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Integrating International Humanitarian Law and Human Rights in the Use of AI for Conflict Prevention in Outer Space

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Abstract: The rapid increase of space debris and the accelerating use of anti-satellite (ASAT) weapons have generated complex legal challenges that threaten orbital sustainability, global security, and civilian infrastructure. This study examines how International Humanitarian Law (IHL) can be integrated into the governance of artificial intelligence (AI) used in space debris management as a preventive mechanism against the escalation of armed conflict in outer space. Using a normative juridical method supported by textual, comparative, and case-study analyses, this research evaluates key international legal instruments including the Outer Space Treaty (1967) and Additional Protocol I (1977) alongside case studies of the 2007 Chinese and 2021 Russian ASAT tests. The findings demonstrate that the IHL principles of distinction, proportionality, and precaution can be operationalized into AI algorithms to enhance object identification accuracy, minimize civilian harm, and reduce the risk of inadvertent conflict. This study identifies critical governance gaps, particularly in the ambiguous interpretation of "peaceful use," weak verification mechanisms, and the absence of accountability structures for AI-driven orbital activities. The research contributes a novel framework for embedding IHL into AI design parameters, positioning AI not merely as a technological tool but as a strategic legal instrument for safeguarding orbital stability. Strengthening international space law through transparency norms, AI verification protocols, and updated treaty provisions is therefore essential to ensure outer space remains a peaceful and sustainable global commons for future generations.

Keywords: International, Humanitarian Law, Artificial Intelligence, Space Debris

Introduction

The geopolitical dynamics of outer space have accelerated significantly with the increasing activities of major powers in satellite launches, exploration, and the testing of space weapon technologies. These activities have a direct impact on global security as low Earth orbit becomes increasingly congested with active satellites and space debris. In this context, integrating international humanitarian law principles with artificial intelligence

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(AI) represents a strategic step toward preventing conflict and safeguarding humanitarian interests in orbit.

In 2021, a piece of space debris narrowly missed the International Space Station, forcing astronauts to take emergency shelter. This incident highlights the growing threat of orbital clutter and its potential to spark conflict in outer space. Space debris, a byproduct of human activities in orbit, has the potential to disrupt not only space operations but also critical communication systems, including those essential for International Humanitarian Law (IHL).[1] IHL relies on telecommunication networks, especially in conflict zones (the "red zone"), to coordinate humanitarian efforts, monitor ceasefires, and protect civilians.[2] However, the intentional destruction of satellites during hostilities can create vast amounts of debris, triggering a cascading effect known as the Kessler Syndrome.[3] This phenomenon not only endangers the warring parties' own space assets but also threatens civilian satellites and spacecraft, effectively hindering future space operations for all nations. Such scenarios highlight the risk of a "space debris arms race," where nations may hesitate to destroy enemy satellites due to the fear of generating debris that could harm their own systems.[4]

To address these challenges, both space safety and space security must be prioritized. Space safety ensures that no accidental incidents occur, while space security prevents deliberate actions that could escalate conflicts or trigger an arms race in space. As artificial intelligence (AI) emerges as a key tool for managing space debris, its dual-use potential raises critical legal and ethical questions under IHL. This essay explores how the application of IHL to AI-driven space debris management can prevent armed conflict in outer space and ensure the responsible use of AI technologies. Since the launch of Sputnik 1 by Soviet Union in 1957, outer space has no longer been an exclusive domain for scientists but has evolved into a strategic global arena infused with political, economic, and military interests. This event triggered the beginning of the space arms race between the United States and the Soviet Union, with space exploration becoming a symbol of technological and ideological supremacy during the Cold War. Against this geopolitical backdrop, major powers recognized the necessity of establishing an international legal framework to preserve outer space as a peaceful domain and prevent unilateral territorial claims.[5]

This awareness led to the establishment of the United Nations Office for Outer Space Affairs (UNOOSA) in 1958 and culminated in the adoption of the Outer Space Treaty (OST) in 1967. The treaty declares outer space to be the “province of all mankind” and must be used for peaceful purposes. It prohibits the placement of weapons of mass destruction and the establishment of military bases in space. Nevertheless, legal scholarship has demonstrated that the OST leaves interpretive ambiguities that allow major powers to pursue militarization activities without formally violating the treaty.[6]

Human activities in Low Earth Orbit (LEO) have intensified since the late 20th century, triggering an explosion in the amount of space debris that now poses a systemic threat to the sustainability of the orbital ecosystem. This threat is not merely technical but also involves complex legal and humanitarian dimensions. Global communication systems, navigation satellites, and disaster management infrastructures heavily depend on orbital

[1] James Murray, Tim Kennedy, dan Mark Matney, “Observations of Small Debris from the Cosmos 1408 Anti-Satellite Test using the HUSIR and Goldstone Radars” (2022): 1–10, www.amostech.com.

[2] Red Crescent, “International humanitarian law and the challenges of contemporary armed conflicts,” *International Review of the Red Cross* 106, no. 927 (2024): 1357–1450.

[3] Donald J Kessler, Nicholas L Johnson, and Mark Matney, “The Kessler Syndrome: Implicatinos to Future Space Operation,” *33rd Annual AAS Guidance and Control Conference* 137 (2010): AAS 10-016.

[4] Suzanne Pritchard, “The Final Frontier,” *International Water Power and Dam Construction* 65, no. 12 (2013): 18–19.

[5] BRUCE M. DEBLOIS, “The Advent of Space Weapons,” *Astropolitics* 1, no. 1 (2003): 29–53, https://doi.org/10.1080/1477-760391832507.

