

An Introduction to the Regulation of Outer Space Environmental Pollution

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Abstract

The development of outer space through exploration and exploitation has grown rapidly since the launch of Sputnik-I in 1957, bringing economic benefits and scientific progress. However, the space debris accumulation has created grave environmental challenges. Some 10 million kilograms of space debris, made up of fragments larger than 1 millimeter, challenge the sustainability of space activities. These debris particles can have high velocities and, therefore, they can pose threats to spacecraft, satellites, and even to the safety of astronauts. Despite enormous technological advances, the existing international agreements do not provide adequate definitions and proper mechanisms of functioning for the management of space debris. The existing legal frameworks, including the Outer Space Treaty and the Liability Convention, have not been designed to deal properly with the complexities involved in regulating and accounting for space debris. International cooperation and advanced legislation are necessary in order to mitigate the increase of space debris and make a sustainable use of outer space. It is in this regard that coordination in the use of technology and clarity in legal responsibilities become indispensable elements to protect space exploration in the future from a growing environmental threat—that is, space debris.

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I. Introduction

As a part of exploring the outer space for the first-time human made satellite³ 'Sputnik-I'⁴ was launched by the previously known as Soviet Union on 4 October 1957.⁵ The outer space mystery has propelled human race to explore this area and the advancement of technology in the 21st century is commendable.⁶ The scientists have expressed their views relating to qualitative and quantitative expansion of space activities.⁷ The exploration of rich natural resources of the earth and economic benefits obtained while sustainably exploiting them have been made possible because of several outer space satellite operational activities.⁸

Several Nations made remarkable and significant accomplishments in the outer space technology⁹ but, because of this, human operation in outer space¹⁰, the environmental harm caused in this sector cannot be overlooked.¹¹ Approximately 10 million Kg. of space debris¹² available in the outer space consisting of fragments larger than 1 millimetre in diameter and bigger than 1

³ Sharon L. Fjordbak, *The International Direct Broadcast Satellite Controversy*, 55 J. AIR L. & COM. 903 (1990).

⁴ Eugene Pepin, *Legal Problems Created by the Sputnik*, 4 MCGILL L. J. 66 (1957).

⁵ Andrew Swatkovsky, *The Soviet Attitude on Outer Space*, 9 Probs. Communism 19 (1960).

⁶ Diane M. Janosek, *Innovative Thinking: Modernizing Outer Space Governance*, 29 CATH. U. J. L. & TECH 63 (2021).

⁷ Edwin W. Paxson II., *Sharing the Benefits of Outer Space Exploration: Space Law and Economic Development*, 14 MICH. J. INT'L L. 487 (1993).

⁸ Art Dula, *Private Sector Activities in Outer Space*, 19 INT'L L. 159 (1985).

⁹ Stephan Frhr. von Welck, *Export Limitations for Sensitive Outer Space Technology / Exportbeschränkungen für Sensitive Weltraumtechnologie / Des Limitations d'Export pour Technologies Spatiales Sensitives*, 36 ZLW 365 (1987).

¹⁰ P. Subin Joseph, *Military Ambitions in Outer Space*, 5 INT'L J.L. MGMT. & HUMAN. 995 (2022).

¹¹ I. H. Ph. Diederiks-Verschoor, *Environmental Protection in Outer Space*, 30 GERMAN Y.B. INT'L L. 144 (1987).

¹² Paul B. Larsen, *Solving the Space Debris Crisis*, 83 J. AIR L. & COM. 475 (2018).

cm¹³ in length.¹⁴ Mitigation to environmental harm caused by the space debris is difficult because of its uniqueness in comparison to that of conventional garbage.¹⁵ There will be serious danger to the sustainable use of space, if Nations fail to give proper attention to their respective duties for prevention of environmental degradation of outer space.¹⁶

II. Space Debris Causing Harm

The travel speed of single piece of space debris will be more than 15 km/s, as per the scientific calculations.¹⁷ In an ordinary operation of the spacecraft¹⁸ and orbiting satellites¹⁹ the space debris larger than the centimetres level can cause serious harm.²⁰ There is possibility of causing adverse impact to the internal control system and can penetrate the satellite's clock by a fine particle of the cm level space debris definitely will lead to huge damage of the spacecraft and satellites.²¹ It is also claimed that the surface of the spacecraft can be damaged by a few microscopic particles moving at a slow speed thereby altering the surface performance of the space objects and the space operations will have adverse impact.²² Space debris can be increased with the impact of space junk among and between them and also between the spacecraft and satellites.²³ The

¹³ 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. 173 (2017).

¹⁴ Benjamin Jacobs, *Debris Mitigation Certification and the Commercial Space Industry: A New Weapon in the Fight against Space Pollution*, 20 MEDIA L. & POL'y 117 (2011).

¹⁵ Edward G. Lee & D. W. Sproule, *Liability for Damage Caused by Space Debris: The Cosmos 954 Claim*, 26 CAN. Y.B. INT'L L. 273 (1988).

¹⁶ Bruce L. McDermott, *Outer Space: The Latest Polluted Frontier*, 36 A.F. L. REV. 143 (1992).

