LEGAL ASPECTS OF SPACE DEBRIS REMEDIATION: ACTIVE REMOVAL OF DEBRIS AND ON-ORBIT SATELLITE SERVICING

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To

The sole radiant star in my Universe,

The source of my sustenance,

The reason for my being,

Maa.

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ABSTRACT

With the alarming proliferation in the population of orbital debris, scientific analysis has indicated a need to perform space debris remediation through active removal of debris and on-orbit satellite servicing. This thesis aims to study the implications of the existing framework of international space law and public international law on space debris remediation.

Following a description of the hypothesis and the research methodology, the introductory chapter explains the current state of the debris environment and the consequent need to perform space debris remediation. With that understanding, the economic and technological feasibility for such an endeavour is also assessed. The second chapter addresses the concerns regarding the current definition of a 'space object' and examines the requirement for the adoption of a separate legal definition of space debris to facilitate space debris remediation activities. The key question of legitimate exercise of jurisdiction and control over space objects, in the realm of space debris remediation, along with contentious issues such as transfer of ownership and/or registry of space objects are discussed in the third chapter. The fourth chapter elaborates on the related responsibility and liability considerations linked to remediation activities in outer space. The final chapter contains a summary of the important conclusions from the earlier chapters and presents some overall observations on the entire analysis.

RÉSUMÉ

Avec la prolifération alarmante du nombre de débris orbitaux, des études scientifiques ont montré la nécessité d'effectuer un nettoyage des débris spatiaux, par le biais de la suppression effective de ces débris ainsi que la mise en place d'un système orbital de « service » aux satellites. Cette thèse vise à étudier les effets du cadre actuel du droit spatial international et du droit international public, sur la gestion du problème des débris spatiaux.

Après une description du postulat et de la méthodologie de recherche, le chapitre introductif (chapitre I) explique l'état actuel de l'environnement des débris spatiaux et la nécessité d'éliminer ces débris. Dans ce contexte, la faisabilité économique et technique d'une telle entreprise est évaluée au chapitre II. Le chapitre III traite des questions liées à la définition actuelle d'«objet spatial» et examine les conditions de l'adoption d'une définition juridique distincte pour les débris spatiaux, afin de faciliter les activités de nettoyage afférentes. La question essentielle de l'exercice légitime de la juridiction et du contrôle des objets spatiaux, s'agissant de leur nettoyage, ainsi que les sujets controversés tels que le transfert de propriété et/ou l'enregistrement des objets spatiaux, sont examinés dans le chapitre IV. Le chapitre V entre dans le détail des réflexions sur la responsabilité liée aux activités de dépollution dans l'espace. La section finale (chapitre VI) comprend un résumé des conclusions importantes des chapitres précédents, et présente quelques observations générales sur toute l'analyse.

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1. INTRODUCTION

1.1. The Context

Orbital debris have been defined as "artificial objects, including derelict spacecraft and spent launch vehicle orbital stages, left in orbit which no longer serve a useful purpose."[1] Since the launch of Sputnik I in 1957,[2] these uncontrollable man-made objects in the earth orbit continue to pose increasing navigational threats to functional satellites and other space assets, including human space flight and robotic missions.[3]

While the alarming rise in the population of space debris, the exponential increase in the number of space actors coupled with the inadequacy of the current legal regime may seem to constitute the perfect recipe for a manifestation of the "tragedy of the commons" in earth orbit,[4] it is discernible from a closer look at the situation that it

[1] *NASA Handbook for Limiting Orbital Debris 8719.14* (Washington, DC: NASA, 2008) at 21 (hereinafter *NASA Handbook)*. This definition provides the scientific background to NASA's Orbital Debris Program as defined in NASA Procedural Requirements 8715.6, Procedural Requirements for Limiting Orbital Debris and NASA Standard 8719.14, Process for Limiting Orbital Debris.

[2] Michael Stoiko, *Soviet Rocketry: Past, Present, and Future* (Holt, Rinehart & Winston, 1970) at 79.

[3] Interagency Report on Orbital Debris (Office of Science and Technology Policy, U.S. National Science and Technology Council, Washington, DC, 1995); *Technical Report on Space Debris*, text of the Report adopted by the Scientific and Technical Subcommittee of the United Nations Committee on Peaceful Uses of Outer Space, UN Doc A/AC.105/720 (New York: United Nations, 1999) (hereinafter *Technical Report on Space Debris*).

[4] The tragedy of the commons posits the situation where rational individuals, acting in their own self-interest, may ultimately render a shared and limited resource unusable, even when it is clearly not in their interest to do so. Garrett Hardin, "The Tragedy of the Commons" (1968) 162 Science 1243, cited in Richard dalBello & Michael Mendelson, "Private Risk Management in Orbital Operations, Inter-operator Liability and the Space Data Association" (2011) 60 ZLW 218 at 224.

resembles the corollary of the 'tragedy of the anti-commons'[5] by preventing the optimum utilisation of space resources.

1.2. Hypothesis

There are a number of private enterprises that are investing heavily in the realm of space debris remediation and on-orbit satellite servicing by developing robotic spacecraft technology.[6] Additionally, the public sector and the government agencies have also expressed significant interest by actively soliciting Requests for Proposals from private actors for the development of this technology.

Indeed, owing to the increasing proliferation in the population of space debris in the earth orbit, remediation activities at full throttle pose a mere question of 'when' in the near future. With space debris remediation operations a given certainty, the central hypothesis of this study is that one of the major inhibiting factors of this development is the absence of clarity in the legal framework to govern remediation activities in outer space. The existing *corpus juris spatialis* is often subjected to criticism for its failure to keep pace with the rapid technological advancements and the contemporary

[5] Michael Heller, "The Tragedy of the Anticommons: Property in the Transition from Marx to Markets" (1998) 111 Harv. L. Rev. 621, cited in Richard dalBello & Michael Mendelson, ibid. "The 'tragedy of the anti-commons' is used to describe the situation where the existence of numerous rights-holders can also prevent the realisation of a socially desirable outcome."

[6] See *infra* Chapter 2, Section 3.

commercialisation.[7] This study explores the body of space law and its implications on space debris remediation.

The existing framework of international space law does not authorise interception with space objects without the prior consent of the State of Registry. In the case of a removal of an object without the authorisation of the State of Registry, it would constitute an internationally wrongful act. However, such wrongfulness may be precluded by the defence of necessity under the given circumstances. In order for the smooth operation of space debris remediation, it is essential to effectuate unambiguous interpretation of the existing provisions of international space law, which are adequate to address potential legal controversies arising in this context. There is no need for any amendment or reform in the current legal framework or to conclude a separate treaty in this regard, which will amount to a diplomatic impossibility in the present geo-political environment

1.3. Scope

The purview of this study does not include *jus ad bellum*[8] and the legal analysis undertaken herein is confined to space debris remediation activities conducted in times of peace. The findings of this dissertation will yield fallacious outcomes if they are extrapolated to conflict scenarios.

[7] Generally, Bin Cheng, "The Commercial Development of Space: The Need for New Treaties" (1991) 19 J. Sp. L. 17; Tare C. Brisibe, "Satellite Servicing On-Orbit by Automation and Robotics: Legal and Regulatory Considerations" (2003) 29 J. Sp. L. 21; Hanneke L. van Traa-Engelman, *Commercial Utilisation of Outer Space: Law and Practice* (Martinus Nijhoff, 1993); Kunihiko Tatsuzawa (ed.), *Legal Aspects of Space Commercialisation* (CSP Japan, 1992); Marietta Benkö, Kai Uwe Schrogl & Denise Digrell (eds.), *Space Law: Current Legal Problems and Perspectives for Future Regulation* (Eleven International, 2005).

[8] Ricky J. Lee, "The *Jus Ad Bellum In Spatialis*: The Exact Content and Practical Implications of the Law on the Use of Force In Outer Space" (2003) 29 J. Sp. L. 93.

The aim of this study is to review the controversial legal issues concerning 'jurisdiction and control' of space objects, even after they cease to be functional in outer space and the related responsibility and liability considerations stemming from them.

This study will examine the space behaviour of States as subjects of public international law and *a fortiori*, international space law. The regulatory concerns about the activities of private actors will not be addressed directly because ultimately, States shall "bear international responsibility" for such activities, which "require authorisation and continuing supervision" by the appropriate State under the dictate of Article VI of the Outer Space Treaty. Hence, this study will explore the duties and responsibilities of States as members of the international space community and their legal rights and obligations for space debris remediation conducted under their national jurisdiction and control.

1.4. Methodology

The primary tool for gathering data was through a literature review based on a host of traditional library sources, multiple legal databases and internet-based research. The research methodology employed in this thesis is mainly doctrinal in character. The sources relied on comprise several categories, including primary sources (such as treaties, customary international law, judicial decisions, international legal declarations and resolutions), secondary sources (mostly books, journal articles, online news reports), and other miscellaneous sources. Finally, the Canadian Guide to Uniform Legal Citation has been followed to ensure uniformity in citation of references.

1.5. Overview of the Problem

1.5.1. Current Space Debris Environment

Space activities are expanding at a phenomenal rate worldwide resulting in a massive increase in space traffic, especially in the past three decades.[9] The earth orbits, especially the Low Earth Orbit (LEO), are becoming increasingly crowded by a steady growth in the population of space debris.[10] The United States Space Surveillance Network, managed by the United States Strategic Command, currently tracks 16,530 objects in orbit out of which 12,993 are space debris while the remaining 3537 objects are active payloads.[11] The European Space Agency MASTER 2005 Debris Environment Model had

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[9] Lt. General Larry James, Commander, Joint Functional Component Command For Space, 'Keeping the Space Environment Safe For Civil and Commercial Users', Statement before the Subcommittee on Space and Aeronautics, House Committee on Science and Technology, (28 April 2009), online: http://gop.science.house.gov/Media/hearings/space09/april28/james.pdf. "In 1980 only 10 countries were operating satellites in space. Today, 9 countries operate spaceports, more than 50 countries own or have partial ownership in satellites and citizens of 39 nations have traveled in space. In 1980 we were tracking approximately 4,700 objects in space; 280 of those objects were active payloads/spacecraft, while another 2,600 were debris. Today we are tracking approximately 319,000 objects; 1,300 active payloads and 7,500 pieces of debris. In 29 years, space traffic has quadrupled."

[10] Lubos Perek, "Actual Situation in the Geostationary Orbit" (2012) 55 Proc. Of Colloq. On Law of Outer Sp.; George T. Hacket, *Space Debris and the Corpus Iuris Spatialis* (Editions Frontiéres, 1994) at 36-40; Howard A. Baker, *Space Debris: Legal and Policy Implications* (Martinus Nijhoff, 1989) at 3-60; *Active Debris Removal — An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space: A Report of the International Interdisciplinary Congress on Space Debris Remediation and On-Orbit Satellite Servicing*, UNCOPUOSOR, 49th Sess, UNCOPUOS A/AC.105/C.1/2012/CRP.16 (27 January 2012) at 15-21 (hereinafter *Active Debris Removal Congress Report*); *Towards Long-term Sustainability of Space Activities: Overcoming the Challenges of Space Debris – A Report of the International Interdisciplinary Congress on Space Debris*, UNCOPUOSOR, 48th Sess, UN Doc A/AC.105/C.1/2011/CRP.14 (3 February 2011) at 11-20 (hereinafter *Towards Long-term Sustainability of Space Activities*). For distribution of debris population, see *Orbital Debris: A Technical Assessment*, (National Academy Press, 1995), online: http://www.nap.edu/catalog/4765.html at 63-78.

[11] Satellite Box Score (as of 3 October 2012, catalogued by the U.S. Space Surveillance Network), (2012) 16 Orbital Debris Quarterly News 12, online: http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv16i4.pdf. Also, see the response to the question "How many orbital debris are currently in Earth orbit?" in the FAQ section on the website of the NASA Orbital Debris Program Office, online: http://orbitaldebris.jsc.nasa.gov/faqs.html#3.

estimated the presence of 16 million objects smaller than a centimetre, 270,000 objects upto ten centimetres and 14,000 objects larger than that in LEO.[12] There are currently 1016 active satellites traversing the earth, out of which 489 are located in the LEO.[13] Approximately 6700 tons of mass has already accumulated in Earth orbit.[14]

Debris smaller than one centimetre are capable of inflicting substantial harm to vulnerable portions of a satellite while those greater than one centimetre can severely damage or destroy a satellite.[15] Even minute untrackable particles in the LEO such as paint chips, flecks are capable of inflicting considerable harm by imparting tremendous energy during collision due to high velocities of 11 km/s on average.[16] Further, such tiny pieces of debris in the range of five to ten centimetres cannot be accurately tracked for conjunction analysis.[17] The International Space Station has had to perform more than a dozen collision avoidance manoeuvres in the last decade.[18]

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[12] David Wright, "Space Debris" (2007) 60 Physics Today 35 at 36.

[13] UCS Satellite Database (last revised 12 July 2012), online: Union of Concerned Scientists, http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html.

[14] Heiner Kinkrad, Space Debris Mitigation Activities at ESA, Presentation at the 40th session of the UN COPUOS Scientific & Technical Subcommittee (February 2011), online: http://www.oosa.unvienna.org/pdf/pres/stsc2011/tech-40.pdf, at2

[15] David Wright, "Colliding Satellites: Consequences and Implications" (26 February 2009), online: Union of Concerned Scientists, http://www.ucsusa.org/assets/documents/nwgs/SatelliteCollision-2-12-09.pdf at 2.

[16] *NASA Handbook*, note 8, at 23. "During the flight of STS-7 in 1983, a paint fleck only 0.2 mm in size impacted the window and created a pit 0.4 mm deep, which exceeded the allowable damage criteria for reuse of the window outer pane during subsequent launches. This was the first documented example of damage to the Space Shuttle from an orbital debris impact. … The Space Shuttle program replaces, on average, one to two windows per shuttle flight due to hypervelocity impacts (HVIs) from space debris including micrometeoroids."

[17] For distinction between tracked debris and catalogues debris and their classification according to size, see *Active Debris Removal Congress Report*, note 10, at 15.

[18] "International Space Station Again Dodges Debris" (2011) 15 Orbital Debris Quarterly News 1, online: http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv15i3.pdf

The worst debris-generating event in the history of space activities has been the Chinese anti-satellite test in 2007 when China destroyed its defunct meteorological satellite, Fengyun-1C by a ground-based missile.[19] Out of the top ten satellite breakups accounting for one-third of all catalogued objects currently in orbit, it has been described as the "largest debris event recorded"[20] responsible for 18% of the entire debris population.[21] The U.S. Space Surveillance Network had reported tracking 2317 debris from the incident while data collected from the Haystack (X-band) radar[22] suggests at least 150,000 debris larger than one centimetre are in orbit.[23] There was an inadvertent collision two years later in February 2009 between a 500 kg functional Iridium 33 communications satellite and Cosmos 2251, a 900 kg decomissioned Russian communications satellite, which added 1,658 trackable objects to the U.S. catalogue.[24]

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[19] J.-C. Liou, N.L. Johnson, "Characterization of the cataloged Fengyun-1C fragments and their long-term effect on the LEO environment, (2009) 43 Adv. Space Res. 1407; "Chinese Anti-satellite Test Creates Most Severe Orbital Debris Cloud in History" (2007) 11 Orbital Debris Quarterly News 2, online: http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv11i2.pdf; T.S. Kelso, "Analysis of the 2007 Chinese ASAT Test and the Impact of its Debris on the Space Environment" 2007 Advanced Maui Optical and Space Surveillance Technologies (AMOS) Conference 321, online http://www.centerforspace.com/downloads/files/pubs/AMOS-2007.pdf; Shirley Kan, China's Anti-Satellite Weapon Test, CRS Report for Congress (23 April 2006), online: http://fpc.state.gov/documents/organization/84322.pdf.

[20] Timothy Carrico, et al, "Investigating Orbital Debris Events Using Numerical Methods With Full Force Model Orbit Propagation" (Galveston: AAS/AIAA Spaceflight Mechanics Meeting, 2008), online: http://www.agi.com/downloads/resources/white-papers/Investigating-Orbital-Debris-Events-Using-Numerical-Methods-with-Full-Force-Model-Orbit-Propagation.pdf at 5.

[21] "Top Ten Satellite Breakups" (2010) 14 Orbital Debris Quarterly News 2, online: http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv14i3.pdf, at 2-3. Also, see Nicholas L. Johnson et al., *History of On-orbit Satellite Fragmentations*, 14th ed., (NASA, Lyndon B. Johnson Space Centre, 2008), online: http://orbitaldebris.jsc.nasa.gov/library/SatelliteFragHistory/TM-2008-214779.pdf.

[22] C. Stokely & M. Matney, "Haystack Radar Observations of Debris from the Fengyun-1C Antisatellite Test" (2008) 12 Orbital Debris Quarterly News 7, online: http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv12i3.pdf.

[23] "Fengyun-1C Debris: One Year Later," (2008) 12 Orbital Debris Quarterly News 2, online: http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv12i1.pdf, at 2-3.

[24] T.S. Kelso, "Analysis of the Iridium 33-Cosmos 2251 Collision" 2009 Advanced Maui Optical and Space Surveillance (AMOS) Conference, online: http://www.centerforspace.com/downloads/files/pubs/AAS%2009-368.pdf; Michael A. Earl, "Iridium

1.5.2. International Efforts towards Space Debris Mitigation

The international space community has been cognisant of the growing threat of orbital congestion since the 1980s. However, concerted international action to address the problem did not begin until the establishment of the Inter-Agency Space Debris Coordination Committee (IADC) by the various national space agencies in 1993 to foster dialogue across nations.[25] The IADC adopted a set of guidelines for space debris mitigation measures in 2002.[26]

Based on a 1994 General Assembly resolution,[27] the Scientific and Technical Subcommittee of the United Nations Committee on Peaceful Uses of Outer Space (UN COPUOS) considered space debris on its agenda for the first time in its 31st session in

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33 and Cosmos 2251: An Historic Collision" (2009) 48 Ottawa RASC Astronotes, online: http://www.castor2.ca/08_Papers/collision.pdf; Brian Weeden, "2009 Iridium-Cosmos Collision Fact Sheet" (10 November 2010), online: http://swfound.org/media/6575/2009%20iridium-cosmos%20collision%20factsheet.pdf; Ting Wang, "Analysis of Debris from the Collision of the Cosmos 2251 and the Iridium 33 Satellites" (2010) 18 Science and Global Security 87, online: http://scienceandglobalsecurity.org/archive/sgs18tingwang.pdf; David Wright, "Colliding Satellites: Consequences and Implications" (26 February 2009), online: Union of Concerned Scientists, http://www.ucsusa.org/assets/documents/nwgs/SatelliteCollision-2-12-09.pdf; Ram Jakhu, "Iridium-Cosmos Collision and its implications for space operations" in *ESPI Yearbook on Space Policy 2008/2009: Setting New Trends* (Vienna: Springer Vienna, 2010) at 254-275; Frans G. von der Dunk, "Too-Close Encounters of the Third Party Kind: Will the Liability Convention Stand the Test of the Cosmos 2251-Iridium 33 Collision?" (2009) Proc. Of Colloq. On Law of Outer Sp. 199, online: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1027&context=spacelaw

[25] Terms of Reference for the Inter-Agency Space Debris Coordination Committee (IADC), online: http://www.iadc-online.org/index.cgi?item=torp_pdf. "The primary purpose of the IADC is to exchange information on space debris research activities between member space agencies, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities and to identify debris mitigation options"

[26] IADC Space Debris Mitigation Guidelines (2002) (hereinafter IADC Guidelines), online: http://www.iadconline.org/docs_pub/IADC-101502.Mit.Guidelines.pdf.

[27] *International Cooperation in the Peaceful Uses of Outer Space*, GA Res 48/39, UNGAOR, 48th Sess, UN Doc A/Res/48/39 (1994) at para 27. "…it is essential that Member States pay more attention to the problem of collisions of space objects, including nuclear power sources, with space debris, and other aspects of space debris, and calls for the continuation of national research on this question, for the development of improved technology for the monitoring of space debris and for the compilation and dissemination of data on space debris and that, to the extent possible, information thereon should be provided to the Scientific and Technical Subcommittee."

1994.[28] In order to further deliberations based on a common understanding, the subcommittee agreed to adopt a technical report on space debris in its 33rd session[29] which was accomplished three years later in 1999 "to have a firm scientific and technical basis for future action on the complex attributes of space debris."[30]

With a view to expediting the international adoption of voluntary debris mitigation measures, a Working Group of the UN COPUOS Subcommittee collaborated with the IADC to update and revise the IADC guidelines on debris mitigation. Finally, the agreed upon guidelines were adopted by the subcommittee[31] and subsequently endorsed by COPUOS in 2007,[32] as the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space.

Both the IADC and the UN COPUOS guidelines generally call for measures to limit the debris released during normal operations by amending the designs of the satellites and rocket stages, minimise potential breakups by depleting propellant from non-operational satellites, regulate post mission disposal, avoid intentional destruction such as irresponsible anti-satellite tests and prevent on-orbit collisions.

1.5.3. Inadequacy of Space Debris Mitigation

[28] *Report of the Scientific and Technical Subcommittee on the Work of its Thirty-first Session*, UNCOPUOS, 31st Sess, UN Doc A/AC.105/571 (1994) at 12-13. Generally, see Stephen Gorove, "Preservation of Near Earth Space for Future Generations: Current Initiatives on Space Debris in the United Nations" in John A. Simpson (ed.), *Preservation of Near-Earth Space for Future Generations* (Cambridge University Press, 1994) at 205-213.

[29] *Report of the Scientific and Technical Subcommittee on the Work of its Thirty-third Session*, UNCOPUOS, 33rd Sess, UN Doc A/AC.105/637 (1996) at 16-24.

[30] *Technical Report on Space Debris*, note 3, at 1.

[31] *Report of the Scientific and Technical Subcommittee on the Work of its Forty-fourth Session*, UNCOPUOS, 50th Sess, UN Doc A/AC.105/890 (2007) at para 99.

[32] *Report of the Committee on the Peaceful Uses of Outer* Space, UNGAOR, 62nd Sess, Supp No 20, UN Doc A/62/20 (2007) at para 118-119.