[6] Danylo Stonis, “Ambiguities in Space Law as Path towards Weaponization of Space: The Case of the Outer Space Treaty. Remarks on Regulation of Weaponization of Outer Space by Space Law,” *Copernicus Political and Legal Studies* 1, no. 4 (2022): 74–84, https://doi.org/10.15804/cpls.20224.08.

stability, which is increasingly jeopardized by anti-satellite (ASAT) weapon tests and the growing volume of debris. Therefore, integrating the principles of International Humanitarian Law (IHL) into the governance of artificial intelligence (AI) technologies in orbit has become an urgent and innovative legal strategy. The unique finding of this study lies in the explicit application of the IHL principles of distinction, proportionality, and precaution within the framework of orbital AI governance. This approach not only strengthens the protection of civilian assets in outer space but also serves as a preventive legal instrument to avoid the escalation of armed conflict in orbit. Thus, AI is positioned not as a tool of threat but as a strategic instrument for preserving peace in outer space.

The uniqueness of this paper lies in its proposed legal operationalization framework that integrates the principles of International Humanitarian Law (IHL) directly into the design of artificial intelligence (AI) algorithms for orbital debris management an approach that has not been elaborated in detail within existing IHL or space law literature. This approach positions the principles of distinction, proportionality, and precaution as technical parameters that can be programmed into object-identification modules, risk-calculation systems, and automated decision-making processes within AI systems.

Technological developments in the 21st century have further transformed the landscape of outer space activities. Control of space is no longer dominated by states; instead, private companies such as SpaceX, Blue Origin, and OneWeb have become major operators of commercial satellite constellations. According to Union of Concerned Scientists, by early 2025, there were more than 9,000 active satellites in orbit, the majority owned by non-state actors. This shift presents serious legal and regulatory challenges, as existing space law regimes such as the OST were designed primarily for state actors, not private entities.[7]

This growing presence of private actors also exacerbates the accumulation of space debris. Debris consists of defunct rocket bodies, satellite fragments, and other remnants traveling at speeds exceeding 28,000 km/h, posing significant collision risks. From the perspective of Hukum Humaniter Internasional (IHL), this issue carries major humanitarian implications because satellite infrastructure underpins critical services such as emergency communication, navigation, disaster response, and humanitarian coordination. Notes in International Legal Problem of Space Debris, space debris represents not only a technical hazard but also an urgent international legal problem that requires collective governance.[8] Simultaneously, several countries have begun developing anti-satellite weapons (ASAT), raising new security concerns. ASAT tests conducted by China in 2007 and Russia in 2021 created thousands of debris fragments, threatening both civilian and military satellites. From a humanitarian law perspective, such actions risk violating the principles of distinction and proportionality, since civilian infrastructure often forms part of the networks affected by orbital strikes.[9] Many legal scholars consider these developments as evidence of the growing weaponization of outer space the shift from a purely peaceful domain to a militarized strategic arena.

The negative impacts of ASAT testing are not limited to the increase in orbital debris but also create vulnerabilities in global communication, navigation, and disaster mitigation systems. These activities pose a threat to human rights, as satellite infrastructure plays a crucial role in supporting vital public services such as tsunami early warning, air transportation, and emergency communications. Alongside these physical threats, the rapid integration of Kecerdasan Buatan (AI) in orbital activities introduces new layers of legal complexity. AI is increasingly used for space debris tracking, collision prediction, and mitigation. However, AI is inherently dual-use: technology initially developed for peaceful

[7] Munazza Khalid, "Space Legal Regimes, Militarization, and Weaponization of Outer Space," *Astropolitics* 19, no. 1–2 (2021): 128–44, https://doi.org/10.1080/14777622.2021.2008768.

[8] Vasyl Semenyaka1, "International-Legal Problem of Space Debris," *Advanced Space Law* 1 (2018): 84–90, https://doi.org/10.29202/asl/2018/1/10.

[9] Khalid, "Space Legal Regimes, Militarization, and Weaponization of Outer Space."

purposes can easily be repurposed for military objectives, including disabling adversary satellites or conducting covert offensive operations. According to Uçkaç in Examining the Use of Artificial Intelligence in Space Technologies, Taking Into Account the Dimensions of International Law, existing international law has yet to provide clear accountability mechanisms when AI is used in orbital military operations.[10] The relevance of this study is heightened by the fact that satellite infrastructure forms the backbone of modern life, supporting banking systems, maritime and air navigation, international trade, and global humanitarian operations. Disruptions caused by space debris or orbital military activity could trigger cascading effects on political stability, economic security, and humanitarian operations worldwide. Within this context, applying IHL principles to space governance particularly regarding AI-driven activities becomes an essential legal instrument to preserve outer space as a peaceful global commons.[11]

This research addresses three central problems: first, how international humanitarian law principles can be applied to AI-based space debris management; second, how legal challenges arise from the increasing role of non-state actors and dual-use AI technologies; and third, how the strengthening of international legal regimes can prevent the weaponization of space and armed conflicts in orbit. The objectives of this study are to analyze the application of humanitarian law to space debris governance, identify regulatory challenges arising from shifting actors and emerging technologies, and propose legal mechanisms to ensure that outer space remains peaceful and sustainable.[12]

The use of artificial intelligence (AI) in space activities poses significant challenges to the principle of state and stakeholder responsibility. The article "The Nuances of Responsibility of Artificial Intelligence for Irresponsible Space Activity" notes that current international legal instruments, including the Convention on International Liability for Damage Caused by Space Objects (1972), do not fully accommodate situations in which an AI-controlled space object causes damage particularly when the cause cannot be directly traced to a single actor due to the involvement of multiple parties in the design, maintenance, and operation of the AI system.[13]

