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# *Non-cooperative Space Debris Mitigation*

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## *Abstract*

***Unrestrained growth in the amount of space debris is leading to alarming safety of flight consequences for the global space community. This paper examines the legal aspects of employing space tug and other concepts to reduce the potential for space collisions, especially dealing with circumstances where feckless and irresponsible States refuse to avail themselves of the opportunities to move satellites that pose dangers to other operational space systems. According to Article VIII of the Outer Space Treaty, a State retains "jurisdiction and control" over its space objects. Unless this right is relinquished, some argue that peacetime retrieval, alteration of orbit, or any other form of interference with foreign space objects would be unlawful without prior consent under treaty and customary international law, no matter how desirable the end result. This paper presents arguments for movement or disposal of satellites without consent. It suggests that such mitigation actions could be taken by another State or entity consistent with international law.***

## *"It is axiomatic that orbital debris is a global problem."* [1]

Unrestrained growth in the amount of space debris is leading to alarming safety of flight concerns for the global space community. Velocities for space objects are significant, especially in low earth orbit, so even small objects, some as small as a paint chip, can impart significant damage to other objects they impact. Given the threat, space traffic growth and management is both a challenge and a significant concern to those who hope to peacefully leverage the benefits of the capabilities enabled by space systems. These threats must be monitored and addressed.

Several nations are exploring technologies for space tugs. A space tug is robotic spacecraft designed to rendezvous and dock with a space object; make an assessment of its position, orientation, and operational status; and then either stabilize the object in its current orbit or move it to a new orbit. A potential important application includes clearing increasingly crowded orbital corridors, especially satellites located in low Earth or geosynchronous orbits that are no longer functioning but pose a frightening danger of adding to the population of in-orbit debris via destructive collision with other objects. This repositioning may be desirable as a means to retire of satellites into "graveyard" orbits or to de-orbit them.

This paper will examine the legal aspects of employing space tug and other concepts to reduce the potential for space collisions, especially dealing with circumstances where feckless and irresponsible States refuse to avail themselves of the opportunities to move satellites that pose dangers to other operational space systems.

According to Article VIII of the *Outer Space Treaty*, a State retains *jurisdiction and control* over its space objects. Unless this right is relinquished, some argue that peacetime retrieval, alteration of

[1] James E. Dunstan and Bob Werb, "Legal and Economics Implications of Orbital Debris Removal: Comments of the Space Frontier Foundation," October 30, 2009, http://www.scribd.com/doc/23379988/Legal-and-Economics-Implications-of-Orbital-Debris-Removal.

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orbit, or any other form of interference with foreign space objects would be unlawful without prior consent under treaty and customary international law, no matter how desirable the end result. Even though Article VI provides that States bear international responsibility for government and private space activities and must supervise and regulate national activities in space, they argue there is no effective lawful enforcement mechanism for failure by a State to perform actions consistent with these responsibilities.

This paper will examine arguments for and against movement or disposal of satellites without consent. The paper will suggest that such mitigation actions could be taken by another State or entity consistent with international law, but also highlight limits and dangers associated with asserting this right. Any such program should be based proper legal regimes such that private industry, if contracted by a government or otherwise, can provide this vital service. Given the growing dangerous threat, the goal should be to establish, at the earliest possible moment, a legal environment where either government or licensed private industry can remove space debris.

### *Growing debris threat threatens all classes of space activities*

Over the last 29 years, space traffic has quadrupled. The low, medium, geosynchronous, and highly elliptical orbits have become increasingly crowded. The easy availability of diverse small spacecraft technologies and providers is now leading to a rapid expansion in the population of active spacecraft. Deployment of these spacecraft and keeping them on orbit after their useful life is driving an associated rapid increase in space debris. As of July 2010, the United States Department of Defense Strategic Command (USSTRATCOM) is thought to tracks over 21,000 objects in orbit. Of these objects, 928 are operating satellites with 437 owned by the U.S., Russia 95 and China 58. Of the operating satellites, 449 are in low earth orbit (LEO), 59 in medium earth orbit, 381 in geosynchronous orbit (GEO) and 39 in elliptical orbits.[2] Some 40 percent of the objects catalogued arise from breakups, fragmentation or collisions; 25 percent are the result of "mission related" debris being produced during nominal operations (e.g. upper stages, fairings, explosive bolts). Over 90 percent of the non-operational objects are uncontrolled and have the potential to collide with operational satellites or other derelict objects.[3]

