

Open Research Online

The Open University's repository of research publications and other research outputs

Space Debris: A Basis for Actively Removing Objects Under an International Legal Order

Journal Item

How to cite:

Steele, Scott Michael (2021). Space Debris: A Basis for Actively Removing Objects Under an International Legal Order. *American Journal of Aerospace Engineering*, 8(2) p. 45.

For guidance on citations see [FAQs](#).

© 2023 Scott Michael Steele

Version: Version of Record

Link(s) to article on publisher's website:
<http://dx.doi.org/doi:10.11648/j.ajae.20210802.11>

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online's [data policy](#) on reuse of materials please consult the policies page.

oro.open.ac.uk

Space Debris: A Basis for Actively Removing Objects Under an International Legal Order

Scott Michael Steele

The Faculty of Business and Law and AstrobiologyOU, The Open University, Milton Keynes, United Kingdom

Email address:

scott.steele@open.ac.uk

To cite this article:

Scott Michael Steele. Space Debris: A Basis for Actively Removing Objects Under an International Legal Order. *American Journal of Aerospace Engineering*. Vol. 8, No. 2, 2022, pp. 45-60. doi: 10.11648/j.ajae.20210802.11

Received: March 24, 2022; **Accepted:** April 14, 2022; **Published:** April 22, 2022

Abstract: With over 500,000 objects in orbit, space pollution has now become a scientific, legal, and ethical issue and raises concerns on what the international community can do through existing ‘hard law’ and the development of ‘soft law’ to help tackle the problem. The purpose of this paper is to examine whether the application of the evolutionary principle of treaty interpretation to the Outer Space Treaty, enables for active removal of space debris in a manner consistent with space governance and which is acceptable to private corporations and States. Active Debris Removal (ADR) has only been used in specific circumstances which successfully removed an object. International law has hindered the process of mass removal of space debris, as objects cannot be removed without the consent of the relevant state. Therefore, this paper will consider whether customary international law and current state practice in analogous areas of international law, would allow or could develop to enable, the removal of an object from space without the need for consent of the launching state. Such an application will form a rigorous approach and introduction of space governance through an international multinational space agency approach for mutual agreement and cooperation without the need for an international treaty or political declaration. Such a principle, although not a new concept in areas such as international environmental law, would be new for international space law. However, as new and innovative activities are planned under the umbrella of the Outer Space Treaty, and by extension, general international law, it is wise to take a new and innovative approach to space law. Moreover, this paper aims at using maritime, environmental and international rules of responsibility to argue that the removal of objects in outer space does not need consent. This will be backed by an evolutionary approach to the interpretation of the Outer Space Treaty. This paper will make a unique and forward-looking legal and governance argument that will test not only the use of international law but also science, technology and political will.

Keywords: Space Debris, International Law, International Space Law, International Environmental Law

1. Introduction

This review article asks: can international law provide a basis for active space debris removal (ADR)? The accumulation of spacecraft and satellite debris by spacefaring nations and private commercial space companies is unsustainable. This assessment is based on the rate of deposition of waste in space and the non-adherence to the legal guidelines. The UN Committee for the Peaceful Uses of Outer Space (COPUOS) and the United Nations Register of Objects Launched into Space UNGA Resolution 3235 [109] has produced normative guidelines for space exploration [82].

The accustomed appealing nature of the European Code of Conduct for the Mitigation of Space Debris [99] created the broader discussion among space agencies towards space

debris and whether mitigation or adaption is a formative way forward, or whether active removal was a possible legal application for the code to build up to. The members were also active members of the Inter-Agency Space Debris Coordination Committee [99]. With space agencies looking towards space, it is only inevitable that debris becomes an issue and the mistakes of the past will be corrected. The uncertainty around whether such codes and agencies hold the ability to action debris removal, or suggest such activities, will be discussed later.

2. Space Debris

Space debris comprises of non-functional materials orbiting the Earth; this includes defunct satellites, objects created through

satellite collisions, pieces ejected from orbiting satellites or spacecraft and other objects. The Outer Space Treaty [109] (OST) and other space laws do not provide a clear framework for orbital debris remediation [51] nor do they define debris. For all intents and purposes, debris are classified as objects and the OST still recognises them as such even if they are untraceable or unidentifiable. Moreover, Article VI of the OST stipulates that states have a duty of care and primary responsibility to monitor and regulate space activities conducted by their nationals [116]; this means that a state is legally responsible for commercial space research activities initiated by companies which are domiciled in their country, for example, the US and companies such as Blue Origin and SpaceX. This consideration is legal, but the responsibility stops. There is no additional stipulation on responsibility. To consider that a state is solely responsible without action, redress or recourse, the OST provides a framework to which international lawyers can only uncover international and national legal precedent to apply to such an area and allow ADR to be carried out. The role of national space agencies is further reinforced by Article VIII, on the liability of states for the damage caused by their space objects [54]. The lack of clear laws does not eliminate responsibility. The role of national space agencies however is not to be overlooked. There are key bodies may play the link between private and states in the future in a normative space governance development aspect. Under such an umbrella ADR seems positive.

2.1. Distribution of Debris in Space

In 2019, NASA estimated that there were millions of space debris objects in the low earth orbit (LEO) [76]. Similarly, ESA estimated that there were about 750,000 objects wider than 1 cm in space [76]. Between 1957 and 2011, more than 6,000 payloads and 4,000 rockets were launched from Earth to space [14]. The accumulation of the debris was correlated with a surge in payload and rocket missions. The industry data contrasts with scholarly data, which provided lower estimates - 15,900 and 2,931 pieces in the geosynchronous earth orbit (GEO) and LEO, respectively [125]; the rate of debris accumulation is unsustainable. LEO and GEO regions (36,000 and 40,000 km) support supportive intelligence, surveillance and reconnaissance (ISR), navigation, communication, weather monitoring and missile warning satellites [26], which are integral to everyday life and national security. Distribution helps us understand a trend towards the future. Key aspects of the report Kessler syndrome grows near. The well-known possibility described by Donald Kessler described a cascade event of debris should the current mitigation efforts fail and objects took over current objects and not removed from orbit. However, there is light apparent! With SpaceX's reusable rocket system recently taken off and landing successfully, hopefully sustainable space transportation is beginning to develop in order to mitigate the distribution of additional debris.

2.2. Non-compliance with the Registration Convention and Collision Risks

There is a risk of satellite/debris collisions between

functional satellites and decommissioned or malfunctioning satellites. For example, thousands of pieces of space debris accumulated following the collision of Russian and US satellites. The event was a microcosm of the frequent collisions in space - both intentional and unintentional collisions have been documented. Intentional collisions have come as countries seek to perfect their satellite interception capabilities using surface missiles-called Anti-Satellite (ASAT) weapons. The ESA estimates that military-related activities accounted for 25% of space debris [35].

The issue of consent has been demonstrated by recent events such as China's (ASAT) interception of defunct satellites [56] within LEO and GEO and Russia's satellite espionage. Consent in space relies upon the state. Ultimate control is a burden of the state to assume, maintain and give, should they wish, under article VI of the OST in which state parties bear the responsibility for their object in space. With the foundations set within the OST the law cannot be more apparent, but the incentive and mechanism of enforcement are not. If a state does not follow suite in their responsibility, what can hold them to their obligations? The ICJ has no jurisdiction but an advisory opinion is reasonable. Without enforcement or a body informing and urging the states to remove their objects, ADR can only be seen as a positive and reasonable step to adaption. The practicality of ADR is discussed below, and the legal aspects of the OST has firmly built the foundations to which ADR can act.

Even though the interception of the satellites using ASAT defense system was perceived as unethical because it contributed to space debris [51], it was legal. The object remaining under the state's control and even after destroying the object the state is responsible for the pieces that dispense into LEO and other areas of space. Presently, there is no legal provision that bars countries from destroying their satellites or defunct satellites in space. In 2020, Russian satellites were accused of spying on US satellites [79]. There is no evidence that China and Russia sought consent from the member countries, or entities, in which the defunct satellites were registered. Russia and the US have deployed similar ASATs technologies to test weapons and destroy defunct satellites in space (such as USA-193) [94]. The Chinese ASAT events was not isolated.

The militarization elevates the risks of debris removal, and states might be unwilling to cooperate if the removal of space debris threatens their national security interests and privacy concerns. The hypothetical scenario is grounded on the high rates of non-compliance in the registration of satellites in space, which leads to international responsibility questions and debates to what the future of space law and governance looks like. Many questions arise under international law with regards to debris and registration. The writer postulates that if an object is not registered, the state cannot be identified and the object is under a certain size, these are prime targets for ADR. Moreover, through international environmental law, if ADR follows the behaviour of due diligence and openly communicates their plans with the international community, then ADR is not an issue.

According to Bockel [55], 1,459 satellites were placed in orbit around the Earth between 2012 and 2017; this was a significant improvement compared to the 1970s when only 197 civilian earth observation satellites were launched [3]. The number of satellites in orbit is anticipated to increase exponentially with the rollout of the commercial crew program, reduction in the cost of satellite technology, and competition between commercial satellite manufacturers [3]. Private actors are pivotal in space research to the point that it could be argued that the driving force in space are the commercial entities. The recent Space X Dragon approach claimed a more economical version to reach the international space agency and future satellite and constellation development. For example, following the successful completion of the Demo 2 mission, Space X launched 60 new satellites into space using the Falcon Heavy rocket system in June 2020 [5]. Cumulatively, the company has placed 422 satellites into orbit since 2019, and it is on course to establish a 12,000-satellite mega constellation [3].

The lack of accurate data on the number of military satellites in space may compromise future space debris removal issues because the exercise should be based on accurate information to facilitate the deployment of appropriate technologies. The reprise and need for data are not just about space debris applications. State security, infrastructure and the commercial benefits of space are all key factors to space.

