VOLUME 9 ISSUE 1 ARTICLES & ESSAYS

UNIVERSITY OF BOLOGNA LAW REVIEW

https://doi.org/10.6092/issn.2531-6133/19718

Received: 01 Oct. 2023 | Accepted: 22 Jan. 2024 | Published: 05 June 2024

Study on Space Debris Mitigation Under the National Space Laws

ANISH DEY* & JITHIN JAGADANANDAN**

*Anish Dey is a financial analyst, researcher and practitioner in the field of space law and related issues. He completed a Bachelor of Commerce (BCom) with a specialisation in advanced management accounting and financial management and a Bachelor of Laws (LLB) at Karnataka State Law University, Hubli (India), with a specialisation in international law and space law. He also obtained a Master of Laws (LLM) at CMR University, Bangalore (India), where he specialised in commercial laws. Currently, he is pursuing a PhD at the School of Law, Christ University, Bengaluru (India), where he is specialising in legal aspects concerning orbital debris and sustainable use of outer space. He has a keen interest in the field of air and space law with a special focus on commercial aspects of the same.
**Jithin VJ is an Assistant Professor of Law at the School of Law, Christ University, Bengaluru (India). He completed a Bachelor of Laws (LLB) at University of Kerala (India) and obtained a Master of Laws (LLM) at Central University of Punjab (India), where is also pursuing a PhD. He is an ardent environmentalist and prolific researcher working towards sustainability, especially assuring sustainable development goals. He has been invited as a guest speaker at prominent universities. His interest in sustainability has expanded his horizons to space law too. He has been contributing towards the study of orbital debris and the expanding scopes of space law through his findings in various research papers in the field of space policy.

@ *anish.dey@res.christuniversity.in **jithin.vj@christuniversity.in
*0000-0003-3741-7216 **0000-0002-1127-6606

ABSTRACT

The international community is beginning to focus on the issue of space debris. Space debris has increased in the low Earth orbit due to accidental collisions between various space objects such as operational satellites. In China, the destruction of the FengYun - 1C weather satellite by an anti-satellite device caused an exponential increase in space debris. During the Ukraine war in 2022, Russia destroyed a defunct satellite which created space debris. This act put astronauts on the International Space Station at risk. Collisions have also happened between American satellites that are widely used for research or to provide communication facilities.

Two unmanned European Space Agency (E.S.A.) satellites — the European Remote Sensing satellite (E.R.S.) and the Environmental Satellite (Envisat) — are currently in orbit reviving the debate over whether or not to engage in active debris removal. Despite gaining the interest of the international space community, efforts to reduce space debris have received scant legal recognition. Recent years have seen a dramatic decrease in launch costs, making space travel more affordable and feasible for the general public. As a result, smaller satellites can now be placed in low Earth orbit. Mega-constellations like SpaceX, OneWeb, Starlink, and Amazon Kuiper have also been launched or will be launched into space.

It is predicted that about five per cent of all satellites will fail to be disposed of at the end of their lives, either because of technical difficulties or a lack of proper planning for the disposal phase. As a result, there is a greater possibility of collision with other celestial bodies. The problem of orbital pollution is made much worse by the fact that each collision can produce a large number of new pieces of debris. The inoperable satellites can only be retrieved from orbit with the active participation of the international community. The space sector is in the midst of a period of profound change. As a result of recent developments in microelectronics, materials, and battery technology, multiple constellations are now able to function in low Earth orbit, at altitudes of less than 1,000 kilometres. When it comes to domestic space regulation, the International Law Association (I.L.A.) Model marked a significant shift. As a result, many nations with space programmes have adopted national space laws that include provisions for dealing with space debris. Guidelines included in soft-law instruments have provided impetus in the absence of a mandatory international regime on space debris.

KEYWORDS

Orbital Debris; Debris Mitigation; National Space Law; Space System Technology; Sustainability

TABLE OF CONTENTS

INTRODUCTION

Space debris includes inoperative man-made spacecrafts in orbit, mission-related debris, abandoned launch vehicle stages, and fragmentation debris. Both artificial, man-made orbital debris and natural meteoroids encompass space debris.[1] The collapse of orbital access happens suddenly during the lack of a coordinated worldwide response to the increasing amount of space debris. Debris accumulation destabilises the low Earth orbit and has a harmful effect on the safety of space missions.[2] In addition, space debris disrupts satellite-based services available on Earth. As of the end of 2022, there were over 4,800 satellites in orbit, although it is suspected that there are more. The likelihood of a collision grows in conjunction with the density of objects in the universe, which could be understood in the purview of the Kessler Syndrome.[3]

Dr. Donald J. Kessler observed in his study that increasing orbital debris accumulation will set off a chain reaction leading to space inaccessibility in the long run.[4] Thus, international effort and collaboration must be undertaken to remove inoperative orbital debris.[5] Kessler and co-author Burton Cour-Palais indicated the Kessler Syndrome, which is referred to as "[o]rbiting fragments produced through satellite collisions, and each of the fragments would augment the probability of additional collisions, resulting in the increasing amount of debris around the Earth". Increasing orbital debris flux around the Earth could surpass the natural meteoroid flux influencing spacecraft designs in the near future.[6] Hence, voluntary obligations on mitigating space debris using current international instruments may fall short of achieving their intended purpose.[7] According to the data provided by the European Space Agency [hereinafter E.S.A.] in 2022, international action on framing the guidelines for mitigating space debris is improving. For instance, the Agency has assisted in the creation of the Zero Debris Charter in an effort to advance global efforts and inspire other space players to follow E.S.A.'s lead. All space entities can sign the worldwide

[1] *See* Mark Garcia, *Space Debris and Human Spacecraft*, NASA (July 21, 2022), https://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

[2] Damian M. Bielicki, *Gruz kosmiczny - problem Polski, Europy i Świata* [*Space Debris - The Problem of Poland, Europe and the World*], *in* Wykorzystanie przestrzeni kosmicznej. Świat - Europa - Polska [The Use of Space: World - Europe - Poland] 110, 120 (Zdzisław Galicki et al. eds, 2010) (Pol.).

[3] *See* Nibedita Mohanta, *Why space debris mitigation is important for long-term sustainability,* GW Prime gw Prime, www.geospatialworld.net/prime/technology-and-innovation/why-space-debris-mitigation-is-important-for-long-term-sustainability/.

[4] Joseph S. Imburgia, *Space Debris and Its Threat to National Security: A Proposal for a Binding International Agreement to Clean Up the Junk*, 44 Vanderbilt J. Transnat'l L. 589, 589-604 (2011).

[5] Joseph N. Pelton, Space Debris and Other Threats from Outer Space (2013).

[6] *See* Mike Wall, *Kessler Syndrome and the space debris problem*, SPACE.com (July 15, 2022), https://www.space.com/kessler-syndrome-space-debris.

[7] Pelton, *supra* note 5.

effort, which was developed by more than forty participants in the space industry, to demonstrate their shared commitment to a future free of debris. However, the prime focus would need to be on space sustainability, thereby implying effective passivation, which involves burning fuel, draining batteries, and other methods to exhaust all residual energy sources after a mission.[8] Three key measures taken by E.S.A. and its partners for better space sustainability include space debris surveillance, in-orbit collision avoidance and active debris removal. Space debris surveillance networks have identified more than 30,000 space debris fragments. New and better technologies on the ground are helping us discover and study smaller fragments of "unidentified" (U.I.) space debris due to collisions or fragmentations from years ago. An illustration of an innovative approach can be observed via E.S.A.'s IZN-1 laser ranging station wherein the detection of small debris and technology is studied for laser ranging of space debris and satellites. The station analyses satellites' velocity, distance, orbit and space objects with high precision, measured in millimetres using brief laser pulses, by measuring the time taken by laser pulses to return to the observatory. This precision will be helpful to eliminate the number of false alarms and redundant collision evasion. As such, expensive spacecraft fuel and engineer time would be saved.