Unfortunately, the 21,000 orbiting objects are only those that can be tracked within the capability of USSTRATCOM's sensors, which have great difficulty tracking objects smaller than the size of a grapefruit or 10 centimeters (cm) in diameter. Exacerbating the challenge, there may millions more objects on orbit...up to 330,000,000 objects of 1 milimeter (mm) to 1 cm size and 560,000 objects of 1 cm to 10 cm.[4] The probability of a satellite colliding with one or more of these small objects is almost a certainty given any amount of time on orbit. And small objects can be very destructive. The author saw firsthand the damage imparted by only a small paint chip to Space Shuttle Challenger's window back in the early 1980s. The chip had been left in space by an explosion of a Delta rocket, and the impact necessitated replacement of the window at high cost.[5]

Satellites fail in the active GEO belt, on an average about one per year, as documented in an annual report published by the European Space

[2] Union of Concerned Scientists Satellite Database, http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html, accessed July 18, 2010.

[3] Dunstan and Werb, "Legal and Economics...," *supra.*

[4] Union of Concerned Scientists Satellite Database, *supra.*

[5] Greg Goldfarb, "Orbiting politics: crises in outer space," *Harvard International Review*, Summer, 1997, http://findarticles.com/p/articles/mi_hb137/is_3_19/ai_n28699040/, accessed July 27, 2010.

Agency.[6] The two most likely causes for these failures are (1) severe space weather events, for which manufacturing or operational solutions that mitigate the threat are not generally or cost-effectively available, or (2) equipment failures on the satellites, perhaps the result of a problem with design or manufacturing.[7] However caused, these events leave satellites in active orbits and they then present long-term dangers to other systems. Weeden has expounded on the problems facing space operators that result:

> Compounding the problem of space debris are satellites that are left in the GEO belt at the end of their service life. According to the recently adopted United Nations Space Debris Mitigation Guidelines, which are based on the more extensive [United Nations Inter-agency Space Debris Coordinating Committee (IADC)] Guidelines, spacecraft operators are supposed to perform an end-of-life disposal maneuver to remove their satellite from the protected GEO region. This usually involves a series of maneuvers to boost it at least 250 kilometers (155 miles) above the active GEO belt.[8]
>
> Unfortunately, the guidelines don't resolve problems associated with spacecraft left in the GEO belt during the early years of the space age, and compliance with these guidelines for new spacecraft is still spotty at best. According to the February 2010 *Classification of Geosynchronous Objects* report, of the 21 GEO spacecraft that reached end-of-life in 2009, only 11 were disposed of properly. Several were moved out of the active belt but not into an orbit high enough to ensure that they do not cause problems in the near future. Three spacecraft, all Russian, appear to have been abandoned in the active belt and are now librating about the 75° East libration point. Four rocket bodies, three Russian and one American, which were used to place payloads in GEO, also orbit within the protected zone.[9]

The space debris problems related by Weeden are not recent phenomena. According to ESA's European Space Operation Center, only 22 of 58 non-functioning satellites in GEO were put into graveyard orbits between 1997 and 2000. Hitchens contends that the key reason for non-compliance with best practices is "costs." Boosting a GEO satellite to higher orbit could cost a company hundreds of millions of dollars in lost revenue by not using the propellant to continue the satellite's orbital station-keeping and mission readiness. "While most debris mitigation measures are not extraordinarily expensive if included during a satellite's design, the small profit margins afforded to space launch firms and the competitive global market mean that achieving compliance with voluntary guideline may be difficult."[10]

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[6] R. Choc and R. Jehn, *Classification of Geosynchronous Objects*, Issue 12, February 2010.