2.3. The Legal Aspects of Active Space Debris Removal

The removal of space debris transcends legal considerations to encompass military, economic, national security and astrobology and related factors; this is because satellites serve multiple industries simultaneously. The main legal concern is whether other parties to the OST can remove space junk registered in another country without the consent of the state or national/private entities, which owns the defunct satellite or object. The issue of consent requires the re-interpretation of the liability, registration conventions and the OST. The Liability Convention says that “states are liable for accidents and damages caused by space objects registered and launched within their jurisdiction” [117]. The OST dictates that “states shall be responsible for national space activities whether carried out by governmental or non-governmental entities” (Article VII) [109]. However, such provisions are valuable for the liable party only if they are willing to pay damages. The failure to remove debris has no legal implications considering that there is no legal implication and the same enforcement mechanism backs the OST. The OST is a non- self-executing in certain jurisdictions. However, the issue has been addressed by the enactment of new laws to facilitate the domestication of the OST. The problem of enforcement is a wide issue, yet the research considers that if a state is widely accepting certain obligations under the OST, all can apply. If these self-executing principles are not being carried out, then ADR can work under a hostile umbrella, as it would be reasonable to include all states in the removal of debris, because some may not be sure that the object is their own. Therefore, by creating

an acceptable mandate of a size, for example, that can be removed, ADR would have successful traction.

3. The Enhancement of the OST Through International Law

Article III shows that “States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the Moon and other celestial bodies, under international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international cooperation and understanding”. If this article is read as an evolutionary article within the OST, principles, although not intended for space, can be compared and potentially used in the future. The demonstration of international law through areas of similarities are comprised of areas of the environment, the high seas and Antarctica. Although not limited to such areas, these counterparts hold similarities on the jurisdiction, evolving principles through science and exploration, and the need to restore such areas to their respective natural state. The writer considers this to be the most applicable way to consider the OST and ADR. If a case was to be accepted by states and held in the ICJ, space law would be relied upon directly. However, distinctions would be made to consider was redress and what amounts to a non-jurisdictional area for example. The following chapter will discuss these ideas further.

3.1. United Nations Convention on the Law of the Sea (UNCLOS)

A crucial insight on the regulation of ADR can be drawn from international laws regulating activities in seas. Developed in 1982, UNCLOS [113] is another comprehensive legal framework governing the use of high seas. [97] Before UNCLOS, there were minor laws that applied to the high seas. Significantly, the law was created to clarify and formalize obligations and rights encompassed, including settlement of disputes and sharing of marine resources. It is also worth noting that participation of UNCLOS is not restricted to members of the UN, but open to all states. Under this convention, a state with a coastal line is entitled to a sea territorial, of at most 12 nautical miles, to exercise its sovereignty. [97] It could therefore be used as a direct ascendant to space, in such a way that its openness and dispute function could be the formulation of a formal adoption under article III of the OST. Moreover, the application of UNCLOS is more or less the same. The openness functionality resonates with the principle that space is for all and the non-appropriation principle.

Notably, the rights contained in UNCLOS regarding high seas hold direct correlation to space. Specifically, the right of peaceful passage pertains directly to UNCLOS and Maritime law and holds allowance to Article I and II of the OST. The passage can, therefore, be interpreted into the use and forgoing of exploration. The ICJ entrenched the right of peaceful passage into international law in the Corfu Channel Case in

1949, [19] which gives the potential of authorities to launch and cross internationally waters. Using a similar scenario, the distinction between common straits and space hold direct effect to consider UNCLOS a suitable application to space law. ‘The international community made clear per the Corfu case that this right is intertwined with responsibility for any act of willful and serious pollution’. [113] Therefore, this principle must apply to space with the consideration for the traditions of maritime law. [49] The application to access space is a core and founding principle of the OST. If space debris can be considered as an obstacle that restricts access, the OST would be in violation and the principle of peaceful passage may be useful to such a violation. As the OST has no dispute mechanism, UNCLOS may extend its dispute settlement abilities to space endeavors. The application to ADR must, therefore, be considered as a solution to restore access to space under the OST, and if UNCLOS is accepted, peaceful passage. The writer argues that restriction space would not only breach the OST, but the argument would reply upon this doctrine in a tribunal or court. By using similar examples can not only this doctrine apply, but through article III can the extension of space law be created. By doing so ADR begins to build a legal argument for its sponsored beginning within international law.

Similar to the space law, the significant threat to the maritime environment health is the debris that results from land-based activities. It is acknowledged that this debris can cause pollution, hence disrupting and destroying the delicate balance of the marine environment. While this type of pollution causes harm to marine living organisms, it also poses a higher risk to human health. Some of the recognized debris that can cause harm to the marine ecosystem include plastic and some metals. A high amount of these debris poses a more significant threat to marine habitats. If the debris can be considered as pollution, this would further enhance any claim of the link between the treaties. If space debris is formally categorized as pollution in such a space environment then this applicable principle could be argued in order to use ADR to clean up such an area. It is a given that the international principles of transboundary harm, which will be discussed later, state responsibility and the possibility of a wrongful act, ADR seems a fitting alternative to clean up such an area without the cost and stance of litigation on such a stage. It is therefore not so much of an exaggeration to see that the rights of access and use are both enshrined in the core principles of UNCLOS and the OST. The question that should be asked is to what allowance a crossover should have. It would be ludicrous to suggest that all the principles are transferable. Still, the notion of passage and pollution seem to fall between both areas and consider the same general considerations that the Corfu case ruled on. This would, therefore, allow ADR to be recognized as a function of passage and fair access to space. However, without a foundation and subscribed mechanisms for removal, future challenges would be considered without an agreed method of removal. The writer considers article III to be the evolutionary process of the OST, and it shows that this treaty of principles was never meant to be only the foundations, but to slowly develop and build the cornerstone of space law,

to which adaption and mitigation is one.

Just like the passage of the seas, passage through space is an argued given right, [100] and this is where space debris presents a direct problem. If the Kessler syndrome is plausible, then the notion of a cascade of debris orbiting the Earth would breach the passage and access to space principle. If the amount of space debris increases significantly, it will not only restrict the ability for some states to access space, but it presents a unique question as to whether a state has created a wrongful act by restricting access to space by not cleaning up their debris. Such a question not only presents a legally questionable conundrum, but a paradox of excitement into the realm of new space custom to where ADR is not only carried out, but extended to the removal of all debris in the last-ditch attempt of adaption and mitigation working in a synergetic approach.

Transboundary harm is a principle in which no one has a right to use their property to cause another significant harm: *sic utere tuo ut alienum non laedas*. [1] Principle 2 of the Rio Declaration of 1992 provides that states have “the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or areas beyond the limits of national jurisdiction” [86]. Principle 2 hailed from the Trail Smelter arbitration [108] held that “no state has the right to use or permit the use of its territory in such a manner as to cause injury [97] to the territory of another or the properties or person therein” [108]. It is, therefore, observed that no one could appropriate space under the OST article I, yet the principle of transboundary harm is carried out in space on a daily basis. The writer argues that the creation of debris, and by allowing it to cause additional smaller debris, is in essence transboundary harm at its core. A breach of the obligation to prevent transboundary harm is, in terms of international law, a delict. [106] States are under a proactive obligation to cooperate “to develop further the international law regarding liability and compensation for the victims of pollution or other environmental damage caused by activities within the jurisdiction or control of such states to areas beyond their jurisdiction” [91]. The LC allows for the state to be identified as the launching state. The OST and LC demonstrate that objects remain the responsibility of the launching state, which, therefore, can be compared with TBH.

The International Law Commission (ILC) attempted to create state responsibility for such a scenario. The ILC explains that “harm must lead to a real detrimental effect on matters such as, ‘human health, industry, property, environment or agriculture in other states’ [47], and that the obligation of the state of origin to take preventive or minimization measures is one of due diligence. Hence, due diligence in ensuring safety requires a state to keep abreast with technological changes and scientific developments [47]. These statements and considerations present a complicated legal issue because the pioneer states of space exploration should have predicted the problem of space debris and addressed it at the earlier stage to protect future generations. Even when reading the OST, the notions of an obligation to remove the debris is not clear, and terms of debris, ADR, and

responsibility are not considered. It can, therefore, only be surmised to how the OST would react to ADR. Such an application is proactive, to which the nature of all laws is reactive. The formation and applicability of state responsibility and due diligence presents an evolving principle in which ADR may work, omitted by an agreed-upon framework of responsibility.

Therefore, in exploring outer space, states must ensure that their activities consider the interests of other states as they would act while in high seas recognizing that “the freedom they have within their jurisdiction is not unlimited” [47]. This obligation of common responsible use is defined not principally by the avoidance of harm to any victim but by the obligation to sustain the availability of means of preventing such harm [47]. Accumulation of space debris hinders the right of peaceful passage and the principle of responsibility for transboundary harm. A theory which can be developed, entails requiring states to act affirmatively to protect the space environment from preventable collisions that pollute space with debris [21], to which ADR could be affordance a mandate to be carried out.

The legal obligation of states to recover pollutants that they produced beyond national jurisdiction, remains contingent on their contractual consent. In the law of the seas, states subject to UNCLOS have the responsibility to take measures that are necessary to prevent, reduce and control pollution of the marine environment [113]. Therefore, failing to consider or carry out ADR in light of the correlation between such treaty provision, should be considered to be a wrongful act in which a state must show they have considered ADR and cannot, or do not have, the ability to act. The due diligence principle requires states to demonstrate awareness and discuss such actions with their neighbors should the act be transboundary. As space is the province of all humankind, such actions of debris must be registered or discussed at the international level. Therefore, the possibility of a wrongful act occurring is possible, yet impossible to consider under a current international space regime. Still, the state must show that provisions have been put in place to mitigate their efforts. Even then, the international community should consider the obligations placed on the state to treat space like the High Seas and other areas of common interest.

