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## Management Of Space-debris And India's Legal Framework: Current Practices And Evolving Directions For Sustainable Management

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### ABSTRACT

The rapid increase in debris in the space presents a major threat towards the sustainability of outer space-operations, impacting satellite functionality and space missions globally and this burgeoning issue threatens the integrity of space operations, presenting formidable challenges to satellite functionality and space exploration. This paper delves into and explores the current situation of space-debris management within the context of India's legal framework and evaluates potential future directions for improvement. Initially, the paper makes an attempt to examine India's existing regulatory measures and policies concerning space-debris, including provisions under the 'Indian Space Research Organization' (ISRO) guidelines and national space-law. It then assesses the effectiveness of those measures in mitigating the debris-related risks and ensuring compliance with best international practices. The methodology used will be doctrinal in nature in order to evaluate the given stances through a comparative and critical analysis. The paper, through a comparative analysis with global standards, identifies gaps in the current legal framework and proposes enhancements to strengthen India's approach to debris management. By examination of international treaties, such as the United Nations' guidelines on space-debris, and integrating them into India's legal context, this paper aims to offer comprehensive recommendations for evolving India's space law to address the growing challenges of space-debris and promote sustainable space operations.

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### Keywords

Space-debris, Sustainability, Satellite Functionality, Legal Framework, Regulatory Measures.

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<sup>2</sup> NASA, "Sputnik, the Dawn of the Space Age" (October 4, 2017) NASA 2 August 2024 available at <https://www.nasa.gov/image-article/oct-4-1957-sputnik-dawn-of-space-age/>.

<sup>3</sup> National Aeronautics and Space Administration (NASA), "Historical Overview of Satellite Launches" (2023) NASA 2 August 2024, available at <https://www.nasa.gov/history>

<sup>4</sup> Launius, R.D., "The historical dimension of space exploration: reflections and possibilities", 2000, *Space Policy*, 16(1), 23-38.

## 1. Introduction

### 1.1. Background

The launch of ‘Sputnik’ by the USSR on October 4, 1957, marked the very beginning of a new era in human history, opening outer space for exploration.<sup>2</sup> This event was shortly followed by successful satellite launches from the USA in 1958, and subsequently by various other countries, including France, Japan, China, the UK, India, and Israel.<sup>3</sup> Over nearly five decades since Sputnik's launch, orbital activities have expanded significantly, showing a remarkable achievement in the exploring of the space.<sup>4</sup> However, this growth has led to the inevitable side effects of space-debris accumulation.<sup>5</sup> By the early 1990s, the issue of space-debris gained importance and fame as countries recognized its exponential increase. Initial issues rose from major space-faring nations focused on the safety of manned missions and space stations.<sup>6</sup> This issue became a global concern as technical discussions took place from 1994 to 1998 within the UN's Committee on the Peaceful Uses of Outer Space (COPUOS), specifically in its Scientific and Technical Subcommittee (STSC). These discussions culminated in the UN's Technical Report on Space-debris, highlighting the urgent need to address the growing problem of space-debris.<sup>7</sup> Space-debris, often referred to as ‘space-junk’, encompasses a wide array of objects that litter Earth's orbital environment. This category includes defunct satellites that have reached the end of their operational lives, spent rocket stages that have completed their missions, and a multitude of fragments resulting from collisions between these objects.<sup>8</sup> As the space-activities have intensified, so has the accumulation of such debris, presenting a growing and multifaceted challenge.<sup>9</sup> The ever-rising issue of space-debris encompasses a spectrum of problematic entities, including defunct satellites<sup>10</sup>, spent rocket stages<sup>11</sup>, and collision fragments<sup>12</sup>, each contributing to the hazardous