[7] Brian Weeden, "Dealing with Galaxy 15: Zombiesats and on-orbit servicing," *The Space Review*, May 24, 2010, http://www.thespacereview.com/article/1634/1, accessed July 17, 2010.

[8] In 2007, the United Nation's Committee on the Peaceful Uses of Outer Space (UNCOPUOS) adopted its Space Debris Mitigation Guidelines. These were later adopted by the General Assembly. The guidelines call for launching states and satellite operators to:

1) Limit debris released during normal operations including deployment; 2) Minimize potential break-ups during operational phases (by utilizing better failure mode analysis); 3) Limit the probability of accidental collision in orbit by pre-launch prediction models, careful choice of orbits, etc. 4) Avoid intentional destruction and other harmful activities 5) Minimize potential for post-mission break-ups resulting from stored energy 6) Limit the long-term presence of spacecraft and launch vehicle orbital stages in LEO (removal) 7) Limit the long-term interference of spacecraft and launch vehicle orbital stages with in GEO (safe orbits).

According to Dunstan and Werb, the U.S. has actually gone "beyond these guidelines" by requiring that all entities requiring an FCC license for operations or the like provide the FCC with an orbital debris mitigation plan. See 47 C.F.R. § 25.114(d)(14). These regulations include requirements for safe disposal after the satellites end-of-life. Dunstan and Werb, "Legal and Economics...," *supra.*

[9] *Ibid.* According to Peter B. Selding: "In 2008 and 2009 alone, four geostationary orbiting satellites — the U.S. EchoStar 2 and the Russian Gorizont 33, Raduga 1-5, Cosmos 2371 and Cosmos 2379 — were all left to expire on the geostationary arc without performing end-of-mission orbit-raising maneuvers. EchoStar 2 failed suddenly in orbit and could not be moved." Peter B. Selding, "NASA may move orbital debris mitigation off back burner," *Space News*, July 23, 2010, http://www.spacenews.com/civil/100723-nasa-orbital-debris-mitigation.html, accessed July 25, 2010.

[10] Theresa Hitchens, "Space Debris: Next Steps," Presentation to "Safeguarding Space For All: Security and

Most space-faring States have operated under a "big skies" mentality, treating orbital space as so large that the probabilities of any two object's orbits intersecting would be considered quite small. This feckless thinking has been encouraged, in part, by an international legal regime that makes it easier to "fire and forget," than to manage assets in a way that encourages the mitigation of orbital debris and removal of space objects at end of life.[11] As a result, the orbits occupied by space junk are surprisingly concentrated. The most "polluted" orbits are polar or near sun-synchronous orbits. These orbits are vital to remote sensing because of the ability to view the totality of the Earth's surface, but also present particular problems because the spacing of the orbits decrease, even converge, over the poles.[12]

After decades of continuing and expanding numbers of space debris and orbiting systems, space-faring States are now beginning recognize the heightened safety of flight issues that result. We are nearing the point where whole sectors of the space domain are saturated and thus lost to safe and secure satellite and manned spacecraft operations. Experts such as Donald J. Kessler, John Gabbard, and Nicholas L. Johnson have forecast the debris will eventually and continually collide with other debris and active space objects; these collisions will then multiply and create even greater numbers of objects that could damage other spacecraft.[13] This phenomenon has been described for more than 30 years as the "Kessler Syndrome", and alternatively as "collisional cascading."[14]

The January 11, 2007 test of a Chinese ground-based, direct-ascent anti-satellite (ASAT) interceptor against one of their own defunct Feng Yun-1C weather satellites generated additional considerable alarm across the U.S. and international space and related defense communities. There is a growing international consensus that these very real risks and threats must be addressed, deterred, and protected against by a comprehensive global space security strategy. The Chinese ASAT test left over 2,400 trackable and potentially destructive pieces on orbit. In addition, over 870 pieces of debris have been tracked as a result of a collision between two communications satellites on February 10, 2009. The collision involved an operational Iridium 33 of the 66-satellite Iridium constellation and defunct Cosmos 2251. The Cosmos satellite had been launched in 1993 and ceased operations only about two years later.[15]