In one of his seminal articles in 1978, Donald J. Kessler had predicted the phenomenon of collisional cascading of space debris in the Earth's orbit which would have a prohibitive impact on the sustainable use of space.[33] This has popularly come to be known as the 'Kessler syndrome.'[34] In a recent study conducted by the United States National Research Council, it was revealed that the current orbital debris environment has already reached a "tipping point" – the threshold where debris will begin to continually collide with itself, generating further debris.[35]

The results of a parametric simulation conducted by NASA using its LEGEND model[36] in 2005 underlined the inevitable future growth of the debris population.[37] With an assumed rate of future launches, environment projections for 200 years based on various rates of debris removal from orbit along with different selection criteria for such removal were compared with the baseline scenario.[38] It was predicted that in certain critically dense orbits, the rate of generation of new debris larger than ten centimetres would

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[33] Donald J. Kessler & B.G. Cour-Palais, "Collisional Frequency of Artificial Satellites: The Creation of a Debris Belt" (1978) 83 Journal of Geophysical Research 2637.

[34] D.J. Kessler, et al, "The Kessler syndrome: Implications to future space operations" (2010) 137 Advances in the Astronautical Sciences 47. Also, see "The Kessler Syndrome: As Discussed by Donald J. Kessler" (March 8, 2009) online: http://webpages.charter.net/dkessler/files/KesSym.html; The Kessler Effect and how to stop it (13 November 2012), online: ESA Technology, http://www.esa.int/SPECIALS/Technology/SEMDD74S18H_0.html.

[35] Committee for the Assessment of NASA's Orbital Debris Programs, National Research Council, *Limiting Future Collision Risk to Spacecraft: An Assessment of NASA's Meteoroid and Orbital Debris Programs* (Washington, DC: National Academies Press, 2011), online: http://www.nap.edu/catalog.php?record_id=13244 at 1.

[36] LEGEND (LEO-to-GEO Environment Debris model) is a high-fidelity three-dimensional physical model developed by the NASA that is capable of simulating the historical environment, as well as the evolution of future debris populations. J.-C. Liou, et al, "LEGEND—a three dimensional LEO-to-GEO debris evolutionary model" (2004) 34 Adv. Space Res. 981.

[37] J.-C. Liou, N.L. Johnson, "Instability of the present LEO satellite populations" (2008) 41 Adv. Space Res. 1046; J.C. Liou & Nicholas L. Johnson, "Risks in Space from Orbiting Debris" (2006) 311 Science 340-341, online: http://www.sciencemag.org/content/311/5759/340.full.

[38] It was adopted to be a scenario where, at the end of mission lifetimes, spacecraft and upper stages were moved to 25-year decay orbits.

exceed the natural rate of orbital decay of objects.[39] This outcome is consistent with the results of several other environment projection studies that have indicated the unstable nature of the debris population due to the potential of "random, accidental collisions among resident space objects."[40] The study finally concluded that "mitigation measure will be insufficient to constrain the Earth satellite population" and "only remediation of the near-Earth environment—the removal of existing large objects from orbit—can prevent future problems for research in and commercialization of space."[41] The most striking outcome of this study was that in order to attain stability in the LEO environment, a removal rate of five objects per year is necessary for the next two centuries.[42]

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[39] "The Earth's upper atmosphere extends into space and creates significant drag effects on space objects below approximately 1000 kilometres. This drag effect dissipates their orbital energy, reduces their altitude, and eventually causes them to re-enter the atmosphere through a process known as natural decay. Thus, the lifetime of an object on orbit is a function of its altitude and area-to-mass ratio." *Towards Long-term Sustainability of Space Activities*, note 10, at 15, Figure 1.

[40] D.J. Kessler, "Collisional cascading: The limits of population growth in low Earth orbit" (1991) 11 Advances in Space Research 63; S.-Y. Su, "On runaway conditions of orbital debris environment" (1993) 13 Advances in Space Research 221; A. Rossi, et al, "Collisional evolution of the Earth's orbital debris cloud" (1994) 11 Journal of Geophysical Research—Planets 99; L. Anselmo, et al, "Modelling the Evolution of the Space Debris Population: Recent Research Work in Pisa" (1997) ESA SP-393, European Space Operations Centre, European Space Agency, Darmstadt, Germany at 339; D.J. Kessler, "Critical Density of Spacecraft in Low Earth Orbit Using Fragmentation Data to Evaluate the Stability of the Orbital Debris Environment" (2000) Report LMSEAT-3393, Lockheed Martin; P.H. Krisko, J.N. Opiela & D.J. Kessler, "The Critical Density Theory in LEO as Analyzed by EVOLVE 4.0" (2001) ESA SP-473, European Space Operations Centre, European Space Agency, Darmstadt, Germany 273; J.-C. Liou & N.L. Johnson, "Risks in space from orbital debris" (2006) 311 Science 340, cited in, *Limiting Future Collision Risk to Spacecraft: An Assessment of NASA's Meteoroid and Orbital Debris Programs*, note 35.

[41] J.C. Liou & Nicholas L. Johnson, "Risks in Space from Orbiting Debris" (2006) 311 Science 340-341, online: http://www.sciencemag.org/content/311/5759/340.full; also see, H. Klinkrad, N. L. Johnson, "Space Debris environment remediation concepts" 5th European Conference on Space Debris, Darmstadt, Germany, 2009.

[42] J.-C. Liou, N.L. Johnson & N.M. Hill, "Controlling the growth of future LEO debris populations with active debris removal" (2010) 66 Acta Astronautica 648.

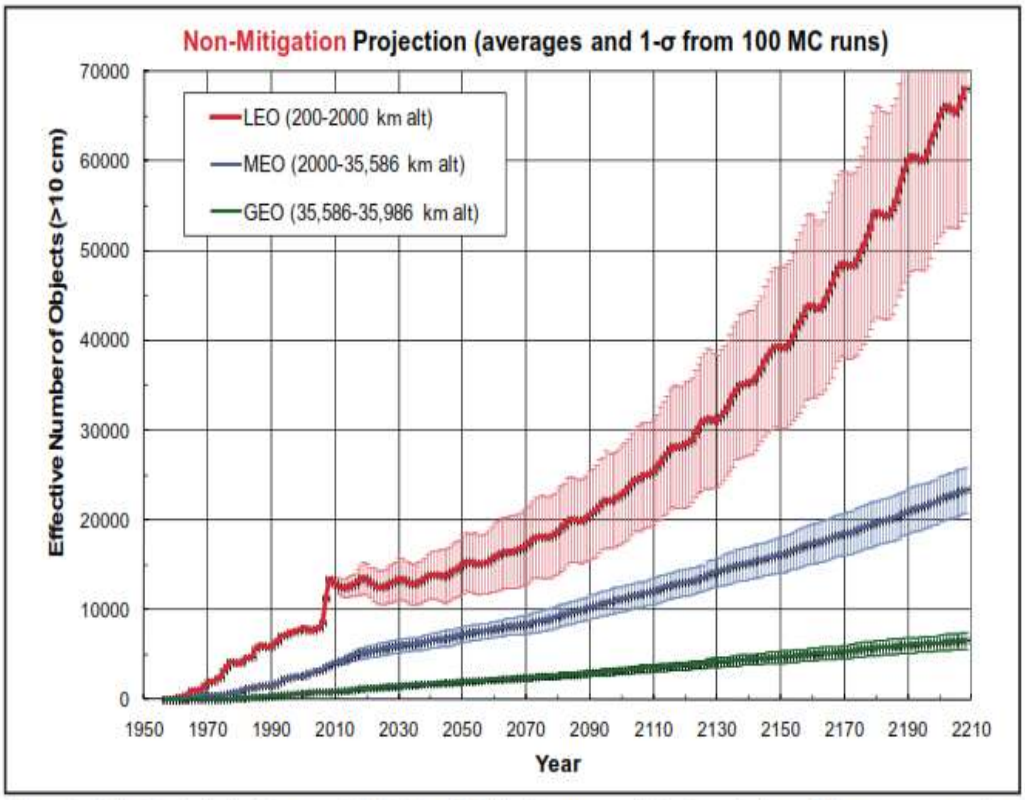

Figure 1. Updated (includes Fengyun-1C ASAT and Iridium/Cosmos collisions) projection of the runaway growth of >10 cm resident space objects if postmission disposal measures are not implemented. Figure includes 1 σ uncertainties. [43]

What makes this finding particularly disturbing is that the key assumption was there would be no launches conducted after December 2004, which has obviously not been the case. Hence, this represents a best-case scenario.[44] It is important to note that Euroconsult's newly released research report, 'Satellites to be Built & Launched by 2021: World Market Survey' anticipates that 1,075 satellites will be built for launch worldwide over the next decade (2012-2021).[45]

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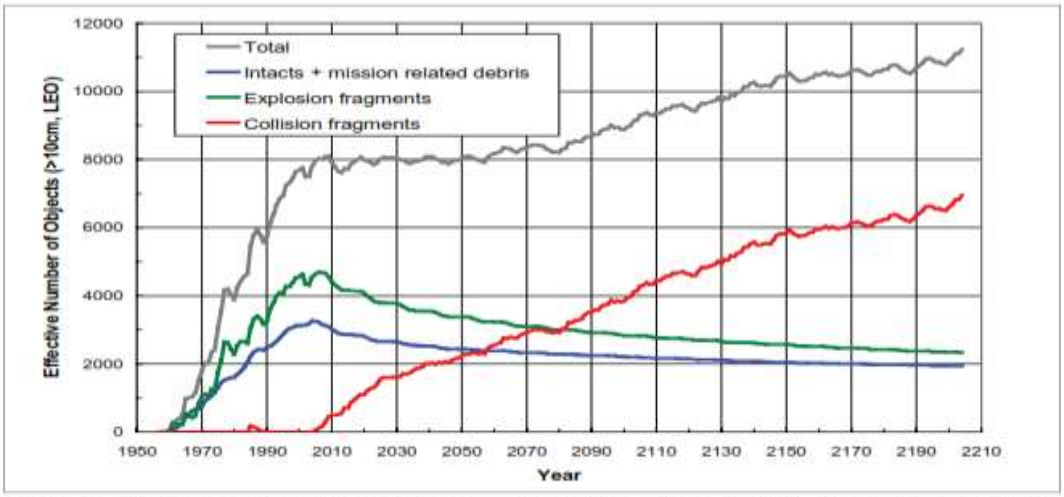
[43] Figure 1, "NASA and DARPA Sponsor International Debris Removal Conference" (2010) 14 Orbital Debris Quarterly News 1 at 1, online: http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv14i1.pdf.

[44] "Instability of the Current Orbital Debris Population" (2006) 10 Orbital Debris Quarterly News 1 at 1, http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv10i2.pdf.

[45] Press Release, 1,000+ Satellites to be Launched in the Decade Ahead; Over One-Third Commercial (8 November 2012), online: Euroconsult, http://www.euroconsult-ec.com/news/press-release-33-1/65.html



Effective number of LEO objects, 10 cm and larger, from the simulation. The effective number is defined as the fractional time, per orbital period, an object spends between 200 and 2000 km altitudes. The future projection parts of the curves (years 2005 to 2204) are averages from 50 Monte Carlo runs. Intacts are rocket bodies and spacecraft that have not experienced breakups. [46]

Further, a testimony by Nicholas Johnson representing NASA's Orbital Debris Program Office to the United States Congress Committee on Science and Technology affirmed that, "collisions are likely to be the principal source of new space debris. The most effective means of limiting satellite collisions is to remove non-functional spacecraft and launch vehicle orbital stages from orbit."[47]

While assessing the effectiveness of debris mitigation, the European Space Agency (ESA) has relied on its DELTA (Debris Environment Long-Term Analysis) model to confirm the above finding that a progressive, uncontrolled increase in debris objects will lead to "collisions becoming the primary debris source within less than 50 years" and "the removal of mass from orbit turns out to be the most effective way of preventing this collisional cascading process from setting in."[48]

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[46] "Instability of the Current Orbital Debris Population", note 44.

[47] Nicholas L. Johnson, 'Keeping the Space Environment Safe For Civil and Commercial Users', Statement before the Subcommittee on Space and Aeronautics, House Committee on Science and Technology, (28 April 2009), online: http://gop.science.house.gov/Media/hearings/space09/april28/johnson.pdf.

[48] ESA Space Debris: Analysis and Prediction (20 February 2009), online: European Space Agency, http://www.esa.int/esaMI/Space_Debris/SEMXP0WPXPF_0.html.

Hence, it is a scientific certainty that based on these projections, it is imperative to retrieve mass from the orbits if collisional cascading in the form of a "chain reaction"[49] is to be averted. The following sections will establish the existence of a robust business case for space debris remediation and then assert the availability of advanced technology necessary for conducting remediation activities in outer space.

1.6. Economic and technological feasibility of space debris remediation

"Heavy as they are, the costs of action must be weighed against the price of inaction."[50]

The most oft-cited impediments to a thriving space debris remediation industry are the absence of cost-effectiveness and technological maturity. Experts have identified the following parameters as essential prerequisites in this regard:[51]

- A "cost effective" technique
- A proper legal and policy framework to protect the parties involved and to deal with "alternative use" concerns

[49] "The fragments generated by a collision among two larger objects in earth orbits could produce new collisions and this can successively lead to the formation of an artificial belt in the way of a chain reaction." P. Eichler & D. Rex, "Chain Reaction of Debris Generation by Collision in Space – A Final Threat to Spaceflight?" presented at the 40th International Astronautical Congress, Malaga, Spain (1989), quoted in Hacket, *Corpus Iuris Spatialis*, note 10, at 31.

[50] U.S. President Bill Clinton, in his address from the Oval Office for Operation Desert Fox (December 1998).

[51] *Active Debris Removal Congress Report*, note 17, at 18; also, see William Ailor, "Space Debris Remediation & On-Orbit Servicing: Concepts, Considerations, Moving Forward," presented at the International Interdisciplinary Congress on Space Debris Remediation, Montreal, Canada (November 2011), online: http://www.mcgill.ca/iasl/sites/mcgill.ca.iasl/files/sdc2011_2_ailor.pdf, at 7 and 8-9 (for cost-effectiveness).

- Available and willing target for removal or customer for servicing
- Someone to pay
- Accurate tracking and necessary assistance during operations
- Capability to locate, approach, connect deorbit/servicing device, control orientation and to move the target object to desired destination.
- Safety of the public on ground, at sea and travelling by air.

1.6.1. Business case[52]

Space debris remediation, particularly active removal of debris, will reap perceptible benefits in the long term by eliminating the possibility of a cascading collision among the uncontrolled debris. Hence, although there might not be any instantaneously appreciable outcomes for active removal of debris, the objective of long-term sustainable utilisation of space resources ought to drive the fund-raising efforts for the development of the requisite robotic technology.

In contrast to that, the advantages of on-orbit satellite servicing, such as mission life extension by refuelling, passivation and other post-mission disposal requirements, will yield immediate results. The possibility of life extension for satellites is of particular interest to operators because it could add years of life to a spacecraft that would otherwise be decommissioned for lack of fuel or minor technical glitches. The following

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[52] Generally, see Michelle E. McVey, *Valuation Techniques for Complex Space Systems: An Analysis of a Potential Satellite Servicing Market* (Master's thesis), Department of Aeronautics and Astronautics, Massachusetts Institute of Technology (2002); Joseph H. Saleh, "Flexibility and the Value of On-Orbit Servicing: New Customer-Centric Perspective" (2003) 40 Journal of Spacecraft and Rockets 279; Joerg Kreisel, "On-Orbit Servicing of Satellites (OOS): Its Potential Market & Impact" Proceedings of the 7th ESA Workshop on Advanced Space Technologies for Robotics and Automation 'ASTRA 2002', ESTEC, Noordwijk, The Netherlands (November 2002), online: http://robotics.estec.esa.int/ASTRA/Astra2002/Papers/astra2002_1.4-1.pdf. Also, SpaceTech students prepared a report representing a reference project for on-orbit satellite servicing for a business case study. For the Executive Summary (November 2003), online: http://www.lr.tudelft.nl/fileadmin/Faculteit/LR/Opleidingen/SpaceTech/Central_Case_Project/doc/ST6_On-Orbit_Servicing_for_GEO_Comsats__Sponsored_Topic!_.pdf.

description of events will further underline the interest of satellite operators to have regular and affordable access to on-orbit satellite servicing.

The Intelsat 19 communications satellite, following a successful launch atop a Zenit-3SL rocket earlier this year, experienced delay in the deployment of its south solar arrays.[53] The corrective action took twelve days and four apogee manoeuvre firings which resulted in a decline in its fuel supply.[54] A worse fate befell the Intelsat New Dawn satellite, which failed to deploy its C-band reflector antenna because the antenna's spring-loaded deployment mechanism got caught in the billows of its sun shield,[55] thus depriving the satellite of half its intended functionality and resulting in loss of a contract backlog of approximately $310 million.[56] Moreover, its operating life will be additionally reduced as it will likely consume more fuel to maintain its stabilisation in orbit due to its failure to deploy one of its broadcast antennae.[57] An on-orbit servicing capability could have provided a potentially simpler and cost-effective remedy to such situations. Furthermore, cases of partial launch failures resulting in a significant loss of satellite lifespan such as

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[53] Press Release, Intelsat 19 Satellite Update (1 June 2012), online: Intelsat, http://www.intelsat.com/press/news-releases/2012/20120601-2.asp.

[54] Intelsat 19 Mission Update, online: Intelsat, http://www.intelsat.com/network/satellite/intelsat19/is19-mission-updates.asp.

[55] Press Release, Intelsat Reports Antenna Reflector Deployment Delay with Intelsat New Dawn Satellite (3 May 2011), online: Intelsat, http://www.intelsat.com/press/news-releases/2011/20110503-1.asp; Investigators Cite Design Defect in Intelsat New Dawn Antenna Failure (5 August 2011), online: Space News, http://www.spacenews.com/article/investigators-cite-design-defect-intelsat-new-dawn-antenna-failure. For further information on significant anomalies suffered by Intelsat satellites in 2011, see Form 10-K submitted to the United States Securities and Exchange Commission, Annual Report Pursuant to Section 13 or 15(D) of the Securities Exchange Act of 1934, online: http://www.intelsat.com/_files/investors/financial/2011/Q4-2011-Intelsat-Form10K.pdf, at 17-19, 31-33.

[56] Doug Mohney, "Intelsat-MDA In-orbit Robotic Satellite Servicing Deal Falls Apart, Satellite Spotlight" (18 January 2012), online: Satellite Spotlight, http://satellite.tmcnet.com/topics/satellite/articles/256504-intelsat-mda-in-orbit-robotic-satellite-servicing-deal.htm

[57] Peter B. de Selding, Impaired New Dawn Satellite Also Had Trouble Deploying Ku-band Antenna (3 June 2011), online: Space News, http://www.spacenews.com/satellite_telecom/110603-intelsat-new-dawn.html.

those of ArabSat 4A resulting in commanded re-entry (February 2006), Rascom-QAF1 due to propulsion system failure (December 2007), AMC-14 (March 2008), Palapa-D (August 2009) could have been remedied with the help of on-orbit servicing.[58]

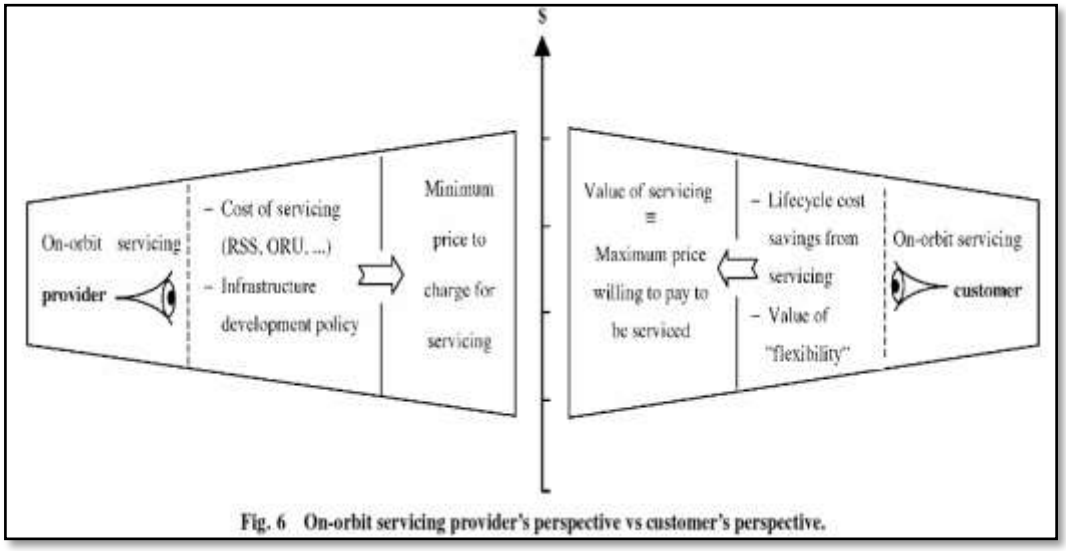

Fig. 6 On-orbit servicing provider's perspective vs customer's perspective.

[59]

From the perspective of cost consideration, there has been an encouraging response from companies like Intelsat,[60] Lockheed Martin[61] for the business prospects of on-orbit

[58] Baard Eilertsen, Swedish Space Corporation "Market Interest in Fleet Management On orbit Services – A Commercial Approach" presented at the NASA 2010 International Workshop on On-Orbit Satellite Servicing (24 March 2010), online: http://ssco.gsfc.nasa.gov/workshop_2010/day1/Baard_Eilersten/NASA_OOS_Workshop-Baard_Eilertsen.pdf at 7.

[59] Saleh, "Flexibility and the Value of On-Orbit Servicing: New Customer-Centric Perspective," note 52 at 284.

[60] Particularly for life extension, mission recovery, inspection and towing, see Richard dal Bello, Intelsat, "Commercial In-orbit Servicing Perspectives," presented at the McGill International Interdisciplinary Congress on Space Debris Remediation, Montreal, Canada (November 2011), online: http://www.mcgill.ca/iasl/sites/mcgill.ca.iasl/files/sdc2011_4_dalbello.pdf.