Research Methods

This study employs a qualitative doctrinal approach through a normative legal analysis of international legal instruments, particularly the Outer Space Treaty (OST) and the Additional Protocols to the Geneva Conventions, alongside scholarly works and institutional reports. The research method focuses on. Textual analysis of primary international legal sources such as the OST, the UN Charter, and IHL conventions.[14] Comparative review of contemporary literature on the intersection of AI, space law, and humanitarian law. Case study approach, analyzing past incidents of debris-generating events (e.g., China's 2007 ASAT test and Russia's 2021 ASAT test) to identify governance weaknesses and potential IHL violations. Doctrinal synthesis, which integrates findings into recommendations for strengthening the governance of outer space activities under the IHL framework.

The research methodology employed in this study adopts a normative legal approach supported by a legal hermeneutic framework to interpret international documents such as

[10] Mehmet Uçkaç, "Examining the Use of Artificial Intelligence in Space Technologies , Taking Into Account the Dimensions of International Law" 2, no. 3 (2025): 66–80.

[11] Semenyaka, "International-Legal Problem of Space Debris."

[12] Khalid, "Space Legal Regimes, Militarization, and Weaponization of Outer Space."

[13] Anna Hurova, "The Nuances of Responsibility of Artificial Intelligence for Irresponsible Space Activity," *Philosophy and Cosmology* 32 (2024): 27–33.

[14] United Nations, *United Nations Treaties and Principles on Space Law* (OFFICE FOR OUTER SPACE AFFAIRS, 1967), http://www.oosa.unvienna.org/oosa/SpaceLaw/treaties.html.

the OST, the UN Charter, and Additional Protocol I. The interpretation is conducted through textual, systemic, and teleological approaches. The analysis is then linked to the technical design of AI through the IHL–AI Analytical Linking Framework, which maps how IHL principles can be translated into algorithmic parameters. Case studies of the 2007 and 2021 ASAT incidents are used to assess potential violations and identify how AI could prevent the emergence of debris that threatens civilian infrastructure. The humanitarian implications of orbital conflicts extend far beyond the physical destruction of satellites and space infrastructure. Orbital networks form the backbone of critical services such as international telecommunications, navigation, weather forecasting, disaster management, and humanitarian aid coordination. If orbital environments become weaponized or severely contaminated with debris, the resulting disruptions could paralyze these essential services and exacerbate the suffering of vulnerable populations in conflict zones. According to Murray et al. (2022), the 2021 anti-satellite (ASAT) test by Russia increased collision risks by 30%, raising immediate concerns about the security of international space infrastructure.[15]

Based on the methodological framework described above, the following section analyzes the growing threats posed by orbital debris, the application of International Humanitarian Law to AI-based operations.

Results and Discussion

The normative juridical approach was chosen because it is well-suited to analyze the interaction between international legal norms and emerging technologies. Primary legal materials used in this study include the Outer Space Treaty (1967), the Charter of the United Nations, Additional Protocol I to the Geneva Conventions (1977), and relevant United Nations General Assembly resolutions, while secondary materials consist of academic publications and international journals on space governance and artificial intelligence. The legal analysis applies hermeneutic and comparative methods to interpret the relationship between humanitarian law principles and AI governance in outer space. In addition, human rights considerations—particularly the economic dimension—must be emphasized, as the accumulation of space debris, militarization activities, and unequal access to space-based infrastructure increasingly generate economic disparities, threaten global development, and impact the fundamental right to benefit from scientific progress.

1. The Growing Threat of Space Debris

Space debris, often referred to as 'space junk,' consists of man-made decommissioned objects orbiting Earth, such as old satellites, spent rocket stages, and fragments from collisions or anti-satellite (ASAT) tests.[16] hese things move at astonishing speeds of up to 28,000 kilometres per hour, posing a significant risk to operating spacecraft. The Kessler syndromic effect proposed by NASA scientist Donald Kessler describes a chain reaction of collisions that generates more debris, exponentially increasing orbital density and threatening global communications and navigation systems.[17] This phenomenon was first warned of by Donald J. Kessler of NASA through the Kessler Syndrome in 1978. Kessler described an "orbital critical point" scenario in which one major collision could trigger a chain reaction of further collisions, exponentially increasing the amount of debris and rendering certain orbital regions unusable for both civilian and military purposes.[18]

The deployment of AI in orbital operations inherently presents a dual-use dilemma, as systems designed for peaceful purposes, such as debris tracking or collision avoidance, can

[15] Carmen Pardini dan Luciano Anselmo, "Evaluating the impact of space activities in low earth orbit," *Acta Astronautica* 184, no. April (2021): 11–22, https://doi.org/10.1016/j.actaastro.2021.03.030.
[16] ESA Space Debris Office, "ESA 2025 Annual Space Environment Report," no. 9.0 (2025): 1–144.
[17] T.S. Kelso, "Analysis of the 2007 Chinese ASAT Test and the Impact of its Debris on the Space Environment," *Advanced Maui Optical and Space Surveillance Technologies* (2007): 321–330, http://www.m.celestrak.com/publications/AMOS/2007/AMOS-2007.pdf.
[18] Donald J Kessler dan Burton G Cour-palais, "Was Observed" 83, no. 8 (1978): 918–924.

be repurposed for military objectives. The ethical implications are profound: autonomous AI decision-making can blur the line between civilian and military applications, raising accountability questions. For example, if an AI-controlled debris removal system accidentally disables a satellite, the attribution of responsibility becomes complex. This scenario highlights the need for embedding ethical constraints directly into AI design, including clear operational boundaries, fail-safe mechanisms, and human-in-the-loop oversight.