Through international law, ADR gains the potential to foster up some form of obligation arising from the UN Charter. Even when considering the powers of UNGA and UNSC, is it still considered a farfetched option that these bodies would look at this stage and concern themselves with debris and ADR. However, should a Kessler cascade event occur, the mandate may surpass the UNGA and divert the UNSC actions to resolving the debris issue for now and the immediate future. In conducting ADR, critics would disagree that objects under 10 cm are a questionable size to which no consent is needed. The state would argue that again, consent is needed. Yet, the obligation to protect such an environment from transboundary harm, access to space, and principles of good faith and cooperation presents a strong enough case against the state that refuses to consent to ADR. The foundations upon which

ADR can be considered are within international law, and many arguments can be made for ADR.

Moreover, arguments may be found closer to a critical view of UNCLOS and maritime law. The allowance of these ancient and agreed-upon principles awards some form of highlighted perspective to ADR. Just like sailing through the seas, humanity’s quest for the stars allows for a new, formative sailing through orbit and to the great unknown, in which a unique and debris free environment awaits all that are awarded the right of space.

3.2. International Environmental Law

International space and environmental laws are significantly entwined. [59] Space debris has over the years gained prominence on technical, scientific, political and legal agendas in line with the future sustainability of humanity in outer space. International space law is concerned with how humanity’s activities in outer space are organized. Currently, there are several scientific plans and efforts to reduce outer space pollution, especially by eliminating space debris. However, like environmental law, activities in space are undermined by a lack of a legal instrument stipulating the obligations of various stakeholders. [105] The law is expected to perform the task of requiring states and other space actors to respect the space environment to ensure the sustainability of benefits obtained by explorers. [9].

International obligations concerning outer space mainly manifest in a few customary norms [23] and five major space treaties. [109] Space environmental issues are discussed primarily in OST under Article IX. However, the provision of space environmental protection falls short of offering the required protection. It uses the terms ‘harmful contamination’ about the space environment and ‘adverse changes’ regarding the Earth’s environment. [23] Article III OST makes international law concerning space activities operative. The activities include those within the jurisdiction of a control state that registered the space objects during launch. Attribution of nation-states is contained in Article VI of the OST. According to Article II of OST, the outer space, including the Moon and other celestial bodies, is not subject to any national appropriation.

Essentially, sustainable development is mainly defined by the ability to achieve present goals without undermining the future economic potential of a resource. [87] Sustainability, by this definition, includes an ecological, economic, and social component. [6] This definition is the most widely accepted one and hence, can be employed for this paper.

The term ‘planetary sustainability’ is often used when referring to sustainable activities which should be encouraged on the Earth to ensure the preservation of outer space. [65] The concept considers two main issues regarding sustainable development. Firstly, humanity should harmoniously operate within a life-supporting framework of the Earth, including the atmosphere. [93].

Fitting the space environment into other aspects of sustainable development can be done in different ways. One option is to consider outer space as one way of meeting the 17

Sustainable Development Goals on Earth set by the UN. [115] UNOOSA Director Ms Simonetta Di Pippo described this as, ‘To build resilient and sustainable societies, we have to pay attention to responsible usage of outer space’. [27] On a similar note, she explained at the UNISPACE+50 conference in June 2018 that the Space2030 framework was intended ‘to make space a driver for equality and the attainment of the Sustainable Development Goals’. [27] As such, the space environment can be recognized as an 18th autonomous goal, together with the existing 17 Sustainable Development Goals as defined by the UN.

Newman and Williamson put emphasis on the legal and policy aspects about ‘space sustainability’ within the context of human-made space debris. Still, they reach similar conclusions that ‘if space activity is to be sustainable for future generations, the different values that underpin state activity and commercial activity will need to be reconciled with the need for respect for the fragile space environment.’ [77].

A crucial question which has since triggered debate is whether the space environment should be considered in its potential for the 17 UN Sustainable Development Goals, and as to whether space is awarded an autonomous 18th goal of sustainable development. If the space environment is an autonomous aspect of sustainable development, and a precautionary approach is taken, human space exploration might have to be restricted or reassessed to reduce irreversible changes (with unforeseeable consequences) to the space environment. [77].

Therefore, to build more resilience, space debris should be considered as inhibitors of outer space exploration. [88] Policies and laws should be put in place to ensure that outer space is sustainable. [9] Promoting international cooperation in ADR and improving access to space technology, are among the steps that will make the space environment preservation a driver for equality and sustainable development. [96] Countries that cannot afford standalone ADR should be supported for the combined benefit of all players. [31] Space nuisances should also be avoided since it has a low threshold of fault. A nuisance does not imply malevolence nor any specific intent to inflict harm. [96] Most significantly, nuisances defy conceptions of accountability because attributing causation of harm to any specific incident, much less assessing responsibility for future economic loss, is challenging. [72] As such, it is conceivable that actions against states could, in the future, be a possibility. The notion of a nuisance would allow for the establishment of tort laws within environmental principles to be used to either pressure a state to act or to create ADR to remove the debris. The formation of this kind of space governance has already been considered by the Draft International Code of Conduct for Outer Space Activities (ICoC), which was initially proposed by the EU but has gained considerable support from the US, Canada, Australia, and Japan. The ICoC applies to all activities in the outer space that are conducted by a subscribing state, non-governmental organizations, or a joint association of states. [80] The ICoC is aimed at enhancing the

safety, security, and sustainable use of all outer space activities pertaining to space objects and environment. [30] The code also serves to strengthen the already existing UN treaties and outer space principles.

3.2.1. Polluter Pays Principle

The polluter pays principle advocates that those responsible for the pollution should pay for the cleanup of damage caused to the environment, as well as pollution prevention programs without any exception. [92] Adoption of the principle in regards to outer space would require an international consensus such as the High seas to enable it to gain traction. [62] Such an allowance would increase the chances of ADR research through a fund which is disused later. The primary focus of ADR is to clean up space. However, the consideration of private entities preserving this as a profit-driving enterprise must be considered. It seems that a possible public, a private partnership must be able to comply with the OST and can perform ADR successfully. The principle has so far received widespread approval and was extensively incorporated in the 2009 Copenhagen Accord and the 2016 Paris Agreement in which countries agreed to implement carbon emissions taxation as a way of discouraging air pollution.

Moreover, with multiple space actors and contributors expressing concern towards space pollution, it would be challenging to fix individual liability of the polluters. The principle, however, may offer a theoretical approach to ADR. By allowing NASA to manage operations within outer space, a ‘clean up tax’ could be added to facilitate ADR’s implementation. Other international organizations such as ESA could also ensure it oversees the removal of all space debris from EU countries by imposing costs on the launching states. This form of multilateral acceptance would see ADR work in a multifaceted approach to which space agencies monitor, discuss, negotiate and control the actions of ADR, to which they are better suited and nonpolitical.

3.2.2. Precautionary Principle

The precautionary principle is based on preventing harm rather than acting after the harm is caused. [41] This is justifiable due to the uncertainty of space-related activities, coupled with the idea that damage cannot be undone or adequately compensated once it occurs. As a result, a due diligence requirement imposes a heavy burden on states to establish effective mechanisms to minimize the effects of their activities. The most unambiguous expression of the principle can be found under the Rio Declaration. [91].

The application of the PP, with its impact assessment, would be of utmost significance to risky space ventures. [102] It would help in planning launches and preventing debris creation due to explosion or collision. [9] Since the anticipatory actions to prevent or minimize the damage are a pre-requisite under the PP, every actor would be under an obligation to bring back the defunct object launched to avoid the unwanted consequence of debris creation, [9] thereby creating an obligation to carry out ADR. With the recent launch of Dragon, by SpaceX, the first returnable rocket landed, and thus debris was mitigated. Clean technology must

form the future of ADR, and mitigation must be first. Once mitigation and reusable technology are truly sustainable and accessible, adaption in the form of ADR can be considered a natural next step.

3.2.3. *Duty to Cooperate*

Cooperation of states at an international level is critical in the current globalized world. States are not only bound to notify and consult with each other, but also cooperate by promptly responding to concerns of other states about their activities. [10] They should negotiate in good faith on the issues of common concern and collectively play an active role in the protection of the environment. [10] This would form further allowance under article III of the OST, to evolve the OST and the principles of space law through international law. The international adjudicating bodies recognized these principles in several cases, including Lac Lanoux Arbitration, [61] Gabjikovo-Nagymaros [40] case, MOX Plant [73] case, and the Land Reclamation case by Singapore [67] regarding the Straits of Johor. The Space Benefits Declaration [25] emphasizes freedom of states in outer space exploration if they cooperate with other states and ensure they act peacefully. [45] Such an application of space debris and the hazards that debris causes, present not only an environmental issue but a state responsibility scenario to which a duty to cooperate may not have been carried out.

The principle of cooperation is extensively included in most of the space treaties. The treaties advocate for states' cooperation in exploration, scientific developments, and access to each other's space stations. As with the principles of good faith, ADR is a pressing issue and must be considered. [10] If a state is willing and able to conduct ADR, the possibility of allowing them to do so would be acting in such a manner to satisfy this principle and that of the UN Charter to cooperate. ADR is not a one-state issue, and community involvement is necessary for ADR to work. The works of Astroscale and the University of Surrey presents a unique opportunity to ADR and the development of a structural ADR mandate.

3.2.4. *Sustainable Use*

The principle of sustainably usually advocates for the use of resources in such a manner that ensures longevity and prevents rapid depletion. [32] The application of the sustainable use principle in space jurisprudence is significant in a variety of ways. [122] The use of GEO and LEO can be regulated by employing the principle of sustainable use. [43] To minimize debris creation, states may be asked to not only enhance their mitigation components, but also consider contributing to an international fund that supports ADR. [2].