congestion in Earth's orbit.<sup>13</sup> Defunct satellites, though no longer are they operational, persist in orbit, adding to the orbital debris field and amplifying collision risks with active spacecraft. Similarly, spent rocket stages, once essential for payload deployment, now present a significant threat due to their size and velocity. Collision fragments, resulting from impacts or explosions, generate numerous smaller debris particles, ranging from minute paint flecks to substantial satellite components, each posing a peril due to their high relative speeds.<sup>14</sup> The rapid proliferation of space missions and satellite launches has accelerated debris accumulation in ‘Low Earth Orbit’ (LEO), creating a self-perpetuating cycle where increased debris fosters more collisions and fragments.<sup>15</sup> This burgeoning debris field jeopardizes critical space operations, threatening communication networks, weather forecasting systems, and navigation infrastructure, and imperiling crewed missions. In ensuring the long-term sustainability of outer space activities, it is imperative to implement effective debris management strategies, including the design of debris-minimizing technologies, development of debris removal methods, and the establishment of robust international regulations and guidelines.<sup>16</sup> The need for comprehensive legal frameworks and international cooperation has never been more pressing to safeguard the future of space exploration and operations.<sup>17</sup> On January 11 in the year 2007, China had conducted a high-profile test by intentionally destroying its weather satellite, Fengyun-1C.<sup>18</sup> This test resulted in a dramatic increase in traceable space- debris, raising the number of detectable objects in orbit by approximately 25%. At that time, it was the largest single creation of space-debris ever recorded. Subsequently, India also carried out a similar test in 2019<sup>19</sup> with “Mission Shakti,” becoming the fourth nation to demonstrate such a capability after the United States, China, and Russia.<sup>20</sup> This test underscored the growing challenge of space-debris management.

5 A Brief History of Space-Debris, Aerospace Aug 3, 2024 available at <https://aerospace.org/article/brief-history-space-debris>.

6 Gerald Brachet, “The origins of the Long-term Sustainability of Outer Space Activities initiative at UN COPUOS”, *Elsivier*, Volume 28, Issue, August 2012, 161-165.  
7 *Ibid*.

8 Jonathan O'Callaghan, ‘What is space junk and why is it a problem?’, Natural History Museum, available at <https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html> last visited on Aug 3, 2024.

9 Philip R. Harris, “The Impact of Culture on Human and Space Development—New Millennial Challenge,” *Acta Astronautica* 36, No. 7 (1995), 399-408.

10 A defunct satellite is an artificial satellite that has been abandoned, neglected, or rendered nonfunctional but remains in orbit. As of June 2024, the Natural History Museum in London estimates that there are approximately 3,000 defunct satellites in orbit, in addition to over 29,000 pieces of space-debris larger than a softball that are being monitored by scientists: Space-debris and defunct satellites, Natural History Museum, 2024, available at <https://www.nhm.ac.uk/discover/space-debris.html> last visited on Aug 4, 2024.

## 1.2. Importance of the Study

India, with its ambitious space program and notable contributions to space exploration, faces distinct challenges and opportunities in the realm of space-debris management while simultaneously dealing with global co-operation and technological advancements. To ensure the safety and sustainability of its space endeavors, it is imperative to refine and fortify its legal framework. Addressing these escalating issue of space-debris necessitates a sophisticated regulatory approach, active international collaboration, and the integration of cutting-edge debris mitigation and removal technologies. By advancing its legal and regulatory measures, India can significantly influence global space-debris management, protecting its space assets and contributing to the preservation of the orbital environment.

## 1.3 Hypothesis

Strengthening India's legal and regulatory framework for space-debris management will not only reduce collision risks and promote the long-term sustainability of space operations but also position India as a leader in global debris mitigation efforts, fostering greater international collaboration in space environmental protection.

## 1.4 Objectives of the article

The objective of this study is to assess and enhance India's legal framework for space-debris management. This includes identifying gaps and challenges in the current regulatory measures, and proposing improvements to better address space-debris issues. The study attempts to give the ideas on promotion international collaboration by exploring strategies to align India's policies with global standards. Additionally, it will evaluate the integration of emerging technologies into the regulatory framework to support effective debris mitigation. Ultimately, the study seeks to ensure the long-term sustainable space operations through a comprehensive approach to managing space-debris.