In both events, thousands of smaller pieces of space debris can't be tracked because of surveillance system limitations. A few pieces have de-orbited thus far, but many will be in orbit for decades. While

Peaceful Use," March 24-25, 2004, Geneva, Switzerland. April 1, 2004, http://www.unidir.org/pdf/articles/pdf-art2378.pdf, citing "Garbage Mountains in Orbit, ESA news release, Paris, March 23, 2001, and Andrew C. Revkin, Highway Patrol: Outer Limits: The final frontier is becoming cluttered with garbage and satellites. Scientists are trying to set some ground rules for controlling pollution and traffic in space, *Edmonton Journal*, 2 March 2003, D9.

[11] Dunstan and Werb, "Legal and Economics...," *supra.*

[12] *Ibid.*

[13] Nicholas L. Johnson, "Orbital Debris: The Growing Threat to Space Operations," *2010 American Astronomical Society Guidance and Control Conference, Breckenridge, CO, Feb. 6-10, 2010,* AAS-10-011.

[14] According to Donald J. Kessler, former NASA engineer, the term "Kessler Syndrome" originated in 1978 with a colleague, John Gabbard, a NORAD analyst. Donald J. Kessler, "The Kessler Syndrome," March 8, 2009. See also Donald J. Kessler and Burton G. Cour-Palais, "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt," Paper 8A0210, *Journal of Geophysical Research,* Vol. 83, No. A6 (1 Jun 1978): 2637; Donald J. Kessler, "Collisional Cascading: The limits of population growth in low earth orbit," *Advances in Science Research*, Volume 11, Issue 12 (1991): 63-66.

[15] Lieutenant General Larry James, Commander, Joint Functional Component Command for Space, "Keeping the Space Environment Safe for Civil and Commercial Users," Statement before the Subcommittee on Space and Aeronautics, House Committee on Science and Technology, April 28, 2009. CelesTrak reports different and smaller numbers. It reports the 382 pieces of debris associated with the Iridium 33 and 893 with the Cosmos 2251. "Iridium 33/Cosmos 2251 Collision," Celestrak.com/events/collision.asp, updated July 15, 2009, and accessed July 23, 2010.

the debris will slowly decay due to natural forces, they will remain a hazard to manned and unmanned spaceflight in low Earth orbit, and to satellites transiting that region for many decades to come.[16]

These two events have demonstrated that the greatest risk of increasing space debris occurs in a "large/large" collision. Given the size and cross section of larger objects, the probability is higher that these "targets" will be hit, resulting in significant potential "cascade effect" debris proliferation. Nicholas Johnson has shown that the removal of just a few large objects can slow, and begin to reverse, the near exponential increase in space debris that the world now faces. Any space debris removal program therefore should focus first on identifying and removing the large objects that travel in the most congested orbits.[17]

The problem will not go away. The European Space Agency (ESA) in a few years will be the "owner," but non-operator, of what is possibly is the most dangerous piece of space debris circling the Earth: the 8,000-kilogram Envisat Earth observation satellite. Launched in 2002, Envisat, is the biggest nonmilitary Earth observation satellite ever built. At $2.9 billion in today's dollars, it is arguably also one of the most expensive. Its mission is viewed as a success and has exceeded the original five-year mission by an addition six years, extended to 11 years, with retirement scheduled in 2013. Envisat will become a huge problem that will not go away for about 150 years in a near-polar orbit at 782.4 kilometers in altitude. That is how long it will take for Envisat, given its orbit and its area-to-mass ratio, to deorbit into the Earth's atmosphere.[18]

Envisat's 8,000-kilogram mass puts it onto the top tier of space debris threats. "But Envisat's configuration in orbit makes it a unique concern, even beyond its weight. The satellite's in-orbit size is 26 meters by 10 meters by five meters. Its suite of observing instruments uses a small farm of antennas that likely have become more fragile after a decade in orbit. That means that even a small piece of debris — pieces too small to be cataloged by the Space Surveillance Network — could cause what debris specialists refer to as a 'fragmentation event' that would produce its own population of space garbage."[19]

