Quest Journals
Journal of Research in Humanities and Social Science
Volume 11 ~ Issue 5 (2023) pp: 378-383
ISSN(Online):2321-9467
www.questjournals.org

Research Paper

International Liability for Outer Space Environment: A Continuous Threat Caused By Space Junk

Dr Sushma Sharma[1]
Ruchi Jain[2]

***R**eceived 17 May, 2023; **R**evised 28 May, 2023; **A**ccepted 31 May, 2023 © The author(s) 2023.*
P**ublished with open access at **www.questjournals.org

I. INTRODUCTION

We are currently orbited by more than 160 million manmade space debris forming a cage of steel, aluminium & paint chips travelling at 23 times faster than the speed of sound.[3] If space debris continues to pile up, we could create a Kessler effect, a continuously colliding debris field that no satellite could survive and no spaceship could escape, trapping us on earth.[4]

Over the past 50 years, humans have made great strides in space travel. We have put a man on the moon, built permanent stations in space, & created a vast network of satellites which are vital to many terrestrial technologies and economies. However, wherever mankind goes so does the waste we produce, & space is no different.[5]

Half a century of both manned and unmanned missions (& probes) have resulted in the build-up of a cosmic dumping ground. According to NASA and the US Department of Defense, there are currently more than 23,000 pieces of debris larger than a baseball and roughly 5,00,00 pieces the size of a marble, & these are the pieces we can track. NASA's statistical analysis estimates several hundred million millimetres and smaller-sized pieces of debris.[6] And why is that a problem? Space debris travels in our orbit at speeds of up to 20km per second; fast enough that even a tiny piece of debris could damage or destroy a spacecraft or a satellite. As an example, a 0.2-millimetre chip of paint travelling at that speed has about the same destructive power as a hand grenade and multiple times has left large impact craters on the windows of space shutters.[7] In 2007, China tested an anti-satellite missile on a defunct weather satellite to prove that it was capable of hitting US space assets. This test alone added more than 3,500 pieces of trackable debris. We risk approaching a point of no return whereby the amount of debris in space causes a runaway cycle of collisions in an event known as the Kessler Syndrome or Kessler Event. [8]

[1] Associate Professor, National Law Institute University, Bhopal; Contact No.- 9425025114; E-mail ID-Sushma.sharma@nliu.ac.in.
[2] Research Scholar, National Law Institute University, Bhopal; Contact No.- 9425679763; E-mail ID-ruchijain903@gmail.com.
[3] Mark Garcia, Space Debris and Human Spacecraft, NASA (May 26, 2021), https://www.nasa.gov/mission_pages/station/news/orbital_debris.html.
[4] Stephen Johnson, How Space Debris created the World's largest garbage dump, BIG THINK (May 17, 2021), https://bigthink.com/hard-science/space-debris-solutions/.
[5] Jonathan O'Callaghan, What is space junk and why is it a problem, Natural History Museum, https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html.
[6] Mark Garcia, Space Debris and Human Spacecraft, NASA (May 26, 2021), https://www.nasa.gov/mission_pages/station/news/orbital_debris.html.
[7] Stephen Johnson, How Space Debris created the World's largest garbage dump, BIG THINK (May 17, 2021), https://bigthink.com/hard-science/space-debris-solutions/.
[8] Maya Wei-Haas, Space Junk is a huge problem and its only getting bigger, National Geographic (April 25, 2019), https://www.nationalgeographic.com/science/article/space-junk.

STATEMENT OF PROBLEM

If action is not taken effectively and actively to reduce the amount of space junk in our orbit, then we risk creating a cage of metal swirling around our planet, inhospitable to satellites and untraversable by spacecraft. A major challenge, however, in cleaning up our orbit is finding a way of docking with or capturing space junk to recycle it on earth or destroy it in our atmosphere.

RESEARCH OBJECTIVES

The research objectives of this article are three-fold. Firstly, to understand the effect of space debris on the outer space environment and also the damages caused by them. Secondly, to analyze the legal provisions that regulate the outer space environment and specifically the damages caused by space debris. And lastly, to explore the measures to prevent or remove space debris from the outer space environment.

HYPOTHESIS

Space debris has become a continuous threat to the outer space environment and this will become a bigger problem if nothing is done to prevent it.

RESEARCH QUESTIONS

- How space debris affects the outer space environment and what type of damage can it cause?
- What legislation regulates the outer space environment and the damages caused by space debris?
- What measures and actions can be taken to remove space debris from outer space?