¹⁷ Timothy Justin Trapp, *Taking up Space by Any Other Means: Coming to Terms with Nonappropriation Article of the Outer Space Treaty*, 2013 U. ILL. L. REV. 1681 (2013).

¹⁸ Lubos Perek, *Outer Space Activities versus Outer Space*, 7 J. Space L. 115 (1979).

¹⁹ Kuo Lee Li. *World Wide Space Law Bibliography* (1978).

²⁰ Meghan R. Plantz, *Orbital Debris: Out of Space*, 40 GA. J. INT'L & COMP. L. 585 (2012).

²¹ Nicolas Mateesco Matte. *Aerospace Law* (1969).

²² Ivan A. Vlasic, Editor. *Explorations in Aerospace Law: Selected Essays by John Cobb Cooper, 1946-1966* (1968).

²³ Michael S. Dodge, *Regulating Orbital Debris: The Federal Communications Commission Tackles Space Junk*, 96 N.D. L. REV. 181 (2021).

sustainability of the ecosystem in outer space is under threat because of these factors.²⁴

III. Space Objects and Their Collision

There will be extensive damage to this ordinary space objects if the high-speed space debris fall on them.²⁵ Inside the space object the microscopic space debris particles will reach and amount to significant damage in the internal system.²⁶ Similarly, there will be reduction of the performance of the space objects as soon as it gets impact from the space debris.²⁷ The space junk can receive catastrophic harm from these particles even though they are small in size.²⁸ It is expected that over the next 200 years the objects still in the orbit will lead to collapse with one another.²⁹ It is reciprocal that as soon as there will be enhancement of the space objects similarly, there will be enhancement of space debris.³⁰ It will be difficult for nations to send a space object to the outer space because of huge production of debris that will make the orbit excessively populated to use and there will be possibility of forming a low earth orbit by these debris.³¹ There will be a vicious circle because of the collision with of space objects and space debris.³²

²⁴ Diane M. Janosek, *Innovative Thinking: Modernizing Outer Space Governance*, 29 CATH. U. J. L. & TECH 63 (2021).

²⁵ Kevin D. Heard, *Space Debris and Liability: An Overview*, 17 CUMB. L. REV. 167 (1986).

²⁶ Timothy G. Nelson, *Regulating the Void: In-Orbit Collisions and Space Debris*, 40 J. Space L. 105 (2015-2016).

²⁷ Gunnar Leinberg, *Orbital Space Debris*, 4 J.L. & TECH. 93 (1989).

²⁸ Robert C. Bird, *Procedural Challenges to Environmental Regulation of Space Debris*, 40 AM. Bus. L.J. 635 (2003).

²⁹ Cort S. Thompson, *Avoiding Pyrrhic Victories in Orbit: A Need for Kinetic Anti-Satellite Arms Control in the Twenty-First Century*, 85 J. AIR L. & COM. 105 (2020).

³⁰ David Enrico Reibel, *Environmental Regulation of Space Activity: The Case of Orbital Debris*, 10 Stan. ENVTL. L. J. 97 (1991).

³¹ N. Jasentuliyana, *Space Debris and International Law*, 26 J. Space L. 139 (1998).

³² Isavella Maria Vasilogeorgi, *Military Uses of Outer Space: Legal Limitations, Contemporary Perspectives*, 39 J. Space L. 379 (2014).

For exploration and utilisation of resources in outer space a critical role is performed by spacecraft and satellites.³³ There will be positive impact on the human existence, health care, agriculture, including education and other disciplines because of success achieved by the science behind satellites and spacecraft.³⁴ However, the significant amount of material and financial support is required for the establishment of spacecraft and satellites.³⁵ Once these spacecraft and satellites are destroyed there will be many direct and indirect reactions.³⁶

IV. Life Risk of Astronauts

Maintenance of on orbit satellite including lunar exploration, among other things, are performed by astronauts as a part of extravehicular task and they must be outside the hermetic space capsule to do so, is a part and course of outer space travel.³⁷ The life of astronaut may face the risk at any moment from the deep space hostile atmosphere.³⁸ Even a small piece of the space debris may cause extensive injury to the astronaut because such debris runs more than seven times the speed of a bullet.³⁹ The space suits are well equipped with gas cleansing device, liquid cooling equipment, temperature and humidity control equipment and the breath support device.⁴⁰ As soon as there will be impact of high-speed space debris with the secure space suit most of the devices are rendered

³³ Scot W. Anderson, Julia La Manna & Korey J. Christensen, *The Development of Natural Resources in Outer Space*, 51 ENVTL. L. REP. 10835 (2021).

³⁴ Michael I. Stockman, *The Education Value of Direct Broadcasting Satellites and the Heightened Need for International Agreement*, 9 LOY. L.A. INT'L & COMP. L.J. 377 (1987).

³⁵ I. H. Ph. Diederiks-Verschoor, *Financing and Insurance Aspects of Spacecraft*, 24 J. Space L. 97 (1996).

³⁶ Julian G. Verplaetse, *On the Definition and Legal Status of Spacecraft*, 29 J. AIR L. & COM. 131 (1963).

³⁷ R. Cargill Hall, *Rescue and Return of Astronauts on Earth and in Outer Space*, 63 AM. J. INT'L L. 197 (1969).