How could this happen? In retrospect the Envisat design and end-of-life mission solution chosen appear to be stunningly irresponsible, especially since the problem of space debris has been understood for many decades. According de Selding's reporting:

> Envisat program managers say that for many reasons, including industrial policy and overall program costs, Envisat was built with a fuel tank used by the French Spot 4 optical Earth observation satellite, whose launch weight was less than half of Envisat's.
>
> With such a small fuel tank, any attempt to bring the satellite's orbit down to where it could re-enter the atmosphere would have meant retiring Envisat just a few months after its launch.
>
> ESA officials insist that the international guidelines on disposal of debris were not in force when Envisat was designed.[20]

In sum, the problem the space-faring global community faces is complex and serious. The dangers posed by the space debris to operational unmanned and manned spacecraft are growing. Because of the immediate threat to human life, the challenges for manned spaceflight are particularly troublesome. The Space Shuttle has had to maneuver to avoid collisions with other objects on several occasions. The International Space Station is moved at least four times a year to avoid debris collisions.[21]

[16] *Ibid.*

[17] Dunstan and Werb, "Legal and Economics...," *supra.*

[18] Peter B. de Selding, "Envisat to Pose Big Orbital Debris Threat for 150 Years, Experts Say," *Space News*, July 23, 2010, http://www.spacenews.com/civil/100723-envisat-orbital-debris-threat.html

[19] *Ibid.* There are "nearly a dozen spent Russian rocket upper stages that weigh as much as or more than Envisat.

[20] *Ibid.*

[21] Orbital Debris Threatens Future Space Journeys, *China Daily,* 26 November 2003, at

### *Space Tugs to the rescue?*

Since the amount of space debris and numbers of satellites are on the increase, effective and reasonable mitigation measures are indispensable for future space development activities. Space debris left in orbit poses serious collision risks. And collisions generate huge number of smaller bits of debris, degrading the near-Earth space environment. Unless the space faring community begins to remove large debris from orbit, the inevitable collisions involving objects like eight-ton rocket bodies and five-ton dead satellites will create tens of thousands of new pieces, resulting in the Kessler *debris runaway* that would make LEO unusable for hundreds of years.[22]

"To avoid this unpleasant scenario, the active removal of large space debris, that is, defunct or malfunctioning satellites and rockets, is one of the most proactive strategies. However, this requires an active maneuvering vehicle that can rendezvous with and grapple an inert, tumbling, and non-cooperative target, and then transfer it to a disposal orbit."[23]

These operations will require highly sophisticated technologies, and they are receiving some extensive study. Numerous ideas to remove from orbit large satellites that one day could break up and add to the population of space debris have been floated over the past 20 years.[24] According to United Kingdom's Parliamentary Office of Science and Technology:

> Experts agree that to stabilise the amount of debris in the long-term will require existing objects to be removed from orbit. Removing even three or four large objects from orbit each year would vastly reduce the amount of debris generated. Several techniques have been proposed for removal of debris, also known as "remediation":[citation omitted]
>
> • attaching a propulsion device to a debris object to push it out of orbit;
>
> • using a robotic grappling device on another spacecraft to tug an object to a new orbit or to cause it to re-enter the atmosphere destructively;
>
> • using a momentum exchange tether, which acts like a swing, to pull an object out of orbit;
>
> • using an electrodynamic tether, which causes a drag on the satellite due to the magnetic field of the Earth;
>
> • slowing objects using high-powered lasers fired from Earth, so that they move out of orbit.
>
> Such methods would be expensive and technically difficult. The main problem with accessing existing pieces of debris is the fuel expenditure needed to reach more than one piece of debris per launch. Using lasers works only for small objects and they are difficult to point accurately.[25]

Dinerman argues, ultimately, what is required is a new type of space maneuver vehicle. It needs to be one that can rendezvous with, catch, and store a bit of debris, and then proceed to the next one. He suggests that such a vehicle would not need to move very fast: the process could be a "leisurely one," and thus would allow for the use of a highly efficient space propulsion system such as a pulse plasma thruster or ion engine. Each move could also be carefully planned and operations could be carried out according to a plan that would deal with the most dangerous pieces of debris first.[26] According to Kawamoto, Nishida, and Kibe, the servicing satellite must be able to repeat this process a number of times in order to deal with multiple items of space debris. Investigations by their research group have shown that the removal of at most 100 "bits of debris" from

<www.1.chinadaily.com.cn/en/doc/2003-11/26/content_284869.htm>.

