parties and the previous owner is still internationally liable for a space object it does not own anymore. An additional issue arises for the transfer of ownership between a launching and a non-launching State as it is impossible to transfer jurisdiction and control.

4. Solutions overcoming the lack of binding regulation

The previous chapter discussed legal aspects and issues of space debris remediation and offered some of the solutions to the specific legal issues. However, as the issues are closely interconnected, they need to be solved as a whole. It is best to discuss solutions to certain problems, such as the lack of regulation, which is a recurring issue for all the problems analysed above, together. International collaboration and thorough deliberation are key to addressing these challenges effectively. However, it is out of the scope of this thesis to solve all these complex issues. Therefore, the following chapter rather offers a selection of the sources that can be used in further solving of these issues and their explanation. These solutions aim to establish a detailed and suitable legal framework for efficient space debris remediation. It is important to acknowledge that implementing ideal binding solutions may be challenging due to geopolitical factors.

Firstly, the possibility of creation of customary law through repeated State actions is discussed as a means to create binding rules. Secondly, the creation of a comprehensive Space Traffic Management system is proposed as a mitigation and remediation measure. Furthermore,

[252] VON DER DUNK, *supra* note 105, p. 42.

the chapter introduces the International Organisation for Standardisation as a well-functioning organisation with well-established processes, and analyses standards issued by the International Organisation for Standardisation as an ideal tool for creating precise, up-to-date, and internationally agreed upon rules for space debris remediation and mitigation.

4.1. Customary law

According to some authors, the lack of binding rules regarding space debris and space debris remediation and mitigation could be healed by the establishment of customary law. Presumably, a series of bilateral or multilateral actions regarding space debris remediation could constitute a custom.[253] For a customary rule to be constituted, two elements must be present. *Usus longaevus* and *opinion iuris*, meaning general consistent practice and the belief that such practice is law. Therefore, there must be repeated precedent of such behaviour for *usus longeavus* to exist.[254] Vereshchetin states that in current space law, customs can be a source of rules that are not contained in international treaties.[255] The author proposes as an example the delimitation of air space and outer space and its connection to the right of peaceful passage of spacecraft above another territory and through its air space.[256]

If States registered their objects in compliance with the Registration Convention and followed a unified deadline for registering their space objects, for instance, of approximately no later than one month from the launch and provided all the information requested by the UN Recommendations, such interpretation of the delay set in the Registration Convention could become a customary rule. Furthermore, States joined efforts and repeatedly conducted end-of-mission disposal to graveyard orbits referencing the need to remediate space debris, this behaviour could become a custom. This already is a common practice of States to conduct post-mission disposal in the GEO and according to ESA, the compliance with space debris mitigation measures is increasing as more than 85% of operations try to comply with the mitigation measures out of which more than 60% succeed.[257] Dunstan proposes another instance where customary law could be created. As already mentioned in chapter three, necessity could constitute grounds for interference with another State's object without prior permission in cases of imminent danger. Dunstan proposes that a State could out of necessity de-orbit a space object that was launched by another State on the grounds that this space object posed imminent danger to space activities if it

[253] ANZALDÚA, *supra* note 43, p. 18.
[254] ONDŘEJ, MRÁZEK, KUNZ, Základy mezinárodního práva veřejného. p. 25.
[255] VERESHCHETIN, V. S., DANILENKO, G. M., Custom as a Source of International Law of Outer Space, p. 26.
[256] *Ibid*. p. 27.
[257] ESA , *supra* note 22, p. 7.

were to stay in orbit. However, the State must first conduct necessary analyses showing the seriousness of the danger posed by such a space object.[258] In addition, such behaviour would be in compliance with Articles on Responsibility of States for Internationally Wrongful Acts, which is a non-binding document.[259] The compliance with certain behaviours by a majority of States would be beneficial for space debris remediation and could, therefore, lead to a creation of customary law.