³⁸ Thomas J. Herron, *Deep Space Thinking: What Elon Musk's Idea to Nuke Mars Teaches Us about Regulating the Visionaries and Daredevils of Outer Space*, 41 COLUM. J. ENVTL. L. 553 (2016).

³⁹ Irene Atney-Yurdin, *Space Debris Legal Research Guide*, 3 PACE Y.B. INT'L L. 167 (1991).

⁴⁰ Carol Weisbrod, *A Comment on Property and Divorce*, 32 CONN. L. REV. 291 (1999).

irreparable.⁴¹ The death of astronauts is possible from the malfunctioning of the multiple functions applicable in the space suits.⁴²

V. Adversity on People's Living Conditions

The falling of satellite from the outer space to the surface of the Earth is unavoidable when that is influenced by the atmospheric resistance to the satellites roaming in low earth orbit.⁴³ During the launching of large satellites, the earth surface receives partial burnout debris from the same.⁴⁴ This procedure can potentially cause massive property damage and risk to human life if not managed timely and correctly.⁴⁵

The nuclear power-driven⁴⁶ satellites and spacecrafts are sent to the outer space as a consequence of the advancement in science and technology.⁴⁷ There will be adverse impact on people's living conditions as soon as nuclear material accompanied space debris fall from the sky.⁴⁸ The adverse impact of nuclear material will have long-term consequences to humans and other living organisms on earth and potential harm to the ecological balance can be witnessed as soon as they encounter such harmful materials.⁴⁹

⁴¹ Barry Kellman, *Space: The Fouled Frontier: Adjudicating Space Debris as an International Environmental Nuisance*, 39 J. Space L. 227 (2014).

⁴² Heather A. Douglas, *Death in Pursuit of Space Travel: An Analysis of Current Methods of Recovery for Families of Astronauts and the Need for Reform*, 26 WHITTIER L. REV. 333 (2004).

⁴³ Gary L. Hopkins, *Legal Implications of Remote Sensing of Earth Resources by Satellite*, 78 MIL. L. REV. 57 (1977).

⁴⁴ Elizabeth Seebode Waldrop, *Integration of Military and Civilian Space Assets: Legal and National Security Implications*, 55 A.F. L. REV. 157 (2004).

⁴⁵ Luke Punnakanta, *Space Torts: Applying Nuisance and Negligence to Orbital Debris*, 86 S. CAL. L. REV. 163 (2012).

⁴⁶ Andrew J. Young, *Legal and Techno-Political Implications of the Use of Nuclear Power Sources in Outer Space*, 12 Rutgers COMPUTER & TECH. L.J. 305 (1987).

⁴⁷ Joseph J. MacAvoy, *Nuclear Space and the Earth Environment: The Benefits, Danagers, and Legality of Nuclear Power and Propulsion in Outer Space*, 29 WM. & MARY ENVTL. L. & POL'y REV. 191 (2004).

⁴⁸ Philip McGarrigle, *Hazardous Biological Activities in Outer Space*, 18 AKRON L. REV. 103 (1984).

⁴⁹ Isabelle Bouvet, *Use of Nuclear Power Sources in Outer Space: Key Technology Legal Challenges*, 30 J. Space L. 203 (2004).

VI. Definition of Space Debris is Missing

The decommissioned satellites, spacecraft, and other space objects, in general, may be considered as space debris.⁵⁰ The legal concept of space debris under the international agreement has not been defined.⁵¹ It is important to note here that the parties under the Moon Agreement are required to take preventive steps to protect the moon's existing environmental balance.⁵² Accordingly, the contamination of the moon's environment with harmful extra-environmental matter or by incorporating adverse changes to the moon's existing environmental balance is completely prohibited.⁵³ The prevention of entry of extra-terrestrial materials or other factors that may cause harmful and adverse impact on the space environment is the responsibility of the government.⁵⁴ The inclusion of space debris under the category of extra-environmental matter is ambiguous and has not given any concrete conclusion.⁵⁵

There is a specific provision, in addition to the above-mentioned provisions, under Article 5 of the Convention on International Liability for Damage Caused by Space Objects, 1971 (Liability Convention⁵⁶), which came into force in September 1972.⁵⁷ The launching state will be responsible for damage caused by its own fault or by the fault of individuals in control of such

⁵⁰ Emily M. Nevala, *Waste in Space: Remediating Space Debris through the Doctrine of Abandonment and the Law of Capture*, 66 AM. U. L. REV. 1495 (2017).

⁵¹ Sophie Kaineg, *The Growing Problem of Space Debris*, 26 Hastings ENVTL L. J. 277 (2020).

⁵² Paul B. Larsen, *Application of the Precautionary Principle to the Moon*, 71 J. AIR L. & COM. 295 (2006).

⁵³ David Everett Marko, *A Kinder, Gentler Moon Treaty: A Critical Review of the Current Moon Treaty and a Proposed Alternative*, 8 J. NAT. Resources & ENVTL. L. 293 (1992).

⁵⁴ George Paul Sloup, *Peaceful Resolution of Outer Space Conflicts through the International Court of Justice: The Line of Least Resistance*, 20 DEPAUL L. REV. 618 (1971).