[22] Jerome Pearson, "The ElectroDynamic Debris Eliminator (EDDE): Removing Debris in Space, *The Bent of Tau Beta Pi*, Spring 2010, p.17, citing Nicholas Johnson.

[23] Satomi Kawamoto, Shin'ichiro Nishida and Seishiro Kibe, "Research on a Space Debris Removal System," *JAXA*, p. 84, "http://airex.tksc.jaxa.jp/dr/prc/japan/contents/NALRP2003032/nalrp2003032.pdf.

[24] Peter B. de Selding, "Canada's MDA Sees Business Case for In-orbit Satellite Servicing," *Space News*, May 6, 2010.

[25] "Postnote:Space Debris," *Parliamentary Office of Science and Technology*, March 2010, Number 355, p.4, citing H. Klinkrad and N.L. Johnson, "Space Debris Environment Remediation Concepts," *Fifth European Conference on Space Debris*, 2009.

[26] Taylor Dinerman, "Unilateral orbital cleanup," *The Space Review*, May 4, 2009, http://www.thespacereview.com/article/1365/1.

densely-populated regions (orbits of about 800-1,400 kilometer altitude) would reduce the total collision risk significantly.[27]

"Satellite operators have said they are unsure whether it is worthwhile to spend money to refuel an orbital asset depreciated over 15 years, especially since some satellite components unrelated to the fuel supply are more likely to fail after so much time in orbit."[28] To date, nobody has been willing to commercially invest in on-orbit servicing satellites or in systems that clear crowded orbital corridors of non-functioning satellites that pose a danger of adding to the population of space debris. That might be changing, however. It has been announced that Bremen, Germany-based OHB Technology will serve as system prime contractor for a German government program to demonstrate in-orbit servicing and de-orbiting of satellites and other hardware. The German space agency, DLR, has awarded contracts for five components of its DEOS system, an acronym for German Orbital Servicing Mission. The demonstration and hardware are expected to cost up to 200 million Euros ($272 million) once the decision is made to build a flight demonstrator. The planned DEOS demonstration mission would launch two satellites into low Earth orbit. They would then separate, after which the clearing spacecraft would close on the target satellite, capture it and guide it into a destructive re-entry into the Earth's atmosphere.[29]

[27] Kawamoto, Nishida and Kibe, "Research on a Space Debris...," *supra*. They contend that that their studies show that the removal of at most 100 bits of debris from densely-populated regions (orbits of about 800-1,400 km alt.) would reduce the total collision risk significantly.

[28] Peter B. de Selding, "MDA May Scrap In-orbit Satellite Servicing Plan," *Space News*, July 30, 2010.

[29] Peter B. de Selding, "DLR Takes Step Toward In-orbit Servicing Demonstration," *Space News*, February 24, 2010, http://www.spacenews.com/civil/022410-dlr-takes-step-toward-in-orbit-servicing-demo.html. See also "OHB awarded contract for overall systems management for the definition phase of the DEOS German robotics mission," *UHB Technology Press Release*, February 24, 2010.

### *The legal and diplomatic issues are daunting*

The need to remove space debris exists; space objects such as the Envisat-class satellites and other large spent rocket bodies pose a great danger and some orbits are much more "polluted" than others. Technologies to effect removal are being examined and developed. These efforts depend in large part on launching States agreeing to removal of the satellite or object from space. Unfortunately, States may fail or refuse to cooperate with or even reject efforts to remove their threatening objects from space. This creates a number of legal problems which can exacerbate efforts to comprehensively craft means to solve the debris problem.[30]

Provisions of existing treaties have been overtaken by technology advancement and the rapidly growing and dangerous space debris problems. Existing space law only addresses the use of space and not debris regulation and mitigation.[31] This interpretation of space treaties and associated international law has served as a barrier to resolving the orbital debris problems and led space operators to often ignore them. Other complex political and diplomatic realities must be recognized and taken into account when developing the necessary international and municipal law to respond.

