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CLEAN UP TIME! THE GLOBAL COMMUNITY NEEDS TO PRESERVE, PROTECT, AND PROMOTE A CLEANER OUTER SPACE

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Environmental concerns on earth have garnered substantial international attention with hundreds of international agreements and the work of vocal environmental activists, like Greta Thunberg. However, environment-oriented concern for outer space remains galaxies away. It is time to address this important issue, given society's reliance on space-based satellites and space activities. The International Academy of Astronauts and the European Space Agency summarize some of the ways that human life is affected on a daily basis by space-based initiatives:

> Strengthening and promoting European science, improving medical science, generating new technologies, promoting industrial development, protecting the Earth, assisting agriculture, developing more accurate weather forecasts, improving communications, creating accurate maps, improving navigation, increasing employment, and preventing the brain drain.[1]

Given these social benefits, it is vitally important that the international community strives to clean up and prevent space debris.

After more than 50 years of space exploration, there is a shocking amount of space debris, as noted by Mia Rabson: "129 million pieces of garbage are circling the Earth, pieces of old satellites, broken up rockets, and castoffs from human missions to space."[2] While space activities are governed by the 1967 Outer Space Treaty and a handful of other treaties, "the drafters . . . did not anticipate the problem of space debris and the risk of a collisional cascade among space assets, in which collisions between artificial satellites and other objects create more debris, leading to more collisions," as noted by the Outer Space Institute.[3] Through a gap

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[1] International Academy of Astronauts and the European Space Agency, "The Impact of Space Activities Upon Society," *European Space Agency* (February 2005),136, http://www.esa.int/esapub/br/br237/br237.pdf

[2] Mia Rabson, "Canadian military wants help taking out trash — in space," *Global News* (16 January 2020), n.p., https://globalnews.ca/news/6422713/canadian-military-space-debris/

[3] Outer Space Institute, "The Legal Setting," The University of British Columbia, n.p., http://outerspaceinstitute.ca/legalframework.html

analysis, this essay will explore the current space debris issue, related to the volume of space debris, the self-perpetuating nature of space debris, the increase in commercial activity, and the concerns that space debris pose to human space flight and satellite activity. This essay will then unearth some of the ways that the international community can improve the space environment, using a holistic 3P approach: preserve, protect, and promote. Ultimately, this galactic issue requires global imperative.

Space Debris: A Gravitas Situation

Before considering the ways in which the international community can improve the space environment, it is important to uncover the magnitude of the issue. Katarina Damjanov offers specific data on the nature of the space debris problem, stating that the space community is "track[ing] about 22,000 pieces that are larger than ten centimeters in diameter, and it is estimated that there are also about 500,000 fragments between one and ten centimeters and millions of smaller particles that are all too minute to be pursued."[4] The National Aeronautics Space Administration (NASA) expresses similar concerns related to the volume of space debris, noting that "there are close to 6,000 tons of materials in low Earth orbit," illustrating the weight of the problem.[5] With millions of pieces of space debris orbiting the earth at various fast speeds, Damjanov underscores that the space-faring community is manifesting the concerns of the "Kessler Syndrome," which posits that space debris collisions will create more space debris, increasing the volume of pieces of trash floating around in earth's orbit.[6] NASA also underscores that the speed of orbit travel and the amount of debris in low-earth orbit could jeopardize the

[4] Katarina Damjanov, "Of Defunct Satellites and Other Space Debris: Media Waste in the Orbital Commons," *Science, Technology, & Human Values* 42, no. 1 (January 2017), 168.
[5] National Aeronautics Space Administration, *Space Debris* (1 July 2019), n.p, https://www.nasa.gov/centers/hq/library/find/bibliographies/space_debris
[6] Damjanov, "Of Defunct Satellites and Other Space Debris: Media Waste in the Orbital Commons" . . ., 180.

safety and "people and property in space," with more and more potential collisions.[7] Space debris is a gravitas problem.

Given the cost and the technological capability required to plan and execute space operations, space exploration was previously limited to very few nations, allowing for easier monitoring. Today, more and more nations are considered to be space-faring, and commercial enterprises also hold the key to space. Underscoring the importance of monitoring, Michael Byers and Aaron Boley describe the catastrophic results of China's 2007 destruction of a non-functional weather satellite, which created more than 2,000 pieces of space debris of more than 10 centimetres in size as well as other space debris pieces[8]. In addition to creating a serious space debris problem, China's actions also placed 700 satellites in peril and resulted in the disabling of a Russian satellite in 2013, as noted by Byers and Boley,[9] illustrating the long-term and potentially severe consequences of the space debris issue. This example demonstrates the need for careful monitoring of space activity from an environmental and security perspective.

