Barriers and Gateways to Cleaning Up Earth Orbit: The Legal, Economic, and Political dimensions of Debris Remediation

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The preponderance of human-made debris in Earth orbit has long been recognised as a significant threat to continued safe operations in space. National space agencies and private space companies are paying considerable attention to the technical questions surrounding the active removal of debris (ADR). Nonetheless there are still significant legal, economic, and geopolitical questions that need to be addressed before any meaningful and sustained industry around the removal of debris can be established. This discussion will focus on identifying the legal issues of responsibility, jurisdiction and liability and proposing possible solutions within the current nexus of international agreements. Yet these must be considered alongside the economic roadblocks to funding ADR; the challenges for states looking to collaborate in current geopolitical circumstances; and the often overlooked 'data deficit' in respect of the space surveillance and tracking (SST) capabilities needed to enable the safe removal of debris. It is contended that any system for managing ADR, Debris Mitigation and general protection of the space environment should not emerge in isolation. A coherent system of managing and coordinating the orbital environment needs to be developed. This article will argue that it is for individual nations to show political leadership and an economic commitment to properly manage the delicate extraterrestrial environment. Failure to do so will represent a missed opportunity and leave a troubling legacy for future generations.

Keywords: Active Debris Removal, Astropolitics, Space Law, Dual use technology, Space Environment

1 INTRODUCTION

The removal of space debris from the orbit of the Earth is a technically formidable undertaking, and while both private companies and national space agencies have made significant progress in the area, the activity is still in the experimental stage of development.[2] Establishing the technical feasibility of the remediation process is only the first step towards solving the debris problem.[3] The next area of inquiry is whether the removal of debris is lawful. This question gives rise to several legal issues surrounding the status of objects launched into space and how to deal with such objects when they pose a threat to the continued safe operations in space. From this follows questions regarding the economic viability of debris remediation and

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[2] Jonathan Amos, *Astroscale space debris removal demo set for launch*, BBC News, 17 March 2021, https://www.bbc.co.uk/news/science-environment-56420047 All websites cited in this article were accessed 31 Dec. 2022.

[3] C. Priyant Mark & Surekha Kamath, *Review of Active Space Debris Removal Methods*, (2019) 47 Space Policy, 194–206.

the diplomatic problems involving technology that can be used for both peaceful debris removal and hostile attacks on satellites. Furthermore, it will be suggested that current tracking capabilities of the space environment are not sufficiently advanced to fully support debris remediation missions.

When determining the suitability of the current legal order to deal with the challenges posed by remediation of space debris, several key areas will need to be considered. Part One of the discussion will involve examination of the definitional problems that have bedevilled the whole area of space debris. Next to be considered is the fundamental question regarding the lawfulness of debris remediation, which will feed into questions of responsibility, jurisdiction, and control of the debris as well as protection of proprietary technology and liability. Perhaps of more significance, and the essence of what needs to be considered, is whether the new ideas and concepts for dealing with debris pose insurmountable problems for the established legal order. Addressing that question will go a long way to help framing a system for which the only purpose will be the cleaning of orbits and celestial bodies from the detritus of human space activity.

The question of legality alone provides an incomplete picture of the barriers to establishing a system for the remediation of debris. Part Two of this article will start by addressing the elementary economic question as to who will pay for the development of expensive novel remediation systems. The discussion will then examine the so-called dual use conundrum as many of the concepts underpinning debris remediation could be used as aggressive, anti-satellite weapons as well as for the active removal of debris. Finally, the problems of insufficient space surveillance and tracking will be considered, and the discussion will highlight that the data needed to safely undertake debris remediation may not be available to either operators or governments. This article will be both original and significant in highlighting all of these problems together with the legal concerns from a holistic perspective rather than each as separate issues to be solved in isolation.

The third part of the discussion will provide solutions to the problems outlined in the previous two parts. It will be argued that, while there are certainly intricate legal problems to be solved, these are not insurmountable. The implementation of non-binding guidelines around the mitigation of debris and long-term sustainability of outer space activity will highlight the value of coordination of information and data to provide a complete picture of the orbital environment. The fundamental idea underpinning this discussion is that political will is the only ingredient missing. If just one space-active nation with legacy debris provided economic investment and made a political commitment to remove their own debris, this could provide impetus to both clean up Earth orbit and put in place the data and security requirements to secure the future of human space activity.

1.1 THE LEGAL CONCERNS OF DEBRIS REMEDIATION

It is not within the purview of this piece to provide an overview of the general legal environment governing human space activity. The focus will remain on the development of the optimal method of governance for debris remediation. Nonetheless, some exposition of the extant law is a necessary first step to understanding why the legalities of debris remediation are perceived as being unclear. The legal framework providing for law in outer space is an intricate nexus of international treaties and national legislation.[4] Any consideration of the legal framework, however, must start with the five international treaties negotiated during the early years of human exploration within the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS).

The Outer Space Treaty of 1967[5] reflected the normative principles that had emerged in the early years of human space activity through UNCOPUOS and expressed through various UN General Assembly resolutions.[6] Indeed the 1967 Treaty still provides the central trunk of international space law and the first port of call when trying to establish the legal position of a particular activity. Article I of the 1967 Treaty confers upon State Parties the freedom to use and explore outer space and other celestial bodies free from discrimination, on the basis of equality and in accordance with international law. Article I provides freedom of access for States and freedom of scientific investigation. These are the three broad activities; use, exploration and scientific investigation, which are the province of all mankind. The Treaty, therefore, 'grants certain freedoms relating to these activities' and then places limitations upon them, ensuring that the use, exploration and scientific investigation of outer space is never unfettered.[7]

The Outer Space Treaty, then, provides core principles upon which human activity in space can be built. By drawing the activities that are permitted in the widest possible way, the treaty avoids mention of specific technologies or techniques within the Articles themselves. In respect of the removal of debris, the

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4 Christopher Johnson, *International Law governing outer space activities*, in Yanal Abul Failat & Anél Ferreira-Snyman *Outer Space Law 2nd Edition* (Global Law and Business 2022) 13–30, 14.

5 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, October 10, 1967, 610 U.N.T.S. 205 (hereinafter referred to as the Outer Space Treaty).

6 Bin Cheng, *Studies in International Space Law,* (OUP 2004), 264 referring to *inter alia* 'International cooperation in the peaceful uses of Outer Space.' Resolution 1721 (XVI) of 20 December 1961 A/5026 and 'Declaration of legal principles governing the activities of States in the exploration and use of outer space.' Resolution 1962 (XVIII) of 13 December 1963 A/RES/1962 (XVIII).

7 Stephan Hobe, 'Article I', in Stephan Hobe, Bernhard Schmidt-Tedd and Kai-Uwe Schrogl (eds) *Cologne Commentary on Space Law Vol I* (Carl Heymanns Verlag 2009) 25–43, 27.

fundamental question is whether the mission itself falls within the 'use' of outer space as permitted by the Treaty. Both as a technique in and of itself, but also as a means of developing the technological capacity to clean up space, there is little doubt that any State that either engages in or authorises debris remediation missions will be using space within the constraints placed on it by Article I.