4.2. Space Traffic Management

Traffic rules are well established and important in three environments, namely there are rules of the road, rules on the sea and traffic rules in the air. All traffic rules are based on similar principles, which could be also applied to space traffic. For instance, collision avoidance rules, separating traffic according to opposite directions, or rules on inactive space objects as proposed by Perek.[260] For a safe and sustainable outer space environment, operators of space activities must cooperate and coordinate their activities by sharing data, defining procedures on collision avoidance manoeuvres, and situational awareness.[261] Space situational awareness (SSA) including space surveillance and tracking used for detecting and cataloguing space debris are examples of STM measures already in place. Their aim is to identify space objects in outer space, locate them and identify the risks they potentially face.[262] These are key first steps in a successful and efficient creation of a space traffic management system.

The International Telecommunication Union (ITU) is a good example. The ITU has rules for satellites in the GEO. Each satellite has its nominal position in the orbit, which prevents conjunctions. There is a risk of close encounters only when satellites are being put in orbit, transferred, or removed from orbit. During their functional stage, satellites keep their designated positions, permitted tolerances are counted on.[263] In respect to separation of traffic, the rules applied to GEO could also be applied to the LEO where density of debris is critical and the risk of collision high.[264] Specifically for communication satellites that are associated in systems, and each have a fixed position within this system in an orbital shell. If every satellite system had a specific spot reserved in orbit, the risk of collision would decrease.[265] In 1993 the ITU approved recommendations to re-orbit satellites into disposal orbit at the end of their lifetimes. To create a

[258] DUNSTEN, J. E. "Space trash": Lessons learned (and ignored) from Space Law and Government., p. 74.
[259] *Ibid.* p. 75.
[260] PEREK, *supra* note 92, p. 2.
[261] RAND CORPORATION. The time for International Space Traffic Management is now, p. 3.
[262] EUSPA, Space Situational Awareness.
[263] PEREK, *supra* note 15, p. 3.
[264] *Ibid*.
[265] *Ibid*. p. 4.

safer environment, the IADC calculated the minimum distance that two objects should have between them. The optimal minimum distance was between 245 km to 435 km depending on how compactly or loosely the satellites were built.[266] Such rules are needed in everyday space activities, and they would be very practical with regard to the problem of space debris remediation. Firstly, if rules for space traffic were created, they would represent a standard of desired behaviour and the non-compliance with such behaviour by ADR and OOS operators and the owners of the targeted space objects could constitute negligence. In addition, a standard of fault could be constituted as fault of a State could be assumed if its behaviour was in contradiction to the space traffic management rules. Rules on space traffic management could help simplify the ambiguities around liability in the context of ADR and OOS operations. Furthermore, such rules could contribute to a smoother execution of space debris remediation operations.

Some argue that an international organisation that would deal with space traffic management should be established.[267] An international space traffic management organisation could be in charge of creating rules on space traffic management. The adherence to the rules would be ensured by mechanisms of compliance and enforcement. However, States are not in agreement over the creation of such organisation.[268] Perek states that the ISO could assume a role in STM rulemaking.[269] The next subchapter shows that ISO is already developing such rules, including a standard on space traffic coordination.

4.3. International Organisation for Standardisation Standards

International Organisation for Standardisation (ISO) is an international non-governmental organisation with its Secretariat in Geneva. It has 169 members, and its role is to adopt international standards on various issues.[270] International standards are developed on a voluntary and consensual basis and are very relevant and respected in the industry, technology, and business field. Could ISO's standards be the future of space law rulemaking? The ISO has already issued many standards on space debris remediation and mitigation that are gaining relevance.

The ISO's standards are gaining recognition even in the space industry. Leaders at the G7 summit in 2021 urged space faring nations to collaborate with the ISO and join efforts to remediate and mitigate space debris.[271] The ISO is composed of national standards bodies. Membership in the ISO is divided into three categories: full members, correspondent members, and subscriber

[266] PEREK, *supra* note 15, p. 4.
[267] RAND CORPORATION, *supra* note 261, p. 4.
[268] *Ibid*. p. 5.
[269] PEREK *supra* note 15, p. 4.
[270] ISO. About Us.
[271] ISO. The Great Space Clean-up.

members. According to the division, members have a different level of influence on the ISO system.[272] Full member bodies have the power to vote in technical and policy meetings and can, therefore, directly influence the development of standards and they can adopt the ISO standards nationally. Correspondent members can attend technical and policy meetings as observers, but they do not have the right to vote. However, they also can adopt the ISO standards nationally. Subscriber members cannot adopt ISO standards, nor can they participate in the technical and policy meetings. In the Czech Republic, this body is The Czech Office for Standards, Metrology and Testing (COSMT), which has full membership in the organisation allowing its full participation in the standard development process and national adoption of such standards.[273] Such structure and organisation of the membership allows States to promote their interests and be part of the adoption process.