[61] Barry Miller, Lockheed Martin, "On-orbit Satellite Servicing – Is there a business case that makes sense", presented at the NASA 2010 International Workshop on On-Orbit Satellite Servicing (24 March 2010), online: http://ssco.gsfc.nasa.gov/workshop_2010/day1/Barry_Miller/LM_On-Orbit_Satellite_Servicing-Is_There_A_Business_Case_That_Makes_Sense.pdf

satellite servicing and studies indicate that Iridium can also potentially be an interested customer for servicing satellites, especially space tug services.[62]

With the objective of offering economic incentives as a solution, the "organic" development of an international economic fund administered by a consortium of international banks or insurance companies has been proposed. With a timeline of 25 years to achieve stability in the population of space debris, it will collect fees prior to launches which will then be used to compensate licensed private actors (akin to maritime 'salvage reward') for performing successful debris remediation or collision avoidance manoeuvres. Such a system would offer economic incentives by allowing rebates for limiting the generation of debris during normal operations, especially launches, and post mission disposal on a competitive basis.[63]

There have been similar suggestions in this context. A proposal has been made for the creation of an Orbital Debris Removal and Recycling Fund by levying a governmental fee on spacecraft operators (based on technical parameters of the launch) and the collected fees would be escrowed by a non-profit corporation, which would determine which objects in orbit should be removed and assign deorbiting contracts to companies. Although the remediation will be performed by private actors, there will be adequate governmental "authorisation and continuing supervision" in the form of licensing

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[62] Colin Doughan, "Servicing Iridium's Satellite Constellation: Business Case (Part 1)" (15 December 2010), online: The Space Business Blog, http://spacebusinessblog.blogspot.ca/2010/12/servicing-iridiums-satellite.html; Jonathan Goff, "Servicing Iridium's Satellite Constellation: Business Case (Part 2)– Background and Technical Challenges" (18 December 2010), online: Selenian Boondocks, http://selenianboondocks.com/2010/12/servicing-iridiums-satellite-constellation-business-case-part-2-background-and-technical-challenges/.

[63] Joseph Pelton, "A Global Fund for Space Debris Remediation: A New Way Forward to Address the Mounting Space Debris Problem", presented at the 16th ISU Symposium on Sustainability of Space Activities: International Issues and Potential Solutions, Strasbourg, France (February 2012), online: http://space.saao.ac.za/presentations/Pelton_12_03_13_Space_debris_fund.pdf.

mechanisms, insurance requirements, and indemnification clauses for the companies if they incur any additional losses.[64]

Most importantly, it is in the interest of space actors to begin investing in space sustainability for the sake of securing their own space assets.[65] Therefore, it can be said that although it is still in its nascent stage, there exists a lucrative 'business case' in favour of space debris remediation.

1.6.2. Technological maturity

There are several technological capabilities, robotic and otherwise, being developed and/or considered for space debris remediation. The technological roadmap to execute an active debris removal or on-orbit satellite servicing mission is to "first identify the threat(s), determine the time available to react, plan the access for minimum energy, rendezvous and establish the orbit modification device, plan the orbit modification to ensure that the risk is less than that of the original circumstance, and execute the mission with extreme vigilance."[66]

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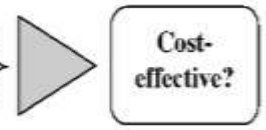
[64] James Dunstan and Berin Szoka, "Beware of Space Junk" (17 December 2009), online: Forbes.com, http://www.forbes.com/2009/12/17/space-junk-environment-global-opinions-contributors-berin-szoka-james-dunstan.html; Jeff Foust, "Putting a bounty on orbital debris" (27 July 2009), online: Space Review, http://www.thespacereview.com/article/1427/1. For further details, see James Dunstan & Bob Werb, "Legal and Economic Implications of Orbital Debris Removal" (30 October 2009), online: http://www.scribd.com/doc/23379988/Legal-and-Economics-Implications-of-Orbital-Debris-Removal at 6-7.

[65] Generally, see, Karl Doetsch, "Space Debris Remediation: Organisational and Operational Requirements," presented at the McGill International Interdisciplinary Congress on Space Debris Remediation, Montreal, Canada (November 2011), online: http://www.mcgill.ca/iasl/sites/mcgill.ca.iasl/files/sdc2011_4_doetsch.pdf.

[66] *Active Debris Removal Congress Report*, note 17, at 18.

[67]

On-orbit servicing architecture	Modifications required to make spacecraft serviceable	Design of host vehicle to perform on-orbit servicing
# servicers per plane per satellite	Component accessibility	Autonomous Rendezvous and Docking capability (AR&D)
Characteristics of ORU canisters	Docking adapter/interface	Dexterous manipulator(s)
Space depots	Modularity, standardization (e.g., HST modular design allows 90 components to be replaced)	Electrical/mechanical interface



Some technologies for the removal of smaller as well as large objects include:[68]

- thin film
- ground-based or space based lasers
- momentum exchange or electrodynamic (LEO only) tether;
- attaching a deboost motor;
- inflating a balloon (LEO only) or adding a device to the object to increase drag;
- deploying a reusable space tug that grapples and moves;[69] and,
- retrieval (return to earth, recycling in space) of the object.

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[67] Sequence of issues addressed in the traditional approach to on-orbit servicing; cost-effectiveness of on-orbit servicing is left as an output. Saleh, "Flexibility and the Value of On-Orbit Servicing: New Customer-Centric Perspective", note 52, at 283.

[68] *Active Debris Removal Congress Report*, note 17, at 18.

[69] Matthew G. Richards, Philip N. Springmann &Michelle E. McVey, "Assessing the Challenges to a Geosynchronous Space Tug System" (2005) 5799 Proceedings – SPIE The International Society For Optical Engineering (Modelling, Simulation, and Verification of Space-based Systems II) 135, online: http://web.mit.edu/mgr/www/Portfolio/Assessing%20the%20Challenges%20to%20a%20Geosynchronous%20Space%20Tug%20System.pdf; Kalina K. Galabova, Olivier L. de Weck, "Economic case for the retirement of geosynchronous communication satellites via space tugs" (2006) 58 Acta Astronautica 485

1.7. Current space debris remediation initiatives

This section will present a survey of the international space debris remediation initiatives around the globe undertaken both by government actors as well as the private industry. The National Aeronautics and Space Administration (NASA) and the Defence Advanced Research Projects Agency (DARPA) in the United States have sponsored conferences on space debris remediation to encourage expert dialogue among the international space community.[70] There has also been consensus among international experts in the form of a key finding at a conference organised by the European Space Agency (ESA) in 2009 that, "active space debris remediation measures will need to be devised and implemented … there is no alternative to protect space as a valuable resource."[71]

In a motion for a resolution on the European Space Policy – Green Paper in 2003, the Committee on Industry, External Trade, Research and Energy of the European Parliament underlined the significance "to establish the necessary international cooperation to develop in-orbit servicing" and called upon ESA "to establish a research,

[70] "NASA and DARPA Sponsor International Debris Removal Conference" (2010) 14 Orbital Debris Quarterly News 1 at 1, http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv14i1.pdf; DARPA held a conference on 'Fostering Sustainable Satellite Servicing' on 26 June 2012 at Arlington, Virginia – announcement on the DARPA website (24 April 2012), online: http://www.darpa.mil/NewsEvents/Releases/2012/04/24.aspx. For an overview of the conference, see David Barnhart, Program Manager, DARPA TTO, "Overview on DARPA's 'Fostering Sustainable Satellite Servicing Conference'" presented at the European Conference on On-Orbit Satellite Servicing and Active Debris Removal, Brussels, Belgium (30 October 2012), online: http://swfound.org/media/94297/Barnhart-Fostering_DC_Confernece_Overview.pdf. NASA's Goddard Space Flight Centre has organised two international workshops on on-orbit satellite servicing in May 2012 and March 2010, see the website of the Satellite Servicing Capabilities Office, online: http://ssco.gsfc.nasa.gov/workshops.html.

[71] Key Findings from the 5th European Conference on Space Debris (2 April 2009), online: European Space Agency http://www.esa.int/esaMI/Space_Debris/SEMYN9LTYRF_0.html.

development and demonstration programme on in-orbit servicing as a matter of priority, given its potential strategic advantage for the European space sector."[72]

In the United States, the NASA Satellite Servicing Capabilities Office has been established in 2009 to *inter alia*, "advance the state of robotic servicing technology" and "help to enable a future U.S. industry for the servicing of satellites."[73] Further, the United States Air Force and the National Reconnaissance Office have jointly established a space protection program office to advise the military and intelligence community on the safeguarding of space assets.[74]

1.7.1. Phoenix Program, DARPA [75]

The Phoenix program under the aegis of the Unites States Defence Advanced Research Projects Agency is focussed on recycling space assets – usable antennas, solar arrays and other components – from defunct or inactive satellites in orbit. Its goal is to "develop and demonstrate technologies to cooperatively harvest and re-use valuable components from retired, nonworking satellites in GEO and demonstrate the ability to create new space systems at greatly reduced cost."[76] It aims to secure "around-the-clock, globally

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[72] Report on European space policy – Green Paper (2003/2092(INI)) (10 September 2003), online: European Parliament, http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&reference=A5-2003-0294&language=EN#title2.

[73] Satellite Servicing Capabilities Office, NASA Goddard Space Flight Centre, online: http://ssco.gsfc.nasa.gov/about.html.

[74] Jeremy Singer, "U.S. Air Force, Spy Agency Team up for Space Protection" (9 April 2008), online: Space.Com http://www.space.com/5224-air-force-spy-agency-team-space-protection.html. For further details, see Budget Justification for the Space Protection Program (February 2012), online: http://www.dtic.mil/descriptivesum/Y2013/AirForce/stamped/0603830F_4_PB_2013.pdf.

[75] David Barnhart, Program Manager, Tactical Technology Office, "DARPA's Phoenix Project" presented at the NASA Second International Workshop on On-Orbit Satellite Servicing (May 2012), online: http://ssco.gsfc.nasa.gov/workshop_2012/McGuirk_final_presentation_2012_workshop.pdf.

[76] DARPA Phoenix Satellite Servicing, Tactical Technology Office, online: http://www.darpa.mil/Our_Work/TTO/Programs/Phoenix.aspx.

persistent communication capability…by robotically removing and re-using GEO-based space apertures and antennas from de-commissioned satellites in the graveyard or disposal orbit."[77]

The Phoenix program will develop miniature satellites which could be transported to the GEO region through a 'piggyback' ride on a commercial satellite launch, and then used to create a new space system by robotically attaching it to the antenna of a non-functional cooperating satellite. It has set its first keystone mission in 2015 to "demonstrate harvesting an existing, cooperative, retired satellite aperture, by physically separating it from the host non-working satellite using on-orbit grappling tools controlled remotely from earth," which will then be "reconfigured into a 'new' free-flying space system and operated independently" to boost the notion of space recycling.[78] DARPA has selected Honeybee Robotics Spacecraft Mechanisms Corporation to develop new tele-robotic end effector prototypes designed to enable a servicing satellite to dock with and manipulate communications satellites in GEO.[79]

1.7.2. Deutsche Orbitale Servicing Mission (DEOS)[80]

With regard to pursuing sustainable space operations as a stated objective of the 2010 German space strategy, the goal of DEOS is to "demonstrate the availability of technology and verify procedures and techniques for rendezvous, capture, maintenance

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[77] Ibid.

[78] Ibid.

[79] Honeybee Robotics selected for DARPA Phoenix program for on-orbit satellite servicing, online: http://www.honeybeerobotics.com/about/honeybee-news/130-darpa-phoenix-selection.

[80] Thomas Wolf, DLR, "Deutsche Orbitale Servicing Mission: The In-flight Technology Demonstration of German's Robotics Approach to Dispose Malfunctioned Satellites", online: http://robotics.estec.esa.int/ASTRA/Astra2011/Presentations/Plenary%202/04_wolf.pdf.

and removal of an uncontrollable satellite from its operational orbit through a demonstration mission."[81] This project entails two satellites: a 'client' satellite representing a non-cooperative, instable drifting and tumbling satellite that has to be captured by a servicing satellite for repair, refuelling, or disposal.[82] Under the supervision of the German Aerospace Centre, DLR and funded by the German Federal Ministry of Economics and Technology (BMWi), it has reached its definition phase.[83]

1.7.3. Orbital Express Space Operations Architecture, DARPA[84]

The Orbital Express Space Operations Architecture program by DARPA was designed as a three-month mission in 2007 to "validate the technical feasibility of robotic, autonomous on-orbit refuelling and reconfiguration of satellites"[85] by the deployment of two satellites: a surrogate next generation serviceable satellite (NextSat) and a prototype servicing satellite (ASTRO). This pair of satellites will perform a series of experiments to demonstrate autonomous rendezvous and docking capability, unassisted on-orbit re-

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[81] B. Sommer & K. Landzettel, DLR, "DEOS Deutsche Orbitale Servicing Mission: The In-flight Technology Demonstration of Germany's Robotics Approach to Service Satellites" presented at the NASA Second International Workshop on On-Orbit Satellite Servicing (May 2012), online: http://ssco.gsfc.nasa.gov/workshop_2012/Landzettel_DEOS_final_presentation_2012_workshop.pdf. For its mission objectives, see DEOS Overview, online: http://www.weblab.dlr.de/rbrt/OOS/DEOS/DEOS.html.

[82] DEOS: A Robot serves Defective Satellites to prevent space debris, Research in Germany, online: http://www.research-in-germany.de/main/research-areas/space-technologies/2-nr-2-research-projects/43000/3-nr-3-deos,print=true,slc=dachportal_2Fen.html.

[83] Astrium wins DEOS contract to demonstrate in-orbit servicing (13 September 2012), online: Astrium http://www.astrium.eads.net/en/press_centre/-kx9.html.

[84] Tracey M. Espero, Boeing "Future Space Robotics and Large Optical Systems: A Picture of Orbital Express", presented at the NASA Workshop on "Astronomy Enabled by Ares V," NASA Ames Research Centre (27 April 2008), online: http://event.arc.nasa.gov/aresv/ppt/Sunday/1Espero/1Espero.pdf. Also, see Daniel Hastings, *Studies to Enable a Paradigm Shift in the Space Enterprise: Atro/Orbital Express*, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology (January 2006), online: http://www.dtic.mil/dtic/tr/fulltext/u2/a455064.pdf.

[85] Orbital Express Space Operations Architecture, online: DARPA Tactical Technology Office, http://archive.darpa.mil/orbitalexpress/index.html.

fuelling and component exchange and replacement.[86] A compact state-of-the-art automated guidance system known as Advanced Video Guidance Sensor (AVGS)[87] was used for the manoeuvres such that ASTRO will refuel NextSat, transferring hydrazine propellant into NextSat's fuel tank via a non-proprietary interface and also insert a battery module aboard NextSat.

1.7.4. NASA Robotic Refueling Mission (RRM)

The Robotic Refueling Mission (RRM) is a joint effort between NASA and the Canadian Space Agency (CSA) in the form of an external experiment related to the International Space Station (ISS) to "demonstrate and test the tools, technologies, and techniques needed to robotically refuel satellites in space—especially satellites not designed to be serviced."[88] Canada's Special Purpose Dexterous Manipulator on the ISS, 'Dextre' has been used for assembly and support operations including numerous instances of HTV capture and docking.[89] It was used by the crew members of STS-49 when they had repaired the stranded communications satellite Intelsat-VI by retrieving it with the help of the Canadarm and equipping it with a new kick motor.[90]

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[86] DARPA Orbital Express Fact Sheet (March 2007), online: http://archive.darpa.mil/orbitalexpress/pdf/oe_fact_sheet_final.pdf.

[87] For further details on AVGS, see Rick Smith, "Orbital Express scheduled to launch March 8: Marshall-developed automated rendezvous and docking technology to be tested in space" (2007) 47 NASA Marshall Star 1, online: http://marshallstar.msfc.nasa.gov/3-1-07.pdf at 3.

[88] NASA Robotic Refueling Mission Fact Sheet, online: http://ssco.gsfc.nasa.gov/images/RRM_Factsheet.pdf.

[89] *Active Debris Removal Congress Report*, note 17, at 18.

[90] Flight History of Canadarm, online: Canadian Space Agency, http://www.asc-csa.gc.ca/eng/canadarm/flight.asp.

1.7.5. Space Infrastructure Servicing (SIS), MacDonald Detwittler Associates[91]

MDA, the Canadian space company has developed its Space Infrastructure Servicing (SIS) vehicle whose robotic arm is capable of performing critical maintenance and repair tasks, refuelling, as well as deorbiting procedures. It has recently been selected as a key participant to support the DARPA Phoenix program.[92] In 2011, it had entered into an agreement with Intelsat as its anchor tenant to provide on-orbit servicing to the latter's communications satellites, which has been terminated.[93]

1.7.6. ViviSat

ViviSat, jointly owned by U.S. Space LLC and ATK Aerospace Systems, is offering on-orbit mission life extension and fleet management services through its Mission Extension Vehicle (MEV) by providing long-term station-keeping and attitude control, relocation and re-orbiting of satellites to alternative orbital slots or to different orbits and de-orbiting satellites at the end of their lives.[94]

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[91] Steve Oldham, Vice-President MDA, "What the Future Holds: Near-Term Servicing Plans" presented at the NASA Second International Workshop on On-Orbit Satellite Servicing (May 2012), online: http://ssco.gsfc.nasa.gov/workshop_2012/Oldham_final_%20presentation_2012_workshop.pdf.

[92] Press Release, MDA to be key supplier in satellite servicing demonstration for US Government (18 October 2012), online: MDA, http://www.mdacorporation.com/corporate/news/pr/pr2012101801.cfm.

[93] Press Release, Space Infrastructure Servicing Update (11 January 2012), online: MDA http://www.mdacorporation.com/corporate/news/pr/pr2012011101.cfm. Also see, Peter de Selding, "Canadas MDA Sees Business Case for In-orbit Satellite Servicing," (6 May 2010), online: Space News, http://www.spacenews.com/satellite_telecom/100506-mda-in-orbit-servicing.html.

[94] ViviSat, online US Space, http://www.usspacellc.com/in-orbit-servicing/vivisat. Also, see Bryan McGuirk, COO ViviSat, "Satellite Life Extension and GEO Fleet Management Opportunity" presented at the NASA Second International Workshop on On-Orbit Satellite Servicing (May 2012), online: http://ssco.gsfc.nasa.gov/workshop_2012/McGuirk_final_presentation_2012_workshop.pdf; Craig Weston & Tom Wilson, "New Life for Old Satellites – A Compelling Industry Need is Now Addressed" (2011) SatMagazine 8, online: http://www.satmagazine.com/2011/SM_Apr_2011.pdf.

1.7.7. CleanSpace One

The Swiss Space Agency has announced the CleanSpace One project to develop and build the first instalment of a fleet of satellites designed to deorbit space debris.[95]

1.7.8. Conclusion

The concept of mitigation is essentially preventive in nature – it refers to a class of actions designed to ameliorate the severity of a situation. As opposed to that, remediation is a corrective approach and aims to reverse or halt the undesirable turn of events.[96] Unlike space debris mitigation which aims to arrest the generation of further debris, space debris remediation refers to actively remedying the congested nature of outer space. Remediation activities can include retrieval of a space object from the outer space environment or from a particular orbit, repairing/servicing a space object, refuelling missions to extend the life of the space object or salvaging a space object for recycling or other purposes. On-orbit servicing and salvaging operations remediate space debris by repairing and restoring manoeuvrability in an object or removing it to avoid collision with a functional satellite.

From the foregoing discussion, it is apparent that the preventive measure taken during the last decade in the form of voluntary non-binding debris mitigation guidelines have

[95] Cleaning up Earth's orbit: A Swiss satellite to tackle space debris, online: EPFL, http://actu.epfl.ch/news/cleaning-up-earth-s-orbit-a-swiss-satellite-to-tac/.

[96] Dave Baiocchi & William Welser IV, *Confronting Space Debris: Strategies and Warnings from Comparable Examples Including Deepwater Horizon* (RAND Corporation, 2010), available online: http://www.rand.org/pubs/monographs/2010/RAND_MG1042.pdf, at 13-14.

clearly not been able to effectively address the impending catastrophic situation and the only way to ensure secure and sustained access to and long-term utilisation of space is through space debris remediation in the form of active removal of debris and on-orbit satellite servicing.[97]

However, this gives rise to a plethora of regulatory complexities and unanswered legal questions. Imagine the following hypothetical scenario: Conjunction analysis has identified an uncontrolled satellite, X belonging to State A as a high-probability threat to a functional satellite, Y belonging to State B, which attempts to deorbit X without authorisation from State A. Due to technical anomalies, it erroneously incapacitates another satellite belonging to State A. In the meanwhile, State A manages to successfully revive satellite X and manoeuvre it back to its allotted orbit.

The succeeding chapters attempt to address the following broad spectrum of legal questions:

- What is the legal status of satellite X in its non-functional phase? Can it be termed as space debris? Should space debris also be considered as space objects?
- Is State A under an international legal obligation to avoid causing damage to another State's space assets?
- Is State B justified in exercising jurisdiction and control over satellite X to avoid collision with its own space asset?
- Should State B have exercised 'due diligence while performing the remediation? What are the legal implications of unauthorised active debris removal?

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[97] Generally, see J.C. Liou, "A Note on Active Debris Removal" (2011) 15 Orbital Debris Quarterly News 7, online: http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv15i3.pdf at 7-8.

2. DEFINITION OF SPACE DEBRIS FOR ACTIVE REMEDIATION

2.1. Introduction

The current regime of international space law consisting of the five United Nations treaties and five Declarations does not contain any definition of 'space debris.' The operative terminology used in those instruments is a 'space object,' which has been rather obliquely defined. The concern over the absence of a proper definition of 'space object'[98] is aggravated by the fact that "the basis of liability is that the damages or injury is caused by a space object."[99]

The objective of this chapter is to study the question: is 'space debris' equivalent to a 'space object' *ad infinitum*?[100] To understand the legal milieu in which space debris are sought to be regulated, it is necessary to study the definition of 'space debris.' First, this chapter will chronologically discuss the international legislative attempts to define a

[98] Armel Kerrest, "Liability for Damage Caused by Space Activities" in Marietta Benkö & Kai-Uwe Schrogl, *Space Law: Current Problems and Perspectives for Future Regulation* (Utrecht: Eleven International, 2005) at 97-98; S. Gorove, "Legal and Policy Issues of the Aerospace Plane" (1988) 16 J. Space L. 147 at 154; Julian G. Verplaetse, "On the Definition and Legal Status of Spacecraft" (1963) 29 J. Air L. & Com. 131.

[99] S.B. Rosenfield, "Where Air Space Ends and Outer Space Begins" (1979) 7 J. Space L. 137 at 145; Outer Space Treaty, Art. VII; Liability Conventions Arts. II, III.

[100] For distinction between 'space object' and 'space debris,' see Luboš Perek, "Ex Factor Sequitur Lex: Facts which Merit Reflection in Space Law in Particular with Regard to Registration and Space Debris Mitigation" in Marietta Benkö & Kai-Uwe Schrogl, *Space Law: Current Problems and Perspectives for Future Regulation* (Utrecht: Eleven International, 2005) at 40-43.

'space object.' It will then address the current definition of 'space debris' with its origin in 'soft law' and its implications in the operation of space activities. Finally, it will describe two fairly recent events – the resuscitation of Intelsat Galaxy-15 satellite and the decommissioning of Envisat satellite – to illustrate the legal uncertainties surrounding the status of objects in space vacillating between that of a 'space object' and/or 'space debris.'