Strategically, the dual-use nature of AI can exacerbate tensions in space security. Unregulated deployment of AI may lead to a new arms race in orbit, where states seek to enhance their military capabilities under the pretext of debris mitigation. Galliott (2018) warns that without an international governance framework, peaceful AI technologies could be weaponized into precision orbital weapons. This risk underscores the necessity of aligning AI governance with international humanitarian law (IHL) principles, ensuring that distinction, proportionality, and precaution guide both development and operational deployment.

Anti-satellite (ASAT) weapon tests, such as the one conducted by Russia against the satellite Cosmos-1408, have added a long-lasting layer of space contamination which, according to Claudya & Handayani, can be considered as 'contamination' causing international harm under the interpretation of Article IX of the Outer Space Treaty (1967). Such activities violate states' obligations to conduct international consultations and take precautionary measures before carrying out actions that could generate significant space debris.[19]

The dangers of space debris extend beyond technical challenges, carrying implications for armed conflict. Debris can damage or destroy satellites, disrupting both civilian and military operations. Moreover, debris may be weaponized through ASAT tests, creating persistent orbital hazards for all nations. Historical examples include the 2007 Chinese ASAT test, which produced over 3,000 trackable debris pieces, and the 2021 Russian ASAT test, which created over 1,500 fragments that forced ISS astronauts to take emergency shelter. These incidents highlight how debris-generating activities can escalate geopolitical tensions and undermine global space security. ASAT testing activities have been proven to have a destructive impact on the global orbital environment. The 2007 ASAT test conducted by the People's Liberation Army and the 2021 test by the Russian Armed Forces generated thousands of debris fragments, most of which are expected to remain in orbit for decades. This phenomenon accelerates the Kessler Syndrome effect a chain reaction of collisions between orbital objects that can render certain orbital paths unusable. Orbital sustainability is not only relevant to IHL but is also closely connected to the regime of International Human Rights Law (IHRL). Damage to civilian satellites caused by ASAT tests can disrupt the right to information, communication, and other vital public services related to the right to life and security. Developing countries that rely on shared satellites become the most affected if orbital environments become unusable. Therefore, orbital governance constitutes part of the fulfillment of human rights obligations, requiring states to prevent actions that endanger global critical infrastructure.

Such a condition would disrupt communication, weather forecasting, navigation, and global logistics systems that sustain modern life. Furthermore, its indirect impact includes an increased risk of debris reentering the atmosphere, potentially damaging ground

[19] Ribqha Claudya dan Irawati Handayani, "The Challenges of Environmental Protection in Outer Space Following Russia's Anti-Satellite (ASAT) Weapon Test Activities," *Yustisia* 13, no. 2 (2024): 210–229.

infrastructure and posing threats to civilian safety. The international community's reliance on satellites for disaster mitigation and humanitarian aid delivery means that disruptions in orbit can directly affect access to assistance for vulnerable populations. In other words, ASAT activities are not only a military threat but also a global humanitarian threat.

Space debris poses a dual threat. The first is a technical threat, as debris can damage or destroy critical infrastructure such as navigation, communication, meteorological, and military satellites. The second is a strategic and legal threat, as debris can result from unilateral military actions like ASAT tests, which heighten geopolitical tensions and raise questions of international legal responsibility. In armed conflict scenarios, debris may also become an indirectly "weaponized" instrument, causing indiscriminate and long-term damage to the global orbital environment.

In addition to physical risks to satellites, space debris poses normative and international legal challenges. Claudya & Handayani (2023) emphasize that ASAT activities that generate long-term fragments violate international consultation obligations and the principle of precaution under Article IX of the Outer Space Treaty (1967). Strategically, increased orbital density reinforces the Kessler Syndrome effect, which not only disrupts global communications and navigation, but also has the potential to become an indirect weapon. Therefore, debris can be categorized as a transnational risk that requires state responsibility for mitigation, as well as the application of international humanitarian law principles.

2. Applying International Humanitarian Law (IHL) to AI-Driven Space Debris Management

The application of IHL to AI-driven debris management ensures responsible use of emerging technologies in outer space. Three core principles of IHL are particularly relevant. Distinction Parties must distinguish between military objectives and civilian objects AI systems must be programmed to differentiate between military and civilian satellites to avoid harming civilian assets.[20] The principle of distinction requires the separation of military objectives from civilian objects. In orbital contexts, AI used for satellite maneuvering or debris removal must be capable of distinguishing between civilian and military satellites to avoid misidentification. This is particularly important given that many civilian satellites serve dual-use functions such as navigation and communications.

The humanitarian legal position regarding the orbital environment should be viewed as part of the broader framework of international civilian protection. The precautionary principle in humanitarian law can be applied to prevent actions that cause widespread damage to the orbital environment. In this way, international law functions not only to regulate states but also to safeguard the shared global interests of humanity. Proportionality Attacks causing excessive civilian damage relative to military advantage are prohibited. AI-driven deorbiting operations must prevent excessive debris generation that endangers civilian infrastructure.[21] Precaution States must take constant care to protect civilians and civilian objects during operations. AI algorithms should include safeguards minimizing collateral damage and ensuring human oversight to avoid automation errors. The principle of precaution obliges states to take preventive measures to minimize risks to civilian

[20] Michael N. Schmitt, "International Humanitarian Law and the Targeting of Non-State Intelligence Personnel and Objects," *Duke Journal of Comparative & International Law* 30, no. 2 (2020): 309–346.