The ISO comprises of a General Assembly which organises annual meetings and has ultimate authority. The ISO Council is a governance body and is based on rotating membership. The Technical management board manages the technical work in the ISO and is responsible for technical committees that develop standards. Other organs of the ISO include the President's Committee, Council Standing Committees, Advisory Groups and Policy Development Committees. Standards relating to space and space operation are developed in the technical committee for Aircraft and space vehicles, which is divided into subcommittees including the Space systems and operations subcommittee.[274] This subcommittee is further divided into working groups one of them being the Orbital Debris Working Group.[275] The standards adopted by the ISO are reviewed periodically every five years, which ensures that they are up-to-date, and that they follow the latest space activities trends and needs. Simultaneously, the five-year period leaves enough space for the changes to be accepted and not to be too abrupt and disrupt stability in the space law environment. The standards are also helpful because they contain definitions of certain terms.[276]

At the top of the ISO standards hierarchy is the ISO 24113:2023 Space systems — Space debris mitigation requirements. The ISO standard applies to all unmanned space objects launched into space. These rules aim to reduce the generation of debris during all stages of the space object's lifetime through responsible design, operation and disposal that prevents debris creation. The

[272] ISO. Members.
[273] ISO. UNMZ Czech Republic.
[274] ISO. ISO/TC 20.
[275] ISO. ISO/TC 20/SC 14 – Space systems and operations.
[276] STOKES, H., BONDARENKO, A., DESTEFANIS, R., FUENTES, N., KATO, A., LACROIX, A., OLTROGGE, D., TANG, M., Status of the ISO Space Debris Mitigation Standards, p. 7.

standard also provides measures to reduce safety risks connected to the re-entry of space objects to Earth.[277] The ISO adopted multiple mitigation standards addressing the space debris issue.[278] Although the standards provide mitigation rules, they are also key for space debris remediation as they contain rules, for example, on post-mission disposal. The 24113:2023 is the top-level standard containing high-level requirements for space debris mitigation. The top-level requirements, embodied in the 24113:2023 standard, are then developed and specified in a set of lower-level standards and reports of technical character. These contain more precise rules, technical requirements, and implementation measures on end-of-life disposal, collision avoidance, design, and break-ups prevention. Further, the lower-level implementation standards contain methods and processes to employ those high-level requirements to conform to them.[279] At the bottom of the ISO international standard hierarchy are two supporting Technical Reports on design and operation guidelines for spacecraft and design and operation manual for launch vehicles.[280]

The 24113:2023 Space systems — Space debris mitigation requirements standard published in May 2023 is the fourth version of this international standard and replaces the withdrawn 2019 version. It aims to reduce the creation of space debris by implementing requirements such as avoiding intentional generation of space debris during normal operations, avoiding in orbit break-ups, conducting end-of-mission disposal of space objects in protected orbital regions, carrying out collision avoidance manoeuvres when needed, and measures relating to the risk posed to human life in case of atmospheric re-entry of space objects. The standard stresses the importance of implementing these remediation and mitigation requirements especially for space objects that have a long lifespan and remain in orbit for a long time, for missions operating in densely populated regions and in protected regions, for missions carried out close to manned missions. The ISO also addresses the need for compliance with the standard and with the 25-year rule for operations taking place in the LEO protected region. In addition, it is noted that the 25-year rule should be reduced.[281]

Other documents adopted by the ISO include standards on estimating the on-orbit lifetime of space objects, on estimating the mass of remaining usable propellant, on re-entry risk management, on collision avoidance, on survivability of space objects against impacts from space debris, and on best practices for remediation including rendezvous operations and on-orbit servicing. In addition,