2.2. Defining a 'Space object'

Even prior to the promulgation of any of the space law treaties, the Convention for the Establishment of a European Organisation for the Development and Construction of Space Vehicle Launchers (ELDO) defined a 'space vehicle' as "a vehicle designed to be placed in orbit as a satellite of the Earth or of another heavenly body, or to be caused to traverse some other path in space…"[101]

Throughout the legislative history of the United Nations treaties, several countries have put forth their views regarding the definition of a 'space object.' At the second session of the UN COPUOS Legal Sub-Committee in 1963, Belgium had submitted a working paper on the unification of rules governing liability for damage caused by space vehicles where a 'space device' was defined as 'any device which is intended to move in space, remaining there by means other than the reaction of the air."[102] In its third session in

[101] Annex to art. 19, UNTS 507 at 205. Also, see J.A.C. Gutteridge, "The United Nations Committee on the Peaceful Uses of Outer Space" in *Current Problems in Space Law: A Symposium* (British Institute of International and Comparative Law, Holland, 1986) at 36.

[102] Report of the Legal Subcommittee on the Work of its Second Session to the COPUOS, UN Doc. A/AC.105/12 (6 May 1963), Annex I, Part H, "Working Paper Submitted by the Belgian Delegation on the Unification of Certain Rules Governing Liability for Damage Caused by Space Vehicles" at 11.

1964, Hungary presented a draft agreement on liability, which defined 'space objects' as "space ships, satellites, 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 of such objects."[103] At the sixth session in 1967, Argentina submitted a proposal on agreement for damage caused by space vehicles which described a 'space vehicle' as "any device launched by man exclusively for peaceful purposes, for the exploration or use of outer space, including the Moon and other celestial bodies, as well as the equipment used for launching and propulsion and any parts detached therefrom."[104]

In the 1963 Declaration of Legal Principles[105] which serves as the precursor to the 1967 Outer Space Treaty, a space object has not been defined but has been referred to as "object launched into outer space and … their component parts." Adopting this language, the 1967 Outer Space Treaty has alluded to a 'space object' in Articles VII and VIII as "an object launched into outer space," including "objects landed or constructed on a celestial body." The terminology of Article VIII of the Outer Space Treaty is echoed in paragraph (1) of Article 12 of the Moon Agreement when it refers to "vehicles, equipment, facilities, stations and installations." Article 3(2) of the Moon Agreement has included the above terms under the phrase 'man-made space objects.'[106]

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[103] Hungary: Proposed Draft Agreement, UN Doc. A/AC.105/C.2/L.10 (16 March 1964) at 2, available at: http://www.oosa.unvienna.org/pdf/limited/c2/AC105_C2_L010E.pdf

[104] UN Doc. A/AC.105/C.2/L.22 (23 June 1967), available at: http://www.oosa.unvienna.org/pdf/limited/c2/AC105_C2_L022E.pdf

[105] Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, UN GA Res. 1962 (XVIII) 13 December 1963.

[106] Stephan Hobe, "Spacecraft, Satellites and Space Objects" Max Planck Encyclopedia of Public International Law

The 1972 Liability Convention was the first international agreement to attempt to define a 'space object' as "component parts of a space object as well as its launch vehicle and parts thereof."[107] The Registration Convention adopted this depiction in its Article I(b).[108] This description fails to define the term exhaustively while merely providing a vague inclusive boundary for the term. Strikingly enough, it does not include functionality as a decisive criterion.[109] The term 'space object' has not yet been defined in international space law. More importantly, it is also silent as to when, if at all, a space object or its component or fragmented parts, ceases to be a 'space object.' Assuming that there is no change in the status of such fragmented space objects and are still continued to be regarded as 'space objects' under international space law, then *de jure* jurisdiction and control will be retained by the State of Registry.[110]

It has been argued that 'space objects' should be given a broad interpretation to include objects constructed or assembled in outer space under the regime of the Liability Convention to ensure that States do not ignore the law by constructing or assembling their space objects in outer space.[111] This is important to address issues arising from the

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[107] Convention on International Liability for Damage Caused by Space objects, 29 March 1972, 961 UNTS 187, art I(d). See Bess C.M. Reijnen, *The United Nations Space Treaties Analysed* (Editions Frontieres, 1992) at 182-83.

[108] Convention on Registration of Objects Launched into Outer Space, 29 November 1971, UN GA Res. 3235 (XXIX).

[109] Mathias Forteau, "Space Law" in James Crawford, et al (eds.), *The Law of International Responsibility*, (Oxford University Press, 2010) at 906.

[110] See *infra* Chapter 3.

[111] Bruce A. Hurwitz, *State Liability for Outer Space Activities in Accordance with the 1972 Convention on International Liability for Damage Caused by Space Activities*, (Martinus Nijhoff, 1992) at 23-24. This conclusion is supported by the 1980 NASA Authorization Act which defines "space vehicle" as "an object intended for launch, *launched or assembled in outer space*, including the Space Shuttle and other components of a space transportation system [the official designation of the Shuttle], together with related equipment, devices, components and parts." National Aeronautics and Space Administration Authorization Act, 1980, Pub. L. No. 96-48, 93 State. 348 (1979), Section 308 – Insurance and Indemnification at Sec. 308(f), quoted by G.J. Mossinghoff, "Managing Tort Liability Risks in the Era of the Space Shuttle" (1979) 7 J. Space L. 121 at 127-128. Emphasis added.

status of satellites whose components have been derived from functional parts of 'space debris' salvaged or serviced in outer space. It is not a technologically distant dream because the aim of the DARPA Phoenix program is to demonstrate the ability to recycle space assets from inactive satellites by 2015.[112]

From the above discussion, the definition for a 'space object' prescribed by Baker in his excellent treatise on the legal status of space debris is of particular importance. He postulates that a 'space object' –

1. Means
   (a) any object
      (i) intended for launch, whether or not into orbit or beyond;
      (ii) launched, whether or not into orbit or beyond; or
      (iii) any instrumentality used as a means of delivery of any object as defined in 1(a); and
2. Includes
   2.1. any part thereof or
   2.2. any object on board which becomes detached, ejected, emitted, launched or thrown, either intentionally or unintentionally, from the moment of ignition of the first-stage boosters.[113]

With the above understanding of the legal definition of a 'space object,' the following section will focus on the definition and attributes of space debris, for the purposes of active remediation.

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[112] See *supra* Section 1.7.1, Phoenix Program, DARPA.

[113] H.A. Baker, "Liability for Damage Caused in Outer Space by Space Refuse" (1988) 12 Ann. Air & Sp. L. 183 at 225.

2.3. Defining 'space debris'

Unanimously adopted at its 66th conference in 1994, the International Law Association's International Instrument on Space Debris[114] was the first international attempt to provide a legal definition of 'space debris.' In the first article on definitions, space debris has been defined in paragraph (c) as:

Space debris means man-made objects in outer space, other than active or otherwise useful satellites, when no change can reasonably be expected in these conditions in the foreseeable future.[115]

The Technical Report on Space Debris was published in 1999 as a product of the multi-year workplan 1996-1998 of the Scientific and Technical Subcommittee of the UN COPUOS. It was one of the earliest United Nations documents on space debris which served as a basis for further deliberations on the topic of congestion in the space environment. It reports the following definition proposed at the 32nd session of the S&T Subcommittee for the sake of a common understanding of the term 'space debris.'

"Space debris are all manmade 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

[114] The ILA Finalizes its International Instrument on Space Debris in Buenos Aires, August 1994, (1995) 23 J. Space L. 47.

[115] For the text of the instrument, see Karl-Heinz Böckstiegel, "ILA Draft Convention on Space Debris" (1995) 44 ZLW 29. It further lists the following sources of space debris:

- Routine space operations including spent stages of rockets and space vehicles, and hardware released during normal manoeuvres.
- Orbital explosions and satellite breakups, whether intentional or accidental.
- Collision-generated debris.
- Particles and other forms of pollution ejected, for example, by solid rocket exhaust.
- Abandoned satellites.

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."[116]

In 2002, pursuant to its charter, the IADC developed the 'IADC Space Debris Mitigation Guidelines' based on the fundamental principles present in the national policies of the member agencies and were agreed to by consensus.[117] The definition of space debris contained therein was an abbreviated form of the above-mentioned definition, which was later borrowed verbatim in the United Nations Space Debris Mitigation Guidelines. The publication of the IADC Guidelines prompted the Scientific and Technical Subcommittee of the UN COPUOS to create a Space Debris Working Group,[118] which produced a draft set of "high-level qualitative guidelines" based on the work of the IADC.[119] This draft was adopted by COPUOS in 2007 and endorsed by the General Assembly later that year through Resolution 62/217.[120] The General Assembly recognised that the Guidelines reflect existing State practice and urged the States to implement them in their domestic framework. The definition of space debris provided in the UN COPUOS Guidelines is as follows:

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[116] *Technical Report on Space Debris*, note 3, at 2, para. 6.

[117] IADC Guidelines, note 26. The IADC Guidelines have been elaborated upon by *Support to the IADC Space Debris Mitigation Guidelines* (2004), online: http://www.iadconline.org/docs_pub/IADC.SD.AI20.3.10.2004.pdf.

[118] *Report of the Scientific and Technical Subcommittee on the Work of its Forty-First Session*, UN COPUOS, UN Doc. A/AC.105/823, 2004 at 20.

[119] *Progress Report of the Working Group on Space Debris, Submitted by the Chairman of the Working Group*, UN COPUOS, UN Doc. A/AC.105/C.1/L.284, 2006, at 2.

[120] GA Res 62/217, 21 December 2007, 'International cooperation in the peaceful uses of outer space,' para 26. In GA Res 63/90, 5 December 2008, the General Assembly invited States to 'implement' these Guidelines (para 26).

"All man-made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional."[121]

It is interesting to note that the definition of 'space debris' is not contained in any of the actual Guidelines but it is included in the introductory section entitled 'Background' of the document. Further, it is important to bear in mind that this definition is explicitly limited to the purpose of this document by a preceding proviso.[122]

Although the General Assembly has declared that the UN Guidelines "reflect the existing practices as developed by a number of national and international organisations the legal status of the Guidelines are amply clear insofar as it states, in no uncertain terms, that "They are not legally binding under international law."[123] It further states that "Member States and international organisations should *voluntarily* take measures…to ensure that these Guidelines are implemented."[124] (emphasis added) It is evident that these Guidelines reflect technical best practices. The technical nature of the Guidelines is underscored over its legal implications by the fact that they were adopted solely by the Scientific and Technical Subcommittee without any involvement or contribution from the Legal Subcommittee.

Thus, the definition of space debris enshrined in the UN Guidelines can be classified as 'soft law.' Although soft law is said to lack the requisite normative content to create enforceable rights and obligations, these international norms and principles are viewed as

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[121] Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, as annexed to UN doc. A/62/20, Report of the COPUOS (2007) at 1.

[122] Ibid.

[123] Ibid., section 3, para. 2.

[124] Ibid., section 2.

"an important element in the progressive institutionalisation of international cooperation"[125] and are capable of producing certain legal effects[126] because they are considered as an expression of emerging notions of an international public order.[127] This normative category has also been endorsed by publicists due to the need for flexibility and responsiveness to the contemporary need for accommodation between competing interests in a diversified and conflicting world community.[128]

Such a relatively less obligatory approach is, in fact, desirable to balance the conflicting priorities of the space players where the mere existence of the soft law instrument signals States to exercise 'due diligence' in their activities.[129] Hence, the definition of 'space debris' contained in the UN Guidelines helps in establishing a minimal standard of care for States in the realm of debris mitigation and remediation measures.

The difficulty faced with the definition of space debris is not independent of the problem of timely registration and furnishing updated information about space objects to the UN Secretary-General under the Registration Convention. This is reflected by the data available in the public domain, which has been interpreted in the following words:

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[125] Francesco Francioni, "International 'Soft Law': A Contemporary Assessment" in Vaughan Lowe and Malgosia Fitzmaurice (eds.), *Fifty Years of the International Court of Justice, Essays in Honour of Sir Robert Jennings* (Cambridge University Press, 1996) at 178.

[126] Ibid., at 168.

[127] "A Hard Look at Soft Law" (1988) 82 Am. Soc'y Int'l L. Proc. 371 at 371-372 (remarks of Michael W. Reisman).

[128] Joseph Gold, "Strengthening the Soft International Law of Exchange Agreements" (1983) 77 AJIL 443; Christine Chinkin, "A Hard Look at Soft Law" (1988) Proceedings ASIL 371, at 389; C. Schreuer, "Recommendations and the Traditional Sources of International Law" (1977) 20 German Yearbook of Int'l Law 103.

[129] Patricia Birnie & Alan Boyle, *International Law and the Environment* (2002) at 26. Also, see *infra* Section 4.5, Due Diligence.

"[W]hile the UN OOSA website claims that approximately 93.5% of all functional space objects have been registered with the Secretary-General, it has also been noted that about 56% of all registered space objects are non-functional. Rather than representing a hopeful trend among states to register their debris, this figure is really testament to the poor track record of registering states to voluntarily update the transmitted information on functional space objects."[130]

However, some launching States have advocated for furnishing updated information on the functionality of their space objects.[131] In the past, States have made announcements regarding the imminent decay of space objects or the end of mission. For example, Sweden had declared the decommissioning of its satellites Freja, Twele-X, and Astrid[132] and Italy had specifically designated Beppo Sax as space debris after its end of mission.[133]

The formulation of a "transparent and reasonable selection matrix on the basis of which objects are targeted"[134] is a prudent method to ascertain which space objects can be candidates for removal. In the wide gamut of views put forth by experts,[135] the consensual opinion seems to be based on the common denominator of "the ability of the man-made instrumentality to traverse in outer space."[136] Hence, the manoeuvrability or

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[130] Philip De Man, "The Threat of Space Debris to the Further Exploration of Outer Space: An ITU Solution?" (2012) Paper presented at the GLEX Conference, Washington D.C., at 3-4.

[131] Lubos Perek, "Rational Space Traffic Management" (2004) 53 ZLW 573 at 581.

[132] Documents ST/SG/SER.E/318, 335, and 364, published in 1997 - 1999.

[133] Document A/AC.105/803 of 23 December 2002.

[134] Jan Helge Mey, "Space Debris Remediation: Some Aspects of International Law Relating to the Removal of Space Junk from Earth Orbit" (2012) 61 ZLW 251 at 271.

[135] S.M. Beresford, "Requirements for an International Convention on Spacecraft Liability" (1963) 6 Proc. Colloq. L. Outer Sp. 1 at 11; G.D. Schrader, "Space Activities and resulting Tort Liability" (1963) 6 Proc. Colloq. L. Outer Sp. 1 at 2.

[136] Hurwitz, *State Liability for Outer Space Activities*, note 111, at 23.

functionality of the space object is key to determining its status as space debris so that it can be classified as a candidate for remediation.

2.4. Revival of Zombie-sat Galaxy-15

On 5 April 2010, Intelsat's Galaxy-15, a Star-2 communications satellite manufactured by Orbital Sciences Corporation, stopped responding to ground station commands due to an anomaly in its telemetry and control system, which also prevented the execution of station-keeping operations. However, strangely enough, its communications transponders were active and continued to transmit C-band signals.[137] Three days later, Intelsat made an announcement that all media traffic on Galaxy-15 was being transitioned to another in-orbit spare satellite, Galaxy 12.[138] Thus, although there was no service interruption to Intelsat's customers, the uncontrolled Galaxy-15, popularly dubbed as Zombie-sat by the media, continued to drift across the LEO and posed a navigational threat to other active satellites and constituted radio frequency interference due to its active communications payload.[139]

[137] Doug Mohney, "Intelsat Galaxy 15 drifts from Zombie to a Phoenix-like Recovery" (13 January 2011), online: Satellite Spotlight, http://satellite.tmcnet.com/topics/satellite/articles/134564-intelsat-galaxy-15-drifts-from-zombie-a-phoenix.htm.

[138] News Release, Galaxy 15 Commercial Customers to Transition to Galaxy 12 Following Anomaly (8 April 2010), online: Intelsat, http://www.intelsat.com/press/news-releases/2010/20100408-1.asp.

[139] Galaxy 15, Still Adrift, Poses Threat to Its Orbital Neighbors (30 April 2010), online: Space News, http://www.spacenews.com/article/galaxy-15-still-adrift-poses-threat-its-orbital-neighbors; Denise Chow, Frustrating Zombie Satellite Still Adrift In Space (7 July 2010), online: Space.Com, http://www.space.com/8724-frustrating-zombie-satellite-adrift-space.html.

Following months of speculations about the malfunction caused by solar flares,[140] investigations conducted by Intelsat along with the manufacturer Orbital Sciences Corp. revealed that the electrostatic discharge had crippled the software on-board the satellite. After Galaxy-15 lost its earth lock resulting in an exhaustion of its power supply and a system re-boot, Intelsat was able to re-establish communications with the satellite and upload updated software in its system.[141] In October 2011, Galaxy 15 resumed normal service when media traffic was transferred back to it from Galaxy 12.

This is one of the most glaring examples of an object in space having an oscillating status between a 'space object' and 'space debris'. During its un-operational phase, Galaxy-15, for all intents and purposes, can be termed as 'space debris.' However, once it was revived, it can be said to have re-assumed the status of a functional 'space object.'

In those eight months of its sojourn across the geostationary belt from April to December, Galaxy 15 passed by more than a dozen operational C-band communications satellites owned by Intelsat, SES, Telesat of Canada and Satmex of Mexico. Intelsat continued to share information pertaining to Galaxy 15 by relaying fly-by advice and "assisting neighbouring satellite operators with interference mitigation planning."[142] It also eliminated risk of a physical collision with other spacecraft by performing routine ranging manoeuvres.[143] It cooperated with other satellite operators including its

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[140] News Release, STEREO Reveals Solar Storm May be Related to Failure Aboard Communications Satellite (7 July 2010), online: Naval Research Laboratory, http://www.nrl.navy.mil/media/news-releases/2010/stereo-reveals-solar-storm-may-be-related-to-failure-aboard-communications-satellite; Solar weather, Effects of solar weather, online: Intelsat, http://www.intelsat.com/resources/tech-talk/solar-weather-qa.asp.

[141] Galaxy-15 satellite, online: Intelsat, http://www.intelsat.com/resources/galaxy-15/operational-status.asp.

[142] Galaxy-15 Satellite Fly By, online: Intelsat, http://www.intelsat.com/resources/galaxy-15/fly-by.asp.

[143] Ibid.

competitor, SES World Skies to plan complex manoeuvres to avert any interference with their satellites.[144] Intelsat also reached out to network providers such as Starz Entertainment,[145] Sportsman Channel,[146] MTV Networks,[147] Turner Networks,[148] among others, in an effort to notify them of any potential interference and pursue correctional measures thereto. By doing so, Intelsat has set a responsible standard of care for satellite operators in similar situations based on close cooperation and transparent communication with the space community.[149]

2.5. Decommissioning of Envisat

On 8 April 2012, ESA lost contact with Envisat, the largest non-military earth observations satellite in orbit.[150] After several failed attempts to regain control of the satellite, ESA declared the end of its mission on 9 May 2012.[151]

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[144] Stephen Clark, "Zombiesat has three more satellites in its crosshairs" (25 July 2010), online: Spaceflight Now, http://www.spaceflightnow.com/news/n1007/25galaxy15/.

[145] Correspondence available on the Intelsat website, online: http://www.intelsat.com/_files/resources/g-15_programmer-updates/Starz_Affiliate-Note_G14.pdf.

[146] Ibid., online: http://www.intelsat.com/_files/resources/g-15_programmer-updates/Sportsman_Channel-G15-flyby-letter.pdf.

[147] Ibid., online: http://www.intelsat.com/_files/resources/g-15_programmer-updates/MTV-Networks_G-18_notice.pdf

[148] Ibid., online: http://www.intelsat.com/_files/resources/g-15_programmer-updates/Turner_G13_fly-by-notice.pdf

[149] Brian Weeden, "Dealing with Galaxy 15: Zombiesats and on-orbit servicing (part 2)" (24 May 2010), online: Space Review, http://www.thespacereview.com/article/1634/2. For a detailed informational analysis on Galaxy-15, see ibid., (part 1), online: Space Review, http://www.thespacereview.com/article/1634/1.

[150] Tariq Malik, Huge Satellite Loses Contact with Earth (16 April 2012), online: Space.Com, http://www.space.com/15290-huge-satellite-envisat-contact-lost.html

It is currently drifting uncontrolled in a sun-synchronous polar orbit and is being tracked by the U.S. Joint Space Operations Centre. Its enormous size – ten metres in length and five metres in width, with an even larger solar array and weighing 8 tons – aggravates the concern of its collision with other functional space objects.[152] It has been estimated that given its orbit and area-to-mass ratio, it will take 150 years for natural decay through atmospheric drag.[153] ESA has calculated a 30 percent collisional probability with other orbital debris in this duration.[154] Therefore, it is potentially an ideal candidate for removal from orbit.[155]

In this case, the question arises whether Envisat can be qualified as 'space debris.' Although it is drifting uncontrolled and is no longer manoeuvrable due to loss of communications, it is otherwise an intact satellite. Further, if technological development allows re-establishing communications with it, as in the case of the Intelsat Galaxy-15 satellite described above, then Envisat can be re-commissioned back to service as a 'space object'.

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[151] ESA Declares End of Mission for Envisat (9 May 2012), online: ESA, http://www.esa.int/Our_Activities/Observing_the_Earth/Envisat/ESA_declares_end_of_mission_for_Envisat.

[152] Mike Wall, Huge Dead Satellite May Be Space Junk for 150 Years (11 May 2012), online: Space.Com, http://www.space.com/15640-envisat-satellite-space-junk-150years.html.

[153] Envisat To Pose Big Orbital Debris Threat for 150 Years, Experts Say (23 July 2010), online: Space News, www.spacenews.com/civil/100723-envisat-orbital-debris-threat.html/.

[154] Space Risks: A New Generation of Challenges, An Insurer's Perspective from Allianz Global Corporate & Specialty, online: http://www.agcs.allianz.com/assets/PDFs/white%20papers/1844%20Allianz%20Space%20White%20Paper%201o.pdf at 5.

[155] For an excellent factual summary of the operation and the life-span of Envisat, see Martha Mejía-Kaiser, "ESA's Choice of Futures: Envisat Removal or First Liability Case" (2012) 55 Proc. Colloq. on the Law of Outer Sp.