Avoidance is unnecessary for all collision alerts. When there is an increase in collision alerts, spacecraft operators will be unable to reply to it manually. E.S.A. and its industrial partners are incorporated in developing automated systems that use both Galileo navigational satellite signals and artificial intelligence [hereinafter A.I.] to assist spacecraft operators in preventing collisions and minimising the number of false alarms. The best strategy to limit space debris growth is to remove at least ninety per cent of newly launched objects from the orbital highways after their mission. ClearSpace-1 will be the first to remove orbital debris. The spacecraft, which was launched in 2013, aims to recover and securely retrieve 112 kilogrammes of inactive rocket parts that were released in the same year. E.S.A. is purchasing the mission from ClearSpace S.A. for the removal of active space debris establishing a sustainable space environment dedicated to eliminating high-risk fragments from restricted orbital highways.

ClearSpace received a $104 million contract from the E.S.A. to launch a 2025 debris removal mission. To prepare for a debris-removal mission, the Japan Aerospace Exploration Agency [hereinafter J.A.X.A.] has chosen Astroscale to launch a spacecraft into orbit in 2023 to inspect a spent rocket upper stage. New Zealand and Astroscale have

[8] The European Space Agency [ESA], ESA's Space Environment Report 2022 (Apr. 27, 2022), https://esoc.esa.int/content/esa-space-debris-environment-report-2022.

also agreed to collaborate on research into cutting-edge methods for clearing orbital space debris. In addition, Astroscale was awarded a contract by the United Kingdom's Space Agency to investigate the prospect of retrieving two decommissioned satellites from low Earth orbit by the year 2025.[9]

Table 1 lists the number of debris objects estimated through a statistical method in Earth's orbit, reported by E.S.A.'s space debris agency functioning at the European Space Operations Centre (E.S.O.C.) in Germany.

Table 1. Number of Debris Objects Estimated through a Statistical Method in Earth's Orbit[10]

From the beginning of the space age in 1957, the number of rocket launches, excluding failures	About 6,170
Number of satellites launched using these rockets that have been placed in the Earth's orbit	About 12,470
Number of satellites still available in space	About 7,840
Number of satellites still functioning in space	About 5,200
Regular tracking and maintenance in their catalogue regarding the number of space debris objects by Space Surveillance networks	About 30,040
Assessed number of explosions, break-ups, or similar events leading to fragmentation	> 630
Total mass of all space debris objects available in the Earth's orbit	> 9,800 tonnes
Estimation of number of debris objects using statistical models in the Earth's orbit	• Objects greater than 10 cm - About 36,500 • Objects between 1 cm to 10 cm - About 1,000,000 • Objects between 1 mm to 1 cm - About 130 million

Subsequently, the United Nations Committee on Peaceful Uses of Outer Space [hereinafter CO.PU.O.S.] described space debris as "man-made artefacts, which include elements and fragments of such, in Earth's orbit or re-entering the Earth's atmosphere, that seem to be non-functional".[11] States have struggled to mitigate space debris under national space laws due to the lack of a definition. It is evident that a global framework with enforceable debris mitigation standards, which would also include accidental or

[9] Mohanta, *supra* note 3.
[10] *Id.*
[11] U.N. Office for Outer Space Affairs, Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (Dec. 22, 2007), https://www.unoosa.org/pdf/publications/st_space_49E.pdf [hereinafter CO.PU.O.S. Guidelines].

intentional space object destruction liability, would alleviate the crisis of space debris. At this juncture, a separate emphasis shall be made by states on the lines of international law to refurbish national space laws to reconcile the concern of space debris.

1. THE INTERNATIONAL REGIME ON SPACE DEBRIS

International space law does not regulate the problem of space debris. Outer space activities are governed by five treaties: (i) The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies of 27 January 1967 [hereinafter Outer Space Treaty or O.S.T.];[12] (ii) the Convention on International Liability for Damage Caused by Space Objects in 1972 [hereinafter Liability Convention];[13] (iii) the Convention on Registration of Objects Launched into Outer Space in 1975 [hereinafter Registration Convention];[14] (iv) the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space;[15] and (v) the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies.[16] The first four are widely accepted treaties in the realm of international law between space-capable states, and only the first three address space debris. These Treaties have limited relevance, but commentators overstate their impact on initiatives aimed at mitigating space debris.[17]

[12] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty].

[13] Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention].

[14] Convention on Registration of Objects Launched into Outer Space, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15.

[15] Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119.

[16] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, Dec. 5, 1979, 1363 U.N.T.S. 21.

[17] Frans G. von der Dunk, *Asteroid Mining: International and National Legal Aspects*, 26 Mich. State Int'l L. Rev. 83, 89–90 (2017).

The most pertinent of all the international laws is the O.S.T., referred to as the "Constitution" of space law, as it involves the fundamental principles of space activities.[18] The O.S.T. explains the avoidance of unfavourable changes to space sustainability. Space activities, leading to orbital debris, often disrupt Earth's orbit. Crowded orbits hinder unlimited access to the outer space environment resulting in national appropriation in breach of Article II of the Outer Space Treaty,[19] along with Article IX, which indicates the limit on space pollution as it is detrimental to the interests of other member States.[20] In 1994, the International Law Association [hereinafter I.L.A.] — at a conference in Buenos Aires — designed an early normative international instrument for Environmental Protection against Damage by Space Debris.[21] The United Nations [hereinafter U.N.] space treaties were drafted before space debris became a major issue,[22] and so the spacefaring countries did not discuss how to deter the space debris threat.[23] The following three Articles are relevant to addressing the problems associated with space debris: (i) Article VI of the O.S.T. which indicates that every State should have global liability for national activities in the outer space environment; (ii) Article VII of the O.S.T. indicating that the State Party from whose facility or territory a space object is launched bears global responsibility for any damage brought upon another State Party to the Treaty; and (iii) According to Article IX of the Outer Space Treaty (O.S.T), if the country undertaking a space mission believes that their activities may cause 'harmful contamination' of the outer space environment, they are required to take necessary measures to prevent this".[24]

The Registration Convention implies a responsibility on states to register the launch of each space object, while the Liability Convention relates to liability standards for damage brought about to another State Party. No provisions have been enacted in the Registration Convention for the presence of space debris.[25] In mitigating space debris, these three Treaties, especially the Outer Space Treaty and the Liability Convention, are not consistent regarding ramifications and obligations. The Liability Convention aims to

[18] Rada Popova & Volker Shaus, *The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space*, 5(2) Aerospace 55 (2018), at 1.

[19] Sreemena Sethu & Mandavi Singh, *Stuck in Space: The Growing Problem of Space Debris Pollution*, UK L. Student Rev. 96 (2014), 115.

[20] *Id.*, *see also* Paul B. Larsen, *Solving the Space Debris Crisis*, 83 J. Air L. & Com. 475, 484 (2018).

[21] Information on the activities of international organizations relating to space Law, UN. Comm. on the Peaceful Uses of Outer Space, on Its Fourty Session, U.N. Doc. A/AC.105/C.1/L.260 (2003), https://www.unoosa.org/pdf/limited/C2/AC105_C2_E223E.pdf.

[22] Fabio Tronchetti, Fundamentals of Space Law and Policy 19 (Springer ed. 2013).

[23] *Id.* at 20; Larsen, *supra* note 20, at 477; *see also* Edwin Kisiel, *Law as an Instrument to Solve the Orbital Debris Problem*, 51 Env't L. 223, 224 (2021).

[24] United Nations Treaties and principles of outer space, U.N. Sales No. E.02.I.20 (2002), https://www.unoosa.org/pdf/publications/STSPACE11E.pdf.