[277] ISO 24113:2023 Space systems — Space debris mitigation requirements.
[278] *Ibid*.
[279] *Ibid*.
[280] STOKES, H., BONDARENKO, A., DESTEFANIS, R., FUENTES, N., KATO, A., LACROIX, A., OLTROGGE, D., TANG, M., *supra* note 276, p. 2.
[281] ISO *supra* note 277.

as the standards reflect the best practices of the space industry, the potential of adoption by operators increases.[282] Standards ISO/TR 18146:2020 Space systems — Space debris mitigation design and operation manual for spacecraft, ISO/TR 20590:2021 Space systems — Space debris mitigation design and operation manual for launch vehicle orbital stages, ISO 20893:2021 Space systems — Detailed space debris mitigation requirements for launch vehicle orbital stages, ISO 16126:2014 Space systems — Assessment of survivability of unmanned spacecraft against space debris and meteoroid impacts to ensure successful post-mission disposal, ISO 23312:2022 Space systems — Detailed space debris mitigation requirements for spacecraft, ISO/TR 16158:2021 Space systems — Avoiding collisions among orbiting objects, ISO 17666:2016 Space systems — Risk management, ISO 24330:2022 Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices, ISO 27852:2016 Space systems — Estimation of orbit lifetime, ISO 27875:2019 Space systems — Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages, are only a few examples of ISO standards on space debris remediation and mitigation. Another international standard published by the ISO is the ISO/TR 16158:2021 Space systems — Avoiding collisions among orbiting objects, it provides techniques and recommendations for dealing with close encounters, estimating collision probability and guidelines on collision avoidance.[283]

The Space Systems and Operations technical committee is also currently developing a standard on space traffic coordination, number ISO/CD 9490.2 Space systems — Space Traffic Coordination. Currently the standard is in the committee for comments. It should provide protocols for Space Traffic Coordination and thus help reduce collision risk and safe flight in space from launch to end of mission disposal, which is highly relevant for space debris remediation. The standard addresses data collection to ensure the availability of accurate data including data on the orbital location and plans of manoeuvres of space objects. The data catalogue should be shared and should provide notifications of planned manoeuvres and close encounters. Such data sharing will also improve possibilities to conduct precise collision avoidance manoeuvres.[284] The goal of this standard is to provide services and accurate, timely and up-to-date data to improve and facilitate flight planning, automate collision avoidance and ensure safe flight in space. If adopted by States, this standard could at least somewhat fill the void in the current legal framework.

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[282] STOKES, H., BONDARENKO, A., DESTEFANIS, R., FUENTES, N., KATO, A., LACROIX, A., OLTROGGE, D., TANG, M., *supra* note 276, p. 9.

[283] ISO. *supra* note 275.

[284] ISO. ISO/CD 9490.2.

These examples of published standards and standards that are currently under development show that ISO is able to produce up-to-date rules on current space activities. While other international organisations manage to recognise the problems posed by space debris, ISO agilely reacts to the trends and developments in space law, notably in space debris remediation. The fact that the ISO publishes tens of standards per year in various fields is a testament to its functionality and usefulness. The ISO reviews its standards every five years during a precise process where the latest version of the standard is either confirmed or amended and revised to fit current situations and the current development of space activities. Such a flexible and well-functioning approach is very much needed in the space industry because of its fast-paced development.

ISO could adopt standards on liability, for example, best practices, principles, and guidelines how to deal with liability in the space debris remediation context, it could try and determine a standard of fault and negligence. For example, what steps need to be taken during and after an ADR operation so that the operation can be considered conducted with due regard. For instance, the ISO 24330:2022 Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic Principles and Practices, contains best practices and guidelines that on-orbit servicing providers should adhere to during OOS and rendezvous operations.[285] Apart from technical rules and hardware and software requirements, the standard includes provisions on liability for damage and insurance of such operations. It imposes the obligation to insure a servicing operation against damage caused by the operation to third party space objects can be compensated.[286] It also provides on transparent operation by setting out rules on notification to States including notification on re-entry hazards. If as a result of the servicing operation, the targeted space object is re-entering the atmosphere, the servicer is obliged to first asses the risk connected to it. The standard also states rules on avoidance of interference, both physical and electromagnetic.[287] According to the 24330:2022 standard, the 24113:2023 standard is applicable to servicing operations and before practicing such operation, the client shall verify, that its space object targeted by the operation also meets requirements set forth in standard 24113:2023.[288] This standard develops a legal base for the relationship between the client and servicer, which is the spacecraft conducting servicing.[289] According to the ISO, this standard should be the high-level standard for RPO and OOS operations and more detailed lower level