2.6. Conclusion

There is no dispute that 'space objects' includes space debris because the jurisdiction and control requirement under Article VIII of the Outer Space Treaty enjoin the State of Registry to retain its jurisdiction and control over the space object. More so, it cannot be abandoned after the expiry of its functional phase because Article VIII grants ownership in perpetuity, which ties the State of Registry to bear international responsibility and liability for any damage caused by its space object, pursuant to Article VII of the Outer Space Treaty, even though it is no longer operational or controllable. Therefore, in the spirit of the Liability Convention as an example of victim-oriented law, it is suggested that the interpretation of space object ought to be "liberal…in favour of an innocent victim."[156]

It has been rightly pointed out by the 2006 IAA Cosmic Study on Space Traffic Management that "no legal distinction is made between valuable active space-craft and valueless space debris."[157] It further recommended the UNCOPUOS to "start discussing whether or not space debris are space objects in the sense used in space law. If it is decided that space debris are space objects, an additional protocol should be elaborated stating what provisions of the treaties apply to valuable spacecraft and which provisions apply to space debris. If it is decided that space debris are not space objects, the protocol

[156] T.E. Wolcott, "Some Aspects of Third Party Liability in Space Shuttle Operations" (1980) 13 Akron L.R. 613 at 617.

[157] Corinne Contant-Jorgenson, Petr Lála, Kai-Uwe Schrogl (eds.), Cosmic Study on Space Traffic Management (Paris: International Academy of Astronautics, 2006) online: http://iaaweb.org/iaa/Studies/spacetraffic.pdf, at 40.

should determine under what conditions space debris may be removed or re-orbited in order to prevent collisions or close encounters with valuable spacecraft"[158]

While a fresh legislative endeavour in the form of an additional protocol or a separate treaty to address this situation is the easiest and ideal solution,[159] our current geo-political environment is not conducive for such an approach due to the competing interests and priorities of different States. Hence, it is essential to investigate a pragmatic alternate resolution to this problem through optimal utilisation of the already available resources, that is, to effectuate a broader interpretation of the existing legal regime in order to accommodate the fast changing commercial and environmental realities of activities conducted in outer space.

[158] Corinne Contant-Jorgenson, Petr Lála & Kai-Uwe Schrogl, "Report: The IAA Cosmic Study on space traffic management" (2006) 22 Space Policy 283 at 287.

[159] Thierry Senechal, "Orbital Debris: Drafting, Negotiating, Implementing a Convention," Master's thesis, Massachusetts Institute of Technology (2007)

3. STATE JURISDICTION AND CONTROL OVER SPACE OBJECTS

3.1. Introduction

The term 'jurisdiction' has been described as "the lawful power of a State to define and enforce the rights and duties, and control the conduct, of natural and juridical persons."[160] It is "the power of the state under international law to regulate or otherwise impact upon people, property and circumstances and reflects the basic principles of state sovereignty, equality of states and non-interference in domestic affairs."[161]

[160] Bernard H. Oxman, "Jurisdiction of States" in R. Bernhardt (ed.), *Encyclopedia of Public International Law*, Vol. 1 (Elsevier, 1992) at 55.

[161] Malcolm N. Shaw, *International Law*, 6th ed., (Cambridge University Press, 2008) at 645. Generally, see C. E. Amerasinghe, *Jurisdiction of International Tribunals*, The Hague, 2003; *Universal Jurisdiction: National Courts and the Prosecution of Serious Crimes under International Law* (ed. S. Macedo), Philadelphia, 2004; L. Reydams, *Universal Jurisdiction: International and Municipal Legal Perspectives*, Oxford, 2002; *La Saisine des Jurisdictions Internationales* (eds. H. Ruiz Fabri and J.-M. Sorel), Paris, 2006; Y. Shany, *The Competing Jurisdictions of International Courts and Tribunals*, Oxford, 2003; M. Hirst, *Jurisdiction and the Ambit of the Criminal Law*, Oxford, 2003; M. Akehurst, 'Jurisdiction in International Law', 46 BYIL, 1972–3, p. 145; F. A. Mann, 'The Doctrine of Jurisdiction in International Law', 111 HR, 1964, p. 1, and Mann, 'The Doctrine of Jurisdiction in International Law Revisited After Twenty Years', 186 HR, 1984, p. 9; D. W. Bowett, 'Jurisdiction: Changing Problems of Authority over Activities and Resources', 53 BYIL, 1982, p. 1; R. Y. Jennings, 'Extraterritorial Jurisdiction and the United States Antitrust Laws', 33 BYIL, 1957, p. 146; *Oppenheim's International Law* (eds. R. Y. Jennings and A. D. Watts), 9th edn, London, 1992, pp. 456 ff.; I. Brownlie, Principles of Public International Law, 6th edn, Oxford, 2003, chapters 14 and 15; O. Schachter, *International Law in Theory and Practice*, Dordrecht, 1991, chapter 12, and R. Higgins, *Problems and Process*, Oxford, 1994, chapter 4. See also *Third US Restatement of Foreign Relations Law*, 1987, vol. I, part IV.

Eminent jurist, Judge Manfred Lachs has defined jurisdiction as "a basic attribute of a State, whereby it exercises fundamental powers as a subject of international law."[162] He has qualified the limits upon the exercise of such jurisdiction as "determined by the rights of other States and the requirements of cooperation in international relations."[163]

This chapter begins with a survey of the identical and uniform treatment bestowed on the twin concepts of 'jurisdiction and control' in international space law followed by some additional comments on related concepts such as ownership and registry of space objects. With the aim to investigate possible extrapolation of concepts from maritime law into space law, this chapter will describe the laws and principles of maritime salvage, removal of wrecks, abandonment and dereliction. It will then conclude with an analysis of the validity of their extrapolation to the realm of space law.

3.2. International Space Law

The vital question of jurisdiction and control for space objects is addressed in *lex spatialis*, first in the 1963 Declaration of Legal Principles and then in the 1967 Outer Space Treaty. At the time of its adoption, the Outer Space Treaty represented "the lowest common denominator of issues on which consensus existed in COPUOS."[164] This sentiment was

[162] Manfred Lachs, *The Law of Outer Space* (Leiden: Sijthoff Publishers, 1972) at 69.

[163] Ibid. Also, see Manfred Lachs, "The International Law of Outer Space" (1964) 113 RdC at 58.

[164] Nicolas Mateesco Matte, "Outer Space Treaty" in R. Bernhardt (ed.), *Encyclopedia of Public International Law*, Vol. 1 (Elsevier, 1992) at 838. "Containing general principles for the peaceful exploration and use of outer space, including the moon and other celestial bodies, it was not to deal with all contingencies that might arise from their exploration and use. It is not a perfect instrument. Some of its principles are obscurely stated and its terms lack precision and definition. Nevertheless, it represents the most important source of space treaty law."

reflected in the views of the then U.S. Secretary of State, who had described the legislative efforts behind the conclusion of the Outer Space Treaty as an "outstanding example of how law and political arrangements can keep pace with science and technology."[165] As of 1 January 2012, the Outer Space Treaty has been ratified by 101 States and signed by 26 signatories.[166] It is noteworthy that all spacefaring States so far have ratified the Treaty which indicates that some of its provisions have likely crystallised into customary international law.[167] The following section will throw light on the specific provisions relating to jurisdiction and control of space objects in public international space law.

3.2.1. Jurisdiction and control

Article VIII of the Outer Space Treaty relates to jurisdiction and control over a space object by a State through launching of the space object. It provides that:

> "A State Party to the Treaty on whose registry an object launched into outer space is carried *shall retain jurisdiction and control* over such object, and over any personnel thereof, while in outer space or on a celestial body."[168] (emphasis added)

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[165] Dean Rusk, "Letter of Submittal from Secretary Rusk to President Johnson" (27 January 1967) in *Hearings on Treaty on Outer Space Before the Senate Committee on Foreign Relations* (1967), 90th Cong., 1st Sess., at 112.

[166] Status of International Agreements Relating to Activities in Outer Space as at 1 January 2012, A/AC.105/C.2/2012/CRP.3, online: United Nations Office of Outer Space Affairs http://www.oosa.unvienna.org/pdf/limited/c2/AC105_C2_2012_CRP03E.pdf.

[167] Bin Cheng, "The 1967 Outer Space Treaty: Thirtieth Anniversary" (1998) 23 Air & Sp. L. 156; Bin Cheng, "United Nations Resolutions on Outer Space: 'Instant' International Customary Law?" (1965) 5 Indian J. Int'l L. 23; Vladlen S. Vereshchetin & Gennady M. Danilenko, "Custom as a Source of International Law of Outer Space" (1985) 13 J. Sp. L. 22.

[168] Outer Space Treaty, Article VIII.

A similar provision is also found in Article 12, paragraph 1 of the Moon Treaty:

> "States Parties *shall retain jurisdiction and control* over their personnel, vehicles, equipment, facilities, stations and installations on the Moon."[169] (emphasis added)

This form of jurisdiction has been termed as "quasi-territorial jurisdiction."[170] It follows that the exercise of such jurisdiction over space objects is reliant on the inclusion of the space object on the domestic registry of the State. This provision is fairly straight-forward when there is only a single State responsible for the launch of the space object in question. However, in the case of multiple launching States, Article VIII of the Outer Space Treaty requires that these States designate one particular State among them, which shall register the object and accordingly, be eligible to exercise jurisdiction and control over it.

Some commentators have suggested a conceptual distinction between 'jurisdiction' and 'control' insofar as describing 'control' in terms of a separate technical function – "a separate concept, to mean not only observation (passive) but, in the first place, an obligation for the State of Registry, to active guidance of the space object; and a prohibition of interference with the space object by a third (non-Registry) State."[171] The Soviet authors have further expanded the concept to include "activities of special services of the State of Registry aimed at monitoring the technical condition of the space object

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[169] Moon Agreement, Article 12(1).

[170] Bin Cheng, "The 1967 Space Treaty" in Bin Cheng, *Studies in International Space Law*, (Oxford: Clarendon Press, 1997) at 231. "The quasi-territorial jurisdiction of the State of registry overrides…the personal jurisdiction of the national State, at least insofar as the power of enforcement or implementation ('jurisaction') is concerned."

[171] Reijnen, *United Nations Space Treaties Analysed*, note 107, at 119.

during the launching and putting into orbit, as well as its functioning in outer space and during the landing."[172] It is unnecessary to dissect the twin concepts of 'jurisdiction and control' that have received identical and uniform treatment throughout international space law instruments. Hence, it has been rightly pointed out that "jurisdiction should induce control and control should be based on the jurisdiction."[173]

In the context of this discussion, it is important to simultaneously take into account the provisions of the Registration Convention because it is viewed as an attempt towards further elaboration of Article VIII of the Outer Space Treaty.[174] Article II(2) of the Registration Convention provides that:

> "Where there are two or more launching States in respect of any such space object, they shall jointly determine which one of them shall register the object…, bearing in mind the provisions of article VIII of the [Outer Space Treaty], and without prejudice to appropriate agreements concluded or to be concluded among the launching States

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[172] Ibid.

[173] Gabriel Lafferranderie, "Jurisdiction and Control of Space Objects and the Case of an International Intergovernmental Organisation (ESA)" (2005) 54 ZLW 228 at 231-232.

[174] Registration Convention, preamble.

> "Desiring, in the light of the [Outer Space Treaty], to make provision for the national registration by launching States of space objects launched into outer space,
>
> Desiring further that a central register of objects launched into outer space be established and maintained, on a mandatory basis, by the Secretary-General of the United Nations,
>
> …
>
> Believing that a mandatory system of registering objects launched into outer space would, in particular, assist in their identification and would contribute to the application and development of international law governing the exploration and use of outer space,"

on jurisdiction and control over the space object and over any personnel thereof."

In order to exercise legitimate jurisdiction, it is essential for the State to identify a "sufficient nexus between itself and the object of its assertion of jurisdiction."[175] There is wide scholarly consensus that registration of space objects establishes such a link between the State and the space object.[176] In case if a space object is not registered, it has been observed that ownership serves as the determining factor to ascertain which State could exercise jurisdiction and control.[177]

In this regard, a literal interpretation has been adopted by Jenks who asserts that "the jurisdiction and control of the State on whose registry the space object is carried clearly implies that no other State is entitled to interfere, by electronic or other means, with its normal operation..., no State is entitled to telecommand, divert or destroy space objects not subject to its jurisdiction except by Agreement."[178]

However, some authors do not consider registration as a "legal confirmation of ownership" or a "binding legal commitment of liability" on the ground that the State of

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[175] Oxman, "Jurisdiction of States," note 160, at 56. "The requisite contacts with a State necessary to support the exercise of jurisdiction differ depending on the nature of the jurisdiction being exercised."

[176] "Registration of space objects seem ipso facto to be sufficient to provide the link between these objects of international law and the subjects of international law." Stephan Hobe, "Spacecraft, Satellites and Space Objects" Max Planck Encyclopedia of Public International Law; "This link has a double intention. On the one hand, it assures to the spacecraft the protection by the State; on the other hand, the interests of third persons are protected by the fact that the State will be responsible for the spacecraft belonging to this State." I.H.Ph Diederiks-Verschoor, "Registration of Spacecraft" in E. McWhinney & M.A. Bradley (eds.), *New Frontiers in Space Law* (Leiden, 1969) at 125.

[177] "Failing registration, the act of launching and the ownership of such space objects seem to provide a sufficient link." Stephan Hobe, "Spacecraft, Satellites and Space Objects," ibid.

[178] C.W. Jenks, *Space Law* (London: Stevens Publishers, 1965) at 238.

Registration may not be the launching State.[179] The State of registry has been defined in the Registration Convention as "a launching State on whose registry a space object is carried…"[180] It follows that the State of registry, therefore, has to be one of the launching States, that is, a State which launches or procures the launching of a space object; a State from whose territory or facility a space object is launched.[181]

In the wake of increasing international collaborative space ventures and private participation, the election of a State of registry among multiple launching States for the purpose of retention of jurisdiction and control is likely more complicated than it may appear.[182] The State whose national is the owner of the payload/satellite will be more interested in acquiring legitimate jurisdiction and control rather than the State from whose territory/facility the launch had taken place. Although State practice with respect to the registration of space objects is sometimes sketchy and seemingly inconsistent, clarifying declarations by spacefaring States help to eliminate the ambiguities.[183]

From the above discussion, it is apparent that public international space law is silent about the legality of remediation when it relates to assuming or transferring legal

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[179] Henry R. Hertzfeld & Ben Baseley-Walker, "A Legal Note on Space Accidents" (2010) 59 ZLW 230 at 233

[180] Registration Convention, Art. I(c)

[181] Liability Convention, Art. I(c); Registration Convention, Art I(a); Outer Space Treaty, Art. VII.

[182] See *infra*, Section 3.2.2. 'Transfer of registry'

[183] Kenneth Hodgkins, U.S. Adviser to the 57th Sess, of the UN General Assembly, *International Cooperation in the Peaceful Uses of Outer Space*, Remarks on Agenda Item 75 in the Fourth Committee of the United Nations General Assembly, New York, 9 October 2002, online: http://2001-2009.state.gov/g/oes/rls/rm/2002/14362.htm. "We intend to include on the U.S. registry all space objects that are owned or operated by U.S. private or governmental entities whether launched from inside or outside U.S. territory. In general, the United States will not include on its registry non-U.S. payloads that are launched from U.S. territory or facilities. It is our view that such non-U.S. payloads should be included on the registry of the State of the payload's owner/operator because that State is best positioned to exercise jurisdiction and control. In addition, we will continue our practice of including certain non-functional objects on the U.S. Registry."

jurisdiction and control of a particular space object. In the event of a remediation carried out by a State or a State licensed actor, it will be considered legitimate if the State retains *de jure* jurisdiction and control of that space object or obtains explicit authorisation from the State of registry. Thus, no legal complications are anticipated when a State seeks to remediate its own space objects. However, when a State or State licensed actor seeks to remediate a space object that it did not carry on its registry, the question will arise whether there can be an exception to this general rule of jurisdiction and control on grounds of the public policy goal of facilitating space debris remediation.

3.2.2. Transfer of registration

Neither the Outer Space Treaty nor the Registration Convention contains any provisions for the transfer of the registration of a space object. Consequently, this has generated extensive academic debate about the validity of such transfer agreements. The process of privatisation of the International Maritime Satellite Organisation (INMARSAT) had highlighted this issue.[184]

Several commentators have argued in favour of an amendment to the Registration Convention to resolve this issue. However, existing State practice demonstrates otherwise where non-launching States have successfully registered space objects over which they retain jurisdiction and control pursuant to Article VIII of the Outer Space Treaty. This was evident in the transfer of satellites registered in the United Kingdom to

[184] David W. Sagar, "The Privatization of Inmarsat" (1998) 41 Proc. of the Colloq. on the Law of Outer Sp.; David W. Sagar, "The Privatization of Inmarsat – Special Problems" (1999) Proceedings of the Third ESA/ECSL Colloquium on International Organizations and Space Law – Their Role and Contributions, Perugia, Italy.

China as a consequence of the handover of Hong Kong in 1998.[185] This is consistent with Article II of the Registration Convention because it does not prohibit subsequent transfers of jurisdiction and control rights among launching States.[186]

However, the Registration Convention does not explicitly regulate subsequent transfers of jurisdiction and control rights to non-launching States. The *note verbale* submitted by the Netherlands to the UN COPUOS to register the transfer of ownership of satellites from New Skies Satellites is particularly interesting because it expressly renounces the status of the launching State or the State of Registry and consequently rejected its obligation to furnish information under Article IV of the Registration Convention. However, by virtue of the in-orbit transfer of ownership, it assumed international responsibility under Article VI of the Outer Space Treaty and also claimed the retention of jurisdiction and control under Article VIII of the Outer Space Treaty.[187]

It is also noteworthy that international jurisprudence espoused by the Permanent Court of International Justice allows States to enter into agreements conferring actual rights of their own to a third State.[188] Therefore, launching States may enter into specific agreements with non-launching States to transfer jurisdiction and control over a space object.

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[185] Information Furnished in Conformity with the Convention on Registration of Objects Launched into Outer Space, *Note verbale* dated 27 March 1998 from the Permanent Mission of the United Kingdom of Great Britain and Northern Ireland to the United Nations (Vienna) addressed to the Secretary-General, UN Doc. ST/SG/SER.E/333 – Notification of the removal of AsiaSat-1 (1990-030A), APSTAR-I (1994-043A), Asiasat-2 (1995-064A) and APSTAR IA (1996-039A) from national register effective 1 July 1997. Also see UN Doc. ST/SG/SER.E/334 for notification of addition of above named satellites to the register of the Hong Kong Special Adminnistrative Region of the People's Republic of China effective 1 July 1997.

[186] Ricky J. Lee, "Effects of Satellite Ownership Transfers on the Liability of the Launching State" (2000) 43 Proc. Of Colloq. On Law of Outer Sp. 148.

[187] UN Doc. A/AC.105/806 (22 August 2003).

[188] *Free Zones of Upper Savoy and the Dictrict of Gex (France v. Switzerland)* [1932] P.C.I.J. (ser. A/B), No. 46 at 147.

The language in Article II of the Registration Convention unambiguously imposes a positive obligation on launching States to register the space object. However, in the event of transfer of ownership to a non-launching State, such a right to register the space object can be found in Article VIII of the Outer Space Treaty for domestic registrations and General Assembly Resolution 1721B (XVI)[189] for registration with the United Nations. Hence, this eliminates any need for an amendment of the Registration Convention and the transfer of 'jurisdiction and control' can be carried out under the existing framework of space law.

3.2.3. Ownership

Under the current legal regime, ownership of space objects is not co-extensive with the jurisdiction and control over such objects. Article VIII of the Outer Space Treaty lays down:

> "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."(emphasis added)

This is also echoed in Article 12(1) of the Moon Agreement, which states:

[189] International co-operation in the peaceful uses of outer space, UN GA Res. 1721 (XVI), online: United Nations Office of Outer Space Affairs, http://www.oosa.unvienna.org/oosa/SpaceLaw/gares/html/gares_16_1721.html. "Calls upon States launching objects into orbit or beyond to furnish information promptly to the Committee on the Peaceful Uses of Outer Space, through the Secretary-General, for the registration of launchings"

> "The ownership of space vehicles, equipment, facilities, stations and installations *shall not be affected* by their presence on the Moon." (emphasis added)

While 'jurisdiction and control' is clearly geo-spatial in nature as it can be retained "while in outer space or on a celestial body,"[190] 'ownership' is in perpetuity as it "is not affected by their presence in outer space or on a celestial body or by their return to the Earth."[191] The law is silent about the temporal factor of 'jurisdiction and control' as to when can a State relinquish *de jure* jurisdiction and control. This is particularly important in cases when a State of registry has lost *de facto* control over a space object due to a technical anomaly which has rendered the space object non-functional and consequently, a potential target for remediation.

While this provision has been alleged as an impediment towards space debris remediation activities,[192] it is, in fact, not an inhibiting factor as States can enter into separate agreements for the transfer of ownership of space objects as discussed in the preceding section. Thus, although international space law does not contain explicit provisions for the transfer of registry, public international law jurisprudence coupled with contemporary State practice have circumvented that lacuna by conclusion of bilateral or multi-lateral agreements. Therefore, it would be misleading to make an unequivocal assertion that space debris remediation activities are being thwarted by the 'ownership' clause in the Outer Space Treaty.

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[190] Outer Space Treaty, Art. VIII. Also see Moon Agreement, Art. 12 (1).

[191] Ibid.

[192] Matthew Schaefer, "Analogues between Space Law and the Law of the Sea/International Maritime Law: Can Space Law Usefully Borrow or Adapt Rules from These Other Areas of Public International Law?" (2012) 55 Proc. Of Colloq. On Law of Outer Sp.

3.3. Analogy with Maritime Law

Several commentators have embarked upon a discourse on borrowing concepts from the law of maritime salvage to propound the development of a legal regime governing space debris remediation activities. Legal literature indicates substantial reliance on the law of maritime salvage to resolve unanswered questions in the realm of space law.[193] The following section considers such arguments and examines the validity of possible extrapolation of maritime law concepts to space law.

3.3.1. Maritime salvage: Definition

In maritime law, salvage is described as "a service voluntarily rendered in relieving property from an impending peril at sea or other navigable waters by those under no legal obligation to do so."[194] The Admiralty Courts have held the view that "salvage service … may be described sufficiently for practical purposes as a service which confers a benefit by saving or helping to save a recognised subject of salvage when in danger from which it cannot be extricated unaided, and if and so far as the rendering of such

[193] R. Cargill Hall, "Comments on Salvage and Removal of Man-made Objects from Outer Space" (1966) 19 Proc. Colloq. On L. of Outer Sp. 117; Martha Keiser, "Removal of Hazardous Debris" in Joseph Pelton & Ram Jakhu (eds.), *Space Safety Regulations and Standards* (Elsevier, 2010) at 372-375; Schaefer, "Analogues between Space Law and the Law of the Sea/International Maritime Law," ibid.