The conventions of space debris push for good faith and cooperation as a principle. Just like international law, debris presents a problem that states are ill-equipped to deal with. The possible extent to which environmental principles can be applied in space activities is not easy to determine because of the non-jurisdictional environment of outer space like High Seas and Antarctica. [51] Cases of intentional outer space pollution through space debris triggers the question regarding

their legal position. The OST may not cover such activities but may have expressly prohibited them through regulations developed in the Environmental Modification Convention, environmental law, or international laws. [45] This has led to instances where individual countries have received benefits from individual missions, while damaging the outer space environment intended for common benefit by all states. [123] A lack of bespoke legally binding environmental provisions has created a mostly unfettered space environment. It is voluntary and non-binding codes of conduct that tend to predominate in environmental space regulation. [15] Moreover, as seen by international environmental law, profits trump protection. Space is a potential gold mine and therefore before the application of exploitation happens, suitable space governance and mechanisms must be considered to develop the space environment and to cater for the needs of Earth from exploration, exploitations and to discover the origins of life.

The conclusion is that such principles could apply to ADR and used to persuade states to follow suit. The worrying prospect is that these principles have failed to depict any legal importance on similar crucial issues such as climate change. [7] As Newman states, 'the environmental case is not working, and therefore, the economic is a viable alternative which can gain traction'. The comments were made off the back of a discussion on the conceptual model for a profitable return on investment from debris as space resource in which ADR is projected to only work where the invested funding has a potential of a return. The offset of the use of these laws relies up article III of the OST. Luckily if a state wishes to challenge their interpretation, an arbitrator, the UN or the ICJ may be asked to consider a dispute. Should this occur the need to make direct correlation in a legal fashion to UNCLOS and international environmental law will be required.

4. Consent

Consent within International law is a cornerstone principle and hence, is an acceptable theory of international legal precedent that the removal of debris by a state or a third party must be with consent of the launching state. A suggestible modern approach, however, has been that a possible principle to which customary law becomes instant, allowing the removal of debris without the consent of the state. Concurrently, a state that has their object removed by another state, or actor without its consent, would have little legal redress under such a model. [68] Such a concept can only be a hypothesized, and the removal of objects under 10 cm could be an achievable objective. Without a legal mechanism with the OST, the only stipulation would be that the object is returned to the launching state.

Carns' school of thought [68], which hypothesizes that legal consent should not apply in the removal of objects smaller than 10 cm; this is because the concept of instant international customary law can be applied. However, it is not globally accepted. For example, Cheng argued that *Opinio Juris* should be virtually unanimous. From a legal standpoint, the claim is partly valid considering there is no

binding clause under customary international law that obliges countries to seek consent in the removal of minuscule space debris. Beyond the vagueness of international customary law, such objects have no economic value, and there are no practical means of economic benefit. If the proposal is implemented and technologies are developed, the focus on small space debris could help clean up space considering there are about 750,000 objects in space that fit the criteria according to ESA [35].

Carns and other scholars who subscribe to these ideals, should acknowledge the fact countries and private companies, can be aggrieved by non-consented cleaning of space, especially because the prevailing laws do not provide a mechanism for legal recourse. From a technological point of view, the Carns' criteria can be challenged because there is no scientific or engineering framework to support the demarcation line. For example, experts may argue that 10 cm criteria are not suitable compared to 20, 15, or 5 cm, in such a hypothetical scenario, it would be difficult to build consensus without irrefutable facts and empirical models.

The realist legal paradigm advanced by Carns [68] clashes with the traditionalist legal regime, which does not compartmentalize space debris based on size. The main question is, how can the space industry move forward at a time when the legal space regime is inconsistent with the realities of the space debris damage and impact on future the space industry?

Despite the legal constraints, the issue of consent should not arise because there are no explicit international provisions on the same, and protection of outer space outweighs concerns about perpetual ownership of space objects. The point of view contradicts the proposals made by the Committee on the Peaceful Uses of Outer Space. The Committee argued that ownership and control over space objects continue *ad infinitum*, and to disregard the control and jurisdiction of the state of the registry could have adverse effects on space security [17]. Additionally, COPUOS proposed that space debris should be removed after seeking and obtaining the consent of the state of the registry.

The operational techniques of ADR assume that consent originates from the state ownership. However, sometimes ownership of space debris cannot be traced to any state especially the smaller pieces of debris. Small bits of debris have usually broken off from spacecraft bodies and as such, it becomes difficult to trace back to the point of origin and eventually to ownership. However, the Convention on Registration and Liability Convention sets out guidelines which are relatively difficult to follow. The guidelines state that "space object includes parts of a space object as well as its launch vehicle and parts thereof." [68]. Although not legally bound by space law, a state must not cause damage to another state. Instead, it must act in good faith and within the set international laws. Therefore, if objects smaller than 10 cm are orbiting in space, it would be up to a state to accept ownership of the objects and admit to the causing of a potential hazard within a non-jurisdictional area.

As discussed, the un-consented approach to ADR

regardless of size seems to conflict, on a primary basis, with international law. [69] It can be argued that the jurisdiction and control that the state possesses over space objects should be qualified by the principles of 'cooperation,' 'mutual assistance', and 'due regard'. Therefore, if the state which registered a space object takes no action to remove such an object when considered threatening and highly destructive, a right to remove it without consent can be applied. [46] Although such a scenario would be unlikely, Moltz describes the orbits as 'Crowded' [53], and hence, it is likely that such a situation may arise. Space debris presents a potential hazard when a state fails to act under or within their obligations to avert collisions. One such case in 2013 when the ISS made 63-course corrections due to small objects threatening the safety of the platform. [59] The possibility of such a future collision occurring should ADR not be acted real merit of a destructive force within the orbit. As within international law, the loss of space objects could have potentially life-threatening consequences for the state in question. They may create political tension between states at an international level to where sanctions and tensions apply.

Without consent from UN states, enforcing ADR under international laws becomes both difficult and weak. If a state becomes aware of the impending dangers of their debris and does not perform their obligations under OST and LC, then they fail to act in good faith. [63] Thus, ADR currently operates on the principle that space object control remains the responsibility of the country that launches it. As such, should space debris cause destruction or cause danger to other space objects without the consent removing it, or interfering with the object maybe create a movement for countermeasures.

4.1. Ownership and Abandonment

To effectively address the issue of ADR, it is crucial to analyse the ownership issues associated with space objects. Article VIII of the OST describes a space object as one which is "launched into outer space, including objects landed and constructed on a celestial body, and of their parts" [68]; therefore ownership of an object is the property of the launching state alone. The jurisdiction of the object allows the state to exercise its sovereign right on the principle of effectiveness'. [98] This issue of jurisdiction and control 'looms large' of ADR. [68] The launching state will remain the proprietary of the object until such time liability is removed.

Article VIII of OST confirms that a state is responsible for the actions of space activities if space objects are registered or launched within their jurisdiction. In doing so, the development of licensing and regulations through domestic law began. States may license private entities to carry out ADR under their jurisdiction and control. [48] However, a challenge can arise in cases where two or more states come together to launch a satellite or a specific object into space. In such instances, Article II of the Registration Convention stipulates that the states involved must agree which one among them will retain the jurisdiction of the launched object. [111] The rule of liability based on the registration, does not

apply in cases of different states being involved in the same space project since the state of registration is not always the launching state.

The UN Office of Outer Space Affairs is the international body mandated with guiding the development of laws and regulations related to space activities. Due to its central position in coordinating space activities of different states, the international body may actively seek a state's permission to remove dangerous debris under its jurisdiction and control but does not have the right or mandate power to do so. Without the consent of the state to which the object belongs, UNOOSA can simply follow its mandate. [120] States should also be encouraged to relinquish jurisdiction and control over objects that have reached the end of life, thereby allowing other states, or the international community, to remove them. [58] The end goal is to de-clutter orbit and enable all states to continue using outer space without the risk and potential of dangers of crowded debris. This objective would effectively allow ADR to work under a transfer of ownership to the UNOOSA, and therefore, state consent is not required.

Unfortunately, the OST does not provide for a scenario in which a transfer of space object ownership can be made. Therefore, currently, there is a need to obtain consent from relevant states before undertaking ADR. Critics of ADR have concerns over the ability to select objects and gain consent. Should ADR be considered, and consent not gained, the prospect of a violation of the OST would be reasonable and therefore predictable.

4.2. Abandonment

Despite the dangers caused by space debris, most states abandon the space objects because of the prohibitive costs needed for their removal. It is estimated that only 7% of orbiting space objects are operational satellites with the rest of the 93% being abandoned non-operational satellites, fragmentation, and rocket bodies. [124] A spent satellite is not abandoned within the legal consequence that it should be treated as being a 'res derelicta'. [42] To qualify as abandoned property, space objects must be abandoned unilaterally with no intended recipient; otherwise, the property would pass from the ownership of one party to another without existing in an abandoned, freely claimable state'. [64] The relevance of such an application is crucial as it shows a continued principle of ownership. Irrelevant of size, functionality, and of using the owner, there seems to be no scope in international space law for consideration of abandonment.

Nevlia explains that debris under a specific size should not be classified as a space object and instead, should be enlisted in a new subgroup. The author notes, 'under this proposal, debris would be excluded from the abandoned property regime, because owners are likely unaware of their ownership of smaller debris pieces, to which owners would likely waive their rights in this situation'. [33] The proposal underlines that once abandonment is established, the doctrine allows a state or company to resort to ADR. [33] The creation of such a law would allow for a limited removal mission to be coordinated between NSA, NGOs, and states to conduct ADR within

specific areas without worrying about ownership issues and consent. By cleaning up orbit, the use and productivity of space is enhanced, and ADR becomes less of a legal issue and more of financial implication. If the peaceful passage principle is also considered, then the obligation to remove any space debris or to ensure the safety of navigation provides a further allowance for such a doctrine to be created. [113].

Strahilevitz's interpretation of abandonment supports the position that debris, by its nature, has been abandoned. As abandoned property, 'debris would not be subject to the property rights of the original launching state' [64] and would be free to be disposed of by other parties. Strahilevitz also posits that the law establishes a free right to abandon the 'chattel property and allows for these items to be freely repossessed by the former owner or a new owner'. [64] It is, therefore, a noticeable trend that abandonment is often-overlooked when considering ADR. [64] However, based on the principle that no one can appropriate space, own or sell as per the OST guideline, it is challenging to consider property rights in space. Also, given that abandonment relies upon ownership of property, the definition of abandonment is legally problematic as it conflicts with the idea expressed in OST. Clear categorization of abandoned property in space is needed. A functional test [11] which would allow for a clear picture to be created, whereby ADR has an effective mandate creating an agreed level of consent within the international community. [13].