[285] ISO 24330:2022 Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices.
[286] *Ibid*. Art. 4.1.4.
[287] *Ibid*. Art. 4.2.6.
[288] *Ibid*., Art. 4.1.2.
[289] *Ibid*. Art. 3.14.

standards are expected to be adopted in the future.[290] The adoption of these standards could be valuable for the conduct of future space debris remediation operations. This standard is a good example of regulation that could help with space debris remediation issues. Adherence to this standard could create a standard of due care which must be complied with during such operations and in case damage is caused during such operation to another space object in outer space, determination of fault liability could be much easier. Adopting a similar standard for active debris removal operations could resolve some of the legal issues connected to it and also set a best practice for States to observe.

While some authors believe the establishment of a new intergovernmental organisation would be appropriate to tackle the issues posed by space debris and its remediation by adopting new rules,[291] the author of this thesis argues that, at least for now, the ISO seems like the ideal organisation for this purpose. As discussed above, it is due to multiple reasons, namely, the process of standard adoption ensures consensus between the member bodies and guarantees regular examination of the recentness and currency of the standards. In addition, as States have the possibility to adopt the standards nationally, the standards have great potential for establishing more consistent practices of States in their space activities.

[290] ISO, *supra* note 285, p. V, p. 1.
[291] RAND CORPORATION, *supra* note 261, p. 4.

Conclusion

Research shows that even without new launches, the space debris population will continue to grow along with the risk of collision between space objects. A chain reaction of collisions could potentially occur in the future, creating a belt of debris in outer space.[292] This threat has been recognised by the international community also by the merit of Luboš Perek, who promoted space debris as a problem before the United Nations.[293] The space treaties were concluded throughout the 1960s and 1970s, during a time when space debris did not even exist neither did the need for space debris remediation. Remediation through active debris removal, either by de-orbiting space debris into the atmosphere or by re-orbiting space objects into a disposal orbit at the end of their operational life, and on-orbit servicing are necessary to reduce the risk of collisional cascading in the future. As space debris issues were not discussed nor considered when drafting the space treaties, the current legal framework presents an encumbrance to space debris remediation as it poses legal issues for conducting active debris removal and on-orbit servicing operations.

While active debris removal technologies are still in development or in testing and experimental stages, they are on the verge of becoming a reality. It is imperative to shed light on the legal issues of space debris remediation and try to understand and offer possible solutions to them. This thesis examines the legal issues specifically related to space debris remediation. The author of this thesis aims to analyse whether the current international space law provides a suitable legal framework for space debris remediation by analysing the current legal framework and its weaknesses. This thesis also discusses possible solutions.

The thesis demonstrates that absolute ownership of space objects, as known by the Outer Space Treaty, is a complicating factor for space debris remediation. Before conducting a space debris removal or on-orbit servicing operation, the operator must first obtain the owner's permission, even if the owner of the space debris is unknown or the space object has fragmented into small pieces of debris where the identification of the owner is improbable. This thesis considers proposals for creating a process of abandonment of unwanted or unidentifiable space objects to facilitate the possibility of their removal. However, this thesis argues that abandonment should only be possible in specifically delimited scenarios for States to have righteous motivations to abandon or not to abandon their space objects.

The second issue highlighted in this thesis is liability. Firstly, the lack of regulation on the prerequisites for liability is a problem. As there is no internationally binding standard of good

[292] KESSLER, COUR-PALAIS, *supra* note 41, p. 2645.
[293] IROZHLAS, *supra* note 5.

practice during active debris removal or on-orbit servicing operations, neither is there a definition of negligence, the assignment of liability is complicated. In certain active debris removal or on-orbit servicing scenarios, it is unclear who would be liable for damage caused during such operation under the current liability framework and to what extent. The only practical solution is concluding bilateral agreements on liability allocation between the States concerned, which only apply to the parties. However, the compensation claim of the victim still falls under the Liability Convention regime. Nevertheless, regulation on an international level is still needed. Some authors propose creating a regime similar to the ISS agreement where States would agree on a cross-waiver of liability for active debris removal and on-orbit servicing missions.[294]