## 1.5 Literature Review

1. 'Toward the Sustainability of Outer Space: Addressing the Issue of Space-debris'<sup>21</sup>: Explores the issues/challenges and strategies linked with managing space-debris so as to ensure the long-term sustainability of outer space activities. The paper also highlights the importance of developing as well as implementing some full-fledged guidelines and also technologies, to manage space-debris and protect the space environment for future generations.<sup>22</sup>

2. 'Active debris removal: A joint task and obligation to cooperate for the benefit of mankind'<sup>23</sup> : This article discusses the concept of 'active debris-removal' (ADR) as a critical and collaborative effort to manage space-debris. Degrange argues that ADR is not only a technical challenge but also a legal and ethical obligation that requires international cooperation.<sup>24</sup>

3. Legal Implications of Space-debris Mitigation and Removal Strategies This paper examines the legal issues and challenges in association with the of mitigation space-debris and removal strategies for it. It shows how current international and national regulations address space-debris and identifies gaps as well as ambiguities in the legal framework. The authors discuss the need for updated and cohesive legal measures to support effective debris management and removal. They highlight the role of legal structures in facilitating technological solutions and ensuring compliance with debris mitigation practices, aiming to balance the advancement of space activities with the need to maintain a sustainable space environment.<sup>25</sup>

4. 'Problem of Space-debris: Developing Countries Point of View and Proposal of Global Convention'<sup>26</sup> This article explores the challenges of space-debris management from the perspective of developing countries. It discusses the specific difficulties these nations face, such as limited

<sup>11</sup> Spent upper stages of launch vehicles represent a major source of space-debris, often remaining in orbit for many years in a non-operational state. Additionally, the breakup of a single upper stage in orbit can occasionally generate extensive fields of debris: Orbital Debris: A Growing Concern, NASA, 2021, available at <https://www.nasa.gov/feature/orbital-debris-a-growing-concern> last visited on Aug 5, 2024.

<sup>16</sup> Desk, Science, "World Economic Forum Releases Guidelines for Tackling Growing Space-debris Problem." The Indian Express, 15 June 2023, available at <https://indianexpress.com/article/technology/science/world-economic-forum-space-debris-8662854/> last visited on Aug 3, 2024.

<sup>17</sup> European Space Agency, 'Space-debris: Mitigation and Removal Strategies', 2023, European Space Agency, available at [https://www.esa.int/Safety\\_Security/Space\\_Debris](https://www.esa.int/Safety_Security/Space_Debris) last visited on Aug 9, 2024.

<sup>18</sup> Leonard David, China's Anti-Satellite Test: Worrisome Debris Cloud Circles Earth, Space.com, November 17, 2021, available at <https://www.space.com/3415-china-anti-satellite-test-worrisome-debris-cloud-circles-earth.html>.

<sup>19</sup> India's mission Shakti: Can we leave space out of earthly conflicts?, Quartz, Oct. 25, 2024, available at <https://qz.com/india/1584560/indias-mission-shakti-lets-leave-space-out-of-earthy-conflicts/> last visited on Aug 11, 2024.

resources and technological constraints. The paper proposes the creation of a global convention to provide a unified and supportive legal framework for space-debris management. This convention aims to enhance international cooperation, address the needs of developing countries, and establish comprehensive guidelines for effective debris mitigation and removal.<sup>27</sup>

5. “Technical and legal issues surrounding space-debris—India's position in the UN”<sup>28</sup> This paper explores the technological/technical and legal challenges associated with space-debris and examines India's role and position within the United Nations framework. It discusses the specific technical difficulties of space-debris management and the legal considerations involved. The paper highlights India's contributions and stance on space-debris issues in UN discussions, emphasizing the need for effective international cooperation and regulatory measures to address the growing problem of space-debris.<sup>29</sup>

## 2. Current Legal Framework For Space-debris Management In India

India's legal framework for space-debris management is still evolving, mirroring the country's expanding engagement in space activities through the Indian Space Research Organisation (ISRO). At present, India lacks a dedicated law specifically addressing space-debris management. However, the issue is addressed through a combination of policies, guidelines, and international obligations.<sup>30</sup> The primary national instrument that indirectly touches upon space-debris management is the Space Activities Bill<sup>31</sup>, which is still in draft form. This bill seeks to take over the regulations of space activities in the nation, including the licensing and supervision of private space endeavors. While the bill does not openly focus on space-debris, it emphasizes the need for compliance with international space treaties, which