[194] Martin J. Norris, *The Law of Salvage* (Baker, Voorhis & Co., 1958) at 2. Generally, see Hans-Heinrich Nöll, "Salvage of Ships" in R. Bernhardt (ed.), *Encyclopedia of Public International Law*, Volume 4 (Amsterdam: Elsevier, 2000), at 309-310.

service in voluntary in the sense of being attributable neither to a pre-existing obligation nor solely for the interests of the salvor."[195]

Salvage has also often defined in terms of the payment of compensation paid to the salvor as "the compensation allowed to persons by whose voluntary assistance a ship at sea or her cargo or both have been saved in whole or in part from impending sea peril, or in recovering such property from actual peril or loss, as in cases of shipwreck, derelict or recapture."[196]

The International Maritime Committee made the first attempt towards general unification of the relevant principles of the law of salvage in 1905, which paved the way for the conclusion of the Brussels Convention on Salvage 1910. In response to its "inadequacy … to meet modern circumstances,"[197] the Draft Convention by the Comité Maritime International was formulated in Montreal in May 1981. Following detailed discussion by the Legal Committee of the International Maritime Organisation, the International Salvage Convention was finally concluded at a diplomatic conference in London on 28 April 1989.

The Montreal Draft Salvage Convention 1981 which eventually became the International Salvage Convention 1989 provides "Salvage operations mean any act or activity

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[195] *The Cythera* [1965] 2 Lloyd's Rep. 454 at 459; *The Meandrosi* [1925] P. 61 at 68; *The Lord Dufferin* (1848) 7 N.o. C, quoted in Francis D. Rose, *Kennedy and Rose Law of Salvage*, 7th ed., (Thomson Reuters, 2010) at 8.

[196] The Sabine (1879) 101 US 384, 25 L ed 982; The Blackwall (1869) 77 US 1 (10 Wall 1) 19 L ed 870; The Clarita and the Clara (1874) 90 US 1 (23 Wall 1) 23 L ed 146, quoted in Norris, *The Law of Salvage*, note 194, at 2.

[197] John Reeder (ed.), *Brice on Maritime Law of Salvage*, 5th ed. (Thomson Reuters, 2011) at 13.

undertaken to assist a vessel or any other property in danger in navigable waters or in any other waters whatsoever."[198]

Therefore, the salient features of a maritime salvage service have been identified as that which is "performed on navigable waters" and "voluntarily rendered by one under no existing duty to do so."[199]

3.3.2. Environmental Salvage[200]

Following multiple references to the "protection of the environment" in its preamble,[201] article 14 of the above Convention stipulates the payment of special compensation for environmental services in cases where no reward is recoverable for property salvage, in other words, for salvage of property of no value.[202]

While enumerating the duties of the salvor and of the salvee,[203] article 8 of the 1989 Convention imposes a duty to exercise due care to prevent or minimise damage to the

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[198] International Salvage Convention 1989, art. 1.

[199] Norris, *The Law of Salvage*, note 194, at 3. Judge Addison Brown defined a salvage service as "a service which is voluntarily rendered to a vessel needing assistance, and is designed to relieve her from distress or danger either present or to be reasonably apprehended." McConnochie v. Kerr, 9 F 50 (DC SD NY 1881) mod. sub. nom. McConnochin v. Kerr, 15 F 545 (CC SD NY 1883), quoted in ibid., at 2.

[200] "Damage to the environment" is defined by International Salvage Convention, art. 1(d). Generally, see Reeder (ed.), *Brice on Maritime Law of Salvage*, note 197, at 397-464.

[201] "The States Parties to the present Convention…[n]oting that substantial developments, in particular the increased concern for the *protection of the environment*, have demonstrated the need to review [the Brussels Convention of 1910], [c]onscious of the major contribution which efficient and timely salvage operations can make…to the *protection of the environment*…" [emphasis added]

[202] "…the effort of environmental services is to restrict the legal liability of salvees and/or to provide a benefit to possibly unidentifiable third parties who are not liable to remunerate the salvor with a salvage reward or possibly on any other basis." Rose, *Kennedy and Rose Law of Salvage*, note 195, at 207.

[203] "The duty on the salvor is expressed in slightly stronger terms by Lloyd's Standard Form of Salvage Agreement 2000, clause B and Special Compensation Protection and Indemnity Clause 2000, clause 10, which state that, while performing the salvage services, the salvor must use his "best endeavours" to

environment on both the salvor[204] (in carrying out his duty to conduct the salvage operations with due care)[205] and the salvee[206] (in carrying out his duty to cooperate fully with the salvor during the course of the salvage operations).[207]

3.3.3. Wreck Removal[208]

A wreck is described as "in addition to a derelict vessel, any part or fragment of a ship or cargo whether afloat or stranded ashore on a beach, reef, bar or jetty."[209] A wreck removal operation is generally perceived as "a contract to remove property which is not worth salving"[210] and consequently, it is not considered to confer a right to salvage.[211]

The 2007 Nairobi International Convention on the Removal of Wrecks,[212] within the context of existing international law,[213] lays down "international rules and procedures to

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prevent or minimise damage to the environment." Rose, *Kennedy and Rose Law of Salvage*, note 195, at 514-515.

[204] Art. 8.1(b)

[205] Art. 8.1(a)

[206] Art. 8.2(b)

[207] Art. 8.2 (a)

[208] Rose, *Kennedy and Rose Law of Salvage*, note 195, at 803-811.

[209] Norris, *The Law of Salvage*, note 194, at 222. It also includes jetsam, flotsam and lagan.

[210] Reeder (ed.), *Brice on Maritime Law of Salvage*, note 197, at 37.

[211] "Even if the person who contracted for removal of the wreck becomes insolvent, there may be no residual claim to salvage for the would-be salvor is usually not a volunteer because of his pre-existing contractual duty."*The Solway Firth* [1893] at 120, quoted in ibid.

[212] International Convention on the Removal of Wrecks, 2007, done at Nairobi (14-18 May 2007) (LEG/CONF.16/19).

[213] First, the Convention is subject to States' rights and obligations under the United Nations Convention on the Law of the Sea, 1982 and under the customary international law of the sea: Art. 16; see also the

ensure the prompt and effective removal of wrecks" that "may pose a hazard to navigation or the marine environment."[214] It emphasises on the proportionality of measures taken to the hazard and prohibits interference with the rights and interests of other States including the State of the ship's registry, and of any person concerned.[215]

3.3.4. Abandonment and dereliction

The term 'derelict' refers to "property on navigable waters which is abandoned and deserted by those who were in charge of it, without hope on their part of recovering it (*sine spe recuperandi*), and without intention of returning to it (*sine animo revertendi*)."[216] Thus, abandonment is characterised by "giving up, a total desertion, and absolute relinquishment…when the owner with specific intent of desertion and relinquishment

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Preamble. Secondly, it does not apply to measures taken under the International Convention relating to the Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969, as amended, or the Protocol relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil, 1973, as amended: Art. 4.1. Thirdly, liability for the costs of wreck removal is also subject to four specified Conventions and to applicable salvage law (which will therefore include the International Salvage Convention 1989 where that applies): Art. 11.1. Rose, *Kennedy and Rose Law of Salvage*, note 195, at 803.

[214] Nairobi Wreck Removal Convention, Preamble

[215] Ibid., Art. 2.

[216] Norris, *The Law of Salvage*, note 194, at 221. Derelicts have also been defined as "boats or other vessels forsaken or found on the seas without any person in them." William Wynne, *Life of Sir Leoline Jenkins Judge of the High-Court of Admirality*, vol. 1 (1724) at 83, quoted in ibid. Also, see *Tyson v. Prior*, Fed Case 14,319 (CC Mass 1812); *Union TowBoat Co. v. The Delphos*, Fed Cas 14,400 (DC La 1849).

casts away or leaves behind his property."[217] Hence, it is essential that the abandonment must have been final without hope of recovery or intention to return.[218]

In order to constitute a maritime derelict, it is irrelevant "whether it arose from accident or necessity or voluntary dereliction" as long as it "is found deserted or abandoned upon seas."[219] It has also been asserted that in the context of dereliction, abandonment is not necessarily a final and binding abandonment of ownership.[220]

3.3.5. Rights of salvors

The salvors are generally entitled to possessory rights in the salved property as against third parties, even where there is no express agreement or contract for salvage.[221] Although the salvors exercise effective control over the wreck as a whole, it does not divest the owner of the title or the right to property of the wreck or the cargo therein.[222]

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[217] *Simpson v. Gowers* (1981) 32 O.R. (2d) 385 at 387, which obtained the definition of abandonment from R.A. Brown, *The Law of Personal Property*, 2nd ed., at 9, quoted in Reeder (ed.), *Brice on Maritime Law of Salvage*, note 197, at 285. "It is sufficient if there has been an abandonment at sea by the master and crew, without hope of recovery, because a mere quitting of the ship for the purpose of procuring assistance from shore, or with an intention of returning to her again, is not an abandonment." *The Aquila* (1798) 1 C. Rob. 37, quoted in Norris, *The Law of Salvage*, note 194, at 221-222

[218] *The Island City* (1861) 66 US 121, 1 Black 121, 17 L ed 70, quoted in Norris, *The Law of Salvage*, note 194, at 222.

[219] *Row v. The Brigh*, Fed Cas 12,093 (CC Mass 1818); see also: *The Boston*, Fed Cas 1673 (CC Mass 1833); The Emulous, Fed Cas 4480 (CC Mass 1832), quoted in Norris, *The Law of Salvage*, note 194, at 221.

[220] Reeder (ed.), *Brice on Maritime Law of Salvage*, note 197 at 279-280. See *HM v. Mar-Dive* [1997] A.M.C. 1000 (Ontario Court, Canada, General Division), quoted in ibid., at 284-285.

[221] *The Tubantia* (1887) 13 App. Cas. 160, quoted in Reeder (ed.), *Brice on Maritime Law of Salvage*, note 197, at 208.

[222] When articles are lost at sea the title of the owner in them remains, even if they are found floating on the surface or after being cast upon the shore. The Akaba, 54 F 197 (CCA4th 1893).

The salvor obtains a right of possession; he does not acquire ownership or title to the salved property which rests in perpetuity with the original owner of the property.[223]

3.3.6. Applicability of maritime law of salvage to international space law

One of the primary and fundamental inconsistencies in juxtaposing maritime law concepts to international space law is that the maritime law of salvage is essentially private international law while international space law is a branch of public international law[224] and its subjects are States.[225] Therefore, an attempt to impose obligations on States identical to those restrictions imposed on private entities under maritime law will produce a skewed outcome.

This is expressly enunciated in both the 1989 International Salvage Convention as well as the Nairobi Wreck Removal Convention which contain specific provisions on exclusions to their applicability. Article 4 of both these Conventions stipulate that "warships or other non-commercial vessels owned or operated by a State"[226] and "warship or other ship owned or operated by a State and used, for the time being, only on Government non-commercial service"[227] will be excluded from the purview of these Conventions. This is also in consonance with Article 96 of the United Nations Convention on the Law

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[223] The Akaba, supra; The Bark Cleone, 6 F 517 (DC Cal 1881); The Port Hunter, 6 F Supp 1009 (DC Mass 1934), quoted in Norris, *The Law of Salvage*, note 194, at 246.

[224] Outer Space Treaty, Art. III.

[225] P. Malanczuk, "Space Law as a Branch of International Law" (1994) 25 NYIL 143.

[226] International Salvage Convention 1989, Art. 4.

[227] Nairobi Wreck Removal Convention 2007, Art. 4.

of the Sea which grants complete immunity to ships used only on government non-commercial service from the jurisdiction of any other State other than the flag State.

Moreover, article 91 of the United Nations Convention on the Law of the Sea confers nationality to the ships conditional upon the existence of a "genuine link between the State and the ship."[228] As opposed to that, early space law literature is inclined towards rejection of the concept of nationality for space objects.[229] Although the current law does grant nationality to space objects through registration, yet such a nexus is not based on the genuine link theory.

Further, unlike *corpus juris spatialis*, the United Nations Convention on the Law of the Sea contains express provisions for transfer of ownership or change of registry.[230] An extension of this concept finds expression in Article 94 on the duties of the flag State whereby every State is required to "effectively exercise its jurisdiction and control," thereby introducing the concepts of *de facto* as well as *de jure* jurisdiction. However, the Outer Space Treaty or any other space law instrument does not include such a distinction.

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[228] "Every State shall fix the conditions for the grant of its nationality to ships, for the registration of ships in its territory, and for the right to fly its flag. Ships have the nationality of the State whose flag they are entitled to fly. There must exist a genuine link between the State and the ship." United Nations Convention on the Law of the Sea, Art. 91(1).

[229] C.W. Jenks, Le droit international des espaces célestes, Rapport préliminaire présenté à l'Institut de Droit International, Genève 1963 at 204-207; International Law Association Report of the 51st Conference, Tokyo (1964) at 713-714; International Law Association Report of the 52nd Conference, Helsinki (1966) at 215; International Law Association Report of the 53rd Conference, Buenos Aires (1968) at 185, quoted in A. Gobriel, "Space Objects in International Law" (1982) 21 Il Diritto Aereo 75.

[230] "Ships shall sail under the flag of one State only and, save in exceptional cases expressly provided for in international treaties or in this Convention, shall be subject to its exclusive jurisdiction on the high seas. A ship may not change its flag during a voyage or while in a port of call, save in the case of a real transfer of ownership or change of registry." United Nations Convention on Law of the Sea, Art. 92(1).

From the foregoing, it is clear that the underlying constitutive elements of maritime law of salvage do not correspond with the fundamental principles of international space law. Hence, it is a legally inaccurate proposition to develop a framework governing space debris remediation activities based on principles borrowed from the law of salvage.

4. STATE RESPONSIBILITY AND LIABILITY FOR COMPLIANCE WITH PRINCIPLES OF INTERNATIONAL LAW

4.1. Introduction

State responsibility has been viewed as "a legal construct that allocates risk for the consequences of acts deemed wrongful by international law to the artificial entity of the State."[231]

Although in the municipal legal sphere, there seems to be no distinction between the two terms 'responsibility' and 'liability', yet they convey specifically different meanings in public international law.[232] The distinction between State responsibility and liability lies in the fact that the prerequisite to the former is an act breaching international law and to the latter, the harmful effects of an activity, which is not *per se* a violation of international law.[233]

[231] Christine Chinkin, "A Critique of the Public/Private Dimension" (1999) 10 EJIL 387 at 477

[232] Sandeepa Bhat B. & P. Ishwara Bhat, "Legal Framework of State Responsibility and Liability for Private Space Activities" in Sandeepa Bhat B. (ed.), *Space Law in the Era of Commercialisation* (Eastern Book Company, 2010).

[233] Rebecca M. M. Wallace, *International Law*, (Sweet & Maxwell, 2003) at 203.

This chapter will address the legal consequences of space debris remediation activities and allocation of risk associated with space debris, in the event of materialisation of such a risk. Following some brief comments on the distinction between the terms 'responsibility' and 'liability,' the imposition of international responsibility enshrined in Article VI of the Outer Space Treaty has been analysed. Further, the two-tiered liability regime present in international space law based on the liability clauses in Article VII of the Outer Space Treaty and the Liability Convention has been examined. Particularly, the domain of fault liability in case of damage caused by a space object in outer space has been studied with particular focus on the definition of fault in international law.

In order to address the absence of any 'standard of care' prescribed in the Liability Convention, it has been proposed that fault liability should stem from absence of a responsible 'standard of care' characterised by due diligence or due care. In this context, the historical origin of the concept of 'due diligence' is traced and its current status in public international law has been explored.

The final section of this chapter attempts to address the question of non-cooperative space debris remediation activities. In the absence of an explicit authorisation from the State of registry, it has been asserted that remediating a space object can be justified on the ground of necessity. To that end, the origin of the concept of 'necessity' in international relations, its codification into international law and its customary status have been described.

4.2. Conceptual distinction between 'responsibility' and 'liability' in public international law

In international law, the term 'responsibility' stands for the consequences arising from

the violation of an international obligation. However, the term 'liability' has been recently introduced in international law, perhaps with the 1972 Liability Convention, to denote the duty to compensate the damage in the absence of a violation of international law.[234]

Commentators have sought to clarify the seemingly twin concepts of responsibility and liability under general international law.[235] In its 1973 Report, the International Law Commission distinguished responsibility for wrongful acts as "a body of secondary norms, that is, norms of effectiveness, or of the application of sanctions from the primary norms of strict or absolute liability."[236] In this regard, Cheng made the following observation:

> "Responsibility means essentially answerability, answerability for one's acts and omissions, for their being in conformity with whichever system of norms, whether moral, legal, religious, political or any other, which may be applicable, as well as answerability for their consequences, whether

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[234] K. Zemanek, "Causes and Forms of International Responsibility" in *Contemporary Problems of Law: Essays in honour of Georg Schwarzenberger* (London: Stevens & Sons, 1988) at 319.

[235] "The term responsibility…includes the attribution of the consequences of conduct in terms of the duties of a man in society. Secondly, it can denote the role of the defendant, 'as the party responsible' for causing harm. In this second sense it establishes the actor's contingent liability. Liability, on the other hand, may be used to contrast that notion and to indicate the consequences of a failure to perform those duties which derive from that responsibility to redress. That is to say, failure to observe one's responsibilities, or of being responsible in a causal sense for harm, carry the legal consequences (i.e., both the sanctioning and compensatory function) of incurring liability. We may explain this latter point by saying that although in certain general contexts legal responsibility and legal liability may be given, in ordinary language, the same meaning, to say that a man is legally responsible for some act or harm is to state his connection with that act or harm is sufficient, according to law, to render him liable to his victims for the consequences of his act or for the harm he has caused. Even after the defendant's responsibility has been established, the remedy to which, in appropriate cases and particularly in nuisance, he may thereupon become liable will vary with such factors as the nature of the harm, the social utility of the harm-inducing activity as it is balanced against the social utility of the interests suffering the harm. These pragmatic considerations point to the importance of distinguishing, in appropriate cases, between responsibility as a constant factor and liability as subject to a number of variable considerations in the process of decision." L.F.E. Goldie, "Responsibility and Liability in the Common Law" in *Legal Aspects Transfrontier Pollution* (OECD Environmental Directorate, 1977), 306 at 344.

[236] L.F.E. Goldie, "Concepts of Strict and Absolute Liability and the Ranking of Liability in Terms of Relative Exposure to Risk" (1985) XVI NYIL 175 at 183-184.

> beneficial or injurious. In law, it applies in particular to a person's answerability for compliance with his or her legal duties, and for any breaches thereof.
>
> The term liability is often used specifically to denote the obligation to bear the consequences of a breach of a legal duty, in particular the obligation to make reparation for any damage caused, especially in the form of monetary payment. The term is often used more generally to denote a legal obligation to repair a loss irrespective of any culpability, especially in cases of assumed or imposed liability. However, both terms responsibility and liability have derivative meanings, where they can assume slightly different connotations. Although responsibility is a broader concept than liability, the two terms are sometimes used interchangeably."[237]

As has been further elucidated by Cheng, international state responsibility in the outer space field arises the moment a breach of an international obligation is produced and not when the State is seen to have failed in its duty to prevent or repress such breach, for the State is immediately accountable for the breach on the international plane as if it itself had breached the international obligation. [238]

In international space law, while responsibility applies to a "State's obligation to regulate and control space activity both in the present, and in the future, to assure compliance

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[237] Bin Cheng, "Article VI of the 1967 Space Treaty Revisited: 'International Responsibility', 'National Activities' and 'The Appropriate State'" (1998) 26 J. Sp. L. 7 at 9.

[238] Ibid., at 15.

with not only the letter but the spirit of the Outer Space Treaty principles", liability on the other hand refers to an "obligation of a State to compensate for damages". [239]

4.3. International Responsibility: Article VI, Outer Space Treaty

Early authors had suggested imposing full international responsibility for any possible damage on the State launching a spacecraft while allowing them the right to make certain reservations as under the Warsaw Convention excluding, for example, liability in the case of force majeure as well as the establishment of an International Guaranty Fund to pay for unintentional accidental damage caused by satellites.[240]

The possible involvement of private enterprises in outer space and the attribution of responsibility for such private activities to the States had been one of the controversial issues between the U.S.A. and the erstwhile Soviet Union during the development of a legal regime governing outer space activities.[241] Principle 5 of the United Nations General Assembly Resolution 1962(XVIII) reflected the compromise reached between the two parties by allowing private participation in space activity subject to the control of the "appropriate State" and imposing consequent international responsibility on the State for

[239] W. B. Wirin, "Practical Implications of Launching State – Appropriate State Definitions", (1994) 37 Proc. of Colloq. on the Law of Outer Sp. at 109.

[240] Isabella H. Ph. Rode-Verschoor, "The Responsibility of States for the Damage Caused by Launched Space-Bodies" (1958) 1 Proc. On Colloq. Law of Outer Sp. 103.

[241] While the U.S.A. urged for private participation in space ventures by arguing that outer space should be used as freely as the high seas and not limited to use by sovereign State actors, the Soviets asserted that only States should participate in space activity and that "to give private companies a free hand in outer space could lead to chaos and anarchy." U.N. Doc. A/AC.105/C.2/SR.28 (9 July 1963) at 13.

such activities.[242] It was later incorporated in Article VI of the 1967 Outer Space Treaty, which states:

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

On deconstructing this article, it is clear that the following obligations are imposed on States:[243]

(i) to bear responsibility for national activities in outer space regardless of whether such activities are carried out by public or private entities;
(ii) to assure that national activities are conducted in conformity with the Outer Space Treaty and, through Article III, with international law;

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[242] Carl Q. Christol, *The Modern International Law of Outer Space*, (New York: Pergamon Press, 1982) at 65.

[243] Ricky Lee, *Law and Regulation of Commercial Mining of Minerals in Outer Space*, (Springer, 2012) at 128.

(iii) to authorise and continually supervise, where appropriate, the activities of nongovernmental entities in outer space; and

(iv) to share international responsibility for the activities of international organisations of which the State is a participant.