[21] Dietrich Schindler and Jiri Toman, "Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts (Protocol I)," *The Laws of Armed Conflicts*, no. August (2021): 711–73, https://doi.org/10.1163/9789047405238_060.

populations. In AI applications, this means algorithmic systems should incorporate meaningful human control and failsafe mechanisms to prevent unintended escalation.[22]

Accordingly, applying IHL to AI technologies is not merely a normative choice but an international legal necessity to ensure that orbital activities do not result in broad humanitarian consequences. In addressing the challenges posed by autonomous technology and AI in space activities, the article "The Normative Challenges of AI in Outer Space" outlines how the unique characteristics of AIsuch as its autonomy, opacity, and adaptive capacity create the need for new legal norms. Since existing space law instruments were established before the emergence of advanced AI, these norms often do not provide sufficient mechanisms for transparency or accountability to ensure AI is used in a manner that is free from errors or violations of humanitarian law.[23]

The implementation of IHL principles in AI not only ensures physical safety, but also regulates legal responsibility. AI in de-orbiting and debris management must implement fail-safe and human-in-the-loop mechanisms[24]. This ensures compliance with the principles of distinction, proportionality, and precaution. Integrating IHL into AI algorithms enables real-time risk assessment, so that orbital decisions do not result in excessive civilian damage. This approach also closes the accountability gap that arises due to AI autonomy, including errors in identifying civilian-military satellites. This paper proposes an operational framework for translating IHL principles into AI modules. The principle of distinction is implemented through multi-sensor fusion classification algorithms designed to differentiate between civilian and military satellites. The principle of proportionality is realized through a risk-damage calculation module that assesses potential impacts on civilian infrastructure. The principle of precaution is enforced through failsafe mechanisms and human-in-the-loop requirements. All decisions are recorded in a blockchain-based audit log architecture to ensure state accountability.

3. Governance Gaps in Outer Space

Despite the Outer Space Treaty's foundational role, significant governance gaps remain. Key principles such as "due regard" and "peaceful use" lack clarity, leading to inconsistent interpretations among states. The dual-use nature of AI technologies serving both civilian and military purposes complicates adherence to the peaceful use principle. Meanwhile, the growing involvement of private space actors (e.g., satellite servicing, mining) has outpaced international regulatory development.[25] National laws implementing OST obligations vary widely, resulting in conflicting interpretations of the treaty's prohibition on "national appropriation." These inconsistencies hinder cooperative and equitable space governance.[26]

Although the Outer Space Treaty (OST) of 1967 remains the cornerstone of space governance, significant regulatory gaps persist. The OST's provisions of "due regard" and "peaceful use" are interpreted differently by states. Some interpret "peaceful use" as a prohibition on offensive military activities, while others view it merely as a ban on weapons

[22] Uçkaç, "Examining the Use of Artificial Intelligence in Space Technologies , Taking Into Account the Dimensions of International Law."

[23] Ugo Pagallo, Eleonora Bassi, dan Massimo Durante, "The Normative Challenges of AI in Outer Space: Law, Ethics, and the Realignment of Terrestrial Standards," *Philosophy and Technology* 36, no. 2 (2023): 1–23, https://doi.org/10.1007/s13347-023-00626-7.

[24] Ashish Kakkar, "Safeguarding orbital sustainability: addressing ai-driven satellite de-orbiting by non-state actors under international law," *Journal on Innovation and Sustainability RISUS* 16, no. 2 (2025): 124–134.

[25] ritanshu Lohani and Luiza Delaflora CassoL, "2024 Outer Space Security Conference Report," no. September (2024): 1–38, https://unidir.org/wp-content/uploads/2025/01/unidir_2024_outer_space_security_conference_report.pdf.

[26] Stephan Hobe, *A. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial BodiesUnited Nations, Treaty Series, Vol. 610, No. 8843.*, *Space Law*, 2019, https://doi.org/10.5771/9783845266343-225.

of mass destruction, thereby permitting conventional military operations.[27] The use of AI in outer space has also sparked debate on how the fundamental principles of space lawsuch as peaceful purposes, non-interference, and precautionshould be reinterpreted. Abashidze et al. (2022) in Artificial Intelligence and Space Law discuss that the current international legal framework is insufficient to ensure that AI does not violate these principles, particularly concerning data confidentiality, information protection, and legal responsibility in cases where AI causes damage to other space objects or the orbital environment.[28]

The principles of precaution and distinction in international humanitarian law require that all actions taken during armed conflict avoid causing harm to civilian infrastructure and the environment. In the orbital context, outer space should be viewed as a "global civilian environment" that supports human life through digital infrastructure and information technology. The use of military force in space, including ASAT testing, has the potential to violate these principles and generate extensive humanitarian impacts. Moreover, damage to the orbital environment is long-term and transboundary in nature, raising complex issues of international legal responsibility. The absence of effective sanction mechanisms in the Outer Space Treaty means that states conducting ASAT tests face no significant legal consequences. This highlights the urgent need to establish a stronger international legal regime that incorporates the protection of the orbital environment as an integral part of humanitarian protection.

Moreover, the OST lacks strong enforcement mechanisms. There is no dedicated enforcement body or sanction system to address violations of the treaty's principles. These loopholes allow states to engage in military space activities without clear legal consequences, undermining efforts to establish a space arms control regime. Another challenge is the growing involvement of non-state actors. Private companies now operate thousands of active satellites and dominate global communications infrastructure.[29] Yet, international legal frameworks remain state-centric, creating a regulatory gap for private activities. Differences in national laws implementing OST obligations further increase the risks of overlapping jurisdictions and geopolitical tensions.