include obligations related to the mitigation of space-debris.<sup>32</sup> India is a signatory to key international treaties on outer space, such as the ‘Outer Space Treaty of 1967’ and the ‘Liability Convention of 1972’. These treaties underpin India's international commitments regarding space-debris. The ‘Outer Space Treaty’ mandates that nations prevent harmful contamination and spoiling of space and celestial bodies, while the ‘Liability Convention’ establishes that countries are accountable for damage caused by their space matters of physical nature, which implicitly includes damage from space-debris.<sup>33</sup> Additionally, ISRO follows the ‘guidelines’ set by the ‘United Nations Committee on the Peaceful Uses of Outer Space’ (also called ‘COPUOS’) and the ‘Inter-Agency Space-debris Coordination Committee’ (IADC). These guidelines provide technical measures for mitigating space-debris, such as the safe disposal of satellites and the avoidance of collisions in orbit.<sup>34</sup> Despite these measures, the absence of a comprehensive and dedicated national law on space-debris management in India leaves a gap in the legal framework. As India's space activities expand, including increased participation from private entities, the need for clear and enforceable regulations specific to space-debris management becomes more pressing. The development of such a framework would not only ensure compliance with international standards but also safeguard India's space assets and contribute to the sustainability of outer space activities.<sup>35</sup>

### 2.1 Legal Framework at International-Level

The foundation of space law concerning debris mitigation is anchored in several key international agreements and treaties. The cornerstone of these is the ‘Outer Space Treaty (OST) of 1967’, which establishes the major principles governing the exploring and use of outer space. While the OST does not explicitly mention space-debris, it lays down general obligations for spacefaring nations to avoid harmful contamination of space, thereby indirectly addressing debris mitigation.<sup>36</sup> In addition to the OST, the ‘Liability Convention’

20 P.T.I. Narendra Modi announces success of mission Shakti, India's anti-satellite missile capability, *The Hindu*, Oct. 25, 2019, available at <https://www.thehindu.com/news/national/narendra-modi-announcessuccessof-mission-shakti-indias-anti-satellite-missile-capability/article26651731.ece> last visited on Aug 11, 2024.

21 Fawaz Haroun, Shalom Ajibade, Philip Oladimeji, and John Kennedy Igbozurike, “Toward the Sustainability of Outer Space: Addressing the Issue of Space-debris”, *Mary Ann Liebert Inc. Publisher March*, 2021, Vol 9 No. 1.

22 Ibid.

23 Valentin Degrange, ‘Active Debris Removal: a joint task and obligation to cooperate for the benefit of Mankind’, *Space Security and Legal Aspects of Active Debris Removal*, 1-15, 2019, available at <https://hal.science/hal-03666577/document>.

24 Ibid.

25 Ibid.

(1972)<sup>37</sup> and the 'Registration Convention (1976)', this further enriches the legal landscape governing space activities. The Liability Convention stipulates that a state is held accountable for damage caused by its space objects, encompassing damage inflicted by space-debris, thereby enhancing the robustness of the legal framework in space operations.<sup>38</sup> The 'Registration Convention' mandates that states register their space objects, which facilitates the tracking and identification of debris, thereby supporting mitigation efforts. Together, these treaties create a robust, albeit indirect, legal framework that underpins international efforts to manage and mitigate space-debris.

## 2.2 United Nations Guidelines and Principles

The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) has issued several guidelines and principles aimed at addressing the challenges posed by space-debris.<sup>39</sup> These guidelines, particularly those formulated by the Inter-Agency Space-debris Coordination Committee (IADC), serve as best practices for spacefaring nations to follow in order to minimize the generation of space-debris.<sup>40</sup> The guidelines advocate for various measures, such as the controlled re-entry or disposal of spacecraft when their operational life ends, the prevention of on-orbit collisions, and the avoidance of intentional destruction of space objects that could generate debris. Additionally, these guidelines emphasize the importance of space traffic management, which involves tracking active satellites and debris to prevent collisions. By promotion of these practices, the United Nations aims to enhance the sustainability of space activities and ensure the long-term viability of the outer space environment for future generations.<sup>41</sup> These international frameworks and guidelines, when combined together, form the basis for global cooperation in mitigating space-debris, underscoring the shared-responsibility of all spacefaring nations to protect the outer space environment.