1.2 DEFINING DEBRIS

Notwithstanding the *prima facie* case for debris remediation as being a legitimate use under the Outer Space Treaty, it is worth considering what is missing from the existing treaties, laws, and agreements in this regard. At first sight, the most egregious absence is any internationally agreed, mandatory governance framework for managing the debris situation. Indeed, at the time of writing, there is no national law which speaks specifically to the removal of debris.[8] With the whole environmental movement being viewed as outside the mainstream for much of the 20th Century,[9] the issue of debris and how to deal with it was simply not a concern of those who were charged with drafting the early principles governing human activity in outer space,[10] concern instead being that any environmental protection measures would 'unnecessarily limit space activities'.[11]

If there are no binding agreements on the management of debris, it is perhaps not surprising that there is no definition of what constitutes space debris in any of the international space treaties either. The closest the treaties get is when making reference to 'space objects.' Although this term is not explicitly defined in any of the international space treaties, it is defined with reference to itself in Article I(d) of the Liability Convention[12] where the term 'space object includes component parts of a space object as well as its launch vehicle and parts thereof.'[13] It has been inferred from the negotiations surrounding the international space treaties that the term 'space object' refers to the 'common understanding of a human-made object which is launched or intended to be launched into outer space.'[14] This term, therefore, is

[8] P.J. Blount, *On-orbit servicing and Active Debris Removal*, in Anja Nakarada Pecujlic & Matteo Tugnoli, *Promoting Productive Cooperation between Space Lawyers and Engineers*, (IGI Global 2019) 179–192, 180.

[9] Christopher J. Newman & Mark Williamson, 'Space sustainability: Reframing the debate' (2018) 46 Space Policy 30-37, 31

[10] Francis Lyall & Paul Larsen, *Space Law: A Treatise 2nd Edition*, (Routledge 2018) 272.

[11] Alessandra Marino & Thomas Cheney, *Centring Environmentalism in Space Governance: Interrogating Dominance and Authority Through a Critical Legal Geography of Outer Space,* (*in press*) Space Policy, 3.

[12] Convention on International Liability for Damage caused by Space Objects, 29 March 1972; 961 UNTS 187: entered into force 1 September 1972 (hereinafter referred to as the 'Liability Convention').

[13] Liability Convention, Art. I(d).

[14] Lesley Jane Smith & Armel Kerrest, Art. I (Definitions) LIAB, in Stephan Hobe, Bernhard Schmidt-Tedd & Kai-Uwe Schrogl (eds) *Cologne Commentary on Space Law Vol II* (Carl Heymanns Verlag 2013), 83–226, 114.

intended to cover everything artificial that is put into space. As such, 'space object' inevitably covers the debris arising from human space activity.

Whilst all space debris will come under the broadly drawn term of 'space object', clearly not all space objects will be debris. The international community (while not in treaty form) has sought to try and define debris as a phenomenon to be tackled. The Inter Agency Debris Coordination Committee,[15] an international forum dedicated to the worldwide coordination of activities to mitigate debris and exchanging research on space debris, drew up a definition of space debris as 'All human made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional.'[16] This definition is one that has been widely adopted by the international community and has been incorporated in subsequent guidelines regarding the mitigation of debris.[17]

Clearly, the definition places two distinctions upon space objects that make them debris. First is their location. The definition limits debris to those objects in Earth orbit or re-entering the atmosphere. The increased activity seen from the United States (US) Project Artemis and the avowed intention to have humans 'living and working on the Moon by 2030'[18] means the creation of an infrastructure involving many missions and a number of satellites. The debris mitigation guidelines are limited to debris in Earth orbit and not those in lunar orbit or on the Moon. If the ultimate aim is to create a system of debris remediation which cleans the detritus of all human activity in space, it would surely be in the interests of all lunar inhabitants that nations, companies, and individuals not replicate the mistakes that have made the debris situation around Earth so perilous.

It is not an insurmountable task to remedy the locational difficulties in the definition. The second issue, that of functionality, is somewhat harder to reconcile. It has several dimensions. First, it must be acknowledged that in respect of functionality, reducing the operational status of a satellite to either simply 'working' or 'not working' may not be helpful, given that the definition does not include the adverb 'completely'. The satellite could be non-functional in respect of one aspect and yet be operational in other respects. It may be non-functional but capable of being serviced to restore that functionality.[19] As has

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[15] For further details on the composition and terms of reference, *see* https://www.iadc-home.org/

[16] IADC Space Debris Mitigation Guidelines, IADC-02-01 Rev. 3 (10/06/2021).

[17] Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, as annexed to UN doc. A/62/20, Report of COPUOS (2007) No. 1 Para. 1.

[18] Ian Sample, *Astronauts to live and work on the moon by 2030, Nasa official says*, The Guardian, 20 Nov 2022, accessed online at https://www.theguardian.com/science/2022/nov/20/astronauts-moon-nasa-artemis-mission-space

[19] For discussion on the commercial and economic viability of on-orbit servicing, *see inter alia* Andrew Graham & Jennifer Kingston, *Assessment of the commercial viability of selected options for on-orbit servicing*, (2015) 117 Acta Astronautica 38–48.

already been noted, the issue of whether functionality is an objective criterion or whether 'the status as functional or not can only be rather subjectively determined by the State of Registry is left unresolved'.[20]

These definitional issues, therefore, provide a first stumbling block in the search for a governance system that can effectively manage the peaceful remediation of space debris. Whilst there is a recognised definition within the guidelines for debris mitigation, this may not address concerns of States or owner/operators who would be concerned about the arbitrary assigning of non-functional status to an asset that they may wish to either attempt to recover or attempt to repair. This section has, thus far, established a *prima facie* case that debris remediation is a legitimate use of outer space by a State. It has also identified a working, if not entirely unproblematic, definition of what exactly is to be removed in any such mission. It is necessary now to turn the focus upon the legal constraints for responsibility, jurisdiction, and control over space objects, to identify what factors a State might consider when authorising such missions.

1.3 RESPONSIBILITY FOR DEBRIS REMEDIATION

When considering establishing a stable governance system for the remediation of debris, it is necessary to consider three key topics addressed in the OST, namely responsibility, jurisdiction and control, and liability.

Article VI is the first of these, as it establishes, inter alia, that States are internationally responsible for all national activities in outer space. The fact that much of the experimental debris remediation is being pursued by private companies does not matter for the purposes of Article VI. Whether remediation of debris is carried out by 'government agencies' or 'non-governmental entities', it is States that are ultimately responsible. Indeed, States are also responsible for ensuring the activities are carried out in accordance with the terms of the treaty.[21]

If debris remediation is to be carried out by non-governmental entities such as private companies, then the 'appropriate State Party to the Treaty' is under a positive duty to ensure that such activities are authorised and subject to continuing supervision.[22] This means that, irrespective of how independent a private company may see itself from State control, or how distant a State may feel from the private activities of a company, the positive duty under Article VI means that the State will still bear international

[20] Stephan Hobe & Jan Helge Mey, *UN Space Debris Mitigation Guidelines*, 58 (2009) ZLW 388–403.
[21] Outer Space Treaty, Art. VI.
[22] Blount, *op. cit.* n. 8 at 185.

responsibility for any harm that a private company may cause. National activities are specified as distinct from the activities of international organisations. Those States that are contemplating debris remediation, or as is more likely, have companies within their boundaries who are similarly engaged, have the twin duties of authorising and continually supervising these missions.