An exciting cross over is that of Maritime law and the doctrine of salvage. Maritime law contains rules for dealing with wreckage which causes or has the potential to cause harm. Such a concept is easily transcribed, and debris is considered an example of wreckage. Hackett poses the question as to why in the law of the sea, an abandoned object may be removed by any state other than the state of registry whereas in outer space this is not allowed [22]. If this question is considered in a broader scope, the answer gives a point to whether customary law already exists to which ADR can remove debris in situations where it may cause harm. By using Hackett's question and Strahilevitz's principles, a cross over into Maritime could work for ADR and allow international law the ability to act.

Additionally, the Nairobi International Convention on the Removal of Wrecks obliges the registered owner to remove its shipwreck in the 'Convention area' of the 'Affected State' if it is determined to constitute a hazard'. [75] ADR practices which resemble the salvage in maritime law may be prohibited under the OST. Still, the principles of peaceful passage, transboundary harm, and customary rules of wreckages pre-date the OST. Therefore, salvage law is an option for the future of ADR if the level of communication and consultation is used before undertaking the debris removal. A key benefit of such a law is that it would ensure entities, given the rights to engage in ADR, receive equitable compensation since they can recover the abandoned satellites and improve them to serve other useful purposes which can generate income. The refurbishment and reuse of two disabled and abandoned satellites, Weststar VI and Palapa B-2, discovered by Shuttle

Discovery in 1984 attests to the viability of the salvage law in ADR. [124].

4.3. A Realistic and Political View of ADR

Based on these legal provisions, it is only legal for companies and nations to remove space debris registered in countries where they are domiciled. For example, it would be acceptable for NASA, Space X, and other companies to deorbit US-registered satellites rather than Chinese or Russian satellites. However, the UN COPUOS also acknowledges that current laws were limited because they did not envisage a growing threat posed by the accumulation of debris. In brief, the Committee proposed that new space regimes should address the following themes: the global framework and international system required to facilitate space debris removal, the legal status of space debris and junk, and the legal issues arising from economic benefits accruing with space debris removal.

The legal ambiguities do not override the secondary concerns relating to the cost and ecological impact on earth-based life forms and backward contamination. As within the London Convention, the principle of precaution is a fundamental obligation for all parties to the treaty [100], which may be a contender for ADR as a founding principle. Beyond maritime protection, the precautionary principle also helps to inform decision making in other domains such as international terrestrial law. According to Bourguignon [28], the principle is particularly useful when scientific evidence is inadequate to inform decision making, and the potential impact on human health and the environment is significant. The law was first applied in Germany before the EU subsequently adopted it in the Maastricht Treaty and the global community through UNESCO [100]. The history of the precautionary principle demonstrates that national laws can develop into customary international laws.

Moreover, if the principle of caution is applied, then the spacefaring nation has a legitimate obligation to remove space junk as a precautionary measure. The spacefaring nations can also claim to the international environmental law, Rio and the Stockholm Declarations [103]; the two declarations constitute an integral part of international environmental law [20], which provide specific guidelines to limit environmental pollution and sustainability. The trans-boundary harm principle indicates that countries have an obligation to repair and are legally bound to compensate affected parties for failure to invoke remedial/preventative measures [114]. Based on the cost implications of compensation, preventing or decreasing any trans-boundary environmental interference is paramount. In brief, critical insights can be drawn from international maritime law, international environmental law and international law to the solidarity of article III and the application of cross legal principles so that ADR can be applied.

A similar case applies to what is commonly referred to as sustainable development and planetary sustainability [6] - there is no universal definition. From one dimension, the removal of space junk might not be regarded as an adequate

strategy for planetary sustainability. From another dimension, the approach could be a starting point if there was a clear legal framework. Moreover, there is a question of whether the precautionary principle, Rio and Stockholm's declarations had become normative rules. The history of environmental law shows that agreements over treaties and declarations alike are slow, and customary laws provide a possible attempt to allow ADR in the evolution of the global legal system. Maritime and environmental laws should serve as models for space environment protection and debris removal.

4.4. Cost Factors in Space Debris Removal

The cumulative mass of orbital debris in LEO is estimated at 6,000 tons. Therefore, the cost of debris cleaning will also have significant implications [76]. A project between ESA and Clear space estimates that it would cost about \$130 million to deorbit one piece of space junk from the LEO [90]. The target has a mass of 100 kg and is part of a spent rocket upper stage. A similar project, NASA's space fence project, which will be developed in partnership with Lockheed Martin, is projected to cost \$914 million [90]. Active space debris removal is expensive, as shown by these projects. Iridium does not think ADR is commercially viable unless affordable technologies are developed, costing at least \$10,000/satellite [16].

Using international and maritime laws as models would help resolve the consent issue. Two facts inform the legal claims. One, international laws on deorbiting defunct satellites to Earth or Space-based destruction using anti-satellite missiles are vague. Two, the cleanup of oceans has assumed a global commons approach; UN member states have pledged to clean up oceans and regulate waste accumulation. Since there is a collective responsibility in the cleanup of space, future space laws, or governance, should indicate whether space objects should be salvaged if they are too small to be identified or abandoned by in space for an extended period. Borrowing from the UNCLOS [110] and the Nairobi International Convention on the Removal of Wrecks [75]. Debris removal of fragments and other detached components should not raise legal concerns if the principles of the shipwreck at sea are applied in space.

Moreover, article VIII presents a distinct objective in with "Such objects or parts found beyond the limits of the State Party to the Treaty on whose registry they are carried shall be returned to that State Party, which shall, upon request, furnish identifying data before their return". If ADR considers that 10 cm and below is the starter principle, then it is almost certain that such objects would not survive atmospheric re-entry. The observation assumes that their owners have abandoned the objects, and Article VIII of the OST is only relevant to functional and operational space objects.

4.5. Sustainability

The lack of COPUOS guidelines on space debris removal has led to the deposition of space junk in the South Pacific Ocean's Nemo point [99] and launch of non-value adding

missions to space such as Tesla's EV car [60]. Drawing from recent events, the lack of express prohibition and legal ambiguities has been misinterpreted as a form of validation of unethical conduct in space exploration. For instance, the accumulation of additional space debris by Space X could be perceived as unethical, considering the volume of waste in space [76]; however, existing guidelines are specific to landing missions.

The possible adverse effect linked to the launch of Tesla EV should be considered from the broader context of the company's operations. The reusability of rockets by Space X would mitigate the carbon footprint in crewed spaceflight and satellite launches and contribute to the development of a circular economy. A circular economy is defined by sustainable use of products through post-consumer use recycling [37]. The carbon savings are significant for the Falcon 9 rocket, which can serve up to 100 cycles [101], with minimal repairs of the heat shielding. In contrast, the closest competitor is Blue Origin's New Glenn rocket which can only withstand 25 launches [101]. The significant improvements in the latter show that SpaceX is a trendsetter in space sustainability; the reusability of rockets such as ALLTRA-M had remained elusive in the 1990s and 2000s [66] before the establishment of SpaceX. Further design and material modifications could see more progress on sustainability. On the downside, there are no LCA analyses of the carbon footprint per launch for different rocket systems.

Ecological studies on the impact of satellite waste are inconclusive. Scholars who articulate these views suggest that satellites deposited in the space graveyard at the Nemo point would have long-term effects on the environment; this assessment is validated by the chemical and mechanical composition of satellites (fuel, coolants, and microparticulate matter) [121]. Matignon argues that there is minimal risk of contaminating marine species because the area is located far from any known colonies of sea species [38]. Despite this, a core issue is whether private space companies and governments should protect marine environments outside their area of jurisdiction [39]. Lucia and Iavicoli [39] argue that states have a responsibility in line with global environmental and maritime laws, which means that it was illegal for Russia, EU-27 (working under ESA) and the US to deposit satellites in the area. However, no action has been taken against these countries because they dominate spaceflight and space exploration - UNOOSA has a limited legal mandate in satellite deorbiting and deposition. However, Space X was not liable for satellite accumulation at sea because it only provided launch services to orbit.

5. Conclusion

The main question examined in this article was whether international law could effectively deal with the removal of space debris.

The issues of debris and ADR have been discussed to understand the legal challenges involved. The biggest concern for ADR is that of consent. Unconsented debris removal by

private operators may trigger inter-state conflict or may not concern the state. The basis of removal must, therefore, follow a due diligence principle to such that the owner of the object is consulted about the proposal. Generally, international law provides that wrongful actions by states occur when they fail to meet their obligation or conduct themselves in a way that undermines the sovereignty of other states. [29] However, as a rule of *lex specialis*, the OST prescribes those states should bear responsibility related to their space objects, irrespective of whether governmental or non-governmental entities own the objects. The above interpretation of outer space treaties is strictly textual. An agreement regarding the interpretation otherwise, however, may be established between states by their subsequent practice if states predominantly refrain from protesting when space debris is removed without consent. [58] Therefore this is the first hurdle of ADR.

As states bear obligations of *erga omnes*, the boundaries to the freedom of individual state activity in space must be formulated at the international level. [44] OST emphasizes the rights of states to use common international areas, so that accumulation of space objects and generation of debris undermines the law. [74] Such a statement under the current space law would not apply to ADR since the debris is not a feature within the treaties. Only by using a varied source of international law can this conclusion be made.