## 2.3 National Regulations and Guidelines

The ISRO has established several guidelines and standards to answer the issue of space-debris, contributing to India's commitment of providing safe and sustainable space activities.<sup>42</sup> These guidelines are encapsulated in key documents such as the 'Indian Space Policy' and various standards aimed at satellite design and strategies of deorbiting.<sup>43</sup>

a. Indian Space Policy The 'Indian Space Policy' provides India's long term vision and goals for its space activities, including the management of space-debris. One of the primary objectives of this policy is to ensure that India's space operations are conducted in such a manner that minimizes the creation of space- debris. The policy emphasizes adherence to international best practices and guidelines, including those set forth by the United Nations and the Inter-Agency Space-debris Coordination Committee (IADC).<sup>44</sup>

b. Technical Standards for Satellite Design ISRO has also developed standards for satellites designing with protective measures to prevent the generation of debris in the event of malfunctions or collisions.<sup>45</sup> Additionally, ISRO mandates that satellites must have a defined operational life, after which they must be deorbited or moved to a graveyard orbit to prevent them from becoming long-term space-debris.<sup>46</sup>

c. Deorbiting Strategies ISRO mandates that all satellites launched under its purview should have a plan for safe disposal afterwards. This includes a controlled re-entry back into atmosphere of the Earth, where the satellite will burn up, or maneuvering the satellite to a graveyard orbit, where it will pose less risk to active satellites and missions.<sup>47</sup> The main objective of ISRO's guidelines is to ensure that India's space activities contribute to the global efforts,<sup>48</sup> but, there are certain limitations to these guidelines. While ISRO's standards are quite good for the satellites, the

26 Prof. V. Balakista Reddy, Problem of Space-debris: Developing Countries Point of View and Proposal of Global Convention, Indian Journal of Air and Space Law, NALSAR Hyderabad, Vol 4 & 5, June 2016-June 2017, ISSN 2394-6091.

27 Ibid.

28 M. Y. S. Prasad, Technical and legal issues surrounding space-debris—India's position in the UN, Elsevier, Volume 21, Issue 4, November 2005, Pages 243-249.

29 Ibid.

30 India's Intent on Debris-Free Space Missions – Explained, Indian Space Research Organization, Department of Space, April 19 2024, available at [https://www.isro.gov.in/Debris\\_Free\\_Space\\_Missions.html](https://www.isro.gov.in/Debris_Free_Space_Missions.html) last visited on Aug 16, 2024.

31 Draft Space Activities Bill, 2017.

32 Anilkumar, M., Ramaprasad, A., Singai, C., & Sreeganga, S. D. (2020), An Ontological Analysis of Space Policy and Law: India's Space Activities Bill of 2017, *Astropolitics*, 18(3), 183–198, available at <https://doi.org/10.1080/14777622.2021.1878413> last visited on Aug 15, 2024.

33 Peter Van Fenema, "Legal aspects of launch services and space transportation", *Handbook of Space Law*, Frans Von Der Dunk (dir.) with Fabio Tronchetti, Edward Elgar Publishing, 2015, 409.

lack of a comprehensive national space law means that private entities and smaller satellite operators may not be fully regulated.<sup>49</sup>

## 2.4 Evaluation of India's Current Policies and Practices

India's approach to managing space-debris involves a combination of national guidelines, technical standards, and adherence to international norms. This section evaluates the effectiveness of these measures by analyzing their compliance with international standards and the practical challenges faced in their implementation.<sup>50</sup>

## 2.4 Evaluation of India's Current Policies and Practices

- **Compliance with International Norms** India's space-debris management strategy is largely influenced by international guidelines and treaties. The Indian Space Policy and ISRO's technical standards align with best practices recommended by the COPUOS and the IADC. These guidelines emphasize reducing debris generation, safe disposal of satellites, and space traffic management.<sup>51</sup>

- **Practical Challenges in Implementation** Despite aligning with international guidelines, India faces several practical challenges in managing space-debris:

**Growing Space Activity:** The rapid expansion of space activities, including the increasing number of satellite launches and the rise of private space enterprises, contributes to the proliferation of space-debris. Managing the debris from these activities requires more sophisticated tracking and mitigation strategies.