⁵⁵ Gabrielle Hollingsworth, *Space Junk: Why the United Nations Must Step in to Save Access to Space*, 53 Santa CLARA L. REV. 239 (2013).

⁵⁶ Paul G. Dembling, *A Liability Treaty for Outer Space Activities*, 19 AM. U. L. REV. 33 (1970).

⁵⁷ Carl Q. Christol, *International Liability for Damage Caused by Space Objects*, 74 AM. J. INT'L L. 346 (1980).

launching.⁵⁸ The responsibility will be for inflicting damage to the property or people of the launching state or to the space object of other states.⁵⁹ The space trash whether constitutes space objects is not clear from this article.⁶⁰ This article is related with joint launching by two or more nations and will be held financially responsible jointly and severally.⁶¹

There is significant undermining of the above-mentioned Article's binding effect in the environmental protection of outer space because there is ambiguity under the liability convention surrounding the definition of space debris.⁶² What space debris that the government must clean up is not clear because of the missing of appropriate definition applicable to space debris.⁶³ Accordingly, the applicable legislation and the authorities under the legislation has disappeared because of the above-mentioned factor for fixing responsibility on environmental damage of the outer space.⁶⁴

V. Uncertainty of the Subject Matter of Liability

In the outer space activity organised by non-governmental agencies or government agencies, the concerned state parties will have an international accountability for their actions undertaken in the outer space.⁶⁵ This is well mentioned under the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial

⁵⁸ Deborah Housen-Couriel, *Disruption of Satellite Transmissions Ad Bellum and in Bello: Launching a New Paradigm of Convergence*, Isr. L. REV. 431 (2012).

⁵⁹ Brian D. Green, *Space Situational Awareness Data Sharing: Safety Tool or Security Threat*, 75 A.F. L. REV. 39 (2016).

⁶⁰ James E. Dunstan, *Space Trash: Lessons Learned (and Ignored) from Space Law and Government*, 39 J. Space L. 23 (2013).

⁶¹ Katherine Durant & Glen M. W. Trowbridge, *Commerce and Outer Space: A Legal Survey*, 37 MERCER L. REV. 1551 (1986).

⁶² Ty S. Twibell, *Space Law: Legal Restraints on Commercialization and Development of Outer Space*, 65 UMKC L. REV. 589 (1997).

⁶³ Irene Atney-Yurdin, *Insuring Third-Party Liability for Commercial Outer Space Enterprises*, 3 INT'L PROP. INV. J. 325 (1987).

⁶⁴ Hamilton Desaussure, *The Impact of Manned Space Stations on the Law of Outer Space*, 21 SAN DIEGO L. REV. 985 (1984).

⁶⁵ Dan L. Burk, *Protection of Trade Secrets in Outer Space Activity: A Study in Federal Preemption*, 23 SETON HALL L. REV. 560 (1993).

Bodies (The Outer Space Treaty), 1966, which came into force in October 1967.⁶⁶ Under the Liability Convention the launching nations are held accountable for compensation for any damage to a space object of one launching state or to people and property on board.⁶⁷ To identify that which nation has majority of space debris in the outer space, given the present state of knowledge and technology, is very difficult to establish.⁶⁸ Even if the nation has registered space objects it is very difficult to determine in which country the concerned space object is registered once it is launched in the outer space or once when it is fragmented because of outer space collision.⁶⁹ This is mentioned under the Convention on Registration of Objects Launched into Outer Space (Registration Convention), 1974, which came into force in 1976.⁷⁰ Among the international community the transfer of satellite ownership is customary in nature.⁷¹ However, the transferee state is not the launching state under the Liability Convention.⁷² Accordingly, there is an imbalance on fixing of responsibility for compensation between launching state and the transferee state because, under the Liability Convention the transferee state is not responsible for environmental harm caused by space objects.⁷³

Many nations have taken steps towards the privatisation and commercialisation of space exploration.⁷⁴ For satellite launch operations many non-governmental

⁶⁶ Cameron K. Wehringer, *The Treaty on Outer Space*, 54 A.B.A. J. 586 (1968).

⁶⁷ Anthony Farnesi, *The Intellectual Space Race: Applying Terrestrial Patent Laws to Private Outer Space Activity*, 28 S. CAL. Interdisc. L.J. 713 (2019).

⁶⁸ Kurt Anderson Baca, *Property Rights in Outer Space*, 58 J. AIR L. & COM. 1041 (1993).

⁶⁹ Arthur M. Dula, *Management of Interparty and Third-Party Liability for Routine Space Shuttle Operations*, 26 DRAKE L. REV. 741 (1976).

⁷⁰ S. Neil Hosenball & Pierce M. Hartman, *The Dilemmas of Outer Space Law*, 60 A.B.A. J. 298 (1974).

⁷¹ Paul B. Larsen, *Small Satellite Legal Issues*, 82 J. AIR L. & COM. 275 (2017).

⁷² Herbert Reis, *Some Reflections on the Liability Convention for Outer Space*, 6 J. Space L. 125 (1978).

⁷³ Michael J. Listner & Joshua T. Smith, *A Litigator's Guide to the Galaxy: A Look at the Pragmatic Questions for Adjudicating Future Outer Space Disputes*, 23 VAND. J. ENT. & TECH. L. 53 (2020).