In addition to more space-faring nations, commercial enterprises like Space X are beginning to have substantial interest and participation in space activities. Byers and Boley enumerate the magnitude of Space X's space activities, noting that the company "has already launched the first 240 of a planned 12,000 Starlink communications satellites, and is proposing to eventually send up 30,000 more."[10] Moreover, they note the frequency of Space X's space activities, stating that with "60 satellites [being launched] every two to four weeks . . . it is proving impossible for national regulators and international organizations to keep up."[11] Space

[7] National Aeronautics Space Administration, *Space Debris* . . ., n.p.
[8] Michael Byers and Aaron Boley, "We Are Polluting Out Outer Space Its Time to Clean Up Our Orbit," *Globe and Mail* (8 February 2020), n.p. https://www.theglobeandmail.com/opinion/article-we-are-polluting-outer-space-its-time-to-clean-up-our-orbit/
[9] Ibid.
[10] Ibid.
[11] Ibid.

X's frequent and numerous space activities alone illustrate the need for increased monitoring. The volume of space debris, space-faring organizations, and space activities all contribute to space monitoring and governance problems related to assuring safe human and satellite operations in space.

Space Laws: Weightless

This study will now consider the space debris problem in relation to the existing governance frameworks, aimed to protect the space environment. The United Nations Office of Outer Space Affairs (UNOOSA) defines "space law" as the "rules, principles and standards of international law appearing in the five international treaties and five sets of principles governing outer space which have been developed under the auspices of the United Nations." [12] As noted by UNOOSA, the Outer Space Treaty (OST) of 1967 decrees the following:

> the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind; outer space shall be free for exploration and use by all States; outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means; States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner; the Moon and other celestial bodies shall be used exclusively for peaceful purposes; astronauts shall be regarded as the envoys of mankind; States shall be responsible for national space activities whether carried out by governmental or non-governmental entities; States shall be liable for damage caused by their space objects; and States shall avoid harmful contamination of space and celestial bodies.[13]

[12] United Nations Office of Outer Space Affairs. "Space Law." United Nations, n.d., https://www.unoosa.org/oosa/en/ourwork/spacelaw/index.html

[13] United Nations Office of Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," n.d., https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html

The OST calls for an egalitarian, non-violent, and humanitarian approach to space. However, it did not anticipate and address the magnitude of the issues related to space debris, as suggested by UNOOSA.[14]

UNOOSA, the Outer Space Treaty, the European Space Agency, National Aeronautics Space Administration (NASA), Inter-Agency Space Debris Coordination Committee (IADC), and other international organizations provide guidelines on the use of space. Moreover, national-level obligations governing each individual space-faring nation provide a layer of protection; however, as highlighted by NASA"[t]here are no international space laws to clean up debris in our LEO [Low Earth Orbit]. LEO is now viewed as the World's largest garbage dump, and it's expensive to remove space debris from LEO because the problem of space junk is huge."[15] To that end, specific and enforceable legislation in relation to space debris is required.

Similarly, scientific and technical-oriented organizations provide some information, sharing best practices and recommended actions; however, they lack the political will and legal weight to hold offenders to account. For instance, the Working Group on Space Debris, established by the Scientific and Technical Subcommittee of the Committee, developed seven guidelines related to space debris. However, these guidelines are non-legally binding under international law, as problematized in other space debris-oriented commitments.[16] Moreover, although the IADC is focused exclusively on space debris, with twelve member agencies representing, eleven nations and the regional European Space Agency, the group is largely technical in nature, lacking legal authority.[17] Damjanov summarizes the challenges associated

[14] Ibid.
[15] National Aeronautics Space Administration, *Space Debris* . . ., n.p.
[16] United Nations Office of Outer Space Affairs, "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space," (n.d.), 1.
[17] Nicolas Johnson, "Origin of the Inter-Agency Space Debris Coordination Committee," National Aeronautics Space Administration, (n.d.), 70, https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150003818.pdf

with space debris governance, noting "it is literally beyond the reach of the global grid of governance."[18] While there are international commitments and treaties governing space, in general, and space debris, specifically, they are challenged to practically be enforced, lacking teeth to render justice to offenders.