[25] U.N. Off. for Outer Space Affairs, Convention on Registration of Objects Launched into Outer Space (1974), https://www.unoosa.org/pdf/gares/ARES_29_3235E.pdf.

create an international liability framework. The parallel route deals with active debris removal.[26] Research scholars proposed solutions to circumvent the issue through treaty amendment or interpretation.[27]Articles VII and VIII of the Outer Space Treaty and Article I of the Liability Convention included that "component parts" are space objects. The component parts are to justify taking into consideration all debris, such as pieces of metal or paint to comprise space objects.[28] Hence, the state who is launching or procuring the launch is legally responsible for any smash-up caused by its orbital debris to another state. As a result, the launching state must have legal responsibility for any damages due to its aircrafts or debris present on the Earth's surface. This is because damage liability in the outer space environment is restricted to proof of "fault".[29]

The rules framed by the U.N. regarding mitigating space debris are non-obligatory.[30] Private enterprises lack the authority to initiate legal proceedings about space debris according to the U.N. Treaties, which endangers the sustainability of Earth's orbit.[31] Future efforts in space exploration depend on the viability of space access. Along with national space agencies, the Deep Space Exploration has participated in space debris avoidance.[32] Orbital debris disrupts space activities like satellite communication, military engagements, scientific research, or weather tracking.[33] As the source of space debris contamination cannot always be pinpointed, affixing liability for space debris can be a difficult task.[34]

International lawmaking has been slow due to a lack of political consensus amongst states to institutionalise enforceable rules. Private companies with business interests are also exploring space for commercializing outer space. For example as the first private corporation, SpaceX is responsible for developing and launching the first liquid-propellant rocket into orbit; recovering a spacecraft after it has reached orbit; sending a spacecraft to the International Space Station and sending passengers to the

[26] *See* Chelsea Muñoz-Patchen, *Regulating the Space Commons: Treating Space Debris as Abandoned Property in Violation of the Outer Space Treaty*, 19 Chi. J. Int'l L. 233, 241 (2018); Arpit Gupta, *Regulating Space Debris as Separate from Space Objects*, 41 Univ. Pa. J. Int'l L. 223, 225 (2019); Larsen, *supra* note 20, at 486.

[27] *See* Muñoz-Patchen, *supra* note 26, at 244-52; Joel A. Dennerley, *State Liability for Space Object Collisions: The Proper Interpretation of 'Fault' for the Purposes of International Space Law*, 29 Eur. J. Int'l L. 281 (2018); Ram S. Jakhu et al., *Regulatory Framework and Organization for Space Debris Removal and on Orbit Servicing of Satellites*, 4 J. Space Safety Eng'g 129, 129-30 (2017); Melissa K. Force, *When the Nature and Duration of Space Becomes Appropriation: "Use" as a Legal Predicate for a State's Objection to Active Debris Removal*, 56 Proceedings Int'l Inst. Space L. 405 (2013).

[28] *See* Muñoz-Patchen, *supra* note 26, at 235-38; Gupta, *supra* note 26, at 232-36; *see also* Peter Stubbe, State Accountability for Space Debris 6 (Brill Nijhoof ed., 2017).

[29] Liability Convention, *supra* note 13.

[30] *See* Sophie Kaineg, *The Growing Problem of Space Debris*, 26 UC L. Env't J. 277, 285 (2020).

[31] *See* Frans G. von der Dunk & Fabio Tronchetti, Handbook of Space Law 717 (Edward Elgar Publishing 2015).

[32] *Id.* at 723.

[33] Kaineg, *supra* note 30, at 281.

[34] *See* Von der Dunk & Tronchetti, *supra* note 31, at 735.

space station.[35] Traditional space-faring states and new space participants must establish a legislative framework which must be sustainable. Long-term harm to outer space cannot be compensated for financially; hence, prevention is the framework's main purpose.[36]

The corpus of international law is comprised of soft laws and treaties influencing the decision-making process of members.[37] U.N. General Assembly resolutions,[38] and guidelines and recommendations adopted by the Inter-Agency Space Debris Coordination Committee [hereinafter I.A.D.C.] and the CO.PU.O.S. are certain treaties pertaining to space debris.[39] The concern is that these guidelines are recommendatory in nature. CO.PU.O.S. implemented policies modelled after the I.A.D.C.'s recommendations because it is also an informal inter-governmental organisation for collaboration amongst the space agencies of space-capable states.[40]

In 1994, CO.PU.O.S. was concerned with the problem of space debris. Since then, soft-law actions have been initiated for framing the international space debris reduction framework. In 2002, the I.A.D.C. established a framework for tackling space debris.[41] Consequently, the I.A.D.C. Guidelines were amended in 2007 and 2011.[42] The I.A.D.C. standards' general policy objectives encompass restricting fragment release during space operations through appropriate spacecraft design limiting on-orbit break-ups, proper planning about orbital debris disposal, and avoidance of on-orbit collisions.[43] According to the I.A.D.C. 2021 and other research studies, unintentional collisions will increase space debris in the outer space environment. In creating the design and mission profile of an orbital stage or spacecraft, a project must evaluate and restrict the likelihood of unintentional collision with known objects during the orbital lifespan of an orbital stage

[35] Kisiel, *supra* note 23, at 228.
[36] *Id.* at 187.
[37] *See* Eyal Benvenisti, The Law of Global Governance 37-68 (2014); *see also* Steven Freeland, *The Role of "Soft Law" in Public International Law and its Relevance to the International Legal Regulation of Outer Space*, *in* Soft Law in Outer Space: The Function of Non-binding Norms in International Space Law 9, 19 (Irmgard Marboe ed. 2012).
[38] *See* Michael Wood (Special Rapporteur), Fifth Rep. on identification of customary international law, Conclusion 12, U.N. Doc. A/CN.4/717 (Mar. 14, 2018); Stephen M. Schwebel, *The Effect of Resolutions of the U.N. General Assembly on Customary International Law*, 73 Proceedings Ann. Meeting 301, 301 (Apr., 1979); Francis Lyall & Paul B. Larsen, Space Law: A Treatise 73 (2nd ed. 2018).
[39] CO.PU.O.S. Guidelines, *supra* note 11; Inter-Agency Space Debris Coordination Committee, IADC Space Debris Mitigation Guidelines, Doc. IADC-02-01, https://orbitaldebris.jsc.nasa.gov/library/iadc_mitigation_guidelines_rev_1_sep07.pdf, (Sept. 2007) [hereinafter I.A.D.C. Guidelines].
[40] Alexander W. Salter, *Space Debris: A Law and Economics Analysis of the Orbital Commons*, 19 Stan. Tech. L. Rev. 221, 224-27 (2016).
[41] I.A.D.C. Guidelines, *supra* note 39.
[42] *Id.*
[43] *See* Frans G. von der Dunk, National Space Legislation in Europe: Issues of Authorization of Private Space Activities in the Light of Developments in European Space Cooperation 70 (2011). *See* Lawrence Li, *Space Debris Mitigation as an International Law Obligation*, 17 Int'l Cmty. L. Rev. 297, 303 (2015).

or spacecraft. If conjunction evaluations and reliable orbital data are available, avoidance spacecraft manoeuvers during every operational phase and launch window coordination for orbital stages for launch vehicles should be addressed. After all operational phases of a spacecraft or orbital stage have been concluded, the risk of integrated collision during the design of the remaining orbit should decrease the possibility of tiny debris collisions that could cause a loss of control and impede post-mission disposal. Lifespan ought to be minimised in accordance with post-mission disposal strategies. Spacecraft design should also reduce the likelihood of colliding with tiny debris, which could result in a loss of control, prohibiting post-mission disposal.[44] However, the rules lack concrete strategies for controlling space debris. Thus, the goal is to minimise space debris in the near future. A timeframe of twenty-five years has been designated for the de-orbiting of short-term debris available in low Earth orbit.

The CO.PU.O.S. approved the Space Debris Mitigation [hereinafter S.D.M.] Guidelines in 2007.[45] In Resolution 67/217 of December 22, 2017, the U.N. General Assembly reaffirmed the S.D.M. Guidelines and urged Member States to adopt a national framework to manage space debris.[46] It is based on I.A.D.C.'s space debris mitigation document making it a derivative work.[47] The S.D.M. Guidelines, like its predecessor, are a voluntary agreement between major space agencies and contain a set of non-legally binding rules. It was anticipated that persistent multilateral effort would result in the voluntary adoption of space debris mitigation rules in response to an increase in orbital collisions and a growing space debris population.