The extent of obligation as far as damage to third parties is concerned is the international responsibility is the obligation to control; in particular to make sure that the obligations set by Article III (activities must be carried on according to international law, including the Charter of the United Nations as *lex generalis*) and Article VI (activities must be carried on according to the Outer Space Treaty as *lex specialis)* of the Outer Space Treaty are implemented.[244]

4.4. International Liability: Article VII, Outer Space Treaty and Liability Convention

In 1962, the United States proposed a set of substantive principles on liability during the first meeting of the Legal Sub-Committee of the UN COPUOS, which fostered agreement among all the participating States to include a provision relating to liability in the 1963 Principles Declaration. Thereafter, Principle 8 of the Declaration was reproduced in Article VII of the Outer Space Treaty:

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

[244] Armel Kerrest, "Liability for Damage Caused by Space Activities," note 98, at 107.

> the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies.

Following a decade of negotiations, the Liability Convention, which elaborates upon Article VII of the Outer Space Treaty, was adopted in 1972 by the General Assembly.

The regime governing international responsibility (or liability) for outer space has been regarded as "something of an exception amongst the various regimes on responsibility" since it is the only system which expressly imposes an absolute obligation of reparation, both on States and on international organisations, in the absence of any wrongful conduct.[245]

The applicability of the Convention is triggered by the occurrence of 'damage'[246] – "if there is no 'damage,' then there is no liability."[247] It has been observed that damage to property implies that "it has been rendered less suitable for those human purposes for which it was originally valued."[248] The jurisprudence espoused by the Trail Smelter arbitral tribunal in 1938 had held damage to be "the amount of reduction in the value of use or rental value of the land caused by fumigations."[249]

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[245] Mathias Forteau, "Space Law" in James Crawford, et al (eds.), *The Law of International Responsibility*, (Oxford University Press, 2010) at 903.

[246] For a detailed analysis of academic debate on the inclusion of indirect damage in the Liability Convention, see Hurwitz, *State Liability for Outer Space Activities,* note 111, at 15.

[247] Ibid., at 12.

[248] B. Schwartz & M.L. Berlin, "After the Fall: An Analysis of Canadian Legal Claims for Damage Caused by Cosmos 954" (1982) McGill L.J. 676 at 714.

[249] *Trail Smelter Arbitral Decision*, [1938], (1939) 33 A.J.I.L. 182-212

Commentators have observed that the specificity of this regime is underlined by the fact that it is strongly oriented in the favour of the victim.[250] This is evident from the definitions in Article I of the Liability Convention, which are "broad and attempt to place an injured party in the most favourable legal position."[251]

Article II of the Liability Convention imposes absolute liability on States for damage caused on the surface of the earth in the following language:

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

It envisages the damage suffered as almost the only foundation of responsibility and is sometimes regarded as a synonym of objective responsibility, which might correspond to responsibility for a wrongful act where 'fault' is not a component element.[252] Thus, in case of any injurious consequences on the surface of the earth arising from space debris remediation activities, it is indisputable that absolute liability will be invoked.

Article III of the Convention, on the other hand, relates to liability incurred for damage caused in outer space by a space object on the basis of fault. It states:

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[250] E.R.C. van Bogaert, *Aspects of Space Law* (Deventer: Kluwer, 1986) at 162-163; C.E.S. Horsford, "Legal Liability in Outer Space – The New Treaty" (1972) 2 Int'l Rel. 137 at 137 & 141; S.M. Williams, "The Role of Equity in the Law of Outer Space" (1975) 5 Int'l Rel. 776 at 777-778; L. Condorelli, 'La reparation des dommages catastrophiques causes par les activités spatiales,' in *La reparation des dommages catastrophiques. Les risques technologiques en droit international et en droit communautaire* (Brussels Bruylant, 1990) at 262 & 265.

[251] W.H. Schwarzchild, "Space Law – Convention on Liability – Procedure Established to Enforce Liability for Damage Caused by Space Objects" (1972) Vand. J. Trans. L. 262 at 164.

[252] Jean-Marc Sorel, "The Concept of 'Soft responsibility'," in James Crawford, et al (eds.), *The Law of International Responsibility* (Oxford University Press, 2010) at 166.

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

4.4.1. Fault liability

The regime of fault liability, as provided by Article III of the Liability Convention, requires "the victim of the presumed wrongful act…[to] prove the fault of the offending State."[253] In contrast to that, the regime of objective responsibility enshrined in Article II invokes responsibility as a sole consequence of conduct contrary to an international obligation but it also permits the State to invoke defences available under international law to absolve from the responsibility.[254] Fault responsibility must be distinguished from causal responsibility, which could be a form of objective responsibility, in which the obligation to compensate arises only from the causal link between the action and the damage.[255]

Fault has often been defined as "the particular subjective and psychological attitude of the actor, which consists in either having wilfully determined the effect produced by its behaviour (malice or *dolus*) or in having failed to take the measures necessary to avoid the injurious event (fault in a strict sense or *culpa*)…a subjective-psychological concept – an

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[253] Ibid.

[254] Ian Brownlie, *The Rule of Law in International Affairs: International Law at the Fiftieth Anniversary of the United Nations* (Martinus Nijhoff, 1998) at 84-85.

[255] J. Barboza, "La responsabilité "causale" á la Commission du Droit International" (1998) 44 AFDI 513.

attitude of the will, a psychological relationship which exists between the specific injury to the right of another and the material author of such injury."[256]

This raises the question that in case of a misdirected remediation activity in outer space causing damage to a functional space object, whether State responsibility is contingent upon "the existence of fault giving rise to a unitary regime of fault responsibility or, upon the sole existence of conduct attributable to the State and contrary to an international obligation which establishes a unitary regime of objective responsibility."[257] The rationale behind establishment of a legal regime governed by "conditional fault" is explained in the backdrop of the ultra-hazardous nature of the activity or venture, whereby a risk for others has already been created for which the State will be held accountable in the event of its conduct causing harm to others. Hence, the idea of conditional fault has been described as a legal fiction, which imputes a contingent blameworthiness (or fault) on the part of the risk-creating enterprise for engaging in inherently dangerous activities.[258]

In international law, the concept of subjective fault can be traced as far back as Grotius and his followers.[259] While Anzilotti's comprehensive theory of objective responsibility[260]

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[256] Riccardo Pisillo-Mazzaschi, 'The Due Diligence Rule and the Nature of the International Responsibility of States', (1992) 35 German Yearbook of International Law 9 at 9 & 11.

[257] Ibid., at 9.

[258] Goldie, "Concepts of Strict and Absolute Liability," note 236 at 189.

[259] The theory of State's complicity in the wrongful acts of individuals based on the notions of *patientia* and *receptus*. Hugo Grotius, De Jure Belli ac Pacis Libri tres, Lausannae MDCCLXII, III, C.XVII, XX, I.

[260] Dionisio Anzilotti, Teoria generale della responsabilitá dello Stato nel diritto internazionale, Parte I, *Il problema della responsabilitá di diritto internazionale*, (Firenze, 1902) at 102-187; Dionisio Anzilotti, "La responsabilité international des états á raison des dommages soufferts par des éstrangers" (1906) XIII Revue Générale de Droit International Public 291 (now published in SIOI, Opere di D. Anzilotti, II, 1 at 149); Dionisio Anzilotti, *Corso di diritto internazionale*, I, (Padova, 1955) at 384-433. The theory has been described as "the concept of a State's due diligence in preventing certain acts of private persons does not represent a particular subjective element of responsibility, but rather the very content of the international duty. In such cases, the concept of fault is only an "easy analogy" in order to synthetically express the content of a special State duty to prevent a given event." Pisillo-Mazzaschi, 'The Due Diligence Rule', note 256, at 15.

is said to have "assassinated" fault in international law,[261] Judge Lauterpacht and Hostie maintain that the 1949 Corfu Channel decision revived fault in the law of State responsibility.[262] Ago examined international practice to develop the modern concept of the theory of psychological fault which postulates psychological fault as an essential requirement for every internationally wrongful act.[263] Scholarly consensus in favour of the theory of psychological fault is in agreement with the arguments put forth by Ago.[264] In the traditional doctrine, fault was perceived as a requirement for responsibility found in the psychological attitude of the State organ, thus making it an aspect of attribution.[265]

In certain cases, this incongruity in the concept of fault in different legal systems may not pose much difficulty, as the factual scenario of the 'damage' in question might be *res ipsa loquitur*. For example, a satellite operator is aware of an impending collision with space debris through conjunction analysis but fails to perform a collision avoidance manoeuvre. It has been suggested that based on "optimal deterrence – the minimisation of the sum of accident costs and accident prevention costs," liability ought to be assessed

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[261] P.M. Dupuy, "Faute de l'état et "fait internationalement illicite"" (1987) 5 Droits 51.

[262] H. Lauterpacht, *Oppenheim's International Law*, vol. I (London: Longmans, Green & Co., 1955) at 343 (para.154); J. Hostie, "The Corfu Channel Case and International Liability of States" in *Liber Amicorum Algot Bagge* (Stockholm: Norstedt, 1956) at 93

[263] Roberto Ago, "Le délit international" (1939) 68 Recueil des Cours, at 450-498. For Roberto Ago, fault in the sense of a psychological attitude is a necessary condition for imputing a breach to a State.

[264] Alf Ross, *A Textbook of International Law* (General Part, 1947) at 241; Edoardo Vitta, *La responsabilitá internazionale dello Stato per atti legislative* (Milano, 1953) at 41; Georg Dahm, *Volkerrecht* (Stuttgart, 1958-1961) III, at 224; Giorgio Balladore Pallieri, *Diritto iternazionale púbblico*, (Milano, 1962) at 246, 247, 351-352; Alfred von Verdoss, *Volkerrecht*, (Wien, 1964) at 376; Gaetano Morelli, *Nozioni di diritto internazionale* (Padova, 1967) at 344-347. But, also see Gabriele Salvioli, "Les régles generals de la paix" (1933) 46 Recueil des Cours at 96; Hildebrando Accioly, "Principes généraux de la responsabilité international d'aprés la doctrine et la jurisprudence" (1959) 96 Recueil des Cours at 369-370; Bin Cheng, *General Principles of Law As Applied by International Courts and Tribunals* (London, 1953) at 163, quoted in Pisillo-Mazzaschi, 'The Due Diligence Rule', note 256, at 12.

[265] Sarah Heathcote, "State Omissions and Due Diligence: Aspects of fault, damage and contribution to injury in the law of state responsibility" in Karine Bannelier, et al (eds.), *The ICJ and the Evolution of International Law: The Enduring Impact of the Corfu Channel Case*, (Routledge, 2012) at 302.

against the party who is best able to choose between allowing an accident to happen and prevention.[266] The circumstances clearly demonstrate that, the satellite operator was at "fault" by failing to take necessary action to avert the impending collision despite having prior knowledge about it.

4.5. Due diligence

The primary criticism against the Liability Convention is that it "does not contain any standard of care which must be observed to avoid the imposition of liability."[267] In order to attribute State responsibility for acts of private persons, the fault element is necessary in relation to which the lack of diligence takes a decisive role.[268] Higgins notes that the duty of care upon States to prevent injury as stipulated in the Trail Smelter arbitral decision has long required States to take care with respect to private activities.[269] The standard of due diligence has thus been "coupled with state omission to penetrate the private sphere of non-responsibility under international law."[270]

The 1978 report of the Working Group to the International Law Commission had observed that an undesirable outcome of the technological revolution were the "injurious consequences" arising outside the national jurisdiction of the State, and the related

[266] G. Calabresi, "Optimal Deterrence and Accidents" (1975) 84 Yale L.J. 656 at 671, quoted in L.F.E. Goldie, "Concepts of Strict and Absolute Liability," note 236, at 184.

[267] P. Sterns & L.I. Tennen, "Obligations of States in the *Corpus Juris Spatialis*: Fathoming Unchartered Waters" (1983) 26 Proc. Colloq. L. Outer Sp. 169 at 173.

[268] Pisillo-Mazzaschi, "The Due Diligence Rule," note 256, at 11. Article 8 of the 1988 Convention on the Regulation of Antarctic Mineral Resource Activities also supports liability without proof of fault.

[269] R. Higgins, *Problems and Process: International Law and How We Use It* (1994) at 17.

[270] Chinkin, "A Critique of the Public/Private Dimension," note 231, at 476.

question of liability resulting from non-prohibited acts.[271] With a view towards balancing the conflicting State interests,[272] the Working Group noted that "the essential obligation owed by a State in such a context has tended to be conceived as one of moderation, or of care or due diligence, in relation to its own activities or of private activities within its jurisdiction or control."[273] It was emphasised in the Special Rapporteur's report that "treaty regimes of a universal character, dealing with acts not prohibited by international law, had been established in relation to," among other issues, the regulation of "space objects."[274]

The notion of due diligence gained prominence in international law through Article 6 (Washington Rules) of the Treaty of Washington (1871) which settled the Alabama claims between the United States of America and United Kingdom after the American Civil War.[275] In an attempt to improve the formulation of the Washington Rules, Article

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[271] ILC Yearbook 1978, vol. II, part two, at 150-151 (Para. 13). The technological revolution was characterized with the capability of "dramatically [extending] man's power to control his environment, creating a corresponding need for the urgent development of legal norms." Ibid., at 150 (Para 10).

[272] "On the one hand there is the benefit to be obtained by the State conducting the activity, but on the other hand there is the injury inflicted on the foreign State as a result of the conducting of that same activity." Hurwitz, *State Liability for Outer Space Activities*, note 111, at 147.

[273] ILC Yearbook 1978, vol. II, part two, at 151 (Para 19)

[274] Preliminary report on international liability for injurious consequences arising out of acts not prohibited by international law. Doc A/AC.4/344 and Add. 1 and 2. Reprinted in ILC Yearbook 1980, Vol. II, part one (Para 4). The law of outer space was included within the category of "recent materials that are, or may be, relevant to the development of a new topic." ILC Yearbook 1978, vol. II, part two, at 150 (Para. 12) Also, see Setsuko Aoki, "The Standard of Due Diligence in Operating a Spacecraft" (2012) 55 Proc. of Colloq. on L. of Outer Sp.

[275] Horst Blomeyer-Barntenstein, "Due Diligence" in R. Bernhardt (ed.), *Encyclopedia of Public International Law*, Vol. 1 (Amsterdam: Elsevier, 1992) at 1110. "[During the arbitration proceedings in Geneva,] the British position urged restrictive interpretation of due diligence; lack of due diligence meant "a failure to use, for the prevention of an act which the government was bound to endeavour to prevent, such care as governments ordinarily employ in their domestic concerns, and may reasonably be expected to exert in matters of international interest and obligation." The view of the United States was that a neutral State owed an "active diligence," commensurate with the emergency or with the magnitude of the results of negligence. It seemed "inconceivable that the belligerents were required to submit without redress to the injuries resulting from neutral negligence." The Arbitral Award of 14 September 1872 favoured the definition of due diligence advanced by the United States." Ibid., at 1111.

8 of the XIIIth Hague Convention of 18 October 1907[276] emphasised on the instrumentalities available to governments rather than the efficiency and care with which they were used by replacing 'due diligence' with the phrase "employ the means at its disposal."

Drawing from State practice and abundant case material,[277] the Institut de Droit International defined due diligence as "the measures to which under the circumstances, it was proper normally to resort in order to prevent or check such actions."[278] Two years later, the Harvard Law School's 1929 draft, based on the interpretation of 'due diligence' as a standard and not a definition, described the concept as "jurisdiction to take measures of prevention as well as opportunity for the State to act, consequent upon knowledge of impending injury or circumstances which would justify an expectation of a probably injury." It also relied on due diligence to define the international responsibility of the State: "A State is responsible if an injury to an alien results from its failure to exercise due diligence to prevent the injury, if local remedies have been exhausted without adequate redress for such failure."[279]

The Environment Committee of the Organisation for Economic Co-operation and Development (OECD) has also observed that there is a "custom based rule of due

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[276] (1908) 2 AJIL, Supp. 202

[277] Digest of decisions of international tribunals relating to State responsibility, UN Doc. A/CN.4/169 and A/CN.4/208, ILC Yearbook, Vol. II (1964) at 132; ILC Yearbook, Vol. II (1969) at 101.

[278] Manley O. Hudson, "The Development of International Law Since the War" (1928) 22 A.J.I.L. 330; original in French in Resolutions Votees Par L'Institut Au Cours de sa XXXI V Session (1927) 33 Ann.I.D.I. 331.

[279] Harvard Law School, Research in International Law, Vol. II, Responsibility of States (1929) at 228, quoted in Blomeyer-Barntenstein, "Due Diligence" at 1112.

diligence imposed on all states in order that activities carried out within their jurisdiction do not cause damage to the environment of other states."[280]

Following the decision to limit the scope of the discourse of the ILC codification only to secondary rules of international responsibility, due diligence was later excluded from its purview in 1963 because Anzilotti's position was accepted that due diligence was a primary rule or an element of obligation. However, it does find mention in Special Rapporteur Baxter's first report on international liability for injurious consequences arising out of acts not prohibited by international law in 1980, where he states:

> "Depending upon the circumstances, the standard of reasonable care or due diligence may well require a standard more exacting than its own as part of a special regime of protection that includes guarantees of redress for the potential victims of any hazard that cannot be wholly eliminated."[281]

He goes on to clarify the controversy regarding the absence of a standard of care in space law with the following remarks:

> "[T]he regime of absolute liability provided in the [Liability Convention] may be regarded not only as an applicable conventional rule, but also as

[280] OECD, Report by the Environment Committee, "Responsibility and Liability of States in Relation to Transfrontier Pollution" (1984) at 4.

[281] Preliminary report on international liability for injurious consequences arising out of acts not prohibited by international law, by Mr. Robert Q. Quentin-Baxter, Special Rapporteur, A/CN.4/334 and Add.1 & Corr.1 and Add.2, reproduced in *ILC Yearbook* (1980) Vol. II (1) at 252.

> evidence of the standard of care which the authors of the Convention believed to be reasonable in relation to that particular activity."[282]

In the opinion of Condorelli, negligence[283] is harder to prove when the State is exercising control over an activity but not a location, for instance, over activities in outer space; both because there is no territory to serve as an initial indicator of potential responsibility, but also because it is harder to show that the State had the means at its disposal to prevent the injury.[284] This raises the question of identifying due diligence as an obligation of conduct or an obligation of result. It has been confirmed by the ICJ in the 2007 *Genocide*[285] and 2010 *Pulp Mills*[286] cases, that a due diligence obligation is an obligation of conduct, rather than result; meaning that it is "an obligation on States to deploy their best efforts to achieve a desired outcome (which might be to prevent a given event), even if that outcome need not be ensured."[287]

In order to discharge this obligation (of conduct), a State must exercise due diligence.[288] While there has been extensive academic debate on the standard of care applicable to a

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[282] Ibid.

[283] Phillippe Sands, *Principles of International Environmental Law,* 2nd ed., (Cambridge University Press: New York, 2003) at 881. Sands characterises 'fault' based on intention or negligence.

[284] L. Condorelli, "L'imputation à l'état d'un fait internationalement illicite: Solutionss classiques et nouvelle tendances" (1984) IV Recueil des Cours 189 at 112-114, quoted in Heathcote, "State Omissions and Due Diligence," note 265, at 300-301.

[285] Application of the Convention on the Prevention and Punishment of the Crime of Genocide (Bosnia and Herzegovina v. Serbia and Montenegro), Judgement, ICJ Reports 2007, para. 430

[286] Case Concerning Pulp Mills on the River Uruguay (Argentina v. Uruguay), Judgement, ICJ Reports 2010, para. 187

[287] Heathcote, "State Omissions and Due Diligence," note 265, at 307-308.

[288] International Law Commission, Draft articles on Prevention of Transboundary Harm from Hazardous Activities, with commentaries, Art. 3, para. 7, (2001) online: UN http://untreaty.un.org/ilc/texts/instruments/english/commentaries/9_7_2001.pdf; Timo Koivurova, "Due Diligence" in Max Planck Encyclopedia of Public International Law (2009), online: www.mpepil.com.

given situation, there is "probably no single basis of international responsibility, applicable in all circumstances, but rather several, the nature of which depends on the particular obligation in question."[289] This issue also finds expression in the ILC Special Rapporteur Garcia Amador's report on acts of individuals and internal disturbances, where he wrote:

> "The learned authorities are in almost unanimous agreement that the rule of 'due diligence' cannot be reduced to a clear and accurate definition which might serve as an objective and automatic standard for deciding, regardless of the circumstances, whether a State was 'diligent' in discharging its duty of vigilance and protection. … In effect, therefore, the rule of 'due diligence' is the expression *par excellence* of the so-called theory of fault (*culpa*)… Accordingly, though the rule is vague and consequently, of only relative value in practice, there is no choice – so long as some better formula is not devised in its stead – but to continue to apply the rule of 'due diligence' in these cases of responsibility."[290]

Hence, it is evident that the required standard of care or due diligence depends on the specific context as is appropriate and proportionate to the degree of risk.[291]

The international legal principle of due regard, articulated in varying forms under the existing international space law treaties, impose an international obligation upon space-

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[289] Oppenheim, *Oppenheim's International Law,* vol. I, (Oxford University Press, 2008) at 509, quoted in Sands, *Principles of International Environmental Law,* note at 881. This was reiterated in the 1929 Harvard Law School draft which stated, "The diligence required may vary with the private or public character of the alien and the circumstances of the case." Harvard Law School, Research in International Law, note , at 228.

[290] 1957 ILC Yearbook, Vol. II at 122

[291] International Law Commission, Draft articles on Prevention of Transboundary Harm from Hazardous Activities, note 288, Art. 3, paras. 11, 17; Timo Koivurova, "Due Diligence," note 288, para 16.

faring nations to take appropriate measures to prevent harm to other States and areas beyond their national jurisdiction and control, or at least minimise the risk thereof, when conducting activities in outer space. Article IX of the Outer Space Treaty imposes a duty on States Parties to exercise "due regard to the corresponding interests of all other States Parties" with respect to the conduct of activities in outer space and to avoid "harmful contamination" of outer space. Though they are not legally binding, the UN COPUOS Guidelines may serve as a point of reference when having to determine whether a particular State has discharged its obligations to exercise due diligence.[292] In extreme cases, a breach of a non-binding instrument might even constitute evidence of a breach of due diligence and related obligations, and could thus have legal consequences.[293] Pursuant to Article III of the Outer Space Treaty, this standard of care is also resonated under general international environmental law as codified by the draft articles adopted by the International Law Commission in 2001 on the "Prevention of Transboundary Harm from Hazardous Activities."

Failure to comply with obligations of due diligence often amount to wrongful omissions in international law, as is illustrated by the ICJ decision in *Corfu Channel* where the Court held that Albania had failed to warn the British warships of the existence of a minefield: "nothing was attempted by the Albanian authorities to prevent the disaster. These grave omissions involve the international responsibility of Albania."[294]

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[292] Stephan Hobe & Jan Helge Mey, "UN Space Debris Mitigation Guidelines" (2009) 58 ZLW 388 at 399-400.