⁷⁴ Gbenga Oduntan, *Aspects of the International Legal Regime concerning Privatization and Commercialization of Space Activities*, 17 GEO. J. INT'L AFF. 79 (2016).

organisation⁷⁵, international organisations and private firms are involved.⁷⁶ However, for fixing financial responsibility to the private entities, because of damage to the outer space environment, no specific legislation has been witnessed.⁷⁷

VI. Lack of Mechanism for Coordination

To track every nation's outer space activity and to eliminate various obstacles faced in outer space utilisation and its exploration, there should be international cooperation mechanism that can be adopted by the international community.⁷⁸ In addition, to play a key role in outer space environmental protection, there should be appropriate forum to resolve disputes emerging from outer space exploration.⁷⁹ Impediments in the implementation of international treaties for the regulation of Outer space is the consequence of absence of a coordinating system.⁸⁰ It is impossible to ensure that the nations will adhere to the international treaty obligation for outer space regulation, unless there is supervision by the core committee nations.⁸¹ It is likely that neither the international community nor the other countries, if a country fails to comply with an international treaty obligation, will be aware of the situation and country's behaviour cannot be legally confined by them.⁸² There is significant diminishing of the concept of legal binding force of the international treaty because failure of which cannot

⁷⁵ Ph. Diederiks-Vershoor & W. Paul Gormley, *Future Legal Status of Nongovernmental Entities in Outer Space: Private Individuals and Companies as Subjects and Beneficiaries of International Space Law*, 5 J. Space L. 125 (1977).

⁷⁶ Stanton Eigenbrodt, *Out to Launch: Private Remedies for Outer Space Claims*, 55 J. AIR L. & COM. 185 (1989).

⁷⁷ Charles L. Deem, *Liability of Private Space Transportation Companies to Their Customers*, 51 Ins. Counsel J. 340 (1984).

⁷⁸ Chukeat Noichim, *International Cooperation for Sustainable Space Development*, 31 J. Space L. 315 (2005).

⁷⁹ Ka Fei Wong, *Collaboration in the Exploration of Outer Space: Using ADR to Resolve Conflicts in Space*, 7 CARDOZO J. CONFLICT Resol. 445 (2006).

⁸⁰ Kenneth S. Pedersen, *International Cooperation and Competition in Space: A Current Perspective*, 11 J. Space L. 21 (1983).

⁸¹ Eilene Galloway, *Maintaining International Space Cooperation for Peaceful Uses*, 30 J. Space L. 311 (2004).

⁸² Lara L. Manzione, *Multinational Investment in the Space Station: An Outer Space Model for International Cooperation*, 18 AM. U. INT'L L. REV. 507 (2002).

legally confine the nation's behaviour.⁸³ The proposal for establishment of international coordination for the regulation of Outer space has not been accepted appropriately, even though at the 19th century some eminent space scientists, about space travel, favoured for the formation of a coordinating structure to deal with the outer space regulation.⁸⁴ To address the pressing challenge of coordinating the regulation of Outer space still there is no worth framework which can be mentioned.⁸⁵

VII. Relevant Legislation on Outer Space Regulation

The Committee on the Peaceful Uses of Outer Space (COPUOS) was established by the United Nations General Assembly in the year 1959.⁸⁶ It has two subsidiary bodies and establishes in the year 1961, for example, the scientific and technical subcommittee and the legal subcommittee.⁸⁷ For reducing the ecological harm of the outer space, there should be reduction in the discharge of space debris became the prerequisite part of space debris remediation guidelines under COPUOS.⁸⁸ There are situations where the space debris remediation can be possible, for example, restricting the accidental crash in orbit⁸⁹, during the operation stage minimisation of the prospect of dissolution, reducing the discharge of debris during normal operation and prevention of deliberate self-destruction.⁹⁰ After the mission has been completed in the low earth orbit, there can be long-term risk in the outer space which can be controlled as suggested by many eminent scholars

⁸³ Stephen J. Garber, *Incentives for Keeping Space Clean: Orbital Debris and Mitigation Waivers*, 41 J. Space L. 179 (2017).

⁸⁴ Andrew G. Haley, *Law of Outer Space--A Problem for International Agreement*, 7 AM. U. L. REV. 70 (1958).

⁸⁵ Michel Bourely, *The Institutional Framework of Space Activities in Outer Space*, 26 J. Space L. 1 (1998).

⁸⁶ Eilene Galloway, *Consensus Decisionmaking by the United Nations Committee on the Peaceful Uses of Outer Space*, 7 J. Space L. 3 (1979).

⁸⁷ *1979 Annual Meeting: Space Commerce and the Space Shuttle, Its Development: Legal, Scientific and Practical Implications*, 21 Jurimetrics J. 73 (1980).

⁸⁸ Ronald L. Spencer Jr., *State Supervision of Space Activity*, 63 A.F. L. REV. 75 (2009).

⁸⁹ Glenn H. Reynolds & Robert P. Merges, *The Role of Commercial Development in Preventing War in Outer Space*, 25 Jurimetrics J. 130 (1985).