Removing debris is a sufficiently complex activity to require collaboration across agencies and even across national boundaries. This is covered within the Outer Space Treaty and such cooperation will be considered a national activity if it is undertaken by one national agency, company or individual alone or working in cooperation on distinct activities.[23] When considering the debris remediation efforts of the European Space Agency (ESA) such as the ClearSpace-1 mission,[24] responsibility for the activities of international organisations is held jointly by the organisation and any States members that are parties to the Treaty.[25]

The contours of Article VI and the drafting of the 1967 Treaty clearly intend to assign all non-governmental space activities to a State.[26] That responsibility means that States intending to authorise remediation activities bear a significant regulatory burden in this respect. It would be unsurprising if State regulators were unduly cautious in granting licences for remediation missions, given the nascent state of the technology and the industry. This, therefore, is the paradox; regulators require proof that the technology is ready, yet the only way for commercial debris removal companies to adequately demonstrate that the technology is ready is by orbital testing.

There have been suggestions made in respect of a future market where a third-party company will engage in remediation missions.[27] It is easy to imagine the reluctance of a regulator in accepting international responsibility for the space activity of a private company in seeking to actively remove the space object of another State from orbit. Article VI of the 1967 Treaty undoubtedly makes national regulators tread cautiously when authorising remediation missions. This, in turn, adversely affects investment in private companies, meaning the technology develops less quickly. This vicious circle is unavoidable and means the more novel and experimental the technique to remove debris is, the more likely

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23 Michael Gerhard, 'Article VI' in Stephan Hobe, Bernhard Schmidt-Tedd & Kai-Uwe Schrogl (eds) *Cologne Commentary on Space Law Vol I* (Carl Heymanns Verlag 2009) 103–125, 109–110.

24 For further details see European Space Agency, *ESA Purchases World-first Debris Removal Mission from Start-up*, https://www.esa.int/Space_Safety/ESA_purchases_world-first_debris_removal_mission_from_start-up

25 Gerhard, *op. cit.* n. 23 at 122.

26 *Id*. at 114.

27 Brian Weeden, *Overview of the Legal and Policy Challenges of Orbital Debris Removal*, (2011) 27 Space Policy 38–43, 41 and Arpit Gupta, *Regulating Space Debris as Separate from Space Objects*, (2019) 41 U Pa J Int'l L 223-248, 230. Both discussions have expressed scepticism as to the legality and viability of such a third market service at the present time.

that investment will have to come from States. The net effect of Article VI is that whilst the private sector may be developing the technology, it is the State which will ultimately end up having to subsidise remediation.

A final thought about the notion of responsibility for national space activity. Article VI holds that States bear the responsibility for national space activity. A question, therefore, arises as to whether there is a duty on States to clean up their debris. Academic comment has suggested that 'there is ample evidence that a duty to remediate space debris can be derived from current International Space Law', although the precise contours of this duty are not clear.[28] Whether such a duty exists in fact and whether States feel bound by it is a different question and likely to be answered in the negative. The reality is, the decision to engage in, finance and authorise debris remediation will always be a question of policy and pragmatism rather than being derived from an abstraction of international law.

1.5 JURISDICTION, CONTROL, AND THE DATA DEFICIT

If Article VI assigns all private and non-State entities who wish to engage in remediation activities to a responsible State, Article VIII of the Outer Space Treaty provides a further layer of accountability, that of the requirement of registration in exchange for jurisdiction and control of a space object.[29] Registration is the linkage that ties a launching State to a particular space object and the Treaty provides an incentive for registration by endowing the State of registry with jurisdiction and control over the space object. As with liability, the Outer Space Treaty serves merely to enunciate the principle. It is the Registration Convention of 1975 that identifies the contours of Article VIII and provides details of the registration requirements.[30]

When a State has a space object placed on its registry, under the terms of Article VIII it obtains perpetual jurisdiction and control over that object. There is no mention in Article VIII that this is dependent on functionality, nor does it depend on the object remaining intact.[31] There are no concepts

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28 Stephan Hobe, *Environmental Protection in Outer Space: Where We Stand and What is Needed to Make Progress with Regard to the Problem of Space Debris*, (2012) 8 Indian J. L. & Tech. 1–10, 8.

29 Registration provides for '… in a sovereignty-free area, a chain of attribution between the launching State, the space object, international responsibility for space activity and jurisdiction and control.' Quoted in Bernhard Schmidt-Tedd and Stephan Mick, 'Article VIII' in Stephan Hobe, Bernhard Schmidt-Tedd & Kai-Uwe Schrogl (eds) *Cologne Commentary on Space Law Vol I* (Carl Heymanns Verlag 2009) 146–168, 147.

30 Convention on Registration of Objects launched into Outer Space, 14 January 1975; 1023 UNTS 15, entered into force 15 September 1976 (hereinafter referred to as the Registration Convention).

31 *See* National Research Council Committee for the Assessment of NASA's Orbital Debris Programs Summary Report, Limiting Future Collision Risk to Spacecraft: An Assessment of NASA's Meteoroid and Orbital Debris Programs, (2011) (hereinafter, NRC Report), http://www.nap.edu/catalog.php?record-id=13244 or https://perma.cc/QCX8-RVMK

within international space law analogous to the Maritime law of abandonment and salvage.[32] Nor does this appear to be a likely development in the near future. The effect of this on remediation is that unilateral action authorised by State 'A' to remove a defunct rocket body registered to State 'B' would lead to the space object of State 'B' being destroyed, violating the core principle of Article VIII and opening State 'A' up to liability for damage under Article VII.[33]

The register itself records details of the launching State and basic orbital parameters of the object and the rocket body.[34] Additionally, the Registration Convention provides that the State of registry may, from time to time, provide the Secretary-General of the UN with additional information concerning a space object carried on its registry.[35] Whilst this practice is broadly observed by States, it is certainly not universal. This, in theory, provides a mechanism for States to provide regular updates on all objects, including those that are non-functional and those that are generated through impacts or explosions. In reality, the majority of States provide information on functional objects and launch vehicle stages but this only extends to the immediate post-launch phase.[36] There is little engagement beyond that, because the crucial aspect of the Registration Convention is that a space object has been registered and a launching State has been assigned jurisdiction and control.[37]

While much discussion has focused on the jurisdiction and sovereignty issues surrounding Article VIII, it is that lack of information about the location and condition of space objects that will be crucial for the newer methods of removing space debris. When considering the level of information that will be required for these novel systems of debris remediation, it must be remembered that the UNOOSA Register should be viewed as a historical document rather than an accurate picture of the current location and condition of the space object. The recently promulgated UNCOPUOS Guidelines for the Long-Term Sustainability of Outer Space Activity (LTS Guidelines)[38] was a tacit recognition that the legal

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32 For further discussion, *see* Martha Mejia-Kaiser, *Removal of Non-Functional Space Objects Without Prior Approval*, (2007) Proc. on L Outer Space 293–296.

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

34 Registration Convention, Art. IV 1(a-e).

35 Registration Convention, Art. IV 2.

36 Schmidt-Tedd & Mick, *op. cit.* n. 29 at 155.

37 *Id*.