[30] This paper will not address the national security implications of removal activities, as some states may with good reason strenuously object to and oppose by other means activities aimed to remove military and intelligence systems from orbit. The paper will also assume that the state attempting to remove and control a hazardous space object would undertake the liability for damages caused by the maneuver or return of the object into the space atmosphere, and indemnify the original launching state for damages that may result, even if the object or satellite left on orbit could have caused damage without the removal action. Otherwise, as noted later in the paper, the *1972 Liability Convention* makes launching states strictly liable for any damage caused on the Earth from a launch or reentry of a manmade object. It also provides for liability arising out of an on-orbit collision based on a fault analysis.

[31] Thierry Sénéchal, "Space Debris Pollution: A Convention Proposal," http://www.pon.org/downloads/ien16.2.Senechal.pdf., p. 53.

Treaties now pose the potential to hobble responses to the threat where the launching State objects to removal efforts. For example, under Article VIII of the *Outer Space Treaty of 1967*[32], space-faring States registering space objects retain the right to exercise *jurisdiction and control* of its satellites and other space objects assets once launched.[33] If strictly interpreted, a launching State can exercise that *jurisdiction and control*, even after the systems are defunct and long abandoned, and even if they threaten a particular orbital regime or another satellite with debris.[34] Thus, under this analysis, only the State of registry would appear to possess the legal right to remove a piece of space debris or defunct satellite, if Article VIII is strictly interpreted. Any entity attempting to remove space junk could run into a claim from a registering State that the removal is a violation of international law.[35]

Beyond the *Outer Space Treaty*, no treaty clearly confirms or establishes a duty to dispose of space junk or to remove threatening or dangerous objects. The *1972 Liability Convention* makes launching States strictly liable for any damage caused on the Earth from a launch or reentry of a manmade object.[36] It also provides for liability arising out of an on-orbit collision based on a fault analysis.[37] The *1976 Registration Convention*[38] merely requires launching States register space objects with the U.N., and provides no penalty for not registering.

Some suggest that the space-related treaties described above encourage space operators to treat orbital debris generation as a marginal issue. While it is true that some space-faring States have taken steps to mitigate the creation of orbital debris, none have taken significant steps toward active debris or derelict satellite removal. No treaty provides that one nation or group is responsible for cleaning space. There is no requirement that launching States capture debris and dead satellites and then de-orbit them or boost them to safer orbits. There is no international legal requirement to do so.

In any event, the technologies and resources needed to achieve the feat have just begun to be developed and deployed. In the meantime, satellite system operators have been left to work under some impression of international law that suggests that if a State just leaves a satellite in its orbit at the end of its life, the State is not at fault for anything that

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[32] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (Outer Space Treaty). The treaty has been signed by all space-faring nations, the space domain is open to every state seeking to engage in satellite launches, even rogue states such as the Democratic Peoples Republic of Korea (North Korea).

[33] *Ibid.*, Article VIII. Article VIII provides in pertinent part that a state party to the treaty "on whose registry an object ... is carried shall retain *jurisdiction and control* over such object... while in outer space or on a celestial body...Ownership of objects...is not affected by their presence in outer space or on a celestial body or by their return to the Earth." (emphasis added)

[34] As of 1989, jurisdiction and control of a State over its space objects was considered "permanent." Howard A. Baker, *Space Debris: Legal and Policy Implication*, Martinus Nijhoff Publishers: Dordrecht, The Netherlands (1989) p. 69.

[35] Ibid. "Ownership of space objects is also permanent, as Article VIII implies that the State of registration may not be divested of title to its space objects, (cit.om.) regardless of the use or condition of the space object. (cit.om.) Moreover, the rights of ownership include the rights of possession, use and disposal, thereby denying a right of encroachment without the consent of the State of registration.(cit.om.)"