II. RESEARCH METHODOLOGY

The researchers for purpose of this article has mainly relied on the doctrinal method and analytical method.

LAW REGULATING OUTER SPACE ENVIRONMENT

The Outer Space Treaty, 1967 (OST) does not define environmental pollution of outer space but it, however, identifies the sources that can pollute the outer space environment.[9] Article IX puts the obligations on the state parties to avoid any such activities that can contaminate or pollute outer space and also ban such experiments which involve the use of any weapons on the Moon or other celestial bodies.[10] Article IX reads as:

"*In the exploration and use of outer space…… States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty has reason to believe that an activity or experiment planned by another State Party in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, may request consultation concerning the activity or experiment*."[11]

Moreover, Article IV of the OST restricts the State parties from using nuclear weapons or weapons of mass destruction. Article IV reads as:

"*States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner. The Moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military manoeuvres on celestial bodies shall be forbidden. The use of military personnel for scientific research or any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the Moon and other celestial bodies shall also not be prohibited*."[12]

[9] Ouarda Layachi, International Liability for Pollution Damage in Outer Space Environment, 16 WSEAS Transactions on Environment and Development 149, 150 (2020).

[10] Tim Robinson, Space Debris: The Legal Issues, RAS (Jan. 3, 2014), https://www.aerosociety.com/news/space-debris-the-legal-issues/.

[11] The Outer Space Treaty, Article IX.

[12] The Outer Space Treaty, Article IV.

Further in resolution No. 52/56 of 1997, the United Nations General Assembly has recommended "to give more attention to all aspects relating to the protection of the outer space environment and conservation, particularly those aspects that have an impact on the Earth's environment."[13]

THE BASIS OF INTERNATIONAL LIABILITY ARISING FROM DAMAGE TO OUTER SPACE POLLUTION

The basis of any international liability arises either from the 'theory of error' or from the 'theory of unlawful action'. The theory of error determines international liability if it is established that the wrongful act results from any intentional act, omission or negligence. Whereas the theory of unlawful action determines the international liability if the conduct of any international unlawful act has been established or the breach of an international obligation. both theories have been proven incapable while determining the legal basis of such damage. Hence the theory of liability or absolute responsibility has emerged.[14]

Under Article I of the OST, all space activities are considered internationally legal according to the principles of use of outer space and the freedom of scientific research but at the same time, the OST has restricted space activities that can pollute, contaminate or cause damage to the outer space. There are two grounds that established the international liability for damages caused by such outer space activities based on the location of damage under the Liability Convention, 1972.

Article II of the Liability Convention puts the liability on the State party by whose space object the damage has been caused either on the surface of the Earth or to any spacecraft in flight. Article II reads as:

"*A launching State shall be liable to pay compensation for damage caused by its space object on the surface of the Earth or to aircraft in flight*."[15]

Further Article III puts the liability on the other launching state party if the first launching state party's spacecraft or person or property has been damaged or harmed due to its fault. Article III reads as:

"*In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible."*[16]

Also, Article IV of the Liability Convention states that if any damage has been caused by a space object which is a joint mission of two or more states then all the state parties involved in that mission shall be held liable jointly and severally. Article IV reads as:

"*In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, and of damage thereby being caused to a third State or its natural or juridical persons, the first two States shall be jointly and severally liable to the third State…*"[17]

IADC SPACE DEBRIS MITIGATION GUIDELINES, 2002

The Inter-Agency Space Debris Coordination Committee or the IADC, an international forum of space agencies, has established certain mitigation guidelines under the IADC Space Debris Mitigation Guidelines. The member of the IADC are as follows- UKSA, SSAU, ROSCOSMOS, NASA, KARI, JAXA, ISRO, ESA, DLR, CSA, CNSA, CNES AND ASI. The objectives of these mitigation measures are as follows:

a) To minimise the potential for on-orbit break-ups.
b) To limit the debris released during normal operations.
c) To provide for post-mission disposal.
d) To prevent on-orbit collisions.

These IADC Guidelines are applied in the various stages:

- Planning of mission.
- Operation and design of spacecraft.
- Orbital stages that will be injected into Earth orbit.

The effectiveness of these IADC Guidelines has been discussed in the work of Frey & Lemmens. A few observations made by them are as follows:

[13] Ouarda Layachi, International Liability for Pollution Damage in Outer Space Environment, 16 WSEAS Transactions on Environment and Development 149, 151 (2020).
[14] Ouarda Layachi, International Liability for Pollution Damage in Outer Space Environment, 16 WSEAS Transactions on Environment and Development 149, 152 (2020).
[15] The Liability Convention, Article II.
[16] The Liability Convention, Article III.
[17] The Liability Convention, Article IV.