In September 2017, the I.A.D.C. released a formal statement about well-known satellite constellations in low-Earth orbit.[48] In its announcement, the satellite industry was made aware of several serious problems and was given instructions on how to fix them. To minimise the risk of collision, the I.A.D.C. has prescribed, firstly, altitude separation in large satellite constellations to mitigate the risk of collision in crowded orbits. Secondly, it recommends that satellite designs ease the removal process in the event of failure or termination of the space mission. In addition, the design must facilitate manoeuvring to avoid a potential collision with other space objects.[49] There are recommendations that shall be manifested by launch vehicle and spacecraft orbital

[44] Inter-Agency Space Debris Coordination Committee, IADC Space Debris Mitigation Guidelines, IADC-02-01 Rev. 3, (June, 2021) [hereinafter I.A.D.C. Guidelines1].
[45] CO.PU.O.S. Guidelines, *supra* note 11.
[46] UN Doc. G. A. Res. 62/217, ¶ 7, point 27 (Dec. 22, 2007).
[47] I.A.D.C. Guidelines, *supra* note 39.
[48] Inter-Agency Space Debris Coordination Committee, IADC Statement on Large Constellations of Satellites in Low Earth Orbit, Doc. IADC-15-03 Rev. 1.1 (July, 2021), https://www.iadc-home.org/documents_public/file_down/id/4195 [hereinafter I.A.D.C. Guidelines2].
[49] *Id.*

stages that are followed during the mission planning, manufacturing, design, and operational phases. These guidelines are imperative in minimising space debris.

Once launch vehicle and spacecraft orbital stages have ended their operation, while passing via the geosynchronous orbital [hereinafter GE.O.] region, in-orbits should be removed to prevent their long-standing meddling in the GEO. region.[50]

The sixty-fifth session of the U.N. General Assembly Report of the CO.PU.O.S. discussed and gave important points regarding the peaceful use of outer space. Outer space, being commons, cannot be misused by nations on the pretext of exploration. This has been the U.N. agenda since 1959 which was reiterated in this session too. In the session, the fundamental significance of space science and technology and their applications for global, regional, national, and local sustainable development processes was sought to be promoted in the formulation of policies and programs of action. Their implementation, including through efforts towards achieving the objectives of those conferences and summits and in implementing the 2030 Agenda for Sustainable Development, was also emphasised. The necessity of promoting the benefits of space technology and its applications, in the major United Nations conferences and summits for economic, social, and cultural development, and related fields, was also acknowledged.

The Committee urged nations that had not yet adopted the S.D.M. Guidelines, voluntarily, to do so. It was also stated that international intergovernmental organisations' and many states' implemented, mitigating measures for space debris had been inconsistent with the S.D.M. Guidelines and the Guidelines for the Long-term Sustainability [hereinafter L.T.S.] of Outer Space Activities (A/74/20, Annex II). In addition, it was also stated that some states were implementing the S.D.M. Guidelines of the CO.PU.O.S. and/or the S.D.M. Guidelines of the I.A.D.C., the International Organisation for Standardisation (I.S.O.) standard 24113:2011 (S.D.M. requirements) and the International Telecommunication Union [hereinafter I.T.U.] Recommendation I.T.U.-R S.1003 (i.e., sustainability of the geostationary satellite orbit) as suggestions in their regulatory frameworks during national space activities. Some states co-operated under the E.U.-funded tracking support and space surveillance framework and E.S.A.'s Space Safety Programme. It is worth mentioning that L.T.S. Guidelines developed, with the ideology that the Earth's orbital space environment is a limited resource that is being used by a growing number of space players, including non-governmental organisations, lead to the extension of the notion of sustainability to space. Concerns over the O.S. safety of space operations are raised by the growth of space debris; the formation of

[50] CO.PU.O.S. Guidelines, *supra* note 11.

massive constellations; the increased risk of collisions; and interference with satellite operations.

Accordingly, 2009 saw the introduction of the subject "Long Term Sustainability of Outer Space Activities" as a CO.PU.O.S. agenda item. This ultimately resulted in the formation of a special Working Group of the Scientific and Technical Sub-Committee in 2010, which Peter Martinez of South Africa chaired. Under the Working Group, four expert groups were formed to address the subjects of space trash, space operations, and instruments to support cooperative space situational awareness. These are examples of sustainable space utilisation that supports sustainable development on Earth. Further suggestions are to have regulations governing space weather and advice for novice participants.

Many states were taking concrete measures to mitigate space debris, like improving their spacecraft and launch vehicle design, passivation, de-orbiting satellites, life extension for satellites, and establishing software and models for S.D.M. Reiterating the Committee reports in the mitigation of space debris and the sustainable use of space, the I.A.D.C. updated its S.D.M. Guidelines in 2022.

The Committee has been concerned about space debris and its effects on future space exploration. It also agreed that international intergovernmental organisations and Member States with permanent observer status should continue to provide details on research about space debris; the safety of spacecraft with nuclear power sources; and its collisions with space debris; and the implementation of S.D.M. Guidelines. The Committee also stated that the space debris should be managed in such a way that it would not harm any emerging nations' space capabilities. In addition, it also stated that future space actors should not be burdened by the history of established space actors. The Committee should prioritise addressing the issues faced by mega-constellations in low Earth orbit – notably those relating to orbit and frequency sustainability. Some delegations stressed the importance of strengthening the capacity of developing countries to implement voluntary measures like the S.D.M. Guidelines and the Guidelines for the L.T.S. of Outer Space Activities.

Major space-faring countries should shoulder the primary responsibility for addressing orbital debris and extend their help to developing and emerging space-faring nations to design spacecrafts respecting the space debris reduction criteria. To avoid miscalculations and misunderstandings, debris reduction and space traffic management should promote transparency and confidence-building.

The S.D.M. Guidelines adopted by CO.PU.O.S. and I.A.D.C. have helped reduce friction in the global community to address the hazard of space debris.[51] As a result, conditions for getting licences for space missions have been included in the mitigation rules made at national level by many state parties such as the Antrix Corporation Limited — the commercial arm of the Indian Space Research Organisation [hereinafter I.S.R.O.]. A foreign firm must enter into a contract with Antrix to receive launch services if they want to launch outside of India. Antrix contracts make up the launch agreement. Only the parties directly engaged have access to the specifics of these contracts.[52]

The Sixty-fifth session of U.N. General Assembly Report of the CO.PU.O.S. discussed and updated the L.T.S. of Outer Space Activities Guidelines in July 2022. The Working Group on the L.T.S. of Outer Space Activities aims to study and identify issues and think of probable new guidelines that are of significant interest to commercial companies and States in schemes for active space debris removal, and the establishment of programmes and plans for the Moon exploration. There is a significant distinction between dealings that limit the sudden generation of space debris and those targeted at performing the same in the long run. Hence, the S.D.M. Guidelines encompass the twin objective of reducing active space debris generated during space missions and disposal events for removing orbital fragments of launched space vehicles and decommissioned spacecraft from areas where functional space objects operate.[53]

Recommendations for the long-term sustainability of space activities were officially unveiled by the U.N. Office for Outer Space Affairs. States should adopt guidelines for mitigating space debris under national laws to incentivise operators and manufacturers to restrict debris generation through appropriate design and operation of space objects. The state should welcome new technological solutions to manage space debris and hold back space collisions.[54] Namely, Active Debris Removal [hereinafter A.D.R.] Services and Obruta. A U.S.-based startup company called Orbit Guardians offers A.D.R. services. It integrates the Internet of Things [hereinafter I.o.T.], A.I., and computer vision technologies to remove space junk at a minimal cost. It uses A.I. and I.o.T. technologies to gather debris data and remove potentially hazardous targets. Space debris of less than twenty centimetres can be cleaned up by low-cost A.D.R. making space safer, while Obruta employs techniques, such as tethered-net removal technology, for debris monitoring. Accelerated deployment masses are necessary for the net capture mechanism to force a net out of a container. The net then expands as it

[51] I.A.D.C Guidelines1, *supra* note 44, at 306.
[52] Von der Dunk & Tronchetti, *supra* note 31, at 587.
[53] I.A.D.C. Guidelines1, *supra* note 44.
[54] CO.PU.O.S. Guidelines, *supra* note 11.

approaches the intended destination. A tether line connection is made to the service spacecraft as soon as the object is caught.