States must establish customary international law on the unilateral conduct of ADR. [68] Michael Scharf calls those who are 'first' to act by acting, which might develop into customary international law as 'custom pioneers'. [71] The effect on ADR would allow the limits to be continuously pushed until a state raises an issue. Such effects may also form accepted practice to which custom is created in future debris removal. There are two main elements when establishing customary law: a subjective element and an objective element. [12] Under the guiding articles of the ICJ, the development of these two elements began with the 1929 *S. S. Lotus* case. [95] There must be an 'opinio Juris,' to which an understanding by states is that whether the rule concerning an issue is written or not, states are obligated to follow behaviour. [78] To establish customary law, the international court employs the two-prong test, which mandates a 'widespread and uniform practice of nations, and nations must willingly engage in the practice.' [50].

'Modern arguments assert development of customary law is done almost instantaneously based on action and resulting acquiescence by some, especially those most affected, if not all for all states'. [68] When considering ADR, these actions are already occurring, such as NSA creating end of life plans for their objects and bringing them back. Also, mitigation measures are making space actors adapt their technology to ensure a minimum amount of debris, which is ultimately cost-effective for them in the long run. Finally, by using principles from other areas of law, ADR can be implemented with little concern for international legal restrictions.

The Clean Hands Doctrine does not address legal challenges involving space debris and ADR. Currently, Clean

Space One only plans to deorbit and remove from space the nanosatellite which it owns. This is where the clean hands doctrine can support limitations on liability. The doctrine explains that a party to a dispute is precluded from invoking another party's responsibility when the former has been guilty of violating a reciprocal obligation. Such a doctrine would not cancel out ADR, but help allow ADR to focus on objects that were unrecognizable and non-functional. Under the licensing and launching agreement of states, such a doctrine could easily be put into place by the states themselves to make NSAs follow such an obligation and help deal with space debris and ADR processes.

The application of environmental principles based on sustainability is crucial for preserving the outer space environment. [84] However, such principles should be efficient by ensuring the cost of compliance is affordable and to ensure they also implementable in different capacities, including management, legal, and technical. The Registration Convention emphasizes the need for states to implement comprehensive space objects registration, including their status and scope of operation which can assist in long-term sustainability through monitoring and identification by other states.' [103] The declaration principles can be included in space law statutes and enforced among the practices of all space-going states. [89].

The second consideration of international law is that of UNCLOS and Maritime Law. Abandonment, salvage, and other maritime principles are also crucial in revealing how space can be responsibly exploited. Allowing passage to space as per the OST is important, but if a state cannot access space due to space debris, then conflict may arise. Should access be restricted, the obligation under the OST is considered in which the space-faring states that violate the OST law are approached to remove their debris. At this point, either a state accepts that their objects are restricting access and posing a danger and accept that they violate international law, or they will deny responsibility. Essentially, ADR becomes the most logical alternative. Consent or unconsented removal of the debris is inevitable.

The financial implication of ADR is prohibitively large. As a result, most private entities are motivated by profits, and therefore there is a need for governments to enforce international regulations including revenue collection, environmental protection, and Labor standards, to ensure sustainability. The private-sector space activities planned, including space tourism and asteroid mining, will also be affected if access to orbit is complicated by space debris. Also, nobody has any incentive to economize activities such as future spacecraft launches that further contribute to space debris clutter.

Another complication is the distinct possibility that private entities' "efficient" use of space might create a developmental structure against the long-term best interests of the entities' state of nationality, or humanity in general. It is clear by general consent that NSA is a profit-based organisation and by spending more money than they gain from ADR, such a project stops being feasible. As a result, the only possible way

of carrying out ADR is by a coalition of space agencies such as ESA to conduct a trial and judge the feasibility on specific designs.

Throughout this article, ways that the international community can deal with space debris removal have been discussed. ADR on an international level should be easy to agree upon as long as the financial implications are agreed upon by all states involved. The ability to sub-classify objects into non-functional items, junk, and hazard is a possible outcome to which space cleanup commences.

The article also noted different instances in which ADR can be undertaken without any formal agreement in place. Specifically, should the ICoC carry on making progress, then it is possible that ADR may become a key pollution mitigation strategy for the outer space environment. However, international law still needs significant amendment, especially in improving UNOOSA and UNGA to integrate the various regulations and ensure different space agencies observe similar rules associated with space sustainability.

With an upcoming space race to the Moon and planet Mars for exploration, it would be interesting to see the challenges in launching objects into space and attempting to avoid debris when getting into space. The possibility of modifying the existing structures, such as the clean hands doctrine and making ADR legal could focus on a specific area of debris which can be removed with ease.

The main challenge of considering environmental laws or maritime law as an alternative to promoting ADR is that they emphasize the need for states to contribute finances towards addressing outer space pollution. For instance, the Paris agreement and Kyoto protocol show that inclusion of financial responsibility limits the number of states willing to engage. Based on the literature discussed, the only objections that would be raised is when a state has a vested interest in the space object being removed or that a potential burden is placed on the state. It would also be a further allowance that ADR indemnifies the states from liability and excludes such actions from the LC, OST and ADR procedures. A practical solution would be that like most space activities, ADR is licensed, insured and controlled by a national or international regulator under a specific legal mandate. ADR is not only reasonable but concludes the OST's international obligations under Article III and that of the UN Charter. Without multilateral actions, debris will increase, and humanity will suffer. The time to act is now, and only when ADR is carried out will the international community discuss the idea either in a positive or negative conversation.

References

- [1] A. E. Boyle, *Globalizing Environmental Liability: The Interplay of National and International Law*, 17 J. ENV. L. (2005).
- [2] Agatha Akers, "To Infinity and Beyond: Orbital Space-Debris and How to Clean It Up," *University of La Verne Law Review* 33 (2012).

- [3] Alan S Belward and Jon O Skoien, 'Who Launched What, When and Why; Trends in Global Land-Cover Observation Capacity from Civilian Earth Observation Satellites' (2015) 103 ISPRS Journal of Photogrammetry and Remote Sensing 115 <http://dx.doi.org/10.1016/j.isprsjprs.2014.03.009> Reassessed 18/8/2020.
- [4] Alexandra Witze, The quest to conquer Earth's space junk problem, (2018), <https://www.nature.com/articles/d41586-018-06170-1> Reassessed 18/8/2020.
- [5] Amy Thompson, SpaceX Launched 60 Internet-Beaming Satellites Into Orbit (2019), <https://www.smithsonianmag.com/innovation/spacex-launched-60-internet-beaming-satellites-orbit-180972211/> Reassessed 18/8/2020.
- [6] André Galli and Andreas Losch, 'Beyond Planetary Protection: What Is Planetary Sustainability and What Are Its Implications for Space Research?' (2019) 23 Life Sciences in Space Research 3 <https://doi.org/10.1016/j.lssr.2019.02.005> Reassessed 18/8/2020.
- [7] Anel Ferreira-Snyman, The Environmental Responsibility of States for Space Debris and the Implications for Developing Countries in Africa, 46 Comp. & Int'l L. J. S. Afr. 19 (2013).
- [8] ARS Technica, (2013), <https://arstechnica.com/science/2013/07/how-nasa-steers-the-international-space-station-around-space-junk/> Accessed 28/06/19 Reassessed 18/8/2020.
- [9] B. Sandeepa Bhat, Application of Environmental Law Principles for the Protection of the Outer Space Environment: A Feasibility Study, 39 Annals Air & Space L. (2014).
- [10] Barry Kellman, Space: The Fouled Frontier: Adjudicating Space Debris as an International Environmental Nuisance, 39 J. Space L. (2014).
- [11] Bin Cheng, Studies in International Space Law (1997).
- [12] Bin Cheng, United Nations Resolutions on Outer Space: "Instant" International Customary Law? 5 INDIAN J. INT'L L. (1965).
- [13] Chelsea Munoz-Patchen, Regulating the Space Commons: Treating Space Debris as Abandoned Property in Violation of the Outer Space Treaty, 19 Chi. J. Int'l L. (2018).
- [14] Chen, Shenyan, The Space Debris Problem, Asian Perspective, Vol. 35, No. 4 (2011) <https://www.questia.com/library/journal/1P3-2610265131/the-space-debris-problem> Reassessed 18/8/2020.
- [15] Chris Newman, The Ethics of Space Exploration, 'The Way to Eden': Environmental Legal and Ethical Values in Interplanetary Space Flight, 2016, Springer International Publishing Switzerland.
- [16] Christian Marxsen*, 'Territorial Integrity in International Law – Its Concept and Implications for Crimea' (2016) 75 ZaoRV 7.
- [17] Committee on the Peaceful and Uses of Outer Space, 'Active Debris Removal — An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space: A Report of the International Interdisciplinary Congress on Space Debris Remediation and On-Orbit Satellite Servicing' 1.
- [18] Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques, 10 Dec. 1976, 1108 U.N.T.S. 151.
- [19] Corfu Channel Case (United Kingdom v. Albania); Merits, I. C. J. Reports (1949).
- [20] Daniel Bodansky, Jutta Brunnée and Ellen Hey, International Environmental Law: Mapping the Field (Oxford University Press 2012).
- [21] Danielle Miller, Calling Space Traffic Control: An Argument for Careful Consideration before Granting Space Traffic Management Authorities, 23 ILSA J. Int'l & Comp. L. (2017).
- [22] DE SAUSSURE: An International Right to Re orbit Earth Threatening Satellites. 2 Annals of Air and Space Law, (1978).
- [23] Declaration of Legal Principles Concerning the Activities of States in the Exploration and Use of Outer Space, UNGA Res 1962 (XVIII) (13 December 1963) <http://un-documents.net/a18r1962.htm> Reassessed 18/8/2020.
- [24] Declaration of the United Nations Conference on the Human Environment A/CONF. 48/14 and Corr. 1; 9 International Legal Materials (1972).
- [25] Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, 13 Dec. 1996, UN GA doc. A/RES/51/122 (1996).
- [26] Defense Intelligence Agency, 'Challenges to Security In Space' 1. <https://media.defense.gov/2019/Feb/11/2002088710/-1/-1/1/SPACE-SECURITY-CHALLENGES.PDF> Reassessed 18/8/2020.
- [27] Di Pippo, S., 2017. To space2030 and beyond: space as a driver for sustainable development. Available online at: <https://www.friendsofeurope.org/insights/to-space2030-and-beyond-space-as-a-driver-for-sustainable-development/>, accessed 17/07/19 Reassessed 18/8/2020.
- [28] Didier Bourguignon, 'The Precautionary Principle: Definitions, Applications and Governance' [2015] European Parliamentary Research Service 1.
- [29] Draft Articles on Responsibility of States for Internationally Wrongful Acts, [2001] 11 (2) Y. B. Int'l L. Comm'n.
- [30] Draft International Code of Conduct for Outer Space Activities of Mar. 31, 2014 [hereinafter ICoC], 1.1, https://eeas.europa.eu/headquarters/headquarters-homepage/427/disarmament-non-proliferation-and-arms-export-control_en Reassessed 18/8/2020.
- [31] E. Antolini, Modernising Public Nuisance: Solving the Paradox of the Special Injury Rule, 28 ECOLOGY L. Q. (2001).
- [32] Edith Brown Weiss, Our Rights and Obligations to Future Generations for the Environment, 84 American Journal of International Law 198 (1990).
- [33] Emily M. Nevala, Waste in Space: Remediating Space Through the Doctrine of Abandonment and the Law of Capture, <https://www.questia.com/library/journal/1P4-1956454233/waste-in-space-remediating-space-debris-through-the> Reassessed 18/8/2020.
- [34] Environment: A Feasibility Study, 39 Annals Air & Space L. (2014) 361.