38 UN Committee on the Peaceful Uses of Outer Space, Guidelines for the Long-Term Sustainability of Outer Space Activities (2018), U.N. Doc. A/AC.105/2018/CRP.20.

requirements for the sharing of data about the location of space objects and debris was woefully inadequate given the current state of the orbital environment.

1.4 LIABILITY AND DEBRIS REMEDIATION

The final area of concern with the substantive areas of international law is in the contentious area of where liability will rest should the novel areas of debris remediation result in damage to a space object of another State. Article VII of the Outer Space Treaty provides for liability for damage caused by a nation launching space objects.[39] This creates a subset of States Parties to the Treaty, that of 'launching States'. Article VII details the four ways in which a State can become a launching State.[40] Article VII is, however, somewhat imprecise about the nature of the liability for damage, and the Liability Convention of 1972 provides some further detail, if not clarity.

It is not the remit of this discussion to conduct a deep dive into the many questions arising out of liability for damage to space objects in outer space.[41] Nonetheless, as can be seen from the Liability Convention, there is a two-tier regime for ascribing liability for damage caused by the space object of one State to another. First, for States whose space objects cause damage to persons or property on the surface of the Earth and aircraft in flight, liability will be absolute.[42] Where the space object of one State causes damage to the space object of another State anywhere but the surface of the Earth or in airspace, liability will be assessed on a fault basis.[43] It is possible that either of these liability regimes could be engaged should more experimental and novel forms of debris remediation be trialled.

Given the experimental nature of the debris remediation methods, the question of liability is crucial to understanding the nature of the governance system that will be universally accepted. Leaving to one side for the moment, the idea of damage on the Earth or to an aircraft in flight, the liability framework for damage on-orbit as found in Article III of the Liability Convention poses the biggest conundrum. The component elements require that damage is caused to the space object of State 'A' by the space object of

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39 *Op. cit.* n. 33.

40 Art. VII provides that a State will be a launching State, first, and most obviously, through launching a space object. Second, by procuring the launch. Third, by allowing its territory to be used for a launch and finally by allowing its facilities to be used. This is confirmed in the Liability Convention, Art. I(c).

41 There are many detailed discussions on this area. *See,* for example, Elina Morozova & Alena Laurenava, *International Liability for Commercial Space Activities and Related Issues of Debris*, (2021) Oxford Research Encyclopedia of Planetary Science. Accessed online at https://oxfordre.com/planetaryscience/view/10.1093/acrefore/9780190647926.001.0001/acrefore-9780190647926-e-63

42 Liability Convention, Art. II.

43 Liability Convention, Art. III.

State 'B',[44] and that State 'B' will be liable only if the damage is due to its fault or the fault of persons for whom it is responsible. This, however, is an overly simplistic illustration. Given the criteria outlined in Article I(d) of the Liability Convention, there may be multiple launching States involved in a remediation mission, such as the launching State of the target and the launching State of the space object designed to remove the target.[45]

Determining the contours of what fault might look like in regular space operations is equally as complex. There may be some common understanding about what the operators of spacecraft should do, and clearly, there will be detailed mission plans. That does not, however, cover all eventualities. If the focus is on the more novel solutions for remediation of space debris, then they will – by their very definition – be highly experimental. The information flow needed between those planning the remediation mission and the state of registry of the target vehicle (and those who will have access to the technical schematics of the target satellite) will need to be significant. If either party fails to provide sufficient information, they may find themselves inadvertently at fault. Similarly, who has the duty to find out the condition of the target vehicle? If it is a defunct satellite, then perhaps the State of Registry may, but this may not be the case for a third stage of a rocket.

This is, therefore, the fulcrum of the international legal regime and the point at which the legal dilemmas facing debris remediation crystalise. The Outer Space Treaty makes States responsible for their national space activities (including private companies) through Article VI, grants perpetual jurisdiction and control over objects to the State that has registered them through Article VIII, and makes launching States liable for damage caused by their space objects through Article VII. Liability, Jurisdiction, Registration and Responsibility all stack up to provide significant legal conundrums when set against highly experimental debris remediation techniques. And each one of these legal issues has the potential to degrade an already fragmenting international order.

Any disruptive technology brings with it legal challenges. The attempts to try and in some way decouple the definition of space debris from the legally accepted term 'space object' is a reach that the international community does not yet seem ready to make and the IADC definition will continue to be used within the realm of debris mitigation. There are sufficient issues in respect of liability, jurisdiction,

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44 Art. III also includes damage to the persons or property on board such a space object. It is assumed that for the purpose of debris remediation, both space objects will be uncrewed and will be items such as spent rocket bodies or non-functioning satellites.

45 Blount *op. cit.* n. 8 at 184.

and control to herald a note of caution for regulators when contemplating third-party remediation.[46] There is certainly no law or treaty to suggest that removal of third-party debris without the consent of the State of registry would be acceptable.

2 GEOPOLITICS, ECONOMICS, AND THE DATA DEFICIT

Having examined the legality of space debris remediation, the discussion will now go on to argue that, despite the protests regarding the current state of the law, the biggest single barriers to the successful development of a thriving, civilian-focused debris mitigation governance framework are a mixture of political, economic, and cultural factors. It will be proposed that these factors limit the creation of the law and governance framework rather than the law and governance framework being the limiting factor. It will be demonstrated that the legal issues highlighted above are not without possible solutions, should the political will exist.

2.1 THE ECONOMIC CHALLENGE FOR DEBRIS REMEDIATION

There is little doubt that the development of space debris remediation capability and the attendant legal framework will be of huge benefit for human activity in outer space. It will reduce, although not remove, the danger posed by debris and could itself become an industry that will generate a significant amount of revenue for the space economy.[47] With the stakes so high, the development of such technology would seem to be imperative for the space sector. Yet progress continues to be slow, not only because of legal questions but also significant economic ones. Like all attempts to build infrastructure in outer space, the cleaning up of the orbit of the Earth will be extremely expensive. The cost of the ClearSpace -1 mission[48] has been estimated at EUR122 million and while that may drop as technology develops, it is still a very large amount (one mission would equate to a quarter of the total space budget of the United Kingdom).[49]

The problem with this financial burden is that, at present, there is no real incentive to pay these vast sums. The private space sector is simply not able to afford it without a heavy government subsidy and

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[46] ClearSpace and Astroscale have both been awarded funds from the United Kingdom (UK) Space Agency to develop the technology for debris remediation projects so this is an area where there may be developments. *See* for details, Clive Simpson, *UK gives space junk clearance missions priority funding*, in Room: The Space Journal of Asgardia, 29 September 2022 accessed online at https://room.eu.com/news/uk-gives-space-junk-clearance-missions-priority-funding

[47] *See*, for example, Ryan Leonard & Ian Williams, *Viability of a circular economy for space debris*, (2023) 155 Waste Management 19–28.