In the purview of sustainability, reference is made to the I.T.U.'s Recommendation S.1003-2, titled "Environmental Protection of the GSO" (i.e., geostationary-satellite orbit [hereinafter G.S.O.]). It provides advice on environmental safeguards to protect the area below and above the geostationary satellite orbit from the fragmentation of space debris following a collision. When it comes to the placement of satellites, the I.T.U. suggests making a reasonable effort to guarantee that there is little pollution in the orbital region.[55] It is also important to reduce debris lifetime. It has been suggested to create a protected zone down below the geosynchronous orbit, which is the location where the operational satellites live and move about. It has been proposed that decommissioned spacecrafts be placed in the geostationary orbit, far from the area where active satellites orbit, to minimise their potential for collisions. Another essential step that must be taken to prevent fragmentation is the passivation of any leftover energy sources that are contained on space objects. The I.T.U. can then efficiently address space debris in the G.S.O. due to its broad mission.[56]

It is necessary for two separate national laws governing space to keep up with the worldwide regulatory standards being developed regarding space debris. The technical measures provide important new perspectives for incorporation into domestic law. The states must go beyond merely enforcing a skeleton of regulations in order to establish a comprehensive framework that can adequately address the risks posed by orbital debris. On the other hand, the subjective interpretation of soft-law instruments by individual states can dilute the application of these instruments as law. States cannot remain complacent under national space rules due to Kessler Syndrome. This may have far-reaching implications for human space travel in the future. For instance, the recent Commercial Space Act of 2023 of the United States of America, where there is an assumption that, due to the new licensing policy, national security of the country would be affected.[57] It is also questioned on the avenues of its effective dynamism, balanced approach and holistic undercurrents.

[55] *See* Environmental protection of the Geostationary-Satellite Orbit, Recommendation ITU-R S. 1003.2, 12/2010 (Jan. 16, 2023), https://www.itu.int/rec/R-REC-S.1003/en.

[56] *See* Ram S. Jakhu, *Space Debris in the Geostationary Orbit: A Matter of Concern for the ITU*, 34 Proceedings on L. Outer Space 205, 212-13 (1991).

[57] *See* John Goering, *The Commercial Space Act of 2023 is bad for National security*, Just Security (Dec. 19, 2023), https://www.justsecurity.org/90567/the-commercial-space-act-of-2023-is-bad-for-national-security/.

2. DEBRIS MITIGATION UNDER I.L.A. MODEL LAW

Article VI of the Outer Space Treaty stipulates that State Parties are required to assume international responsibility for any actions carried out in outer space by either public or private enterprises or government agencies. In order to regulate the activities of those operating in private remote sensing space systems, the law proposes a licensing system.[58] The United Nations General Assembly passed a resolution in 2013 recommending changes to national laws to govern "peaceful exploration and use of outer space".[59] One of the primary objectives is to reduce space debris and so protect the space environment. In order to progress toward the goal, the General Assembly strongly recommended that the appropriate national authorities establish a licensing system for activities in space. The inclusion of safety standards in the authorisation requirements was mandated in accordance with the S.D.M. Guidelines.

Domestic legislation addressing the problem of space debris is still in its early stages of development. On the other hand, a lot of progress has been made in the last decade. To mitigate the risks posed by space debris, states should work towards enacting concrete national space legislation. The nation's laws need to be clear enough so that specific guidelines can be established for all parties involved including organisations that are not affiliated with the government. I.L.A. Model Law was created at the International Law Association's seventy-fifth Annual Conference in Sofia.[60] Using the Model Law as a template, nations can create their own laws to address the growing problem of space junk. It establishes a set of policies and procedures that ought to be followed as a matter of national law.

Article VII of the Model Law imposes a broad mandate that cannot create environmental damage to outer space; nevertheless, it does not put down a precise level of compliance with this mandate. In addition, Article IV stipulates that the national space authority must comply with Article VIII when issuing authorisation for space-related endeavours. The fundamental provision to reduce space debris is included in this article. Article VIII requires that space debris be mitigated "to the maximum feasible extent".

---

[58] *See* Outer Space Treaty, *supra* note 12.

[59] G.A. Res. 68/74, (Jan. 17, 2023).

[60] *See* Comm. on the Peaceful Uses of Outer Space, Legal Subcomm. on Its Fifty-Second Session, Information on the activities of international intergovernmental and non-governmental organizations relating to space law, U.N. Doc. A/AC.105/C.2/2013/CRP.6 (2013); Sofia Guidelines for a Model Law on National Space Legislation, https://ila.vettoreweb.com/Storage/Download.aspx?DbStorageId=1032&StorageFileGuid=f727cb74-4d84-4585-a29e-0d6dfb436672.

States or private companies conducting space missions would have wide latitude in determining how to interpret a "best-efforts clause".[61] Without a uniform minimum standard of compliance, it opens the door to evasion. Thus, it is necessary to harmonise state practice under national space legislation.[62] In addition, the Article specifies responsibilities for minimising in-orbit break-ups, preparing for post-mission disposal, avoiding in-orbit collisions, and limiting operational debris in accordance with "international space debris mitigation standards". According to experts,[63] there are universal norms that should be accepted by the community of space-faring states to streamline national space policies.

In order to fix Article VIII's flaws, we need to take a multifaceted strategy. A global fund for the mitigation and removal of debris might be established by the states on the basis of the principle of "common but differentiated responsibility".[64] The corpus could be used to implement a space debris accumulation-based insurance mechanism analogous to the protection against launch failures in space missions.[65] The corpus could be used to incentivise domestic private players to follow optimal practices to address the space debris situation. It could mitigate the cost rise from mitigation standards. Alternately, states may incentivise debris cleanup in outer space by taxing private space players. The proposal has the potential to generate a sustainable income stream to help clean up space debris.[66] In the United States, for instance, a trust fund has been established by taxing chemical industries to finance clean-up responses and ensure waste disposal as part of the environmental legislation framework.[67] This template is transferable to national laws on space debris mitigation and could be used as a model for similar legislation worldwide keeping sustainable development goals in the purview.

Consequently, the space debris producer — be it a government with space capabilities or a private company — would have to take the initiative to promote responsible orbital space utilisation. The I.L.A. Model Law's greatest strength is that it recognises the problem of space debris as a worldwide issue requiring systemic solutions under national space laws.

---

[61] Sandeepa Bhat B. & Arthad Kurlekar, *A Discourse on the Remodeling of ILA Model Law on National Space Legislation*, 41 J. Space L. 1, 13 (2017).
[62] *See* Stephan Hobe, *The ILA Model Law for National Space Legislation*, 62 Zeitschrift für Luft-und Weltraumrecht [German J. Air & Space L.] 81, 85 (2013).
[63] *See* Bhat B. & Kurlekar, *supra* note 61, at 14.
[64] Von der Dunk & Tronchetti, *supra* note 31, at 801.
[65] *See* Pelton, *supra* note 5, at 28.
[66] *See* Joseph N. Pelton, New Solutions for the Space Debris Problem 33 (2015).
[67] *See* Kisiel, *supra* note 23, at 233.

3. DEVELOPMENTS IN DOMESTIC SPACE LAW

The Space Object Monitoring (S.O.M.) Guidelines are implemented under domestic law by states' political will. Nonetheless, it remains a benchmark for how other national authorities should approach enforcing similar regulatory standards.[68] Several nations have passed legislation at the domestic level to address the issue of space debris, with pioneering spacefaring nations at the forefront. Activities in outer space are often governed by a formal approval process. An array of precautionary measures has been built into the prerequisites for approval.

Since the 1997 Debris Mitigation Standard Practices of the National Aeronautics and Space Administration [hereinafter N.A.S.A.], the United States has implemented various policies on debris mitigation as a prominent spacefaring state. The Guidelines, however, were only applicable to state-run or state-produced space systems.[69] Greater private sector investment has been of primary focus. For this reason, the U.S. Commercial Space Launch Competitiveness Act of 2015 recognised the importance of maintaining a consistent regulatory framework.[70] The statute mandates that the N.A.S.A. Administrator seek advice from a "qualified independent systems engineering and technical support organisation" when conducting research into ways to reduce the effects of orbital debris. Importantly, the update to the orbital traffic management system required a review of the rules around orbital debris as part of the non-binding international arrangements.