"…53.3% of the payloads and 60.3% of the payload mass reaching End-of-Life in LEO between 2006-2015 are compliant. In terms of mass, this share is constantly sloping downward; 71.6% of the rocked bodies reaching End-of-Life in LEO between 2007-2016 are compliant, a fraction virtually unchanged for 8 years in a row despite an increased EOL manoeuvre activity; 66.1% of the payloads reaching EOL in GEO between 2007-2016 are compliant, tendency rising but possibly saturating; The level of adherence 15 years after the introduction of the mitigation guidelines is sobering, the only exception being the clearance of payloads in GEO; The environment around Earth, especially in LEO is continuing to get more hostile almost every year..."[18]

Keeping these observations in mind, the IADC Guidelines were revised in the year 2020, upholding the goal of these mitigation guidelines- "to preserve the Earth's environment for future generations."

COPOUS SPACE DEBRIS MITIGATION GUIDELINES, 2007

The United Nations Office for Outer Space Affairs in the year 2007 established the "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space". the following are the objectives behind the COPOUS Space Debris Mitigation Guidelines:

a) To limit the released debris during normal operations.
b) To lessen the possibility of break-up during operational phases.
c) To reduce the possibility of collision accidents in orbit.
d) To avoid any harmful activity and intentional destruction.
e) To reduce the risk possibilities of post-mission break-ups resulting from stored energy.
f) To lessen the long-term placement of launch vehicles and spacecraft in the Low-Earth Orbit (LEO) region after the completion of its mission.

These guidelines are voluntary in nature and are not made internationally legally binding on the state parties.

WAYS OF REMOVING SPACE DEBRIS

An industry estimated to be approximately 1.4 billion dollars as soon as 2028 & offering a way out of the space prison we are making for ourselves.[19]

Claw Capture

The first technology up is claw capture. ClearSpace-1 is a Swiss-based start-up that spun out from the Swiss Federal Institute of Technology in 2019. ClearSpace has already bid for and secured an 86 million euros [102 million dollars] contract with the European Space Agency to launch their proof of concept mission to retrieve an obsolete satellite.[20] The agency will feature a conventional chemical rocket-powered spacecraft with a purpose-built four-armed claw, which will first match the orbiting trajectory of a target before extending its arms and grasping onto it. ClearSpace's maiden mission is due to launch in 2025 targeting a Vespa, Vega Secondary Payload Adapter, a part of a rocket used to carry a satellite into space which was left over from a bunch in 2013. Once ClearSpace-1 has acquired the client object grass bill then vector, so that it re-enters the atmosphere causing both ClearSpace-1 and the payload to burn up on re-entry.

A key advantage of this system is that it targets large debris objects, removing them from orbit before a collision turns them into many smaller pieces of debris that would need to be collected. However mechanical capture of a target requires careful matching of velocities and tumbling behaviour so as to prevent further debris generation. The claw system also sets an upper and lower size limit on the objects ClearSpace-1 can capture. As of 27 October 2021, ClearSpace was selected by the UK Space Agency to define a space mission able to remove multiple defunct satellites from orbit. With this initiative, the UK Space Agency is driving development in two critical areas needed for commercially viable debris removal, multi-removal missions & refuelling. Never doubt the power of the claw.[21]

Magnetic Capture

The next way to remove space junk is magnetic capture. Astroscale is a Japanese company looking to create a magnetic tugboat debris capture system by matching the orbit trajectory of a satellite or a debris candidate. Astrosacle proposes to magnetically dock to either complete repairs on a satellite or to push the debris into the

[18] Frey & Lemmens, Status of the Space Environment: Current Level of Adherence to the Space Debris Mitigation Policy, 2017.

[19] Jonathan O'Callaghan, What is space junk and why is it a problem, Natural History Museum, https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html.

[20] Daniel Clery, Europe plans space claw to capture orbiting junk, SCIENCEINSIDER (Dec. 1, 2020), https://www.science.org/content/article/europe-plans-space-claw-capture-orbiting-junk#:~:text=The%20ClearSpace%2D1%20mission%2C%20built,the%20atmosphere%20and%20burn%20up..