Governance gaps within the OST and contemporary space law frameworks require significant reform. The establishment of an International Orbital Safety Authority (IOSA), a Space Debris Responsibility Framework (SDRF), and an AI Transparency and Verification Protocol (AITVP) is urgently needed to provide oversight and verification of AI systems. These reforms are essential to ensure compliance with humanitarian norms, close verification gaps, and regulate the activities of both state and non-state actors in outer space.

Although the OST (1967) is the legal foundation, differences in the interpretation of the principles of "peaceful use" and "due regard" have given rise to normative uncertainty. Abashidze et al. (2022) show that current law is insufficient to regulate AI that can act autonomously in orbit. This creates a regulatory gap, especially in regulating non-state actors, which now operate thousands of satellites. This vulnerability emphasizes the need for additional legal instruments, including international verification mechanisms, AI transparency audits, and collective responsibility protocols between countries.

4. The Dual-Use Dilemma of Artificial Intelligence

[27] Stonis, "Ambiguities in Space Law as Path towards Weaponization of Space: The Case of the Outer Space Treaty. Remarks on Regulation of Weaponization of Outer Space by Space Law."
[28] Kakkar, "Safeguarding orbital sustainability: addressing ai-driven satellite de-orbiting by non-state actors under international law."
[29] Khalid, "Space Legal Regimes, Militarization, and Weaponization of Outer Space."

AI-based systems are increasingly deployed for orbital debris tracking, collision avoidance, and remediation. However, their ability to autonomously detect, classify, and manipulate space objects introduces ethical and security dilemmas.[30] AI can improve efficiency but also risks being repurposed for offensive military functions, such as targeting adversary satellites under the guise of debris removal. AI technologies in orbit have inherently strong dual-use characteristics. AI can improve the efficiency of debris tracking, collision avoidance, and active debris removal (ADR) programs. However, these same capabilities can also be repurposed for offensive operations, such as disabling adversary satellites under the pretense of debris mitigation or orbital testing.

AI can play a key role in establishing early warning systems, collision detection, and monitoring orbital activities that have the potential to trigger conflicts. With normative boundaries and technical indicators in place, AI can be utilized as an effective conflict prevention instrument. This approach combines the precautionary principles of law with the analytical speed of modern technology. This dual-use dilemma creates ethical and legal challenges.

Unregulated AI technology could fuel a new orbital arms race, increasing the likelihood of accidental or deliberate escalation. In the worst-case scenario, debris removal technologies designed for peaceful purposes could be transformed into precision orbital weapons.[31] Dual-use AI poses the risk of converting civilian technology into military technology. Galliott warns that without an international legal framework, the use of AI for debris removal could turn into an orbital precision weapon, triggering a new arms race. Therefore, the application of IHL to the technical design of AI is crucial. Strategic recommendations include: multilateral oversight, public transparency, international verification mechanisms, and the integration of IHL principles into AI algorithms. In this way, AI can function as an instrument of conflict prevention, rather than a military threat.

1. Therefore, AI governance in outer space requires a strict international framework, including: Multilateral oversight of AI-based orbital projects,
2. Public transparency in the use of ADR technologies,
3. Verification mechanisms to prevent military misuse, and
4. Integration of IHL principles into the technical and operational design of AI systems.

The application of AI in space debris governance presents significant opportunities for mitigating orbital conflicts. AI can accelerate debris detection, enhance collision prediction accuracy, and strengthen early warning systems. Within the framework of international humanitarian law, AI can help ensure that the principles of distinction and proportionality are upheld in real time. However, its deployment must be strictly regulated to prevent misuse for military or offensive purposes. The necessary implementation boundaries include: transparency in AI use, a mandatory human-in-the-loop requirement (ensuring that final decisions remain in human hands), international verification mechanisms, and sanctions for misuse.

To address the dual-use dilemma effectively, the following strategic steps are recommended:

1. Space AI Early Warning System: Establish an AI-based monitoring mechanism under the UN framework to detect and mitigate potential orbital conflicts at an early stage.[32] International Code of Conduct: Develop binding guidelines for the use

[30] Policy Brief, "ENSURING RESPONSIBLE AI IN SPACE AND EARTH OBSERVATION," no. September (2025).

[31] Claudio Bombardelli dan Jesus Peláez, "Ion beam shepherd for contactless space debris removal," *Journal of Guidance, Control, and Dynamics* 34, no. 3 (2011): 916–920.

[32] Fida Hussain, "The role of Artificial Intelligence in Early Warning System for Violent Conflicts: Explores how technology can predict and prevent Violence, a cutting edge, and interdisciplinary angle," *Advance Social Science Archive Journal* 03, no. 02 (2025): 1961–1970.

of AI in space to ensure consistency, transparency, and accountability across states.[33] Verification and Compliance Mechanisms: Implement international protocols for independent monitoring, reporting, and sanctioning of misuse. Integration of IHL Principles: Embed the principles of distinction, proportionality, and precaution into AI algorithms, operational design, and mission planning.[34] Transparency in Orbital Data: Promote open reporting of debris, satellite maneuvers, and AI interventions to build trust among space-faring nations.[35] Harmonization of National Standards: Align domestic regulations on debris mitigation, AI deployment, and orbital activities with international norms.[36]

2. By combining legal, technical, and ethical measures, the international community can ensure that AI serves as a preventive instrument rather than a destabilizing factor. Such a holistic framework strengthens space security, prevents the militarization of orbit, and preserves outer space as a sustainable global-commons for future generations.
3. In this way, AI is positioned not merely as a technical tool but as a strategic component of global security governance. This approach will reinforce international legal norms aimed at preventing the weaponization of orbital technologies. The exponential growth of space debris and the integration of AI into orbital activities create unprecedented legal and ethical challenges. Current space law lacks an adequate liability regime to address debris generated by military or commercial activities. At the same time, IHL principles must be extended to outer space to respond to these emerging threats.[37] The ethical dimensions of AI use must also be a central concern. When orbital maneuver or debris removal decisions are delegated to algorithms, the risk of automation bias increases. In a conflict scenario, algorithmic errors could escalate military tensions or even trigger inter-state conflict.