Preserving Outer Space

Having identified the space debris problem in overarching technical and governance terms, this study will propose a 3P approach (preserve, protect, and promote) to facilitate better stewardship of outer space. To preserve the outer space environment, there is a need for a governance structure that facilitates greater accountability amongst space-faring nations and commercial enterprises. S.W. Chiu emphasizes the "anarchy" of the larger "international system," characterized by a lack of "superior authority exterior to the State in policing violations of established rules, norms and regulations."[19] Therefore, notes Chiu, "[c]ompliance to international law is based largely on States' voluntary adhesion,"[20] an observation that affirms the need for an authoritative governing body regarding space debris. Damjanov also recognizes the lack of regulatory body governing space debris, calling for an "inclusive mode of governance."[21] As acknowledged by space scholars, there is a need for a comprehensive, inclusive, and enforceable governance model to address space debris.

In addition to the need for an overarching authority related to space debris, other scholars note the need for specific regulations on space operations. Recognizing the lack of accountability in the generation of space debris, Byers and Boley call for a "polluter pays" approach, suggesting

[18] Damjanov, "Of Defunct Satellites and Other Space Debris: Media Waste in the Orbital Commons," 172.
[19] S.W. Chiu, "Promoting International Co-Operation in the Age of Global Space Governance – A Study on on-Orbit Servicing Operations," *Acta Astronautica161* (August 2019), 377-8.
[20] Ibid.
[21] Damjanov, "Of Defunct Satellites and Other Space Debris: Media Waste in the Orbital Commons," 180-1.

that the offending organization needs to be financially responsible,[22] operating the same way as an environmental fine. Moreover, they suggest that there is a need for "right of way" legislation in cases when satellites need to be moved to avoid a collision, recognizing the cost of "precious thruster fuel."[23] These two examples of specific regulations illustrate the need for governance that anticipates the types of scenarios that space-faring nations and commercial enterprises are facing with increased space activity to protect outer space.

In addition to Byers and Boley's specific recommendations for "polluter pays" and "right of way,"[24] Ward Munters also highlights the legal risks associated with cleaning up debris, illustrating the need for legal protection. Ward posits why would a state clean up space debris "in light of the potentially gargantuan international legal responsibility and liability for damages when something goes awry in the application of highly novel and hazardous removal technology when there is no legally enforceable obligation?"[25] To protect the space environment, general and specific, legally binding, enforceable, regulations and protections are required, particularly in light of the cost of cleaning up space debris and the risks that space debris pose to human space flight and vital satellites. As an aside, Byers and Boley cite the Montreal Protocol, which prohibited chlorofluorocarbons, noting that there is a precedence in terms of international cooperation and political will regarding a global issue.[26] At this time, specific laws are required to address space debris to ensure that offenders pay for costly errors and to provide legal liability coverage in challenging clean-up operations..

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[22] Byers and Boley, "We Are Polluting Out Outer Space Its Time to Clean Up Our Orbit" . . ., n.p.
[23] Ibid.
[24] Ibid.
[25] Ward Munters, "Space Debris Conundrum for International Law Makers," *The Space Journal of Ascardia,* Issue #1 (7) (2016), n.p., https://room.eu.com/article/space-debris-conundrum-for-international-law-makers
[26] Byers and Boley, "We Are Polluting Out Outer Space Its Time to Clean Up Our Orbit" . . ., n.p.

To address the aforementioned governance gaps, Joseph Pelton's "international goal-oriented action plan"[27] offers a viable and concrete solution. Pelton's concept of an "action plan" would include "strengthening of guidelines for Mitigation of Orbital Debris;"

> "develop[ing] new more efficient and cost efficient and cost effective technology for debris removal;" "develop[ing] . . . insurance arrangements and/or financial incentives for debris removal;" "creat[ing] . . . model laws;" "develop[ing] provisions related to orbital debris that are defined in 'codes of conduct;'" and "creat[ing] on a 'de facto basis' . . . new procedures that cover registration of space objects, duties and responsibilities of private entities designing, launching, deploying, operating and owning space systems, and liability provisions through insurance and other risk-mitigation initiatives."[28]

Pelton's "action plan" holistically addresses issues related to space debris from insurance to "model laws," to "codes of conduct."[29] Moreover, recognizing the cost of cleaning up the space environment, Pelton also calls for an "Active Debris Removal Fund," "to compensate innovative space entities that develop the needed new technology to remove the defunct spacecraft and upper stage launch vehicles."[30] Furthermore, to ensure appropriate expertise and commitment, Pelton suggests gathering "interdisciplinary teams with a wide range of expertise that would be available to work [together] . . . addressing the problem, and seeking the new solutions," as part of the "action plan." [31] Pelton's vision of gathering government, multinational organizations, space stakeholders, "insurance and risk agencies," and other relevant parties to create a comprehensive "action plan" [32] that is appropriately funded holds substantial promise and facilitates important buy-in.