⁹⁰ Anatoly Kapustin, *Prospects for the Demilitarization of Outer Space: From "Soft Regulation" to "Hard" Treaty Mechanisms?*, 44 J. Space L. 433 (2020).

in the study of outer space.⁹¹ The mitigation process can include pushing obsolescent spacecraft into orbits higher than the geostationary orbit⁹², appropriate recycling of space objects and to minimise the risk of the explosion there should be release of spacecraft's energy at the end of its life.⁹³

To set up legal requirements on space debris creation and detailing the national mitigation strategies as per the above-mentioned guideline is the first worldwide technical statement on the regulation of space debris.⁹⁴ Few organisations and nations have developed these guidelines and measures through the simple thoughts.⁹⁵ COPUOS and its subcommittees are non-binding international instruments including the adoption of declarations and resolutions.⁹⁶ COPUOS is not universal, and it lacks legal power.⁹⁷ Consequently, uniformly applying these policies by the space nations are a challenge.⁹⁸

The Outer Space Treaty of 1966 has been established after the United Nations Gen Assembly resolution.⁹⁹ For peaceful exploration and utilisation of the moon and other celestial bodies this treaty provides a basic legal framework.¹⁰⁰ To manage the space debris damage there is obligation of the state

⁹¹ Anatoly Kapustin, *Prospects for the Demilitarization of Outer Space: From "Soft Regulation" to "Hard" Treaty Mechanisms?*, 44 J. Space L. 433 (2020).

⁹² Ian Blodger, *Reclassifying Geostationary Earth Orbit as Private Property: Why Natural Law and Utilitarian Theories of Property Demand Privatization*, 17 MINN. J.L. Sci. & TECH. 409 (2016).

⁹³ Roy Balleste, *Space Horizons: An Era of Hope in the Geostationary Orbit*, 35 J. ENVTL. L. & LITIG. 165 (2020).

⁹⁴ Jan Helge Mey, *Space Debris Remediation*, 61 ZLW 251 (2012).

⁹⁵ Shouping Li Abbas Sheer, *Space Debris Mounting Global Menace Legal Issues Pertaining to Space Debris Removal: Ought to Revamp Existing Space Law Regime*, 10 BEIJING L. REV. 423 (2019).

⁹⁶ Jesse D. Lively, *Orbital Debris: An Argument in Support of Keeping the Non-Binding Framework*, 42 Transp. L.J. 225 (2015).

⁹⁷ *International Space Law Panel*, 11 WHITEHEAD J. DIPL. & INT'L REL. 7 (2010).

⁹⁸ Nikolay Natov, *Private International Law Aspects of the Draft International Code of Conduct for Outer Space Activities*, 66 ZLW 290 (2017).

⁹⁹ Walter D. Reed, *The Outer Space Treaty - Freedoms-Prohibitions-Duties*, 9 U.S.A.F. JAG L. REV. 26 (1967).

¹⁰⁰ Adam G. Quinn, *The New Age of Space Law: The Outer Space Treaty and the Weaponization of Space*, 17 MINN. J. INT'L L. 475 (2008).

parties under this treaty that at the time of exploration and utilisation of outer space they need to protect the outer space environment.¹⁰¹ Some nations considered to be aviation Giants have not joined the treaty so far¹⁰², since the treaty includes national interests, for example, space technology development¹⁰³, resource development¹⁰⁴, et cetera. The treaty needs participation from all countries including aviation Giants so that the treaty becomes binding in nature.¹⁰⁵

Currently, to regulate the outer space environment there are five treaties in existence.¹⁰⁶ For example, the Outer Space Treaty, the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Returns of Objects Launched into Outer Space (Rescue Agreement)¹⁰⁷, 1967 and came into force in December 1968, the Liability Convention, the Registration Convention¹⁰⁸, and the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement)¹⁰⁹, 1979 and came into force in July 1984. To address the complex legal and environmental concerns associated with the space debris the present five treaties on outer space law are incapable and only establish framework duties.¹¹⁰ There are confusing provisions of regulation of

¹⁰¹ Harold Craig Manson, *The Impact of International Outer Space Commerce on the Environment*, 26 TEX. INT'L L. J. 541 (1991).

¹⁰² Michael Viets, *Piracy in an Ocean of Stars: Proposing a Term to Identify the Practice of Unauthorized Control of Nations' Space Objects*, 54 Stan. J. INT'L L. 159 (2018).

¹⁰³ Lubos Perek, *Interaction between Space Technology and Space Law*, 18 J. Space L. 19 (1990).

¹⁰⁴ Douglas Alan Barritt, *A Reasonable Approach to Resource Development in Outer Space*, 12 LOY. L.A. INT'L & COMP. L.J. 615 (1990).

¹⁰⁵ Kathryn Gundersen, *Beyond the Tardigrades Affair: Planetary Protection, Cospar, and the Future of Private Space Regulation*, 53 N.Y.U. J. INT'L L. & POL. 871 (2021).

¹⁰⁶ Usasi Bannerjee & Rathin Bandyopadhyay, *Impact of Outer Space Activities on the Global Environment: Issues and Remedies under International Space Law*, 8 INDIAN J.L. & Just. 108 (2017).

¹⁰⁷ Paul G. Dembling & Daniel M. Arons, *The Treaty on Rescue and Return of Astronauts and Space Objects*, 9 WM. & MARY L. REV. 630 (1968).