To address these issues, a coherent and multilateral governance framework is essential. Recommended strategic steps include: Policy Recommendation:

1) Establish a Space AI Early Warning Mechanism under the UN framework to detect and mitigate potential orbital conflicts at an early stage.
2) Develop an international Code of Conduct regarding the use of AI in outer space.
3) Implement transparency and joint verification principles to strengthen trust among states.
4) Enhance international legal capacity to integrate IHL principles into technology governance.
5) These steps can strengthen space security and prevent future conflict escalation.
6) Strengthening and amending the Outer Space Treaty to better address AI technologies and debris threats,
7) Establishing a Space Security Council under the United Nations,
8) Harmonizing national standards for debris mitigation obligations,
9) Promoting transparency in orbital data and incident reporting, and

[33] Pagallo, Bassi, dan Durante, "The Normative Challenges of AI in Outer Space: Law, Ethics, and the Realignment of Terrestrial Standards."

[34] Olajide Olugbade, "In search of a global governance mechanism for Artificial Intelligence (AI): a collective action perspective," *Global Public Policy and Governance* 5, no. 2 (2025): 139–161, https://doi.org/10.1007/s43508-025-00113-z.

[35] El Renova Ed. Siregar, Adya Paramita Prabandari, dan Naek Siregar, "International Law Review Of Space Debris Mitigation Efforts," *International Journal of Educational Research & Social Sciences* 5, no. 2 (2024): 217–223.

[36] Ibid.

[37] Schmitt, "International Humanitarian Law and the Targeting of Non-State Intelligence Personnel and Objects."

10) Integrating IHL principles into space law regulations.

Such an approach would not only help prevent the militarization of outer space but also ensure the sustainability of orbital environments as a global commons for humanity. The fundamental weakness of the current space law regime lies in the lack of clear enforcement and sanction mechanisms. The principles of "peaceful use" and "due regard" in the Outer Space Treaty are often narrowly interpreted by major powers to safeguard their strategic interests. This ambiguity creates room for ASAT testing without adequate international legal consequences. Therefore, there is a need to update international legal norms through the creation of new legal instruments or amendments to existing treaties. One strategic idea is the establishment of a Space Security Council under the United Nations, along with specific legal regulations governing the use of AI in orbital conflict mitigation. This step would strengthen the position of humanitarian law in addressing the threat of space militarization.

This study demonstrates that ASAT activities and the increasing congestion of low Earth orbit represent a real threat to international security, the orbital environment, and humanitarian interests. An integrative approach combining international humanitarian law and AI technology can serve as a strategic solution to reduce conflict risks and ensure the sustainability of outer space as a global heritage. Concrete measures are needed through the establishment of early warning mechanisms, an international code of conduct, and the strengthening of international legal norms to ensure that outer space remains a peaceful and secure domain for future generations. A transparently managed, IHL-based AI strategy can enhance international trust and reinforce the stability of space security.

The use of AI in outer space has also sparked debate on how the fundamental principles of space law such as peaceful purposes, non-interference, and precaution should be reinterpreted. in Artificial Intelligence and Space Law discuss that the current international legal framework is insufficient to ensure that AI does not violate these principles, particularly concerning data confidentiality, information protection, and legal responsibility in cases where AI causes damage to other space objects or the orbital environment.[38] To ensure orbital sustainability, the international community must develop a holistic framework that combines law, technology, and ethics. Emphasizes that conflict prevention is more effective than conflict resolution in high-risk domains.[39] Therefore, mechanisms such as the Space AI Early Warning System, international codes of conduct, and enhancing the legal capacity of IHL for AI are strategic steps. National standardization on debris mitigation, orbital data transparency, and harmonization of international rules will strengthen the stability of space as a global commons.

Conclusion

This study demonstrates that ASAT activities and the increasing accumulation of space debris have created a multidimensional threat to global security, the orbital environment, and humanitarian interests, indicating that the application of IHL principles to AI governance in orbit offers a strategic approach to preventing the escalation of armed conflict, strengthening civilian protection, and ensuring the sustainability of the space environment. The findings further show that AI can function as a preventive legal instrument rather than a technological

[38] F. Allard, "Artificial intelligence and space," *Journal of Legal, Ethical and Regulatory Issues* 25, no. 43S (2022).
[39] DEBLOIS, "The Advent of Space Weapons."

threat if it is designed within a transparent and accountable international legal framework, thereby highlighting the need for the international community to strengthen the space law regime through treaty updates, global monitoring mechanisms, and the integration of AI into international humanitarian legal norms. Such efforts are essential to preserve outer space as a global commons for future generations and to prevent it from becoming a new arena of armed conflict.

Bibliography

Allard, F. "Artificial intelligence and space." *Journal of Legal, Ethical and Regulatory Issues* 25, no. 43S (2022).