- [35] ESA, 'About Space Debris' (2020) https://www.esa.int/Safety_Security/Space_Debris/About_space_debris accessed 25 May 2020. Reassessed 18/8/2020.
- [36] European Commission, 'Closing the Loop - An EU Action Plan for the Circular Economy' (2015) <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52015DC0614> accessed 23 April 2020; Reassessed 18/8/2020.
- [37] Mia Pantzar and Timothy Suljada, 'An Analysis of the New EU Circular Economy Action Plan' (Institute for European Environmental Policy, 2020) <https://ieep.eu/publications/an-analysis-of-the-new-eu-circular-economy-action-plan> accessed 23 April 2020. Reassessed 18/8/2020.
- [38] Fauqueux S, 'Marine Pollution Caused by Space Debris' (Space Legal Issues, 2020) <https://www.spacelegalissues.com/marine-pollution-caused-by-space-debris/> accessed 16 May 2020 Reassessed 18/8/2020.
- [39] VITO DE LUCIA AND VIVIANA IAVICOLI*, FROM OUTER SPACE TO OCEAN DEPTHS: THE 'SPACECRAFT CEMETERY' AND THE PROTECTION OF THE MARINE ENVIRONMENT IN AREAS BEYOND NATIONAL JURISDICTION <https://scholarlycommons.law.cwsl.edu/cgi/viewcontent.cgi?article=1551&context=cwilj> Reassessed 18/8/2020.
- [40] Gabcikovo-Nagymaros Project (Hungary/Slovakia) 37 I. L. M. 162 (1998).
- [41] GLENN H. REYNOLDS & ROBERT P. MERGES, OUTER SPACE: PROBLEMS OF LAW AND POLICY 176 (1997).
- [42] Gyula Gal, The ILA Draft Instruments on the Protection of the Environment from Damage Caused by Space Debris, 38 Acta Jur. Hng. (1997).
- [43] Henry R. Hertzfeld & Ray A. Williamson, The Social and Economic Impact of Earth Observing Satellites, in *Societal Impact of Space Flight*, p. 242 (2007), available at <http://history.nasa.gov/sp4801-chapter13.pdf>. Accessed 12/12/18 Reassessed 18/8/2020.
- [44] Henry R. Hertzfeld and Frans von der Dunk, Bringing Space Law into the Commercial World: Property Rights without Sovereignty, Space and Telecommunications Law Program Faculty Publications. Paper 15 (2005).
- [45] Hobe, S., Schmidt-Tedd, B., Schrogl, K. U., Meishan, G., 2015. *Cologne Commentary on Space Law*. Heymanns, Cologne, pp. 2009–2015.
- [46] Huan Yu, Legal study on active removal of the space Debris; p. 18 (Harbin Institute of Technology, 92014).
- [47] ILC Report Chapter V. International Liability for Injurious Consequences Arising out of Acts Not Prohibited by International Law (Prevention of Transboundary Harm from Hazardous Activities, <https://legal.un.org/ilc/reports/2001/english/chp5.pdf> Reassessed 18/8/2020.
- [48] J. Pelton, New solutions for the space debris problem 74 (2015).
- [49] J. H. Barker, A537, Space Orientation Course: Lesson 1, Intro/Space Policy/Organisations, US Army Command and General Staff College.
- [50] Jack L. Goldsmith & Eric A. Posner, A Theory of Customary International Law 5 (The John M. Olin Law and Economics Working Paper No. 63 (2d Series), 1998).
- [51] James Mason and others, 'Orbital Debris-Debris Collision Avoidance' 1; Mark Garcia, 'Space Station: Space Debris and Human Spacecraft' (International Space Station (ISS), 2017) https://www.nasa.gov/mission_pages/station/news/orbital_debris.html accessed 31 March 2020;
- [52] Melissa Kemper Force, 'Active Space Debris Removal: When Consent Is Not an Option' (2016) 29 *The Air & Space Lawyer* 1.
- [53] James Moltz, *Crowded Orbits*, Columbia University Press, isbn 978-0-231-15912-8, (2014) 16.
- [54] JASON KRAUSE, The Outer Space Treaty turns 50. Can it survive a new space race? 2017 https://www.abajournal.com/magazine/article/outer_space_treaty Reassessed 18/8/2020.
- [55] Jean-Marie Bockel, 'The Future of the Space Industry' [2018] NATO Parliamentary Assembly 1. <https://www.nato-pa.int/document/2018-future-space-industry-bockel-report-173-esc-18-e-fin> Reassessed 18/8/2020.
- [56] Jeffrey Lewis, "'Hit-to-Kill" and the Threat to Space Assets'. https://www.peacepalacelibrary.nl/ebooks/files/UNIDIR_pdf-art2673.pdf Reassessed 18/8/2020.
- [57] Jensen, Eric. "Cyber Sovereignty: The Way Ahead." *Texas International Law Journal*, vol. 50, no. 2/3, University of Texas, Austin, School of Law Publications, Inc., Apr. 2015.
- [58] Jinyuan Su, Active Debris Removal: Potential Legal Barriers and Possible Ways Forward, 9 *J. E. Asia & Int'l L.* (2016).
- [59] Juan Manuel de Faraminan Gilbert, "Space Debris: Technical and Legal Aspects", in Gabriel Lafferranderie and Daphne Crowther, eds, *Outlook on Space Law over the Next Thirty Years* (The Hague: Kluwer Law International, 1997).
- [60] Kayla Zacharias, 'Tesla in Space Could Carry Bacteria from Earth' (Purdue University, 2018) <https://www.purdue.edu/newsroom/releases/2018/Q1/tesla-in-space-could-carry-bacteria-from-earth.html> accessed 9 May 2020. Reassessed 18/8/2020.
- [61] LAKE LANOUX ARBITRATION (FRANCE v. SPAIN) (1957) 12 R. I. A. A. 281; 24 I. L. R. 101.
- [62] Lauren Bressack, Addressing the Problem of Orbital Pollution: Defining a Standard of Care to Hold Polluters Accountable, 43 *Geo. Wash. Int'l L. Rev.* (2011).
- [63] Lawrence Li, Space Debris Mitigation as an International Law Obligation, 17 *Int'l Comm. L. Rev.* (2015).
- [64] Lior Jacob Strahilevitz, The Right to Abandon, 158 *U. PA. L. Rev.* (2010).
- [65] Losch, A., 2018b. Interplanetary sustainability. Mars as a means of a long-term sustainable development of humankind in the solar system? In: Szocik, K. (Ed.), *The Human Factor in a Mission to Mars. An Interdisciplinary Approach*. Vol. 2019 Springer.
- [66] M Reichert, 'The Future of Human Spaceflight' (2001) 49 *Acta Astronautica* 495.
- [67] Malaysia v. Singapore (2005) XXVII RIAA 133, ICGJ 372.