[48] For further information see https://www.esa.int/Space_Safety/Clean_Space/ESA_commissions_world_s_first_space_debris_removal

[49] For further details see https://www.gov.uk/government/publications/uk-space-agency-spending-report-may-2022

governments are not willing to commit large sums of money into this venture. The market needs to be kickstarted but, now, there is no sign of where this will come from. There have been suggestions of a launch tax, an orbital usage fee or even an imaginative 'bottle deposit system', where users pay a deposit for each space object they place in orbit, then if they fail to de-orbit the craft, a third-party company could collect the deposit and conduct the de-orbiting.[50] Yet none of these schemes has come to fruition nor even looks remotely likely to be adopted. The launch market is already fiercely competitive, and no State appears likely to introduce a tax to make their launch providers less competitive.[51]

One aspect of the 'how to pay for clean-up' question is to conceptualise space debris as akin to a terrestrial phenomenon and a related environmental issue.[52] Debris could be viewed as either pollution or industrial waste or a redundant asset operating in an extreme environment that requires cleaning up. Certainly, it has already been suggested that a decommissioning regime for satellites is one way to create a market for debris remediation.[53] In the way nations operate for decommissioning nuclear reactors or oil rigs, the regulator could mandate that missions are accompanied by a decommissioning plan and a contribution to the cost of mitigation.[54]

In another sense, space debris can be seen as pollution in that it does cause potential harm as it produces a hazard to 'navigation' even though in general it is 'inert'. Industrial waste may also be an appropriate analogy as it is the by-product of an industrial process and existing regulations for dealing with satellite end of life have more in common with processes for dealing with industrial waste than pollution. Industrial waste is not inherently 'hazardous'; it just needs disposing of – further, there is not a sense of 'blame' connected to producing industrial waste, at least not in the sense as there is with pollution. It is the failure to deal with or properly dispose of industrial waste that is cause for blame.[55]

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[50] The Economist, *Dealing with Celestial Scrap - Removing Space Junk*, 12 Jan. 2021, available online at https://www.economist.com/science-and-technology/2021/01/12/removing-space-junk

[51] *See* https://www.fortunebusinessinsights.com/industry-reports/space-launch-services-market-10193 for details on the current launch market. It also includes comments from launch providers on the possible cost to the industry of space debris.

[52] Nicol Svárovská, *Common but Differentiated Responsibilities for Space Debris Removal*, (2021) 19 Astropolitics 1–2, 1–17, 8.

[53] Harriet Brettle, Christopher Newman, Luc Riesbeck et al, *Applying lessons learned from decommissioning in non-space sectors to active debris removal*, IAC-20,A6,8-E9.1,x57481 71st International Astronautical Congress (IAC) – The CyberSpace Edition, 12–14 October 2020.

[54] *Ibid* at 9.

[55] *See* Lauren Bressack, *Addressing the Problem of Orbital Pollution: Defining a Standard of Care to Hold Polluters Accountable*, (2011) 43 Geo. Wash. Int'l. L. Rev. 741–780.

2.2 WHO PAYS FOR DEBRIS REMEDIATION?

Whether space debris is pollution, industrial waste or a redundant asset in need of decommissioning, the question arises as to the responsibility for dealing with the legacy debris. Without the promise of immediate investment (unlikely, given that there will not be a significant return on the investment other than the intangible benefit of a more stable space environment), the private sector is simply not in a position to solve this problem. Nonetheless, satellite operators need to be persuaded that the short-term costs of fixing and managing debris are worth paying. Currently, the strategy of the space industry is to adopt a 'business as usual' approach. Individual operators have no incentive to be the only ones to change, as that would inevitably place them at an economic disadvantage.[56]

The cost can only be borne by governments. With regard to outer space, it is even clearer that the onus is on governments. First, the majority of older, historic space objects have at least some government stakeholdership (truly 'private' space industry is relatively new).[57] Second, all private sector space activities are explicitly authorised and supervised by governments as per Article VI of the Outer Space Treaty; governments bear the obligation to avoid harmful contamination under Article IX of the Outer Space Treaty; and as has already been shown, governments ultimately bear liability for damages caused on orbit.

The 'private sector' will probably play a significant role in active debris removal, whether in a public-private partnership capacity or simply as the contractor providing the technology. But the 'market' is unlikely to provide a solution as there is no market incentive to spend money cleaning up space debris. Perhaps the material can one day be recycled and then that might provide a market incentive[58] but that relies on the development of effective active debris removal, in space manufacturing and a supply of customers willing and able to buy space objects produced from recycled materials, as well as the legal and regulatory infrastructure to support such an industry. A private individual may provide funds for a philanthropic endeavour but that's not a market solution and none of the 'space billionaires' have shown any inclination to do so yet.[59] The government could create a market,[60] or it could undertake the activity itself directly, but either way space debris clean-up is likely to need significant injections of taxpayer money.

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56 Pierre Letellier & Stephanie Lizy-Destrez, *Debris-efficient On-Orbit-Servicing : Assessing the Techno-economic Viability of the "Recycler" GEO Satellite* (2022) 200 Acta Astronautica 253–261, 254.

57 For discussion on the development of these space objects, *see* Alice Gorman, *Dr Space Junk vs The Universe*, (MIT Press, 2019).

58 *Op. cit.* n. 56 at 260.

59 For a discussion on the ambitions and priorities of the so-called space billionaires, *see* Christian Davenport, *The Space Barons* (Public Affairs, 2019).

60 For example, by instituting a decommissioning regime. *See* Brettle & Newman, *op. cit.* n. 53.

2.3 THE DUAL USE CONUNDRUM

This discussion has examined legal and financial impediments to the creation of a system of debris remediation. One challenge that faces any regime, is that, in the current geopolitical environment, trust between the major space powers is extremely low. This tension has inevitably manifested itself in hostile space activity[61] and suspicion regarding the motives of geopolitical adversaries. The current situation is cause enough for concern. When adding novel methods for debris remediation into the mix, the potential for misunderstanding (either real or confected) creates even more instability.

The military and security issue with debris remediation techniques is a simple one. If capacity exists to de-orbit a non-functional rocket body, that capacity can also be used to disable, disrupt, or destroy a functioning military asset. Known colloquially as the 'dual use' conundrum, it is another barrier to the establishment of a framework for a peaceful mechanism for debris removal. Given that experimental methods recently have included the use of harpoons,[62] any State which develops this technology may well be viewed through the lens of military advantage rather than environmental benevolence.

The US Space Priorities Framework[63] released by the Biden administration stipulates that 'space activities are essential to our way of life' and that 'access to and use of space is a vital national interest'. The Framework goes on to stipulate that the US will support long-term space sustainability efforts with specific reference to tackling the issue of space debris.[64] The framework then moves on to discuss the need for the US to 'defend its national security interests from the growing scope and scale of space and counter-space threats'.[65]

These two objectives are in tension and are related. Space debris is a threat to the security interests of the US in the use of the Earth's orbital environment.[66] Operational satellites, including the international space station, must manoeuvre in order to avoid hazardous space debris.[67] This is a problem that will only

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61 For contrasting perspectives, *see* Jamie Seidel, *China and Russia Conducting Shadow Wars in Space Using Satellites*, News.com.au, 18 Nov. 2022, https://www.news.com.au/technology/innovation/military/china-and-russia-conducting-shadow-wars-in-space-using-satellites/news-story/274e0969d304a5b21dca90137de50e98 ; and Mike Wall, *US Military's X-37B Space Plane Lands, Ending Record-breaking Mystery Mission*, Space.com, 12 Nov. 2022, https://www.space.com/space-force-x-37b-space-plane-otv-6-mission-ends

62 *See*, for example: Tereza Pultarova, *Watch a Satellite Fire a Harpoon in Space in Wild Debris-Catching Test (Video)*, Space.com, 18 Feb. 2019, https://www.space.com/space-junk-harpoon-removedebris-satellite-video.html

63 *The United States Space Priorities Framework* (The White House 2021) available online at https://www.whitehouse.gov/wp-content/uploads/2021/12/united-states-space-priorities-framework-_-december-1-2021.pdf, 3

64 *Ibid*. at 7

65 *Ibid*. at 6

66 Joseph S. Imburgia, *Space Debris and Its Threat to National Security: A Proposal for a Binding International Agreement to Clean Up the Junk*, (2011) 44 Vand. J. Transnat'l L. 589-641.