The National and Commercial Space Programs Code mandates that the N.A.S.A. Administrator work with other federal agencies to acquire technologies that could lessen the effects of orbital debris.[71] An official space debris mitigation strategy is required as a prerequisite for authorising satellite systems under Title 47 (Telecommunications) of the U.S. Code.[72] In addition to this responsibility, it has been ordered that a space station operating in geostationary orbit must dispose of end-of-life debris.[73] In 2019, the U.S. government revised its Orbital Debris Mitigation Standard Practices in an effort to limit the spread of debris in the event of an accident. Designing spacecraft and upper stages to produce as little debris as possible is a mandatory requirement of the regulations. The

[68] *See* Tronchetti, *supra* note 22, at 21.
[69] *Id.*
[70] US Commercial Space Launch Competitiveness Act, Pub L. No. 114-90, 129 Stat. 704 (2015), https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf, accessed 16 Jan. 2023.
[71] National and Commercial Space Programs, 51 U.S.C. (2010), available at https://law.justia.com/codes/us/2010/title51/, accessed 16 Jan. 2023.
[72] 47 C.F.R. (2024), https://www.fcc.gov/wireless/bureau-divisions/technologies-systems-and-innovation-division/rules-regulations-title-47.
[73] *See* Von der Dunk, *supra* note 43, at 22.

operators must assess the risk of space systems becoming a source of debris owing to collisions with "man-made objects or meteoroids".[74]

It is also important for space programmes to plan for the efficient and economical disposal of space structures after their missions have ended.[75] Space debris mitigation standards are applicable to the private sector and are a condition of receiving a safety approval licence from the Federal Aviation Administration.[76] When it comes to reducing the effects of space debris, N.A.S.A. is constantly keeping an eye on emerging trends in technology and looking to implement cutting-edge programmes.[77] The private sector's space communications providers must go through a licensing process with the Federal Communications Commission [hereinafter F.C.C.] which includes the development of a strategy to deal with orbital debris.[78] An important gap in U.S. domestic legislation is the lack of financial incentives for space debris prevention and cleanup.[79]

F.C.C. updated guidelines to mitigate orbital debris in the new space age report and order, as well as the second report and order. Operators of satellites in low-Earth orbit should ensure that their spacecrafts re-enter Earth's atmosphere within twenty-five years after their mission. The Second Report and Order proposes reducing the required timeframe of a satellite's post-mission disposal to five years as part of our ongoing efforts to reduce the generation of orbital debris. The Second Report and Order would[80]

- Implement a "five-year rule", which would mandate space station operators, with plans to dispose of debris through uncontrolled re-entry into Earth's atmosphere, do so as soon as possible and no later than five years after the end of the mission;

- State explicitly that space stations completing their missions in or transiting the low-Earth-orbit region below 2,000 kilometres be subject to the new regulations;

[74] U.S. Government Orbital Debris Mitigation Standard Practices (N.A.S.A. 2019), https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf.
[75] *Id.*
[76] Tronchetti, *supra* note 22, at 22.
[77] *See Mitigation of Orbital debris in the New Age Space*, Federal Communications Commission Order (Dec. 8, 2020), https://www.federalregister.gov/documents/2020/08/25/2020-13185/mitigation-of-orbital-debris-in-the-new-space-agehttps://www.federalregister.gov/documents/2020/08/25/2020-13185/mitigation-of-orbital-debris-in-the-new-space-age.
[78] Von der Dunk & Tronchetti, *supra* note 31, at 143.
[79] Stephen J. Garber, *Incentives for Keeping Space Clean: Orbital Debris and Mitigation Waivers*, 41 J. Space L. 179, 180 (2017).
[80] *See* Fed. Commc'ns Comm'n, IB Docket Nos. 22-271 & 18-313, Space Innovation; Mitigation of Orbital Debris in the New Space Age Second Report and Order (2022), https://docs.fcc.gov/public/attachments/DOC-387024A1.pdf.

- Mandate the above point, in accordance with Part 25 of the Commission's rules, and it applies to both U.S.-licensed satellites and systems and non-U.S.-licensed satellites and systems seeking access to the U.S. market;
- Adopt a companion requirement for organisations seeking amateur satellite deployment under Part 97 of the Commission's rules, or for organisations seeking Part 5 experimental licences for satellites;
- Reduce operator burden specifying a two-year grandfathering period for the new requirement; and,
- Discuss the possibility of exemptions for particular scientific and research expeditions.

To reduce the risk of space debris collisions, the European Union's proposed international code for space activities urges countries to adopt appropriate laws through "their own internal processes".[81] States are also cautioned against pursuing the purposeful destruction of objects in space as this would result in permanent space debris. The only circumstances in which it is permissible to justify the destruction of space objects are those in which human life or health is in danger; or in order to prevent the development of further debris in space; or to exercise one's individual or collective right to self-defence as stipulated in the U.N. Charter. States are dissuaded from contributing to space debris as they would have no legitimate security justification for doing so.[82]

The European Space Agency (E.S.A.) mentioned that preventing in-orbit explosions or collisions is the best short-term strategy to reduce space debris growth. In addition, the best long-term strategy for maintaining a safe level of space debris is ensuring widespread adherence to disposal guidelines post missions.[83]

In the United Kingdom, the Space Industry Act of 2018 mandates that the State regulator take into account "any space debris mitigation guidelines issued by an international organisation in which the Government of the United Kingdom is represented".[84] In order to maintain their space licence, space activity permittees must adhere to any space debris mitigation guidelines that are a part of their licence's terms and conditions.[85] On July 29, 2021, the Space Industry Regulations were officially

[81] *See* European Union Draft International Code of Conduct for Outer Space Activities (Mar. 31, 2014), https://www.eeas.europa.eu/sites/default/files/space_code_conduct_draft_vers_31-march-2014_en.pdf-.
[82] Von der Dunk & Tronchetti, *supra* note 31, at 380.
[83] *See* The European Space Agency [ESA], Mitigating Space Debris Generation (Jan. 18, 2023), https://www.esa.int/Space_Safety/Space_Debris/Mitigating_space_debris_generation, (last visited Jan. 18, 2023).
[84] Space Industry Act 2018, c. 5, §2 (2)(h) (U.K.).
[85] *Id.*

implemented. The rules stipulate that the operator must explain how the "design and operational procedures" limit the discharge of debris into space, and the operator must take reasonable precautions to prevent the release of debris.[86]

The standards used to evaluate licence applications are laid out in detail in the Guidance for Orbital Operator Licence Applicants and Orbital Operator Licensees. This includes international guidelines laid down for mitigating space debris described by the Inter-Agency Space Debris Coordination Committee, international standards for various international space systems defined by the International Organization for Standardization, and European standards for safety defined by the European Cooperation for Space Standardization. This Guidance requires applicants to describe any spacecraft design feature that protects against debris or micrometeoroids, but it does not require satellites to be developed with space debris shields or other impact safety protocols. The licensing process requests this information for information purposes only and not to define a special criterion for operators, which would go beyond international debris mitigation strategies.[87]

Article 5 of the French Space Operation Act establishes a system of state control over space operators through the issuance of authorisations or licences.[88] An environmental assessment, including the restriction of threats caused by space debris, could be among the prerequisites for launching objects into space. In the event that the operator attempts to avoid their responsibilities, the administrative body reserves the right to revoke or suspend the approval. That way, the operator might be obligated to take precautions to mitigate any potential fallout. In the event that a space object causes damage to Earth's ecosystem, the law mandates that responsibility for repairs be split among insurance companies.

Luxembourg space law also establishes a framework for public and private entities to get the necessary authorisations to exploit space legally. The necessary approval is contingent upon a thorough analysis of the risks involved in the space mission. It is the operator's responsibility to pay for any damages.[89] However, the law does not provide a clear mandate for the criteria of authorisation regarding the reduction of space debris.

[86] The Space Industry Regulations 2021, SI 2021/792 (U.K.).

[87] *See* Joanne Wheeler M.B.E., The Space Law Review: United Kingdom, THE LAW REVIEW (Alden Legal Limited, 2023) (U.K.).

[88] Loi 2008-518 du 3 juin 2008 relative aux opérations spatiales (telle que modifiée par la loi n°2013-431 du 28 mai 2013) [Law No. 2008-518 of June 3, 2008, regarding Space Operations (as amended by Law No. 2013-431 of May 28, 2013)] Journal Officiel de la République Française [J.O.] [Official Gazette of France], June 4, 2008 (Fr.).

[89] Loi du 15 décembre 2020 portant sur les activités spatiales [Law of December 15th 2020 on Space Activities], Journal Officiel [Official Journal] Dec. 28, 2020 (Lux.).