[21] Id.

atmosphere so it burns up. On 25 August 2021, Astroscale piloted its end-of-life services through Astroscale demonstration. The mission successfully demonstrated its capability to capture a client object in a trial run-through.[22]

Astroscale proposes that all satellites can be pre-engineered with a lightweight magnetic docking plate to make this process more reliable. This potentially means that the system will not be quite as effective for collecting existing objects without the plate. However, where they are available they should enable easy docking with minimal chance of damaging or creating further debris. As of 26 October 2021, Astroscale Limited, the UK subsidiary of Astroscale, was awarded the UK Space Agency bid to study the removal of two further defunct satellites from space as part of their COSMIC programme 'Cleaning Outer Space Mission through Innovative Capture,' reminding us that half of space exploration is coming up with a catchy naming convention.[23]

'Remove Debris'

The third approach pioneered by Survey Satellite Technology Limited is RemoveDEBRIS- a project conducted by a consortium of companies in collaboration with the University of Surrey. Seemingly taking inspiration from the roman gladiators wielding both net and a spear, the RemoveDEBRIS system designed by Airbus features a tethered harpoon and a weighted net-casting system.[24] In 2019, RemoveDEBRIS successfully tested both capture systems in a series of in-orbit demonstrations. Using their net systems, they captured a target CubeSat which is one of the most common types of small satellites. Their platform tracked the CubeSat and once it was within a seven-meter range, fired their space net so that the deployment masses wrapped around and entangled the target before a motor-driven winch reeled in the neck of the net preventing it from re-opening. In their second test, a 1.5-meter boom was deployed from the satellite platform with a plate mimicking a satellite on the end of it. The platform deployed a special-purpose-made harpoon at 20 meters per second to penetrate the target and lock it in place via a tether attached to the spacecraft.[25]

The key advantage of these systems is they are capable of capturing very large pieces of debris without having to match the tumbling properties of the debris object. However, both approaches risk small pieces of debris separating from the larger structures.

Laser Broom

The fourth and final item to remove space junk is the Laser Broom which is the least exciting name possible for space lasers. Electro Optic Systems [EOS] is an Australian company with experience in developing laser systems for use in the aviation and defence industries. High energy laser pulse radiation may be the most feasible means to mitigate the threat of a collision with a space station or other high-value space asset with orbital debris in the sizes of 1 to 10 centimetres. Under laser irradiation, part of the debris material is ablated or heated and provides an impulse to the debris particle. Proper dissection of the impulse either deflects the object trajectory away from the high-value asset or slows the debris into an intercept course with the upper atmosphere where it ultimately burns up.[26]

The idea would be that this laser system would scan across the sky, systematically removing debris targets out of the trajectory of high value space assets. Most research concentrates on ground-based laser systems because arming satellites with laser systems is generally seen as militarizing space, which is a no-no. For ground-mounded approaches through this means that the systems will need to deal with atmospheric distortions that may make reliably targeting small objects difficult as well as requiring reasonably high power levels. However, this system could be used quickly to target many pieces of debris servicing multiple objects much more quickly than physically capturing them ever could.

[22] The European Space Agency, Magnetic Space Tug could target dead satellites, ESA (Jun. 19, 2017), https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Magnetic_space_tug_could_target_dead_satellites.

[23] Isabelle Dume, Electromagnets could help clean up space junk, PhysicsWorld (Nov. 29, 2021), https://physicsworld.com/a/electromagnets-could-help-clean-up-space-junk/.

[24] Josh Davis, Net to Catch space debris orbiting Earth is successfully deployed, Natural History Museum (September 20, 2018), https://www.nhm.ac.uk/discover/news/2018/september/net-to-catch-space-debris-around-earth-is-successfully-deployed.html.

[25] Id.

[26] Jon Cartwright, Lasers could nudge space debris aside, NATURE (Mar. 15, 2011), https://www.nature.com/articles/news.2011.161.

III. CONCLUSION

Space debris has become a continuous threat to the outer space environment and this will become, if not already, a bigger problem if nothing is done to prevent it. IADC Space Debris Mitigation Guidelines were established in the year 2002 as internationally legally binding guidelines but they are not competent to deal with the increasing space debris issue as these guidelines only talk about mitigative measures but no punitive measures or liability measures are contained in them. COPOUS Space Debris Mitigation Guidelines were established in 2007 but it is not legally binding on states.

The current international space law framework needs to be amended to address the developing issues in the space sector. Further, it is proposed that an international tribunal must be established for addressing and regulating the growing concern of space debris affecting the outer space environment.