¹⁰⁸ *Convention on Registration of Objects Launched into Outer Space*, 14 I.L.M. 43 (1975).

¹⁰⁹ *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, 18 I.L.M. 1434 (1979).

¹¹⁰ Howard A. Baker, *Space Debris: Law and Policy in the United States*, 60 U. COLO. L. REV. 55 (1989).

space debris which are often non-binding and the duties of government in relation to regulation of space debris are not appropriately defined.¹¹¹ Due to the absence of enforcement regulations, there is legal difficulty to address the problems associated with space debris.¹¹² There is lack of modernising the treaties and principles relating to regulation of Outer space signed in the previous century, whereas the use of outer space and human space exploration have increased considerably.¹¹³ It is ironic that treaty provisions lag when environmental contamination in outer space worsens.¹¹⁴ Previous norms no longer apply in their entirety due to the fast growth of outer space research and technology in the present day.¹¹⁵ The improvement and enhancement of space law is the pressing need of the current situation.¹¹⁶

VIII. Solutions through Allocation of State Obligations

The international collaboration to regulate the outer space environment will lead to a failure without the support of application of the law and process.¹¹⁷ The power and resources of the nations in the area of space exploration are different but for the purpose of remediation of space debris, substantial support from the technology and finance are important.¹¹⁸ To maintain the outer space environment, it should be the duty of the respective nations, both developed and

¹¹¹ Jameson Rohrer, *Deciphering and Defending the European Union's Non-Binding Code of Conduct for Outer Space Activities*, 23 DUKE J. COMP. & INT'L L. 187 (2012).

¹¹² Sreemeena Sethu & Mandavi Singh, *Stuck in Space: The Growing Problem of Space Debris Pollution*, 2 UK L. STUDENT REV. 96 (2014).

¹¹³ Ross Brown, *Conflict on the Final Frontier: Deficiencies in the Law of Space Conflict below Armed Attack, and How to Remedy Them*, 51 GEO. J. INT'L L. 11 (2019).

¹¹⁴ Ricky J. Lee, *Reconciling International Space Law with the Commercial Realities of the Twenty-First Century*, 4 SING. J. INT'L & COMP. L. 194 (2000).

¹¹⁵ D. Goedhuis, *The Changing Legal Regime of Air and Outer Space*, 27 INT'L & COMP. L.Q. 576 (1978).

¹¹⁶ Joseph A. Bosco, *International Law Regarding Outer Space - An Overview*, 55 J. AIR L. & COM. 609 (1990).

¹¹⁷ Ram Jakhu, *Legal Issues Relating to the Global Public Interest in Outer Space*, 32 J. SPACE L. 31 (2006).

¹¹⁸ Annie Handmer & Steven Freeland, *The Use of Law to Address Space Debris Mitigation and Remediation: Looking through a Science and Technology Lens*, 87 J. AIR L. & COM. 375 (2022).

developing to share their responsibilities, irrespective of variations in their financial power and resources.¹¹⁹

For outer space exploration the industrialised nations have developed adequate finance and technology.¹²⁰ The scope of outer space exploration varies from nations to nations because the non-industrialised nations are getting started in this sector whereas in the industrialised nations are advanced in the field of exploration.¹²¹

The equal accountability will be unreasonable for nations with the different degrees of space utilisation and exploration.¹²² The Registration Convention of 1975 using the registration system may determine accurately the number of satellites launched by a country but because of presence of ambiguity, it is difficult to examine the efficiency of a country's space technology scenario.¹²³

The information about the amount of harm and culpability can be provided with the quantity of space objects released by a nation.¹²⁴ More scientific, logical and objective accountability to a nation may be assigned based on the number of space objects, it has launched in the outer space.¹²⁵ Based on the relative space technological abilities of industrialised and developing nations

¹¹⁹ J. Henry Glazer, *Domicile and Industry in Outer Space*, 17 COLUM. J. Transnat'l L. 67 (1978).

¹²⁰ Edwin W. Paxson II., *Sharing the Benefits of Outer Space Exploration: Space Law and Economic Development*, 14 MICH. J. INT'L L. 487 (1993).

¹²¹ Todd Sandler & William Schulze, *The Economics of Outer Space*, 21 NAT. Resources J. 371 (1981).

¹²² Zhao Yun, *A Legal Regime for Space Tourism: Creating Legal Certainty in Outer Space*, 74 J. AIR L. & COM. 959 (2009).

¹²³ F. Kenneth Schwetje, *Space Law: Considerations for Space Planners*, 12 Rutgers COMPUTER & TECH. L.J. 245 (1987).

¹²⁴ Fengna Xu, Jinyuan Su & Miqdad Mehdi, *A Re-Examination of Fundamental Principles of International Space Law at the Dawn of Space Mining*, 44 J. Space L. 1 (2020).