Russian space law also requires environmental protection in space operations. However, the law's licensing process does not address the issue of reducing space debris.[90]

The Austrian Outer Space Act, conversely, mandates that operators take measures to reduce the spread of space debris by adhering to best practices established at global level.[91] The competent state body will only provide permission for space activities to the operator if the operator has taken precautions to limit the debris release. Similar to other countries, the Netherlands requires a space debris mitigation framework as part of its licensing requirements.[92]

Article 6 of China's Interim Measures on the Administration of Permits for Civil Space Launch Projects (2002) stipulated that in order to receive state approval for a space mission, an applicant must meet technical standards for preventing pollution and space debris.[93] Safeguards outlined in the I.A.D.C. recommendations have been further replicated in the newly adopted Interim Measures on Space Debris Mitigation and Protective Management.[94] China has also embraced an "integrated system of space debris mitigation design", which lays out a methodical plan for cleaning up the debris.[95] Chinese firms are also concerned about the removal of space debris. In 2022, Origin Space, a Shenzhen space-mining start-up, launched a robot that can catch space debris with a large net. China has backed and followed guidelines from the United Nations and the Inter-Agency Space Debris Coordination Committee on space debris removal. In May 2021, the Government released new management standards for small satellites, which call for operators to submit de-orbiting plans and comprehensive safety measures in the event of malfunctions. The Space (Launches and Returns) Act 2018 in Australia requires a debris reduction strategy to be included in an application for a domestic launch licence or a grant of an international payload permit.[96] Similarly, under New Zealand's national

[90] *See e.g.,* UNOOSA, Law of the Russian Federation about Space activity, https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/russian_federation/decree_104_1996E.html. *Law of the Russian Federation about Space activity*, UNOOSA (Feb. 2, 1996), https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/russian_federation/decree_104_1996E.html.

[91] Bundesgesetz über die Genehmigung von Weltraumaktivitäten und die Einrichtung eines Weltraumregisters (Weltraumgesetz) 2011 [Austrian Federal Law on the Authorisation of Space Activities and the Establishment of a National Registry (Austrian Outer Space Act) 2011] Bundesgesetzblatt [BGBl] I No. 132/2011 as amended https://www.ris.bka.gv.at/Dokumente/Erv/ERV_2011_1_132/ERV_2011_1_132.pdf (Austria).

[92] *See*, Annette Froehlich & Vincent Seffinga, National Space Legislation: A Comparative and Evaluative Analysis 15 (2018).

[93] *Id.* at 54.

[94] *Id.*

[95] *See* UNOOSA, CASC Efforts on Dealing with Space Debris Towards Space Long Term Sustainability, available at https://www.unoosa.org/pdf/pres/stsc2013/2013lts-03E.pdf, accessed 19 Jan. 2023. U.N. Office for Outer Space Affairs, *CASC Efforts on Dealing with Space Debris Towards Space Long Term Sustainability*, https://www.unoosa.org/pdf/pres/stsc2013/2013lts-03E.pdf.

[96] *Space (Launches and Returns) Act 2018* (Cth) (AU).

space law, applicants for a launch licence or payload permission are required to submit a detailed strategy for dealing with orbital debris.[97]

According to Japan's Space Activities Act of 2016, spacecrafts must be designed in accordance with safety regulations to ensure that no harmful debris or waste enters space.[98] Detailed debris mitigation criteria could be outlined in Cabinet Office Orders.[99] The Government regulates space endeavours through a licensing mechanism that sends proposals straight to the Prime Minister for approval. Using cutting-edge technology, J.A.X.A. is cleaning up space debris.[100] For the same reason, the private sector has begun working together.[101] Japan is taking huge measures to remove space debris. The collaboration of J.A.X.A. and Tokyo-based Astroscale aims to complete the very first debris-removal mission and provide regular removal services by 2030.

In addition, Astroscale is working on technologies to refuel and repair satellites in space, which would delay their obsolescence and increase their lifespans. With these same technologies, Astroscale's missions could refuel in space, allowing them to clear out more debris continually.

Japan's Government is collaborating with Astroscale to set global benchmarks. The Government started drafting guidelines for organisations conducting space debris removal studies and missions earlier this year. Transparency and notification should be the norm to avoid suspicion and conflict between competitors – experts say.[102]

Under the space regulations of Japan, the neighbouring state of the Republic of Korea does not define any specific comprehensive regulations for the reduction of debris. The Space Development Promotion Act of 2005, however, mandates that the operator of a rocket get a general launch permit and places responsibility for mishaps caused by space objects on the operator of the rocket.[103]

The I.S.R.O. System for Safe & Sustainable Space Operations and Management (I.S.4.O.M.) for the nation is I.S.R.O.'s comprehensive approach to protecting space assets and sustaining space use for national development. It processes observations for orbit

[97] Outer Space and High-altitude Activities Act 2017 (N.Z.).
[98] Act on Launching of Spacecraft, etc. and Control of Spacecraft, Law No. 76 of 2016 (Japan).
[99] Setsuko Aoki, *Domestic Legal Conditions for Space Activities in Asia* 103 (AJIL Unbound ed., 2019).
[100] *See* Ensuring the safety of space missions now and in the future, J.A.X.A.https://www.kenkai.jaxa.jp/eng/research/debris/debris.html; *Ensuring the safety of space missions now and in the future*, J.A.X.A, https://www.kenkai.jaxa.jp/eng/research/debris/debris.html.
[101] *See* Mitsuru Obe, *Japan's Astroscale Launches Space Debris-removal Satellite*, Nikkei Asia (Mar. 22, 2021), https://asia.nikkei.com/Business/Aerospace-Defense-Industries/Japan-s-Astroscale-launches-space-debris-removal-satellite.
[102] *See* Michelle Ye Hee Lee & Lily Kuo, *For Rivals Japan and China, the New Space Race is About Removing Junk*, The Washington Post (Nov. 20, 2022), https://www.washingtonpost.com/world/2022/11/20/japan-china-space-junk-removal-compete/.
[103] Space Development Promotion Act (S. Kor.).

determination; object characterization and cataloguing; analysis of space environment evolution; risk assessment and mitigation; data exchange and collaboration; and more as a response to the increasing number of objects in space and the associated risk of collisions.[104] The Indian Government's proposed Space Activities Bill also needs approval at national level.[105] Limiting space pollution or "adverse impact or pollution to the earth's environment" is a criterion of licence and approval.[106] The draught legislation does not provide any specifics regarding the prevention of space debris. Recent announcements have been made by the I.S.R.O. on the launch of a project to investigate the detection of space debris.[107]

Major space-faring nations have attempted to include a minimum standard for debris mitigation in their own national space legislation. Many countries have made efforts to follow the guidelines laid down in Article 8 of the I.L.A. Model Law. The traditional method for reducing the effects of space debris has consisted of imposing restrictions on space operations in the form of licensing prerequisites. Because orbital access is at risk, both established space-faring states and new entrants in the field of space exploration have a responsibility to maintain a high level of vigilance to ensure that the standard of compliance is not lowered.

CONCLUSION

The advancement of space system technology has brought about remarkable changes in human life by allowing for improved communication, navigation and remote sensing capabilities.[108] However, there is a serious danger posed by space debris to human endeavours. Lack of effective regulation under national space laws may also severely diminish the commercial utility of outer space. As a result, keeping orbital regions free of debris is crucial for their continued usage in the future.[109]

[104] *See* Nagaraja Gadekal, *ISRO Launches World's First Facility to Track Space Debris, Safeguard Assets*, The New Indian Express (July 12, 2022), https://www.newindianexpress.com/states/karnataka/2022/Jul/12/isro-launches-worlds-first-facility-to-track-space-debris-safeguard-assets-2475563.html.

[105] *See* Space Activities Bill, 2017, Bill No. 11020/2/2015, Acts of Parliament (India).

[106] *Id.*

[107] *See* D. S. Madhumathi, *ISRO Initiates 'Project NETRA' to Safeguard Indian Space Assets from Debris and Other Harm*, The Hindu (Sept. 24, 2019), https://www.thehindu.com/sci-tech/science/isro-initiates-project-netra-to-safeguard-indian-space-assets-from-debris-and-other-harm/article29497795.ece.

[108] *See* Kisiel, *supra* note 23, at 223.