- [68] Marc G. Carns, Consent Not Required: Making the Case That Consent Is Not Required under Customary International Law for Removal of Outer Space Debris Smaller than 10CM, 77 A. F. L. Rev. (2017). 10.7256/2453-8817.2018.2.28640 URL: https://en.nbpublish.com/library_read_article.php?id=28640 Reassessed 18/8/2020.
- [69] Matthew Kleiman, The Little Book of Space Law, American Bar Association, isbn: 978-1-61438-874.
- [70] Mia Pantzar, Think Sustainable Europe, An Analysis of the new EU Circular Economy Action Plan, (2020), https://ieep.eu/uploads/articles/attachments/2f74268d-c72b-4e61-8898-0ce3de81ce4f/Analysis%20of%20the%20EU%20Circular%20Economy%20Action%20Plan%202020_web.pdf?v=63751769974 Reassessed 18/8/2020.
- [71] Michael P. Scharf, Accelerated Formation of Customary International Law, 20 ILSA J. INT'L & COMP. L. 305, 318-329 (2014). <https://www.ilsa.org/Jessup/Jessup15/Second%20Batch/ScharfCustom.pdf> Reassessed 18/8/2020.
- [72] Michael R. Mason the new accountability: environmental responsibility across borders, at introduction, at 3 (Earthscan. London, UK, 2005), <http://eprints.lse.ac.uk/larchive/00000578> Accessed 11/08/18.
- [73] MOX Plant Case, Ireland v United Kingdom Case No 10, ICGJ 343 (ITLOS 2001).
- [74] Muñoz-Pachten, Chelsea. "Regulating the Space Commons: Treating Space Debris as Abandoned Property in Violation of the Outer Space Treaty." Chi. J. Int'l L. 19 (2018) 241.
- [75] Nairobi International Convention on the Removal of Wrecks, <http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/Nairobi-International-Convention-on-the-Removal-of-Wrecks.aspx>
- [76] NASA, 'Space Debris' (2019) https://www.nasa.gov/centers/hq/library/find/bibliographies/space_debris accessed 25 May 2020. Reassessed 18/8/2020.
- [77] Newman, C. J., Williamson, M., 2018. Space sustainability: reframing the debate. Space Policy 46, p. 35. <https://www.sciencedirect.com/science/article/abs/pii/S0265964617300462> Reassessed 18/8/2020.
- [78] North Sea Continental Shelf (Ger. v. Den. & Ger. v. Neth.), Judgment, 1969 I. C. J. Nos. 51 & 52 (Feb. 20).
- [79] O'Flaherty, Russian Spacecraft Stalking U.S. Spy Satellite Sparks Espionage Fears <https://www.forbes.com/sites/kateoflahertyuk/2020/02/05/space-espionage-fears-as-russian-spacecraft-starts-stalking-us-spy-satellite/#5e59d8004028> Reassessed 18/8/2020.
- [80] P. Meredith, A Legal Regime for Orbital Debris: Elements of a Multilateral Treaty, in *Preservation of Near-Earth Space for Future Generations* (J. Simpson ed 2006) 216.
- [81] Pass, J., Dudley-Rowley, M., Gangale, T., 2006. The cultural imperative to colonise space: an astro Sociological perspective. Space 2006, San Jose, California: American Institute of Aeronautics and Astronautics, Reston, Va.
- [82] Paul B Larsen, 'Solving the Space Debris Crisis' (2018) 83 Journal of Air Law and Commerce 475.
- [83] Popova R., Schaus V. — The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space // Space Research. – 2018. – № 2. – P. 175 - 224. DOI: 10.7256/2453-8817.2018.2.28640 URL: https://en.nbpublish.com/library_read_article.php?id=28640 Reassessed 18/8/2020.
- [84] Rada Popova, Volker, Schaus, The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space.
- [85] Regulating the Space Commons: Treating Space Debris as Abandoned Property in Violation of the Outer Space Treaty, Capture, 66 AM. U. L. REV (2017) 1531.
- [86] Report of the United Nations Conference on Environment and Development, Principle 13, United Nations General Assembly (Rio de Janeiro, June 1992) https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/ACONF.15126Vol.I_Declaration.pdf Reassessed 18/8/2020.
- [87] Report of the World Commission on Environment and Development: Our Common Future, <https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf> Accessed 16/07/19 Reassessed 18/8/2020.
- [88] RESTATEMENT (SECOND) OF TORTS §821B (1979).
- [89] Richard Berkley, Space Law versus Space Utilisation: The Inhibition of Private Industry in Outer Space, 15 Wis. Int'l L. J. (1996).
- [90] Richard Smith, 'There's a Junkyard Orbiting Earth. These Companies Want to Clean It Up' [2020] NASDAQ.
- [91] Rio Declaration, <http://www.unesco.org/education/pdf/RIOE.PDF> Accessed 27/06/19 Reassessed 18/8/2020.
- [92] Robert V. Percival, Liability for Environmental Harm and Emerging Global Environmental Law, 25 MD. J. INT'L L. 37 (2010).
- [93] Rockström, J., et al., 2009. A safe operating space for humanity. Nature <https://www.nature.com/articles/461472a> Reassessed 18/8/2020.
- [94] Ross Liemer and Christopher F Chyba, 'A Verifiable Limited Test Ban for Anti-Satellite Weapons' (2010) 33 The Washington Quarterly 149 <https://doi.org/10.1080/0163660X.2010.492346> Reassessed 18/8/2020.
- [95] S. S. Lotus (Fr. v. Turk.), Judgment, 1927 P. C. I. J. No. 9.
- [96] Samantha Lawson, Note, The Conundrum of Climate Change Causation: Using Market Share Liability to Satisfy the Identification Requirement in Native Village of Kivalina v. ExxonMobil Co 22 Fordham Env'tl. L. Rev. (2011).
- [97] Sattler, Rosanna. "Transporting a Legal System for Property Rights: From the Earth to the Stars." Chi. J. Int'l L. 6 (2005).
- [98] Sergio Marchisio, National Jurisdiction for Regulating Space Activities of Governmental and Non-Governmental Entities, <http://www.unoosa.org/pdf/pres/2010/SLW2010/02-02.pdf> Reassessed 18/8/2020.
- [99] Solene Fauqueux, 'Marine Pollution Caused by Space Debris' (Space Legal Issues, 2020) <https://www.spacelegalissues.com/marine-pollution-caused-by-space-debris/> accessed 16 May 2020. Reassessed 18/8/2020.

- [100] Solomon Slonim, *The Right of Innocent Passage and the 1958 Geneva Conference on the Law of the Sea*, 5 *Collum J. TRANSNAT'L L.* 96 (1966).
- [101] Steinar Lag and Tiffany Hildre, 'Reusable Rockets: Revolutionising Access to Outer Space' [2020] *DNV-GL: Technology Outlook 2030*.
- [102] Steven A. Mirmina & David J. Den Herder, *Nuclear Power Sources and Future Space Exploration*, 6 *CHI. J. INT'L L.* 149 (2005).
- [103] Stockholm Declaration, https://thefactor.com/facts/law/civil_law/environmental_laws/stockholm-declaration/871/
- [104] Tatyana V Labutkina, "'Quick" Evaluation of Degrees of Danger for Satellites by Catalogued Objects of Space Debris,' 54th International Astronautical Congress of the International Astronautical Federation, the International Academy of Astronautics, and the International Institute of Space Law (American Institute of Aeronautics and Astronautics 2003) <https://doi.org/10.2514/6.IAC-03-IAA.5>. P. 10 Reassessed 18/8/2020.
- [105] Thierry Senechal, "Orbital Debris: Drafting, Negotiating, Implementing a Convention," <https://web.mit.edu/stgs/pdfs/Orbital%20Debris%20Convention%20Thierry%20Senechal%2011%20May%202007.pdf> Reassessed 18/8/2020.
- [106] Thomas Gehring & Markus Jachtenfuchs, *Liability for Transboundary Environmental Damage - Towards a General Liability Regime?* 4 *EJIL* (1993).
- [107] Thomas N. Keefer, *Dam Safety Monitoring & GEOSS Satellite Telemetry*, <http://www.sutron.com/pdfs/goes-satellitetelemetrydamsafety-monitoring.pdf>. Accessed 23/10/18 Reassessed 18/8/2020.
- [108] *Trail Smelter arbitration* *Arbitral Trib.*, 3 *U.N. Rep. Int'l Arb. Awards* (1941).
- [109] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, 27 January 1967, 610 *UNTS* 205, 18 *UST* 2410, *TIAS* No 6347, 6 *ILM* 386 (entered into force on 10 October 1967) [*Outer Space Treaty*]; *Convention on Registration of Objects Launched into Outer Space*, 6 June 1975, 28 *UST* 695, 1023 *UNTS* 15 (entry into force 15 September 1976) [*Registration Convention*]; *Convention on International Liability for Damage Caused by Space Objects*, 29 March 1972.
- [110] Tyler Wolanin, 'The Abandoned Shipwrecks Act in Florida' (2018) 47 *School of Public Policy Capstones* 1.
- [111] U. N. Office for Outer Space Affairs, (2008). *United Nations Treaties and Principles on Outer Space and Related General Assembly Resolutions*.
- [112] UNEP, 'World Overwhelmingly Commits to Protecting the Oceans and Clean Seas' (2018) <https://www.unenvironment.org/news-and-stories/press-releases/world-overwhelmingly-commits-protecting-oceans-and-clean-seas> accessed 26 May 2020. Reassessed 18/8/2020.
- [113] *United Nations Convention on the Law of the Sea (UNCLOS)* https://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf Reassessed 18/8/2020.
- [114] *United Nations, 'Prevention of Transboundary Harm from Hazardous Activities'*. https://legal.un.org/ilc/texts/instruments/english/draft_articles/9_7_2001.pdf Reassessed 18/8/2020.
- [115] *United Nations, 2015, Transforming our World: The 2030 Agenda for Sustainable Development*, <https://sustainabledevelopment.un.org/post2015/transformingourworld/publication> Accessed 16/07/19 Reassessed 18/8/2020.
- [116] *UNOOSA, 'Space Law Treaties and Principles'* (2020) <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html> accessed 31 March 2020. Reassessed 18/8/2020.
- [117] *UNOOSA, 'Space Law Treaties and Principles'*; McGill University, 'Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched Into Outer Space' [2020] McGill University: Institute of Air and Space Law.
- [118] *UNOOSA, 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies'*; Senate Committee on Commerce Science & Transportation, 'Reopening the American Frontier: Exploring How the Outer Space Treaty Will Impact American Commerce and Settlement in Space'.
- [119] *UNOOSA, 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.'*
- [120] Venkata Rao, *Recent Developments in Space Law*, Springer Publishing (2017).
- [121] Vito De Lucia and Viviana Iavicoli, 'From Outer Space to Ocean Depths: The "Spacecraft Cemetery" and the Protection of the Marine Environment in Areas Beyond National Jurisdiction' (2019) 49 *California Western International Law Journal*.
- [122] Walter Macdougall, *Sputnick, The Space Race and the Cold War* (May 1985) 41 (5) *Bulletin of Atomic Scientists*.
- [123] Welly, N. (2010). *Enlightened state interest: A legal framework for protecting the "Common Interest of All Mankind" from Hardinian Tragedy*. *Journal of Space Law*.
- [124] White, W. (1992). *Salvage law for outer space. Engineering, Construction, and Operations in Space, '92 Proceedings of the Third International Conference, Denver Spac1*.
- [125] Witze, A, *The quest to conquer Earth's space junk problem*, (2018), <https://www.nature.com/articles/d41586-018-06170-1>