[293] Alexandre Kiss & Dinah Shelton, *International Environmental Law*, 2nd ed., (Transnational Publishers, Inc.: Ardsley, New York, 2000) at 52 quoted in Lotta Viikari, *The Environmental Element in Space Law: Assessing the Present and Charting the Future* (2008) at 245.

[294] *Corfu Channel, Merits* [1949] ICJ Rep 4 at 23.

In light of the above discussion, it is clear that States are under an international obligation to exercise due diligence with respect to activities in outer space, in general and space debris remediation, in particular and the 'standard of care' involved in such a situation will depend on the circumstances as is pertinent and commensurate to the extent of risk.

4.6. Necessity as a Circumstance Precluding the Wrongfulness of an Act

"Necessity does not give any right, but may provide a good excuse." [295]

This section will attempt to establish that when an essential interest of a State in the form of space assets or tangible benefits derived from space-based applications is threatened by a space object, then the State can invoke the 'state of necessity' to justify its remediation activities unauthorised by the State of registry of the space object in question.

Necessity or the 'state of necessity' is a defence which refers to situations where the sole means by which a State can protect an essential interest of the State, or perhaps, of the international community as a whole, that is being threatened by a grave and imminent peril is temporarily not to fulfil an international obligation protecting an interest of lesser value.[296]

[295] G. Schwarzenberger, "The fundamental principles of international law" (1955) 30 Recueil des cours de l'Académie de droit international de la Haye, (Leyden, Sijthoff, 1956), at 343.

[296] ILC Articles on State Responsibility, Art. 25.

Necessity has been enumerated as a circumstance precluding the wrongfulness of an act in international law by the ILC in its Articles on State Responsibility. Before proceeding further into a detailed analysis of this doctrine, it is important to bear in mind that:

> [T]he 'circumstances precluding wrongfulness' … must not be confused with other circumstances which might have the effect not of precluding the wrongfulness of the act of the State but of attenuating or aggravating the responsibility entailed by the act. When, in a specific case, circumstances of this type are involved, the existence of the wrongfulness of the act of the State is in no way called into question.[297]

The doctrine of necessity attracts controversy because its application varies "greatly in colour and content according to the circumstances and the time in which it is used."[298] Hence, throughout history, it has not been immune to abuse. Viewed as a simple authoritative phenomenon of an ethical or political nature in the past, States have justified the wrongfulness of their actions by resorting to necessity for achieving power-political ends in disregard of the principle of sovereign equality of States.[299] Necessity was thus invoked to justify the annexations of Krakow by Austria in 1846; of Rome by Italy in 1870; of Bosnia-Herzegovina by Austria-Hungary in 1908; of Ethiopia by Italy in 1936; as well as the occupation of Belgium and Luxembourg in 1914 by Germany; of Korea by Japan during the Russian-Japanese war; of Denmark, Norway, the Netherlands, Belgium, and Luxembourg by Germany; and of Yugoslavia and Greece by Italy, during

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[297] ILC Yearbook (1979) vol. II part 2, quoted in S. P. Jagota, "State responsibility: Circumstances Precluding Wrongfulness" (1985) XVI NYIL 249

[298] Towne v. Eisner, (1918) 245 U.S. 418 at 425.

[299] Sarah Heathcote, "Necessity" in James Crawford, et al (eds.), *The Law of International Responsibility*, (Oxford University Press, 2010) at 492.

the Second World War.[300] However, it is important to bear in mind that the abuse of a rule does not take away its uses – *abusus non tollit usus*.[301]

The foundations of the rule of necessity are somewhat murky. There are two schools of thought[302] – one led by Grotius[303] who favoured the classical version of existential necessity based on Roman law which was later interpreted by the naturalists as a subjective right; and the other derived from the writings of Hegel who relied on the maxim 'necessity knows no law,'[304] *necessitas non habet legem*[305] to substantiate their position. The positivists led by Anzilotti[306] argued in favour of the doctrine.[307] Necessity has also been perceived as an expression of equity to avoid an overly rigid application of the law in the form of the maxim *summum jus, summa injuria*.[308] Modern jurists have chosen to adopt a utilitarian approach by emphasising on a nexus between the defence of necessity and the principle of proportionality. Drawing from this discourse, the ILC,

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[300] J. Salmon, "Faut-il codifier l'état de nécessité en droit international" in J. Makarczyk (ed.), *Essays in International Law in Honour of Judge Manfred Lachs* (The Hague: Martinus Nijhoff, 1984) at 241-243, quoted in ibid.

[301] Glanville Williams, "The Defence of Necessity" (1953) 6 Current Legal Problems 216 at 225.

[302] For a summary of the various author's views, see Sarah Heathcote, *State of Necessity and International Law*, Thesis, (Université de Genève, 2005) at 308-355.

[303] Hugo Grotius, *The Rights Of War And Peace* (Richard Tuck ed., 2005) (1625) at 434.

[304] '*Nécessité n'a point de loi'* or *'Not kennt kein Gebot'* This was stated by the German chancellor in 1914, when the Reich violated Belgian and Luxembourgian neutrality at the outbreak of the First World War

[305] Oliver Cromwell, "Speech to the First Protectorate Parliament (Sept. 12, 1654)" in Thomas Carlyle, *Oliver Cromwell's Letters and Speeches: With Elucidations* (1845) at 301.

[306] D. Anzilotti, 'La responsabilité international des États à raison des dommages soufferts par des éstrangers' (1909) RGDIP 285 at 304.

[307] In his individual opinion in the *Oscar Chinn* Case, Judge Anzilotti had opined: "Necessity may excuse the non-observance of international obligations…The plea of necessity,…by definition, implies the impossibility of proceeding by any other method than the one contrary to law." PCIJ: A/B.63, at 113-114.

[308] Roberto Ago, Addendum to the Eighth Report on State responsibility, ILC Yearbook 1980, Vol. II(1) at 13, 51; ILC Yearbook 1980, Vol. II(2) at 49-50.

with due regard to the binding nature of international law, has claimed the defence of necessity as a strict exception that can temporarily preclude the non-fulfilment of international obligations under certain defined circumstances.[309]

There is extensive academic debate whether the state of necessity codified in Article 25 represents an international custom, or would it be characterised as "progressive development."[310] Some authors are of the opinion that it is "difficult to say which article partakes more of one or the other"[311] because the Articles on State Responsibility blend codification and progressive development.

One commentator, disagreeing with the customary status of the Articles on State Responsibility, has ascribed the veneer of authority that the Articles tend to enjoy to "a combination of the general esteem in which the ILC is held, the succession of eminent special rapporteurs on state responsibility, and the sheer amount of time that preceded the Articles on State Responsibility's publication (nearly half a century)" and described the treatment received by the Articles on State Responsibility as reflective of "an uncontroversial international custom or a widely ratified multilateral treaty" from international tribunals as "misguided."[312]

In the civil law countries, the *jus necessitates* is a creation of the courts (*l'état de necessité*) in France, while in Germany (*Notstand*), Switzerland and Italy (*lo stato di necessitá*), it has been

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[309] Heathcote, "Necessity," note 299, at 492.

[310] UN Charter, Article 13 (1); G.A. Res. 174(II)(21 November 1947) at 105; Donald McRae, "The Work of the International Law Commission, 2007-2011: Progress and Prospects" (2012) 106 AJIL 322 at 324-31.

[311] David D. Caron, "The ILC Articles on State Responsibility: The Paradoxical relationship Between Form and Authority" (2002) 96 AJIL 857.

[312] Robert D. Sloane, "On the Use and Abuse of Necessity in the Law of State Responsibility" (2012) 106 Am. J. Int'l L. 447 at 452.

sanctioned by the written law.[313] One of the earliest judicial decisions relying on the doctrine of necessity was given in *The Neptune*[314] in 1797 where it stated: "The necessity which can be admitted to supersede all laws and to dissolve the distinctions of property and right must be absolute and irresistible, and we cannot, until all other means of self-preservation shall have been exhausted, justify by the plea of necessity the seizure and application to our own use of that which belongs to others."[315]

Following diplomatic exchanges in the Caroline incident of 1837, it was agreed by the British and the Americans that "legitimate necessity…is instant, overwhelming and leaving no choice of means, and no moment of deliberation."[316] In the Russian Fur Seals incident in 1893, Russia had invoked necessity to justify a precautionary measure taken to protect the natural environment in a region that was not regulated by international law or subject to the domestic jurisdiction of any State.[317] The 1967 Torrey Canyon incident,[318] a Liberian oil tanker spilling oil outside British territorial waters was bombed by the British

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313 Bin Cheng, *General Principles of Law as Applied by Internationals Courts and Tribunals*, (New York: Cambridge University Press, 2006) at 69.

314 The Neptune, reproduced in A. de Lapradelle & A. Politis, *Recueil des arbitrages internationaux* (Paris: Editions Internationales, 1955), Vol. I at 139.

315 4 Int. Adj., M.S. p. 433, quoted in Bin Cheng, *General Principles of Law*, at 70.

316 29 British and Foreign State Papers 1129, quoted in ILC Articles on State Responsibility, Commentary to Art. 25, at 196.

317 86 British and Foreign State Papers at 220; *Chasse aux phoques au large de la côte russe* (1893) in H. La Fontaine, *Pasicrisie Internationale, 1794-1900* (The Hague: Martinus Nijhoff, 1997) at 426; 1 IELR 43, quoted in Heathcote, "Necessity," note 299, at 493.

318 Official report of the Liberian Board of Investigation (1967) 6 I.L.M. 480; also see E.D. Brown, "The Lessons of the Torrey Canyon – International Law Aspects" (1968) 21 Current Legal Problems 113; V.P. Nanda, "The Torrey Canyon Disaster: Some Legal Aspects" (1967) 44 Denver Law Journal 400; A. Utton, "Protective Measures and the Torrey Canyon" (1967) 9 Boston College Industrial and Commercial Law Review 613; G.W. Keeton, "The Lessons of the Torrey Canyon: English Law Aspects" (1968) 21 Current Legal problems 94.

to avoid oil pollution along the English coastline.[319] This unilateral action by the British did not draw any international censure from other States. The characterisation of the Torrey Canyon incident by the ILC in its 1980 report reflects its elevation of environmental concerns and a liberalisation of the grounds supporting the defence of necessity.[320]

Judicial decisions pronounced by the international court, and international tribunals in Russian Indemnity,[321] Gabcikovo-Nagyamaros Project,[322] the M.V. Saiga,[323] the Advisory Opinion on the Legal Consequences of the Construction of a Wall in the Occupied Palestinian Territory,[324] and the decision of an ICSDI tribunal in C.M.S. Gas Transmission v. Argentina[325] have upheld the validity of necessity as a defence in international law. While cautioning about its exceptional acceptability, the ICJ has declared that necessity is "a ground recognised by customary international law for

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[319] The "Torrey Canyon," Cmnd. 3246 (London, Her Majesty's Stationery Office, 1967). For a French decision on a similar set of facts, see the 1987 *Nachfolger* judgement, Société Nachfolger Navigation Co. Ltd. (1988) 104 Revue de droit international public et de la science politique 851.

[320] (1980) 2 *ILC Yearbook*, quoted in Robert H. Stansfield, "The Torrey Canyon" in R. Bernhardt, Encyclopedia of Public International Law, Vol. I (North-Holland, Elsevier, 1992) at 867.

[321] Russian Indemnity (Russia/Turkey), 11 November 1912, 12 RIAA 44.

[322] Gabcikovo-Nagyamaros Project (Hungary/Slovakia) (1997) I.C.J. Reports at 7.

[323] M.V. Saiga (No. 2), (Saint Vincent and the Grenadines v. Guinea), ITLOS 1999, (1999) 38 ILM 1323.

[324] Legal Consequences of the Construction of a Wall in the Occupied Palestinian Territory, Advisory Opinion, (2004) ICJ Reports at 136.

[325] CMS Gas Transmission Company v. Argentine Republic (ICSID Case No. ARB/01/8), Award 12 May 2005, 14 ICSID Reports 152. Also, see Sempra Energy Int'l v. Argentine Republic, ICSID Case No. ARB/02/16, Award, para 344 (28 September 2007); Jürgen Kurtz, "Adjudging the Exceptional at International Investment Law: Security, Public Order and Financial Crisis" (2010) 59 Int'l & Comp. L. Q. 325 at 334-35.

precluding the wrongfulness of an act not in conformity with an international obligation."[326]

Although it had been admitted by Special Rapporteur Ago that it is a "dubious undertaking" to ascertain if the principle of necessity can be transferred from national levels to inter-State relations,[327] the above examination evinces the increasing acceptance of the defence of necessity by international courts and tribunals, confirming its normativity threshold as a rule of customary international law constituted by State practice[328] and *opinio juris*.

As opposed to other defences available in the Articles on State Responsibility such as *force majeure* where the fulfilment of the obligation is completely impossible, there exists a choice of action in the case of necessity where the impossibility of fulfilling the obligation is relative. The defence of necessity involves "a choice of the lesser evil…a judgement of value, an adjudication between competing 'goods' and a sacrifice of one to the other."[329] This choice of action or exercise of will is reflected in the words of Hobbes: "There is nothing there involuntary, but the hardness of the choice."[330] As observed by Verdross:

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[326] Gabcˇı´kovo-Nagymaros Project, (1997) I.C.J. Reports 7, para. 51

[327] Roberto Ago, Addendum to the Eighth Report on State Responsibility, ILC Yearbook 1980, Vol. II(1) at 18-19 (para 11).

[328] For detailed analysis of recorded state practice in the nineteenth-century evincing the classical conception of necessity – the 1829 Chinchester affair, the 1832 Anglo-Portuguese dispute and The Caroline incident, see Sloane, "On the Use and Abuse of Necessity, note 312, at 456-457.

[329] Williams, "The Defence of Necessity," note 301, at 224.

[330] Hobbes, *Elements of Law* (1650) at 12.

> "The state of necessity... is characterised by the fact that a State, finding itself torn between protection of its vital interests and respect for the right of another, violates the right of an innocent State in order to save itself."[331]

In order to emphasise the truly restrictive character of this plea, the ILC relied on a drafting technique of using the language in a negative manner to define necessity so as to ensure that it can be invoked under strictly defined conditions that have been cumulatively satisfied.[332] In doing so, it set out the following:

1. Necessity may not be invoked by a State as a ground for precluding the wrongfulness of an act not in conformity with an international obligation of that State unless the act:

    (a) Is the only way for the State to safeguard an essential interest against a grave and imminent peril; and
    (b) Does not seriously impair an essential interest of the State or States towards which the obligation exists, or of the international community as a whole.

2. In any case, necessity may not be invoked by a State as a ground for precluding wrongfulness if:

    (a) The international obligation in question excludes the possibility of invoking necessity; or
    (b) The State has contributed to the situation of necessity.

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[331] A. Verdross, "Régles genérales du droit international de la paix", (1929) 30 Recueil des cours de l'Académie de droit international de la Haye, (Paris: Hachette, 1931), at 488-489.

[332] ILC Report 1980 32nd session, p. 35, para 3. Also, see Gabcikovo-Nagyamaros Project, (1997) ICJ Rep, para 50-51; Sloane, "On the Use and Abuse of Necessity, note 312, at 505.

The first condition laid down in Article 25(1)(a) states that necessity can be invoked to safeguard an essential interest from a grave and imminent peril. The subjective character of the notion of an "essential interest" has raised doubts,[333] and has been qualified as an "open-textured phrase that may lend itself to a more capacious and protean standard in practice."[334] In 1980, Italy suggested that a State should not be allowed to claim a defence of necessity for the protection of its political system or its territorial or military interests.[335] The "essential interest" to be protected might be an individual interest of a State or a collective interest belonging to a plurality of States or even to the international community as whole.[336]

Commenting upon the need to re-evaluate the doctrine of necessity in an attempt to facilitate and incentivise a more transparent appraisal of the competing interests, policies, and values that will virtually always be at stake, Sloan stated:

> "The lodestar of the inquiry should not be the once paramount axiom of the law of nations that States enjoy a natural right to preserve their very existence. In contemporary international law, the plea of necessity instead requires a contextual inquiry into, and candid consideration of, the unavoidable trade-offs among the often incommensurable interests, policies, and values embedded in international law; and the lodestar of the inquiry today should be the reorientation of international law after World

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[333] A/CN.4/351/Add.2 (7 April 1982) at 2.

[334] Sloane, "On the Use and Abuse of Necessity, note 312, at 457.

[335] 5 Italian Yearbook of International Law (1980-1981) 286, quoted in Heathcote, "Necessity," note 299, at 496.

[336] ILC Articles on State Responsibility, Commentary to article 25, para 15.

War II toward promoting human dignity and welfare—perhaps through States, but not for States (qua States)."[337]

The second part of the first condition in Article 25(1)(a) requires the presence of a "grave and imminent peril" threatening the "essential interest." Thus, the main purpose of invoking necessity is preventative. It serves to deal with crisis scenarios which need to be averted in order to escape "grave and imminent peril." The ILC Commentary to Article 25 indicates that the peril has to be "objectively established and not merely apprehended" as well as "imminent in the sense of proximate."[338] The ICJ has further clarified it to include "peril appearing in the long term" and "certain and inevitable."[339]

The Commentary to article 25 notes that a plea of necessity is excluded "if there are other (otherwise lawful) means available, even if they maybe more costly or less convenient" thus making "the course of action taken to be the "only way" available to safeguard the interest."[340] It is significant to note that for the purpose of assessing the peril for a successful plea of necessity, the ILC Commentary indicates that "a measure of uncertainty about the future does not necessarily disqualify a State from invoking necessity, if the peril is clearly established on the basis of the evidence reasonably available at the time."[341] Moreover, both the ILC Commentary[342] and Special Rapporteur

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[337] Sloane, "On the Use and Abuse of Necessity, note 312, at 451.

[338] ILC Articles on State Responsibility, Commentary to article 25, para 15.

[339] Gabcikovo-Nagyamaros Project (Hungary v. Slovakia) [1997] ICJ Rep 7, at 42, para 54.

[340] ILC Articles on State Responsibility, Commentary to article 25, para 15.

[341] ILC Articles on State Responsibility, Commentary to article 25, para 16.

[342] Ibid.

Crawford's Third Report[343] note that although there may be a measure of scientific uncertainty or divergence of opinion among informed experts in assessing whether there is a peril, whether it is grave and imminent and whether the act proposed is the only one available in the circumstances, it need not preclude necessity.

The second paragraph of Article 25 lays down the conditions that restrict the invocation of a plea of necessity. According to article 25(2)(a), the defence cannot be invoked when the international obligation in question implicitly or explicitly excludes the possibility of invoking necessity. Article 25(2)(b) excludes the plea of necessity if the responsible State has contributed to the occurrence of the situation of necessity in a manner that is "sufficiently substantial and not merely incidental or peripheral."[344] This has been reaffirmed by the ICJ.[345] It is important that the State invoking necessity cannot be the sole judge of the question of existence of necessity.[346]

Another critical qualification to the application of Article 25 is Article 55 (*lex specialis*), which states that the Articles on State Responsibility "do not apply where and to the extent that the conditions for the existence of an internationally wrongful act or the content or implementation of the international responsibility of a State are governed by special rules of international law." To infer a *lex specialis*, it is not sufficient that special rules cover the same subject matter as the Articles on State Responsibility; "there must

[343] James Crawford, Second Report on State Responsibility, A/CN.4/498 (1999) at para 288-289.

[344] ILC Articles on State Responsibility, Commentary to article 25, para 20.

[345] Gabcikovo-Nagyamaros Project (Hungary v. Slovakia) [1997] ICJ Rep 7 at 41, para 53.

[346] Ibid., at 40, para 51.

be some actual inconsistency between them, or else a discernible intention that one provision is to exclude the other."[347]

Summing up, it can be inferred from the above discussion that the defence of necessity can be invoked to justify unilateral non-cooperative remediative activities in the absence of explicit permission obtained from the State of registry.

[347] ILC Articles on State Responsibility, Commentary to Article 55, para 4.

5. CONCLUDING REMARKS

The increasing population of space debris in the outer space environment has become a serious threat to the long-term utilisation of space activities. Scientific studies have indicated that the growing congestion of the earth orbits will trigger cascading collisions among the existing space debris. Although the orbital debris mitigation measures have had a positive impact on arresting the rate of generation of debris, they alone are inadequate to address the situation. Space debris remediation – active removal of debris and on-orbit servicing – must be undertaken in conjunction with space debris mitigation measures to stabilise the debris population in the space environment to not only secure space assets in the short-term, but also ensure long-term sustainability of space activities.

The implementation of advanced technology to perform remediative activities poses a number of legal and regulatory challenges mainly because the current regime of international space law is silent or ambiguous towards the facilitation of space debris remediation. The primary concerns arising from definitional issues, jurisdiction and control of space objects and related liability considerations have been analysed.

It has been concluded that the definition of 'space object' includes 'space debris' owing to Article VIII of the Outer Space Treaty which grants ownership in perpetuity and the obligation of the State of Registry under Article VIII to retain its jurisdiction and control over the space object, regardless of loss of manoeuvrability or control over the object.

A comparative study of the maritime law of salvage and international space law reveals that the underlying fundamental principles of these branches of law are incompatible

with each other. International space law deviates from maritime law inasmuch as there is an absence of 'genuine link' between the space object and the State of Registry, an absence of distinction between *de facto* and *de jure* jurisdiction over space objects and no explicit provision for transfer of ownership or change or registry. Thus, it is submitted that relying on the principles of maritime salvage law to develop a framework for governing space debris remediation activities is not recommended.

In the absence of an explicit authorisation obtained from the State of registry, the defence of necessity can be invoked to justify unilateral remediation of a space object to safeguard an essential interest of a State in the form of space assets or tangible benefits derived from space-based applications. However, it is obligatory for States to exercise 'due diligence' and the 'standard of care' involved will be determined based on the circumstances as is appropriate and proportionate to the extent of risk.

Thus, it has been observed that public international law jurisprudence developed over the years can effectively resolve the unanswered questions arising from space debris remediation and principles from public international law can be relied upon to address the lacunae in the legal fabric of international space law.

The next step is for the international community, particularly the established space actors, to engage in discourse for developing State practice and legal and policy guidelines on space debris remediation. Given the lack of political will on the international level towards encouraging remediative activity, it might be prudent for the major space players to undertake unilateral action and also proactively encourage responsible space behaviour amongst their licensed private entities to expedite organisational and operational aspects of space debris remediation.

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