[109] *See* CO.PU.O.S. Guidelines, *supra* note 11, at 5.

Some of the U.N. Guidelines' non-binding aspects have been incorporated into national space legislation to provide a domestically enforceable framework.[110] Because of this, the instruments of soft law have provided the required stimulus.[111] Sustainability in space exploration is crucial to solving the space debris problem.[112] It is imperative that states have adequate motivation to lessen the amount of space debris in order to keep space activities risk-free.[113] The CO.PU.O.S. Scientific and Technical Subcommittee has brought attention to the fact that even with the lack of enforceable international laws, individual nations are taking concerted steps to lessen the amount of debris in space. It entails working on de-orbiting, passivating, extending the life of, and decommissioning satellites, as well as improving launch vehicle and spacecraft designs and software development.[114] Efforts at state level should mirror the mitigation criteria outlined in relevant international agreements.

The alignment of interests across state space agencies and corporate parties, beyond borders, likely accounts for the overall uniformity in domestic legislation. The implementation of the I.L.A. Model brings the process of space regulation under national laws to a higher level of prominence. It establishes a precedent for the widespread acceptance of a minimal level from which no deviation is allowed to be made. To combat the threat of space debris, it is imperative that best practices around the world be incorporated under domestic law and subject to a regime of accountability. Thus, national space laws can provide fuel for the long-term utilisation of space. Improved compliance with debris reduction regulations under national space legislation is encouraging, but the issues remain severe. At first, the purpose of such legislation was limited to fulfilling the requirements of Article VI of the Outer Space Treaty, which called for the regulation of the space operations of non-Government companies.[115] After that, subsequent factors such as globalisation and the unrestricted movement of

[110] *See id.* at 21.

[111] *See generally* Łukasz Kułaga, *Kodyfikacja i postępowy rozwój międzynarodowego prawa kosmicznego przez soft law* [*Codification and Progressive Development of International Space Law Through Soft Law*], 79 Ruch Prawniczy, Ekonomiczny i Socjologiczny [J. L., Econ. & Socio.] 163 (2017) (Pol.).

[112] *See* Hakeem Ijaiya, *Space Debris: Legal and Policy Implications*, 2 Env't Pollution & Prot. 23 (2017) (China); *see also* Maria M. Kenig-Witkowska, Międzynarodowe prawo środowiska. Wybrane zagadnienia systemowe [International Environmental Law. Selected Systemic Issues] 183-86 (2011) (Pol.); *see* Maria M. Kenig-Witkowska, *Environmental Protection in Corpore Iuris Spatialis (Mapping the Issue)*, Studia Iuridica, 2016, at 141 (Pol.); *see* D. Kuzniar-kwiatek, *The United Nations and the Protection of the Environment of Space and Celestial Bodies*, in E. Cata-wacinkiewicz et al., The United Nations System From The Polish Perspective 269-80 (Warsaw: C.H. Beck, 2017) (Pol.); *see* Stubbe, *supra* note 28, at 13-59; *see* Mark Williamson, *Space Ethics and Protection of the Space Environment*, 19 Space Pol'y 47 (2003) (U.K.).

[113] *See* U.N. Office for Outer Space Affairs, Rep. of the Legal Subcommittee, on Its Fifty-fourth Session, U.N. Doc. A/AC.105/1090, pts. 166-167, at 25-26 (Apr. 24, 2015).

[114] *See generally* U.N. Office for Outer Space Affairs, Compendium of Space Debris Mitigation Standards Adopted by States and International Organizations (May 15, 2023), https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html.

[115] *See* Hobe, *supra* note 62, at 82.

transnational money contributed to an increase in the participation of the private sector in space operations. Private space operators support a concrete debris reduction standard because debris threatens capital-intensive assets.[116]

Mandatory debris reduction measures are now a part of the licensing requirements of national space laws. It is a standard part of all legal documents pertaining to legal spaceflight. Sanctions against engaging in space-related activities without proper authorisation need to be strengthened. The limitation shall not only be upon the directions so elaborated by the provisions of the Security Council and General Assembly as given in international law on issuance of sanctions, but on the misuse of space commons too. To ensure long-term space access, a mere box-ticking method is unlikely to be effective. The domino effect of space debris compels a re-examination of existing domestic legislation to make improvements, particularly, in light of the growing risk of inaccessibility.[117]

Technical due diligence procedures must be part of licensing criteria in all jurisdictions. Space collisions can be avoided if deterrent sanctions are implemented. Those who violate the rules for debris reduction should be held liable regardless of whether they are state entities or private space players. The reason for the illegality regarding the formation of debris needs to be investigated by governments. As it is often difficult to identify fault through direct causation in the case of space debris, a system of unlimited liability would be an effective deterrence. Under domestic law, the precautionary concept needs to be clearly established. Domestic space laws might involve punishments and particular remedial actions for the clean-up of orbital debris. States must define who can remove space debris,[118] and perhaps consider hiring private players.[119] In order to protect third-party states from any legal consequences related to the removal of space debris, a restricted waiver scheme could be an effective tool. Legislative changes alone are not enough to build a debris-tracking system, and so continual funding for research is required. States may begin the disposal process once they have identified probable debris clusters in orbit.

When nations pass their own space laws, it serves as a safety valve that can revitalise international cooperation to reduce the threat of space debris. The global framework lacks enforceable orbital debris rules as noted previously. At the I.L.A.'s sixty-sixth Conference in 1996, delegates voted to approve a convention to protect

[116] *See* Tronchetti, *supra* note 22, at 81; *see also* COPUOS Guidelines, *supra* note 11, at 223.
[117] *See* Kaineg, *supra* note 30, at 281.
[118] *See generally* Abbas Sheer & Shouping Li, *Space Debris Mounting Global Menace Legal Issues Pertaining to Space Debris Removal: Ought to Revamp Existing Space Law Regime*, 10 Beijing L. Rev. 423, 425 (2019) (China).
[119] *See generally* Pelton, *supra* note 66, at 44.

Earth's space against debris.[120] National rules required states to cooperate to "avoid, reduce, and control space debris".[121] Domestic regulations may not be a long-term answer if there is a weak international framework for debris mitigation. State governments use their legislative powers to advance their own interests through *ad hoc*, piecemeal interventions.[122] The debris mitigation rules under domestic law may become customary international law soon through consistent state practice and *opinio juris*.[123]According to some academics, the process is finished once a country passes legislation regulating space travel.[124]

Telecom satellites were the first space-based infrastructure to be run by a private company.[125] In the present day, private industry has been at the lead of recent space tourism activities. It is expected that orbital debris would rise with the commercial exploitation of the space. It presents an opportunity for states to pursue timely actions for debris reduction that go beyond their particular domains which is a benefit.

Active space debris reduction and removal must be envisioned as a global, formally institutionalised approach.[126] The long-term gains obtained via regulation may be sufficient to compensate for the costs incurred when establishing an international agency of such extent. It is also necessary to reach an agreement on an appropriate technology for cleaning up space in orbit. Especially since it is being developed using technologies of I.o.t. and A.I. – Spinnaker3 and Obruta being some of the examples that have been developed for proper implementation of A.D.R. services. In order to guarantee long-term access to space, it is necessary to determine whether or not the existing technical requirements and safety procedures can be improved. The CO.PU.O.S. can also be involved in the process of identifying and removing space debris by facilitating the creation of a unique treaty on the regulation of space debris.[127] The spacefaring nations that have space laws in motion and nations that aim to accentuate their being there must include the elements of sustainability and technology to modernise their space laws and establish a robust system for enforcing them.

[120] *See* Karl-Heinz Bockstiegel, *ILA Draft Convention on Space Debris*, 44 Zeitschrift für Luft-und Weltraumrecht [German J. Air & Space L.] 29, 30 (1995) (Ger.).
[121] *Id.* at 31.
[122] *See* Tronchetti, *supra* note 22, at 82; *see* Larsen, *supra* note 20, at 479.
[123] *See* CO.PU.O.S. Guidelines, *supra* note 11, at 272.
[124] *See* Von der Dunk, *supra* note 17, at 319.
[125] *See* Hobe, *supra* note 66, at 81.
[126] *See* Sethu & Singh, *supra* note 19, at 96.
[127] *See* Sheera & Li, *supra* note 122, at 433.