**Regulatory Gaps:** While ISRO's technical standards address satellite design and deorbiting strategies, there is a lack of comprehensive national legislation specifically dedicated to space-debris management. This regulatory

gap means that private entities and smaller satellite operators may not be fully subject to the same standards and oversight as ISRO's missions. **Cost and Resource Constraints:** Implementing advanced debris mitigation technologies and strategies involves significant financial and technical resources. **International Collaboration:** Useful space-debris management generally requires international cooperation. While India participates in global forums and adheres to international guidelines, the implementation of collaborative measures such as joint-debris tracking and avoidance-of-collision strategies, can be complex and challenging to coordinate. **Technological Limitations:** The deployment of new technologies for debris-mitigation, such as 'autonomous collision avoidance systems' and advanced tracking mechanisms, are still evolving.

## 3. International Guidelines And Frameworks

### 3.1 United Nations Space-debris Mitigation Guidelines:

The 'United Nations Space-debris Mitigation Guidelines', established by the 'Committee on the Peaceful Uses of Outer Space' (COPUOS), provide a comprehensive framework for managing space-debris. Key guidelines include: **Avoidance of Creating Debris:** Measures to prevent the creation of space-debris during the operational phase of space missions and through the design of space objects. **End-of-Life Disposal:** Requirements for the safe disposal of satellites and other space objects at the end of their mission life to minimize long-term debris. **Avoidance of Collision:** Guidelines for avoiding collisions between space objects through coordination and planning. The Preamble of the OST talks about the "common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes," which highlights the foundational principles that is relevant to current international debates on maintaining sustainable practices in space.<sup>52</sup>

<sup>34</sup> Space-debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, United Nations Office For Outer Space Affairs UN, Vienna, 2010, available at [https://www.unoosa.org/pdf/publications/st\\_space\\_49E.pdf](https://www.unoosa.org/pdf/publications/st_space_49E.pdf) last visited on Aug 29, 2024.

<sup>35</sup> Lt. Col. S. HUNTER, "How to reach an International Civil Aviation Organization role in Space Traffic Management", November 5, 2014, Space Traffic Management Conference, 21, 5, available at <http://commons.erau.edu/stm/2014/wednesday/21> last visited on Aug 30, 2024.

<sup>36</sup> 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 (entered into force on 10 October 1967), Article IX, available at [http://www.unoosa.org/pdf/gares/ARES\\_21\\_2222E.pdf](http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf) last visited on Aug 3, 2024.

<sup>37</sup> Convention on International Liability for Damage Caused by Space Objects, UN Office of Outer Space Affairs, available at <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introliability-convention.html> last visited on Aug 30, 2024.

<sup>38</sup> Donald J. Kessler and Burton G. Cour-Palais, Collision Frequency of Artificial Satellites: The Creation of a Debris Belt, *Journal of Geophysical Research*, 1978, 83, 2637–2646.

<sup>39</sup> UNCOUOS, Space-debris Mitigation Guidelines, United Nations Office for Outer Space Affairs, 2010, available at [http://www.unoosa.org/pdf/bst/COPUOS\\_SPACE\\_DEBRIS\\_MITIGATION\\_GUIDELINES.pdf](http://www.unoosa.org/pdf/bst/COPUOS_SPACE_DEBRIS_MITIGATION_GUIDELINES.pdf) last visited on 12 Aug, 2024.

<sup>40</sup> National Research Council, *Orbital Debris: A Technical Assessment*, 1995, 224; Scientific and Technical subcommittee of the UNCOUOS, *Technical Report on Space-debris*, United Nations, New York, 1999; National Research Council, *Limiting Future Collision Risk to Spacecraft: An Assessment of NASA's Meteoroid and Orbital Debris Program*, Washington, DC: The National Academies Press, 2011.

### 3.2 Inter-Agency Space-debris Coordination

#### Committee (IADC) Guidelines:

The IADC, an international body focused on space-debris, has developed detailed guidelines that complement those of the UN: **Spacecraft and Rocket Body Design:** Recommendations for designing space objects to minimize the creation of debris. **Post-Mission Disposal:** Strategies for deorbiting defunct spacecraft or moving them to a graveyard orbit. **Space Traffic Management:** Emphasis on tracking space-debris and coordinating space traffic to prevent collisions.<sup>53</sup> These international frameworks provide a benchmark for evaluating India's space-debris management practices by setting standards for best practices in debris mitigation.