Bombardelli, Claudio, dan Jesus Peláez. "Ion beam shepherd for contactless space debris removal." *Journal of Guidance, Control, and Dynamics* 34, no. 3 (2011): 916–920.

Claudya, Ribqha, dan Irawati Handayani. "The Challenges of Environmental Protection in Outer Space Following Russia's Anti-Satellite (ASAT) Weapon Test Activities." *Yustisia* 13, no. 2 (2024): 210–229.

Crescent, Red. "International humanitarian law and the challenges of contemporary armed conflicts." *International Review of the Red Cross* 106, no. 927 (2024): 1357–1450.

DEBLOIS, BRUCE M. "The Advent of Space Weapons." *Astropolitics* 1, no. 1 (2003): 29–53.

Ed. Siregar, El Renova, Adya Paramita Prabandari, dan Naek Siregar. "International Law Review Of Space Debris Mitigation Efforts." *International Journal of Educational Research & Social Sciences* 5, no. 2 (2024): 217–223.

ESA Space Debris Office. "ESA 2025 Annual Space Environment Report," no. 9.0 (2025): 1–144.

Fida Hussain. "The role of Artificial Intelligence in Early Warning System for Violent Conflicts: Explores how technology can predict and prevent Violence, a cutting edge, and interdisciplinary angle." *Advance Social Science Archive Journal* 03, no. 02 (2025): 1961–1970.

Hobe, Stephan. *A. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial BodiesUnited Nations, Treaty Series, vol. 610, No. 8843. Space Law*, 2019.

Hurova, Anna. "The Nuances of Responsibility of Artificial Intelligence for Irresponsible Space Activity." *Philosophy and Cosmology* 32 (2024): 27–33.

Kakkar, Ashish. "Safeguarding orbital sustainability: addressing ai-driven satellite de-orbiting by non-state actors under international law." *Journal on Innovation and Sustainability RISUS* 16, no. 2 (2025): 124–134.

Kelso, T.S. "Analysis of the 2007 Chinese ASAT Test and the Impact of its Debris on the Space Environment." *Advanced Maui Optical and Space Surveillance Technologies* (2007): 321–330. http://www.m.celestrak.com/publications/AMOS/2007/AMOS-2007.pdf.

Kessler, Donald J, dan Burton G Cour-palais. "Was Observed" 83, no. 8 (1978): 918–924.

Kessler, Donald J, Nicholas L Johnson, dan Mark Matney. "The Kessler Syndrome: Implicatinos to Future Space Operation." *33rd Annual AAS Guidance and Control Conference* 137 (2010): AAS 10-016.

Khalid, Munazza. "Space Legal Regimes, Militarization, and Weaponization of Outer Space." *Astropolitics* 19, no. 1–2 (2021): 128–144. https://doi.org/10.1080/14777622.2021.2008768.

Lohani, Ritanshu, dan Luiza Delaflora Cassol. "2024 Outer Space Security Conference Report," no. September (2024): 1–38. https://unidir.org/wp-content/uploads/2025/01/unidir_2024_outer_space_security_conference_report.pdf.

Murray, James, Tim Kennedy, dan Mark Matney. "Observations of Small Debris from the Cosmos 1408 Anti-Satellite Test using the HUSIR and Goldstone Radars" (2022): 1–

10. www.amostech.com.

Nations, United. *Ensuring Responsible Ai In Space And Earth Observation*. Office For Outer Space Affairs, 2025.

Olugbade, Olajide. "In search of a global governance mechanism for Artificial Intelligence (AI): a collective action perspective." *Global Public Policy and Governance* 5, no. 2 (2025): 139–161. https://doi.org/10.1007/s43508-025-00113-z.

Pagallo, Ugo, Eleonora Bassi, dan Massimo Durante. "The Normative Challenges of AI in Outer Space: Law, Ethics, and the Realignment of Terrestrial Standards." *Philosophy and Technology* 36, no. 2 (2023): 1–23. https://doi.org/10.1007/s13347-023-00626-7.

Pardini, Carmen, dan Luciano Anselmo. "Evaluating the impact of space activities in low earth orbit." *Acta Astronautica* 184, no. April (2021): 11–22. https://doi.org/10.1016/j.actaastro.2021.03.030.

Pritchard, Suzanne. "The final frontier." *International Water Power and Dam Construction* 65, no. 12 (2013): 18–19.

Schindler, Dietrich, dan Jiri Toman. "Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts (Protocol I)." *The Laws of Armed Conflicts*, no. August (2021): 711–773.

Schmitt, Michael N. "International Humanitarian Law and the Targeting of Non-State Intelligence Personnel and Objects." *Duke Journal of Comparative & International Law* 30, no. 2 (2020): 309–346.

Semenyaka, Vasyl. "International-Legal Problem of Space Debris." *Advanced Space Law* 1 (2018): 84–90.

Stonis, Danylo. "Ambiguities in Space Law as Path towards Weaponization of Space: the Case of the Outer Space Treaty. Remarks on Regulation of Weaponization of Outer Space by Space Law." *Copernicus Political and Legal Studies* 1, no. 4 (2022): 74–84.

Uçkaç, Mehmet. "Examining the Use of Artificial Intelligence in Space Technologies , Taking Into Account the Dimensions of International Law." *Luminis Applied Science and Engineering* 2, no. 3 (2025): 66–80.

United Nations. *United Nations Treaties and Principles on Space Law*. Office For Outer Space Affairs, 1967. http://www.oosa.unvienna.org/oosa/SpaceLaw/treaties.html.