The third issue analysed by this thesis is the unfortunate formulation of the Registration Convention. In an ideal scenario where States would provide information on a voluntary basis and fulfil their obligations in time, the Registration Convention could be a great tool and helpful for space debris remediation purposes. However, the lack of precise and complete provisions in the Registration Convention, for example, that the information, which States are obliged to provide about the launched objects, is insufficient or the vague determination of the deadline for registration, leads to the Registration Convention not meeting its full potential and not meeting the needs of space remediation. Timely registration and provision of detailed information about the status of the space object would allow for easier identification of space objects and their launching States, which would be helpful for remediation purposes.

The transfer of ownership of space objects is also examined. Instead of being an ideal way to allow active debris removal operators to conduct their operations on space objects without the launching State having to fear potential liability for damage, transfer of ownership is complicated by rigid rules of the Outer Space Treaty, Liability Convention and Registration Convention. As a result, liability cannot be transferred under international space law, and for transfers between a launching and non-launching State, neither can jurisdiction and control connected to registration. At present, the solution to this problem lies in concluding bilateral agreements. However, the thesis shows that these rules should be revisited, and it should be considered whether liability should instead be connected to the State, which possesses control over the space object.

The lack of binding regulation, or any regulation in general, in some instances, is a recurring issue for space debris remediation. Today's geopolitical environment is not favourable to the adoption of a new binding international space treaty. Therefore, this thesis proposes an overview of other possible ways of creating a more suitable legal framework and suggestions on

[294] ANZALDÚA, *supra* note 43, p. 25.

what regulations could be adopted. Firstly, States could undertake bilateral and multilateral action with the intent to create customary laws. Secondly, rules and procedures regarding space traffic management need to be specified, which would help to determine liability in the fault-based regime. Better collaboration on data and information exchange, enhanced collision avoidance processes, and close international cooperation would facilitate space debris mitigation and diminish the legal ambiguities around space debris remediation. Furthermore, special attention is paid to international standards issued by the International Organisation for Standardisation. This thesis argues that the International Organisation for Standardisation is an ideal, well-established and respected organisation among the majority of States, which poses necessary grounds for effective rulemaking. The reason is that the ISO is comprised of member standardisation bodies from all over the world, and the majority participates in a detailed standard adoption process. The international standards are being revised every five years to ensure they are up-to-date and correspond to the development of the space industry and space activities.

The current space treaties fall short in providing a sufficient legal framework for the effective conduct of active debris removal and on-orbit servicing. The existing provisions are too general to address the complex legal relations that arise during these operations and to resolve potential legal issues. This thesis demonstrates that legal issues of space debris remediation are intertwined, and to address these issues effectively, the solutions also need to be interconnected in order to avoid creating even more issues and to avoid disincentivising States from engaging in space debris remediation operations. Achieving this requires collaboration among spacefaring nations and active participation from international organisations and regulatory bodies. These are crucial components to ensure the effective and sustainable management of space debris and maintaining a safe outer space environment. The legal aspects of space debris remediation deserve further attention as it would be interesting to consider whether a different legal framework should be established for space debris remediation activities for the sake of a sustainable space environment.

List of abbreviations

ADR	Active Debris Removal
COSMT	Czech Office for Standards, Metrology and Testing
ESA	European Space Agency
GEO	Geostationary Earth Orbit
GPS	Global Positioning System
IAA	International Academy of Astronautics
IADC	Inter-Agency Space Debris Coordination Committee
INMARSAT	International Maritime Satellite Organisation
INTELSAT	International Telecommunications Satellite Organisation
ISO	International Organisation for Standardisation
ISS	International Space Station
ITU	International Telecommunications Union
LEO	Lower Earth Orbit
NASA	National Aeronautics and Space Administration
OOS	On-Orbit Servicing
OST	Outer Space Treaty
RPO	Rendezvous and Proximity Operations
SSA	Space situational awareness
SSN	Space Surveillance Network
STM	Space traffic management
TSS	Tiangong Space Station
UK	United Kingdom
UN	United Nations
UNCOPUOS	United Nations Committee on the Peaceful Uses of Outer Space
UNOOSA	United Nations Office for Outer Space Affairs
US	United States