67 AFP, 'ISS forced to move to avoid space debris' The Guardian Wed 23 September 2020 available online at https://www.theguardian.com/science/2020/sep/23/iss-forced-to-move-to-avoid-space-debris

increase as the quantity of debris in orbit continues. This threatens the potential to which the US national security community and the US commercial space community can use the Earth orbital environment. Private companies such as internet provider Starlink[68] and Earth observation company Planet [69] contributions to the defence of Ukraine illustrate that these commercial and military interests have significant overlaps.

Remediation of debris, by all space powers, is in the national security interests of the US. Nonetheless, the fact remains that the technology for active debris removal is also technology that can be used as anti-satellite weapons (anything that can grab hold of an object in orbit and alter its orbit including inducing re-entry is a potential anti-satellite weapon). Accordingly, the development of active debris removal technologies by Russia and China will be considered a threat to the US national security interests. Indeed, the notion that Active Debris Removal (ADR) technology developed by the Chinese would be viewed by the US security establishment as a threat to US national security is hardly an absurdity, indeed it is virtually certain.

One potential way to manage these difficulties is to view debris remediation in the context of a broader space arms control package. There is growing support for a destructive Anti-satellite weapons (ASAT) testing moratorium,[70] and that momentum should be built upon. Space is simply part of the broader geopolitical sphere[71] and therefore part of the 'military domain'. As with any other domain where contested human activities occur, there is a recognition that certain kinds of technologies and activities have the potential to be particularly destabilising. Nuclear power technology has been, for many years, the archetype of this genre with nuclear reactors able to provide plentiful and cheap energy but also able to provide nuclear materials for use in nuclear weapons. 'The human capital and research reactors that enable breakthroughs in medical treatments and basic science can provide a knowledge base for a bomb program'.[72]

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68 Alex Hern, *Elon Musk says SpaceX will keep funding Starlink internet in Ukraine*, The Guardian, 16 October 2022 available online at https://www.theguardian.com/world/2022/oct/15/the-hell-with-it-elon-musk-says-spacex-will-fund-starlink-internet-in-ukraine

69 'The war in Ukraine shows how important private satellite companies have become—especially in times of conflict' SatNews, 16 Aug. 2022 available online at https://news.satnews.com/2022/08/16/the-war-in-ukraine-shows-how-important-private-satellite-companies-have-become-especially-in-times-of-conflict/

70 Heather Foye & Gabriela Rosa Hernández, *UN First Committee Calls for ASAT Test Ban*, Arms Control Association, Dec. 2022, https://www.armscontrol.org/act/2022-12/news/un-first-committee-calls-asat-test-ban

71 Bleddyn Bowen, War in Space: Strategy, Spacepower, Geopolitics (Edinburgh University Press 2020).

72 Reid B C Pauly, *Deniability in the Nuclear Nonproliferation Regime: The Upside of the Dual-Use Dilemma*.

Debris remediation programmes and rendezvous and proximity operations in general should be seen as equivalent to this. Debris remediation technology has both legitimate, civilian and peaceful applications but could also be used as anti-satellite weapons. As the former is a legitimate, peaceful 'use' of outer space, States do not need permission for, nor should they be prevented from, developing or deploying these capabilities. Nonetheless, given the national security implications of both of these technologies, this is a clear potential flashpoint for tensions between the space powers.

2.5 THE DATA DEFICIT – THE NEED FOR INCREASED TRACKING

Having identified the legal, economic, and strategic problems, there is one significant problem that lies in the hinterland between technical capability and space security, that of the need for greater space surveillance and tracking capability (SST). The primary method for tracking all objects in space is radar. While this provides some locational information about the space object, it does not provide any data about the function or operation of a satellite.[73] This must be inferred from other forms of data. Currently, the Combined Space Operations Center (CSpOC)[74] under the US Space Force Space Operations Command has the responsibility to track objects on orbit. They provide updates to the SpaceTrak database and advise on potential conjunction warnings and use their capability to develop increased Space Situational Awareness (SSA).

SSA has been defined in a myriad of ways, but in essence it is the search for knowledge of the position and orbit of every object in space. Whilst being a well-established military doctrine, high levels of SST capability leading to a better level of SSA are also crucial in establishing the capability to undertake debris remediation. Having custody of the target and awareness of the remediation vehicle is one thing, but the Low Earth Orbit (LEO) space environment is a busy one and any remediation mission will need to understand what other objects are within the vicinity of the target and may have a possible effect upon the mission.

The current system for tracking objects in space has two fundamental drawbacks when considering its fitness for the purpose of enabling a debris remediation system. The first is that this is, fundamentally, a military capability and it therefore must be at the mercy of the national interests of the United States. The

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73 Gene H McCall & John H Darrah, *Space Situational Awareness: Difficult, expensive and necessary*, (2014) Air and Space Power Journal (November-December) 6–16, 9.

74 For details of the organisational hierarchy, *see* https://www.vandenberg.spaceforce.mil/Portals/18/documents/CFSCC/CSpOC_DEL5_FactSheet_6Aug21.pdf?ver=z3kgshJ87XDdNvYA0Ak61A==

information flow is controlled by the US military and the US Space Force has the most comprehensive network of tracking capability. That reliance on the military means that any concerns about dual usage of remediation systems are going to be exacerbated. Perhaps more significantly it means that when it is of strategic advantage, the military may well be obliged to limit or even cut off the flow of information. Pegging global SST capability so closely to one State's national interests is not the basis of an enduring arrangement to support debris remediation.

The second drawback is that the Space Surveillance Network is far from being global and needs increased coverage in the southern hemisphere, Asia, Africa, and South America.[75] The reliance of other States on the US military for SSA data has meant that the development of other nations' SST capability has been limited. To try and 'contribute to global burden sharing' in the domain of SSA,[76] the European Union established a dedicated capability for Space Surveillance and Tracking (EU SST). This fuses US-provided data with data collected from the EU members' own sensors. Information about space objects is made freely available on the SpaceTrak database. But, again, this is scarcely 'real time' data about the orbital environment. The limitations of the existing data that are available mean that the ultimate SSA goal of having 'knowledge of the position and orbit of every object in space' is far from a reality.

This data deficit is a crucial missing piece of the infrastructure required to have a system of debris remediation that is open and transparent. Knowing the exact position of space objects is a fundamental requirement of any system. Yet, it is not only the tracking capabilities that need upgrading. Understanding the location of a satellite involves a dialogue between the trackers and the satellite operators.[77] While this occurs on an ad-hoc basis, there is no formalised forum to facilitate this. Also, this points to the limitations of the US Space Surveillance Network (SSN) being the lead in this area. They may gain cooperation from US firms, but beyond that, there may be more of a patchwork understanding of what is going into space. Undoubtedly, not being able to track space objects means the chances of establishing fault in relation to Article III of the Liability Convention become very limited. But more broadly, it creates a 'fog of war' in LEO where intentions and perceptions are viewed through the lens of diplomatic conflict. This in turn hampers progress towards peaceful debris remediation activities.