In addition to a more accountable governance structure, new technologies need to be funded and utilized to cleanup existing debris to preserve the space environment. While

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[27] Joseph Pelton, *New Solutions for the Space Debris Problem*. 1st ed. 2015 (Cham: Springer International Publishing, 2015), 82.
[28] Ibid.
[29] Ibid.
[30] Joseph Pelton, *Space Debris and Other Threats from Outer Space*, (New York: Springer, 2013), 33.
[31] Pelton, *New Solutions for the Space Debris Problem* . . ., 82.
[32] Ibid.

Damjanov recognizes that there are a number of "catch-all space sweepers, fishing nets and harpoons, tethers, laser blasts, big and small space tugs" that have the potential to help clean up space debris; however, she notes that many of the clean-up technologies are unaffordable or still in development. [33] Damjanov specifies the potential types of futuristic clean-up instruments, including "ground-based lasers," "solar sail arrays," "tethered nets," "spraying frozen gas mists," "robots," and "sticky adhesive balls."[34] The research and development associated with these innovative tools demonstrate an international desire to clean up space and hold promise; however, the cost of launching these new technologies into space and the time associated with cleaning up minute pieces of debris in outer space is not an easy or inexpensive task. A comprehensive governance structure, informed by Pelton's vision of the "Active Debris Removal Fund" and based on accountability and buy-in is, therefore, required to fund expensive space clean-up.

Protecting Outer Space

From a protection perspective, space debris needs to be limited in the first place, as suggested in the NASA Orbital Debris Standard Practices.[35] The IADC also enumerates the ways in which space debris can be minimized in the first place, protecting future outer space environment. In a slim, 10-page, technical-oriented document, the IADC suggests the following debris mitigating measures: "limit debris released during normal operations," "minimise the potential for post mission break-ups resulting from stored energy," "minimise the potential for break-ups during operational phases," and "avoidance of intentional destruction and other

[33] Damjanov, "Of Defunct Satellites and Other Space Debris: Media Waste in the Orbital Commons" . . ., 179.
[34] Ibid.
[35] National Aeronautics Space Administration, *Handbook for Limiting Orbital Debris* (10 April 2018), 1.

harmful activities."[36] Similarly, NASA posits that "[s]pacecraft and upper stages should be designed to eliminate or minimize debris released during normal operations."[37] In cases when space debris is inevitable, NASA is asserting more stringent restrictions, stating that "each instance of planned release of debris larger than 5 mm in any dimension that remains on orbit for more than 25 years should be evaluated and justified."[38] The IADC also calls for the development of space craft that will provide a greater degree of protection against space debris once in orbit, as described by the Canadian Space Agency (CSA).[39] Related to sustainability, the CSA also discusses the importance of being able to refuel satellites, allowing for reuse and long-term use.[40] At this time, once satellites run out of fuel, they are rendered unusable and become space debris. To that end, an ability to refuel satellites would reduce the amount of space debris and save money building and launching new satellites into space, as described by CSA.[41] It is worthwhile noting that reusing satellites would, therefore, simultaneously help protect the earth and space environments. By minimizing debris in the first place through new shuttle technologies and reusable satellites, for instance, space-faring nations can help prevent the Kessler effect and avoid costly clean-up.

As part of protecting the space domain, space-faring nations and other key stakeholders need to monitor and surveille space activities. To begin, it is vital to catalogue and monitor space debris. Damjanov describes the manner in which space debris is catalogued through the IADC, explaining that "the data on space waste are collected by ground and space-based telescopes,

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[36] Inter-Agency Space Debris Coordination Committee, Action Item Number 22.4, (September 2007), 9, https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf
[37] National Aeronautics Space Administration, *Handbook for Limiting Orbital Debris* . . ., 1.
[38] Ibid.
[39] Canadian Space Agency. "CSA Joins in Space Debris Group." *Parabolic Arc.* (24 November 2010), n.p., http://www.parabolicarc.com/2010/11/27/csa-joins-space-debris-group/
[40] Canadian Space Agency, "Saving Satellites" (11 January 2013), https://www.asc-csa.gc.ca/eng/iss/rrm/satellites.asp
[41] Ibid.

debris radars, and through examination of the surfaces of space-craft that have returned to Earth."[42] She further explains that the data is processed by "analytic algorithms" and "catalogued in databases such as the ESA's Database and Information System Characterizing Objects in Space or the US military operated Space Surveillance Network (SSN)."[43] These processes, notes Damjanov, allow for space debris surveillance.[44] In fact, Byers and Boley describe how "astronomers and lawyers are exploring whether improved tracking of space objects could enable litigation in domestic courts for collisions caused by negligence."[45] The processing and cataloguing of space debris is vital to identify trends, retain statistics regarding the amount and nature of the space debris, and, potentially, to enable legal proceedings. Illustrating the connection between space debris and the defence of national interests, the Royal Canadian Air Force, through its Canadian Space Operations Centre, "monitors space debris and inactive satellites," as described by Sarah Pacey.[46] Monitoring space debris, by defence or other specialist organizations, is of importance to the outer space and earth environments since it holds space-faring entities to account and helps prevent collisions.