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Právní problémy likvidace kosmického smetí

Abstrakt

Aktivity ve vesmíru se neustále vyvíjí a kosmický prostor se zaplňuje do té míry, že k zajištění udržitelného kosmického prostředí je zapotřebí likvidace kosmického smetí. Kosmické smlouvy však likvidaci kosmického smetí neupravují. Tato práce analyzuje právní otázky likvidace kosmického smetí jako jednu z nejnaléhavějších otázek současného kosmického práva. Autor si klade za cíl odpovědět na otázku, zda současné kosmické právo poskytuje dostatečný právní rámec pro likvidaci kosmického smetí, a to analýzou otázek vlastnictví, odpovědnosti, registrace a převodu vlastnictví. Vlastnictví kosmických objektů je podle Kosmické smlouvy nezrušitelné, což platí i pro kosmické smetí, což v některých případech komplikuje jeho likvidaci. Získání povolení vlastníka k likvidaci nebo servisu kosmického objektu není schůdným řešením, pokud je totožnost vlastníka neznámá. Diplomová práce diskutuje opuštění kosmického objektu jako možné řešení tohoto problému. Převod vlastnictví je rovněž komplikovaný, neboť odpovědnost za škodu nelze převést, stejně jako nelze převést jurisdikci a kontrolu, pokud je nabyvatelem stát, který kosmický objekt nevypustil. Problém představuje i samotná odpovědnost, neboť kosmické smlouvy nebyly vypracovány tak, aby vyhovovaly specifickým právním vztahům, které mohou vzniknout během likvidace kosmického smetí. Diskutuje se také o možnosti odlišného režimu odpovědnosti za škodu při likvidaci. Tato diplomová práce tvrdí, že pokud by byla Registrační úmluva řádně dodržována, byla by skvělým nástrojem pro účely likvidace kosmického smetí. Tato práce ukazuje, že současné kosmické právo neposkytuje potřebný právní rámec pro aktivní odstraňování kosmického smetí a servis na oběžné dráze. Obyčejové právo je jednou z možností, jak nahradit chybějící závazná pravidla. Kodifikace pravidel pro řízení kosmického provozu je další možností, jak napomoci likvidaci kosmického smetí a úsilí o udržitelné kosmické prostředí. Tato práce dále navrhuje větší využití mezinárodních standardů vydávaných Mezinárodní organizací pro normalizaci.

Klíčová slova: kosmické smetí, likvidace kosmického smetí, právní problémy

Legal issues of space debris remediation

Abstract

Space activities are growing, and outer space is becoming congested to a point where space debris remediation is needed to ensure a sustainable outer space environment. However, space treaties do not take space debris remediation into account. This thesis analyses legal issues of space debris remediation as one of the most pressing matters of space law. The author aims to answer whether current space law provides a sufficient framework for space debris remediation by analysing the issues of perpetual ownership, liability, registration, and transfer of ownership. Ownership of space objects is permanent under the Outer Space Treaty, this also applies to space debris, which complicates its remediation in certain cases. Obtaining permission is not a viable solution when the owner is unknown. Abandonment is discussed as a solution to the ownership problem. Transfer of ownership is also complicated as liability for damage cannot be transferred, neither can jurisdiction and control when the transferee is a non-launching State. Furthermore, liability presents an issue itself, as the space treaties were not drafted to fit the delicate legal relationships that may arise during space debris remediation operations. The possibility of a different liability regime for remediation is discussed. Additionally, this thesis suggests that if duly followed, the Registration Convention would be a great tool for space debris remediation purposes. This thesis argues that current space law does not provide the necessary framework to conduct active debris removal and on-orbit servicing without legal challenges. Creating customary law is one possibility of compensating for missing binding rules. The codification of space traffic management rules is another way to help space debris remediation and the efforts for a sustainable space environment. This thesis proposes a greater use of the international standards issued by the International Organisation for Standardisation.

Key words: space debris, space debris remediation, legal issues