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75 Brian Weeden, *US Policy and Capability for SSA*, (2019) Secure World Foundation available online at https://swfound.org/media/206348/weeden-us-policy-and-capabilities-for-ssa.pdf

76 Regina Peldszus & Pascal Faucher, *European Space Surveillance and Tracking Support Framework*, (2019) The Handbook of Space Security, available online at https://link.springer.com/referenceworkentry/10.1007/978-3-030-22786-9_104-1

77 Loren Grush, *Why the Air Force Still Cannot Identify More than a Dozen Satellites from one December Launch*, The Verge, 2 Apr. 2019, available online at https://www.theverge.com/2019/4/2/18277344/space-situational-awareness-air-force-tracking-sso-a-spaceflight-cubesats

3 SQUARING THE CIRCLE – THE MOVE TOWARDS A SYSTEM OF DEBRIS REMEDIATION

So far, this discussion has concentrated on the main concerns in respect of establishing a system to allow for the removal of debris from orbit. These concerns have looked at the body of international space law and found there was no irrefutable, binding legal obligation under the extant treaties for a State to remove existing debris. Should a State choose to do this, it will be liable for damage caused in space if fault can be shown and it will need to bear in mind that jurisdiction and control are not contingent on functionality and that remains with the State of registry. The discussion then moved on to discuss the cost of remediation and asked the fundamental question of who will pay. The dual use aspect of remediation technology was highlighted together with the often ignored need to improve and develop SST capability to safely undertake remediation activity and also to help with the transparency of such missions.

The problems facing the creation of a system of governance for safe, peaceful remediation of space debris are formidable. Nonetheless, this concluding section will look at possible solutions and resolutions to the difficulties faced. It will start off by considering how softer, non-binding agreements have been used to try and shape normative behaviour in relation to debris mitigation. Building on this, the LTS Guidelines will be examined as a possible way to deal with the data deficit and SST limitations. The discussion will then look at the way in which arms control dialogue can help reduce tensions over the dual use aspect of the technology. Finally, there will be a call for States to grasp the nettle and look at cleaning up their own debris. The work will conclude by suggesting that there is no single treaty that can lead to a system for which the only purpose is the remediation of debris. Instead, it will be argued that only by addressing the use of Earth orbit holistically will debris remediation become part of the orbital infrastructure, facilitated by increased data about space and monitored and verified to reduce concerns over the use of the technology.

4 ESTABLISHING NORMATIVE BEHAVIOUR, DATA SHARING, AND THE LTS GUIDELINES

This discussion has focused on the barriers to remediation of space debris. It should be noted, however, that the international community has already made significant progress in establishing normative standards for the mitigation of debris. Where remediation is concerned with the removal of legacy debris (that is, debris that is a legacy of over 60 years of human space exploration), mitigation is concerned with new missions.[78] Guideline 1 of the UN Debris Mitigation Guidelines states that space systems should be designed not to release debris during normal operations.[79] The whole thrust of debris mitigation and the UN guidelines is to (at best) eliminate the creation of new debris or (at worst) to minimise the effect of any debris on the outer space environment.[80] Mitigation alone however will not address the problems facing the orbital environment. Debris remediation is required alongside mitigation to actively reduce the threat to the active satellites populating LEO.[81]

Recognising the existential threat posed by the increased use of LEO, UNCOPUOS after nearly a decade of negotiation adopted 21 guidelines that would help contribute to the long-term sustainability of outer space.[82] The Working Group responsible for the development of the LTS Guidelines[83] had a wide remit and considered issues such as space debris, SSA and regulatory issues. They are clearly not intended to be legally binding, in the way the Debris Mitigation Guidelines are not. Instead, they are intended to assist national governments to mitigate some of the risks associated with the conduct of activities in outer space.[84] The Guidelines themselves emphasise the importance of registration[85] and speak in significant detail about the safety of space operations.[86]

Crucially, the guidelines for the safety of space operations provide some of the basic requirements for the sharing of data and the coordination between operators of space objects and national regulators. This is exactly the type of coordination that will be needed in any embedded debris remediation system. The guidelines 'place a lot of emphasis on coordination and information sharing'[87] and recognise that safe operations in space depend upon accurate orbital data 'and [it] encourages States to investigate and promote methods to improve the accuracy of such data'.[88] The LTS Guidelines do not say this explicitly, but State compliance with the majority of the Guidelines would put in place the institutional scaffolding for an embryonic system of Space Traffic Management (STM). Similarly, by developing systems that provide improved accuracy of orbital information would undoubtedly reduce the data deficit.

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[78] UN Space Debris Mitigation Guidelines, *op. cit.* n. 17, no. 3, para. 2, sent. 1; these guidelines are applicable to mission planning and the operation of newly designed spacecraft and orbital stages and, if possible, to existing ones'.

[79] *Ibid*. at no. 4, Guideline 1.

[80] Hobe & Mey, *op. cit.* n. 20, 394.

[81] Adam White & Hugh Lewis, *The Many Futures of Active Debris Removal*, (2014) 95 Acta Astronautica 189–197, 190.

[82] Peter Martinez, *The UN COPUOS Guidelines for the Long-term sustainability of Outer Space Activities*, (2021) 8 J. Space Safety Engineering 98–108, 99.

[83] *Op. cit.* n. 38.

[84] Martinez, *op. cit.* n. 82 at 102.

[85] *Op. cit.* n. 38 at Guideline A.5.

[86] *Ibid*. at B1-10.

[87] Martinez, *op. cit.* n. 82 at 102.

[88] *Id*.

Softer international agreements are being successful in highlighting the steps that need to be taken in order to increase the global capability in respect of SST. Increasing this will enable the SSA and STM activities that will be so essential to ensuring debris remediation is conducted safely. It is not only through the UN that such guidelines are emerging. The work being done in the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS)[89] to develop an industry-led approach to the setting of internationally agreed best practice for rendezvous and proximity operations is also relevant. The International Organization for Standardization (ISO),[90] a non-governmental organisation designed to bring experts together to develop international standards on a range of activities, has developed numerous space-related standards and it will likely be instrumental in leading the way when industrial remediation of debris becomes plausible.[91]

With the publication of ISO 24113, the consensus derived technical and operational standards for rendezvous and proximity operations, the LTS Guidelines, the frameworks to address many of the problems in relation to data sharing, the best practices for coordination of space activities and the building blocks for conduction of remediation operations are in place. It is incumbent on every member of the space community to adhere to, promote and actively develop these non-binding mechanisms.[92] The eternal cry for legally-binding treaty obligations to guarantee compliance is a hollow one if industry and national governments cannot first develop the practices and norms that will catalyse such a treaty.