### 3.3 Best Practices from Space-Faring Nations

#### United States:

The United States has developed a comprehensive approach to space-debris management through various policies and regulations, including: **Orbital Debris Mitigation Standard Practices:** Detailed guidelines issued by NASA and the Department of Defense for satellite design, mission operations, and end-of-life disposal. **Active Debris Removal (ADR) Initiatives:** The U.S. has funded and participated in research and projects aimed at actively removing debris from orbit, such as the development of space tugs and robotic systems.

#### European Union:

The European Union, through the European Space Agency (ESA), has implemented robust practices for managing space-debris: **Space-debris Mitigation Guidelines:** ESA's guidelines align with international standards and include specific measures for satellite design, collision avoidance, and end-of-life disposal. **Space-debris Office:** ESA operates a dedicated office for space-debris, which focuses on monitoring debris, conducting research, and coordinating with other space agencies.

#### Japan:

Japan has made significant strides in space-debris management through: **Technical Standards and Regulations:** Japan has developed stringent technical standards for satellite design and end-of-life disposal to minimize debris. **Active Debris Removal Projects:** Japan has engaged itself in few initiatives, such as the development of a space-debris removal satellite (e.g., the "RemoveDEBRIS" mission) to actively tackle the debris problem.<sup>54</sup>

### 3.4 Comparative Analysis with India

#### Strengths of India's Approach:

**Alignment with International Guidelines:** India's policies and ISRO's technical standards align with international guidelines, reflecting a commitment to global best practices. **Technical Standards:** India's guidelines for satellite design and deorbiting strategies demonstrate a proactive approach to debris mitigation.

#### 3.5 Areas for Improvement:

Unlike other space-faring nations, India lacks a particular law for managing space debris. Creating a robust legal framework may improve regulatory scrutiny and enforceability. India's space debris management strategy prioritises preventative and passive methods. Implementing active debris removal activities, as seen in the United States and Japan, could help to solve the expanding debris problem. Compared to the US and EU, India may have fewer resources for advanced space-debris research and mitigation technology. Increased investment in these areas could bolster India's strategy.

## 4. Identifying Gaps And Proposing Reforms

### 4.1 Critical Gaps In India's Current Framework

**Insufficient Provisions for Debris Mitigation:** India lacks a national law for managing space debris. While the Indian Space Policy and ISRO's technical standards provide some direction, there is no single complete legislative framework that requires precise debris mitigation for all space activities, including those carried

41 US Government, Orbital Debris Mitigation Standard Practices, December 2000, available at [https://orbitaldebris.jsc.nasa.gov/library/usg\\_od\\_standard\\_practices.pdf](https://orbitaldebris.jsc.nasa.gov/library/usg_od_standard_practices.pdf) last visited on 15 Aug, 2024.

42 India aims to achieve debris-free space missions by 2030, The Hindu, April 16 2024, updated April 18, 2024, available on <https://www.thehindu.com/sci-tech/science/india-aims-to-achieve-debris-free-space-missions-by-2030/article68071003.ece> > last accessed on 16 Aug, 2024.

43 Keshav Verma, Mapping India's Path: Pioneering a Space Future Free from Debris, Indian Council of World Affairs, May 2nd, 2020, available on [https://www.icwa.in/show\\_content.php?lang=1&level=3&ls\\_id=10800&lid=6872](https://www.icwa.in/show_content.php?lang=1&level=3&ls_id=10800&lid=6872) last visited on 14 Aug, 2024.

44 Ibid.

45 Indian Space Research Organisation, Technical Standards for Satellite Design to Reduce Space-debris (ISRO), available at <https://www.isro.gov.in/> last accessed on 29 August 2024.

46 Ibid.

47 Indian Space Research Organisation, 'Deorbiting Strategies and Guidelines' (ISRO), available at <https://www.isro.gov.in/> last accessed on 29 August 2024.

48 Dedication of ISRO System for Safe & Sustainable Operations Management (IS4OM) to the Nation, Indian Space Research Organization, 2023, available at <https://www.isro.gov.in/IS4OM.html> last visited on Aug 15 Aug, 2024.