¹²⁵ Jared B. Taylor, *Tragedy of the Space Commons: A Market Mechanism Solution to the Space Debris Problem*, 50 COLUM. J. Transnat'l L. 253 (2011).

the responsibility of environmental conservation of outer space should be fixed as a part of common but varied duties.¹²⁶

IX. Solutions from International Statutes

It is true that under the framework of United Nations five important conventions to regulate the outer space environment has been formed.¹²⁷ The five conventions lag behind in comparison to that of capability of human to explore space has reached a new level.¹²⁸ The applicability of express law to the contemporary events must be assessed in certain instances about their feasibility.¹²⁹

Despite the fact that the guideline has no legal sanctity COPUOS has provided a solid framework for future legislation on the legislative standpoint for the space debris mitigation.¹³⁰ To avoid the vagueness of items in the five conventions relating to regulation of Outer space environment the space debris prevention guidelines provide sufficient relevant information.¹³¹ To set up a threshold for the law's perfection and for efficiently applying the limit of the quantity of space debris at its source the importance in enhancing international law cannot be overlooked.¹³²

To minimise the discharge and formation of space debris at the source, it is more important to enact legislation, but to settle the space debris that has already been produced in the outer space it is vital to pass laws on how to regulate

¹²⁶ Alexander William Salter, *Space Debris: A Law and Economics Analysis of the Orbital Commons*, 19 Stan. TECH. L. REV. 221 (2016).

¹²⁷ Lucas Lixinski, M. M. Losier & Hanna Schreiber, *Envisioning a Legal Framework for Outer Space Cultural Heritage*, 45 J. Space L. 1 (2021).

¹²⁸ Krystyna Wiewiorowska, *Some Problems of State Responsibility in Outer Space Law*, 7 J. Space L. 23 (1979).

¹²⁹ Peter Jankowitsch, *The Role of the United Nations in Outer Space Law Development: Past Achievements and New Challenges*, 26 J. Space L. 101 (1998).

¹³⁰ Henry R. Hertzfeld, *Developing Issues in the Law of Outer Space*, 3 PENN UNDERGRADUATE L.J. 1 (2015).

¹³¹ Justin Rostoff, *Asteroids for Sale: Private Property Rights in Outer Space, and the SPACE Act of 2015*, 51 NEW ENG. L. REV. 373 (2017).

¹³² Caitlyn Georgeson & Matthew Stubbs, *Targeting in Outer Space: An Exploration of Regime Interactions in the Final Frontier*, 85 J. AIR L. & COM. 609 (2020).

them.¹³³ Regulating the complex issues that have already arising, prevention is often simpler and more effective and enacting the legislation to this regard should be seriously considered.¹³⁴

X. Solution through Dispute Resolution Scheme

The issue of space debris has never been resolved due to the absence of coordinating mechanism leading to loss of binding effect of current international agreements.¹³⁵ The International Tribunal for the Law of the Sea¹³⁶ and International Criminal Court¹³⁷ dealing with comparable problems as existing international entities. It is necessary to address several issues along with environmental harm caused by space debris, in this era of ever-growing outer space exploration and resource extraction.¹³⁸ To provide solutions the working of dispute resolution organisation is of immense importance not only to give understanding of binding power of international treaties, but also strengthening the legal knowledge of the nation.¹³⁹ Under this mechanism nation can take assistance and work together to address the crisis of space debris in outer space and provide appropriate remediation with the implementation of international treaty obligation.¹⁴⁰

XI. Conclusion

The unparalleled advancement in space science and technology has been seen in the 21st century. With the scientific method there is gradual revelation of space

¹³³ Elise Epperson Crow, *Waste Management in Space: Addressing the Challenge of Orbital Debris*, 18 Sw. J. INT'L L. 707 (2011).

¹³⁴ Michael W. Taylor, *Trashing the Solar System One Planet at a Time: Earth's Orbital Debris Problem*, 20 GEO. INT'L ENVTL. L. REV. 1 (2007).

¹³⁵ Gershon Hasin, *Confronting Space Debris through the Regime Evolution Approach*, 97 Int'l L. Stud. Ser. US Naval War Col. 1073 (2021).

¹³⁶ Gerald A. Malia, *The New International Tribunal for the Law of the Sea: Prospects for Dispute Resolution at the Sea Court*, 7 GEO. INT'L ENVTL. L. REV. 791 (1995).

¹³⁷ Michael Plachta, *International Criminal Court*, 35 IELR 448 (2019).

¹³⁸ M. Jude Egan & James J. Hurtak, *The Openness Principle in Multilateral Agreements for Space Exploration*, 35 J. Space L. 37 (2009).

¹³⁹ P. P. C. Haanappel, *A Competitive Environment in Outer Space*, 32 J. Space L. 1 (2006).

¹⁴⁰ Karl-Heinz Bockstiegel, *Arbitration and Adjudication Regarding Activities in Outer Space*, 6 J. Space L. 3 (1978).

secrets. There is excessive increase in the use of outer space because of scientific expansion of capacity of humans to explore and utilise the same. The human advancement in various sectors for example, biological, physics, education and others have been achieved because of space exploration. Outer space is not belonging to a single territory of a nation and there is absence of supranational institution in the world community, therefore, resolving the dispute of space debris is more challenging than the other issues to be resolved. The international lawyer's community will have to provide satisfactory reply to few questions such as, how to promote international cooperation in law, how to improve the current legislation to safeguard outer space and how to tackle the significant issue of space debris in outer space. Should the answered be related to sustainable use of outer space by all the space nations, only future will tell.