Enhanced data on the location of space debris could help prevent collisions, protecting the space environment. In fact, the European Space Agency is calling for "automated collision avoidance systems," as described by Byers and Boley, illustrating the seriousness of the existing space debris issue.[47] Moreover, they also allude to an air traffic control system for space, much like the one that exists at the Toronto International Airport.[48] Similarly, the IADC also calls for

[42] Damjanov, "Of Defunct Satellites and Other Space Debris: Media Waste in the Orbital Commons" . . ., 176.
[43] Ibid.
[44] Ibid.
[45] Byers and Boley, "We Are Polluting Out Outer Space Its Time to Clean Up Our Orbit" . . . n.p.
[46] Sarah Pacey, "RCAF Leads Canadian Armed Forces Space Initiative" (26 March 2019(, http://www.rcaf-arc.forces.gc.ca/en/article-template-standard.page?doc=rcaf-leads-canadian-armed-forces-space-initiatives/jtk96x80
[47] Byers and Boley, "We Are Polluting Out Outer Space Its Time to Clean Up Our Orbit" . . ., n.p.
[48] Ibid.

collision avoidance, stating that the pre-mission "design and mission profile of a spacecraft or orbital stage . . . should estimate and limit the probability of accidental collision with known objects during the spacecraft or orbital stage's orbital lifetime"[49]. More precisely, the IADC calls for "avoidance manoeuvres for spacecraft and co-ordination of launch windows" to avoid collisions, which would result in more space debris.[50] Part of protecting the space environment involves important collision avoidance to minimize new space debris through the use of technology and monitoring practices.

Promoting the Human Requirement for Outer Space

Generating a greater awareness of the threat of unrestrained and unregulated space debris is perhaps the most important element of the 3P formula. From a promotion perspective, members of the global community, at large, do not seem to have space debris front of mind in the same way as environmental protection or climate change. S.W. Chiu paints a bleak picture of a world with unfettered space debris, suggesting lack of "access to internet, rural mobile communication, and satellite entertainment (i.e. TV)."[51] Chiu further explains that disrupted satellites could "jeopardize food production, detection of earthquake, and undermine relief efforts in areas hit by natural disasters and humanitarian crises."[52] Members of the public can see garbage float up on the shoreline from the vastness of the ocean; however, they are unable to see space debris, making meaningful engagement with this issue difficult. To that end, members of the public are not encouraging proactive action at the national and international levels, save select space stakeholders. There is a very small group of citizens who are conversant with the

[49] Inter-Agency Space Debris Coordination Committee, Action Item Number 22.4, (September 2007), 10, https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf
[50] Ibid.
[51] S.W. Chiu, "Promoting International Co-Operation in the Age of Global Space Governance – A Study on on-Orbit Servicing Operations." Acta Astronautica161 (August 2019), 377.
[52] Ibid.

space debris debate. Modeling and simulation and engaging spokespersons would help bring the space debris issue out of the darkness of space and into grounded terms that are well-understood. Without an understanding of space debris' potential to affect daily living, there is no possibility for pro-social action.

CONCLUSION

This study has reinforced the importance of political will, diplomatic support, and social engagement in the issue of space debris. At this time, members of the public are not conversant with the risks posed by space debris in the same way that they are with environmental concerns on earth. Given the unfathomable space environment and its sheer vastness, the idea that tiny particles of space debris could pose serious threats to satellites and human space flight is incomprehensible. However, if space debris is allowed to exponentially multiply, with unenforced financial and political accountabilities, society's way of life will inevitably be affected. Communications, internet, weather-monitoring, pandemic-monitoring, and navigational capabilities would be in jeopardy without safeguarding important space-based activities, as described by Pelton.[53] Given the vital role of protecting and monitoring space-based activities in relation to space debris and the complex technical skill sets required to operate in the space domain, are national defence and multinational security organizations ideally poised to defend the space environment for all humanity? Ultimately, if society wants to be able to communicate, to anticipate weather, to farm, to make purchases with a credit card, and to navigate in the air, on the sea, and on the ground, space debris needs to be cleaned up. It's clean up time!

[53] Pelton, *New Solutions for the Space Debris Problem*, . . ., 1.

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