49 ISRO SSA Control Centre Inaugurated by Dr. K. Sivan, Chairman, ISRO/ Secretary, DOS, Indian Space Research Organization, 2020 available at <https://www.isro.gov.in/ISRO%20SSACControl%20Centre.html> last visited on Aug 30, 2024.

out by commercial enterprises. Existing guidelines mostly cover satellite design and disposal but they do not go into the details on more general aspects of debris management. **Inadequacy of Enforcement Mechanisms:** ISRO's criteria for its missions are the main source of authority for the enforcement of debris mitigation procedures. A centralised regulatory body with the power to monitor and enforce compliance in both public and commercial space operations is lacking. It can be difficult to keep an eye on space debris effectively and make sure mitigation procedures are followed. Particularly for commercial operators and international partnerships utilising Indian assets, there is no reliable system in place to monitor adherence to debris mitigation rules. **Limited Investment in Advanced Technologies:** Although India has made progress in satellite technology and debris mitigation, little money has been allocated to state-of-the-art technologies for advanced space traffic management systems and active debris removal. To create cutting-edge methods for monitoring, controlling, and eliminating space debris, more money and attention must be allocated to this area.

#### 4.2. Recommendations for Legal Reforms

**Adoption of Stricter Debris Mitigation Measures:** Creating or develop a special national law that specifies standards for debris mitigation, including some comprehensive rules for the designing, launching, operation, and disposal of satellites at the end of their useful lives would work at best. **Enhancing the Collaborations with International Bodies:** To stay in line with worldwide best practices and support cooperative debris reduction projects, expanding cooperation with international organisations like COPUOS and the IADC. **Integration of Advanced**

**Technologies for Debris Tracking and Removal:** Increasing collaboration with international groups like COPUOS and the IADC to support collaborative debris reduction programs and remain in compliance with global best practices is quite helpful. Also, engagement with international forums to share field of research, information, and strategies for managing space debris.

#### 4.3 Innovations in Space-debris Management

Active debris removal (ADR) is a key area of development as it entails physically capturing and removing debris from space-orbit using tools including net systems, robotic arms, and space tugs. These methods could lessen the likelihood of collisions and drastically cut down on debris. The development of 'tracking technologies' is another interesting direction. India's capacity to handle the expanding debris-problem and preserve a healthy space environment might be significantly increased by including these advance aspects into its space-debris management plan.

#### Conclusion And Recommendations

India's space-debris management law needs major updates and improvements to align with global practices and ensure long-term sustainability in space-operations. The current approach, including the 'Indian Space Policy' and ISRO's technical standards, focuses on satellite design, end-of-life disposal, and compliance with global treaties, but, these measures only address only partially the broader issue of space-debris management due to gaps in the regulatory framework. To improve the effectiveness of space-debris management, India needs to develop legislation in a comprehensive manner, strengthen international collaboration, invest in advanced technologies, establish a centralized regulatory body, and implement robust monitoring systems for real-time tracking of space objects and compliance monitoring.

50 Evaluation of India's Current Policies and Practices for Space-debris Management, Indian Space Research Organization, (2023) available at <https://www.isro.gov.in/> last visited on 29 August 2024.

51 India's Space-debris Management Strategy and International Influence, Indian Space Research Organization, 2023 available at <https://www.isro.gov.in/> last visited on 29 August 2024.

52 United Nations, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 1967, United Nations Office for Outer Space Affairs, available at <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html> last visited on September 3, 2024.

53 Inter-Agency Space-debris Coordination Committee, 'IADC Space-debris Mitigation Guidelines, 2007, available at [https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC\\_space\\_debris\\_mitigation\\_guidelines.pdf](https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC_space_debris_mitigation_guidelines.pdf) last visited on 18 Aug, 2024

54 Japan, India startups to study laser-equipped satellite to tackle space debris, The Economic Times, Dec 17, 2024 available at <https://economictimes.indiatimes.com/news/science/japan-india-startups-to-study-laser-equipped-satellite-to-tackle-space-debris/articleshow/116389685.cms?from=mdr>, last visited 3rd Jan, 2025.