5 RESOLVING DUAL USE THROUGH ARMS CONTROL DISCOURSE

Despite misgivings about the dual use nature of the technology, the fact remains that removal of large debris from Earth orbit is essential for achieving progress on sustainability of space operations. Bridging the data deficit and having established normative methods for conducting remediation operations could bring some reassurance about the benign nature of remediation technology. The cleaning up of Earth orbit could also fall into the category of topics on which the US National Security Strategy pledges to 'engage constructively' with China.[93] Developing on that, and by increasing transparency of such operations could

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[89] *See*, for example, https://www.satelliteconfers.org/publications/ the CONFERS On-Orbit Satellite servicing mission phases (updated 1 Oct. 2019).

[90] *See* the ISO Standards for Debris Mitigation available online at https://www.iso.org/standard/72383.html

[91] *See*, for example, CONFERS publication https://www.satelliteconfers.org/wp-content/uploads/2018/07/2018-04-05CONFERSSatelliteServicingSafetyFramework.docx

[92] Hedley Stokes et al., *Evolution of ISO's space debris mitigation standards*, (2020) 7 Journal of Space Safety Engineering 325–331, 330

[93] US National Security Strategy, October 2022, 25 available at: https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf

lead the way to a diplomatic agreement or even a non-binding series of agreed protocols in respect of debris remediation. This could echo the spirit of arms control agreements with the former Soviet Union such as the Open Skies Treaty.[94] Obviously, such engagement could be a significant boon to both dealing with the space debris issue and relieving tensions between the US and China.

Furthermore, a bilateral agreement between China and the US could open the door to a broader multilateral agreement as 'bilateral agreements between the great powers…' can underpin efforts 'by lessening the fear of other nations that they will suffer harm'.[95] Between them, the US and China account for 64% and 63% of satellites and trackable space objects in orbit[96] so an agreement between them would be hugely significant for the orbital environment, even if it did not lead to broader engagement.

Realistically, it is difficult to envision this happening due to various issues within domestic politics of both powers. Nonetheless, the history of US-Soviet arms control agreements does give some basis for hope. Some form of 'transparency and confidence building measure' is sorely needed for a range of space governance issues and space debris is one of the more pressing ones. The biggest barrier here is not technological, nor is it legal, but political. If the main 'spacefaring' States got together and resolved to develop an agreement, these issues could be resolved. The issue is not a lack of law, or technological ability. It is purely the absence of political will to prioritise the debris problem.

6 GRASPING THE NETTLE – FIRST MOVER ADVANTAGE

Continuing the theme of leadership and the need for positive action, it is worth, again, considering the challenge posed by space debris. Like climate change, plastic pollution, and other environmental issues, space debris is often presented as a global problem. In reality, the number of States responsible for the space debris issue is relatively limited. The US and Western Europe[97] own approximately 66% of satellites currently in orbit (including inactive ones) and 45% of total 'objects' (which includes fragments, upper stages, and rocket bodies which are large enough to be tracked and catalogued). The US itself accounts for 56% of satellites and 41% of trackable objects, with SpaceX alone accounting for 34% of the global total of

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94 Alexandra Bell & Anthony Wier, *Open Skies Treaty: A quiet legacy under threat*, Arms Control Today Vol. 49, No. 1 (January,/February 2019) pp. 13–19.

95 Stuart Casey-Maslen & Tobias Vestner, A Guide to International Disarmament Law (Routledge 2019), 2.

96 Jonathan C. McDowell, General Catalogue of Artificial Space Objects (2022) Release 1.3.1 accessed at https://planet4589.org/space/gcat Accessed 23/11/22 ; The subsequent data analysis was undertaken by the authors. Any error reflects their miscalculations and not the Catalogue.

97 Austria, Belgium, France, Germany, Italy, Luxembourg, Netherlands, and the UK.

satellites (61% of the US total).[98] Russia[99] accounts for 16% of satellites and 30% of trackable objects.[100] China accounts for 8% of satellites and 18% of trackable objects.[101]

The US, Western Europe, Russia, and China, therefore, account for nearly 90% of satellites and 93% of trackable objects. Space debris may be a 'global' problem in the sense that the 'crowding' of Earth orbit, particularly with inactive objects and debris, affects any State that wishes to use orbital space, but it is not a global problem as to who caused it, or who can solve it. The US and Western Europe alone could make a significant impact on the space debris issue by themselves, if they strove to remove their own debris. Even if only the 'significant' debris, they could reduce the total trackable population by a significant percentage. And even if they removed only half of their debris, that would be nearly a quarter of the overall debris population.

7 CONCLUSION: AN INTEGRATED APPROACH TO ORBITAL MANAGEMENT

This discussion has identified the consequences of the development of new systems, concepts, and ideas to address the remediation of debris. The main legal concerns are familiar to any student of space law; uncertainty over definitions, questions of which launching State will be liable should there be any damage, and uncertainty over the contours of fault all sitting alongside issues of jurisdiction and control. Clearly, there can be no 'third party' remediation without explicit consent of the State of registry, there must also be insurance in place and clear contractual terms outlining fault and expectations. Despite this, 'one must have no illusions. The best space law cannot help improve the situation if the space-faring States do not want help'.[102]

It is not, therefore, legal considerations that are inhibiting the development of debris remediation as a staple space activity. This discussion has identified significant economic barriers and a reluctance to having to start to pay for something amongst industry and government that previously has not been paid for. Nonetheless, there are precedents for Governments to invest in environmental solutions. This is

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98 McDowell, *op. cit.* n. 96.
99 Including figures for the Soviet Union.
100 McDowell, *op. cit.* n. 96.
101 *Id*.
102 Hobe, *op. cit.* n. 28 at 10.

another area where governments must show leadership and accept that there will be a cost. In respect of financing a response to space debris, States ultimately face two choices: either they pay the cost now and develop a system for removing debris, or they pay it when there is a collision in orbit and space needs cleaning up. Hopefully, it is one they will resolve in favour of proactively managing the debris.

The fear of dual use technology adds a further layer of tension to an already tense geopolitical landscape. Yet the fact remains: all space assets are potentially dual use (launch systems, tracking, communications). What is needed is transparency in respect of the operations and the mission. To this end, borrowing an approach from arms control discourse will help de-escalate tensions. Similarly, adopting the information sharing and enhancement of data from space provisions found in the LTS Guidelines will also help demystify the space environment. Such a move will provide more transparency for all users of space, more data for operators and information that will help ensure safer debris remediation missions. The need to close the data deficit in orbit and enhance the SST capabilities of all nations is fundamental to any system of debris remediation.

This article, therefore, is not calling for a stand-alone treaty to herald in a new era of debris remediation. The problems are multifaceted and there needs to be a holistic solution that deals with coordination of space traffic, debris management and getting more accurate information about the space environment. The debris situation is so serious that States must not wait for an international agreement. There is no longer the time. The Soviet Union did not wait for the Outer Space Treaty to launch Sputnik nor did the US wait to make progress on Apollo. Space-active States must show leadership now, by funding missions to deal with the low-hanging fruit in this area, such as removing their own rocket bodies.

That act of leadership, coupled with a holistic approach to dealing with Earth orbit and increased data about the orbital environment will lead to the creation of a more stable order in space. Solving these problems can be done while both working collaboratively and furthering individual national interest. States are now at a crossroads. If they demonstrate the political will and the economic muscle, they will provide a firm foundation for a harmonised system of debris remediation built on universally agreed norms. The stakes are high, but the reward is a sustainable future in space for all humanity.