[36] *Convention on International Liability for Damage Caused by Space Objects (1972)*, Article II: "A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight.

[37] *Ibid.*, Article III: "In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible." Article VII of the *Outer Space Treaty* also addresses the notion of direct damage. It says that each "State Party to the Treaty that launches or procures the launching of an object into outer space, including the moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the moon and other celestial bodies."

[38] *Convention on Registration of Objects Launched into Outer Space (1976).*

subsequently happens. One can point to the fact no claims for compensation have been asserted as a consequence of the Cosmos 2251 and Iridium 33 collision. Thus, collisions that occur long after a satellite's end of life and abandonment are treated as though they are the sort of event outside of human control for which no one can be held responsible, as an intervening cause or "Act of God." Launching States or States of registry are thus afforded some defense to liability arising out of a collision, regardless to the requirements of the *Liability Convention*.

Furthermore, space treaties that have been ratified by the major space-faring States were products of an early multilateral approach to outer space. This construct was well suited to a Cold War context that bounded and framed the initial attempts to set out the initial rules for space activities. However, the rules develop decades ago have proven too rigid to accommodate the more complex set of civil, national security, and commercial space activities that have emerged nearly forty to fifty years hence.[39]

The present multilateral regime does not set up a construct to effectively attack and directly reduce threats posed by space objects. The regime has, to some extent, inhibited the development of solutions to the problem. As a consequence, continuing space launches will continue to create even more debris leading to a space domain that is rapidly becoming more and more dangerous and deteriorating from overuse.

[39] The *Outer Space Treaty* was consummated at a time when United States (U.S.) policy makers concluded space offered breathtakingly-unique benefits for the military and political dimensions of the Cold War national security strategy. These policy makers hoped to fashion an agreement to preserve access to the domain and these motivations and the document have endured and continue to serve the U.S. and its allies' national interests. Assuming the mantel of the world's leading space-faring nation, the U.S. helped lead the way on discussions relating to the treaty's formation, crafting the treaty instruments and forging a global consensus to set a tone and worldview that space activities should be prosecuted for peace and the benefit of mankind.

Absent consent by a space-faring State to removal of its hazardous space object(s), or clarification of the Article VIII treaty rights of a State to interfere with jurisdiction and control and ownership, alternative formulations must be explored to rationalize a lawful mechanism to reduce the threat. As noted by Baker: "These issues must be resolved to avoid international friction (cit.om.) or the possibility of international incidents triggered by unauthorized removal (cit.om.), especially where preventative measures by removal are not perceived to be in the common interests of all nations.(cit.om.)"[40]

### *Non-cooperative removal is lawful if initiated upon direction of the United Nations Security Council in accord with the provisions of the United Nations Charter.*

As a first approach, disputes relating to an attempt to remove a space hazard without consent could be submitted through current international dispute mechanisms. International law applies; Article III of the *Outer Space Treaty* provides that parties to the treaty shall carry on activities "in accordance with international law, including the Charter of the United Nations . . . ."[41] This makes international law "...a vital part of the *corpus juris spatialis*."[42] This incorporation of international law, not just the United Nations (UN) Charter, is important and guiding. Article 33 of the Charter requires that parties first "seek a solution by negotiation, enquiry, mediation, conciliation, arbitration, judicial settlement, resort to regional agencies or arrangements, or other peaceful means of their own choice."[43] In the event Article 33 efforts fail to achieve a resolution of the issue, Article 36(3) provides that "legal disputes should as a

[40] Baker, *Space Debris*, *supra*, p. 71.

[41] *Outer Space Treaty*, Article III. See Thierry Sénéchal, "Space Debris Pollution...," *supra*.

[42] P.J. Blount, "Limits on Space Weapons: Incorporating the Law of War into the *Corpus Juris Spatialis*," IAC-08-E8.3.5, Presented to the International Institute of Space Law Colloquium, at the International Astronautics Congress, Glasgow, UK, October 2008, p.1.

[43] *Charter of the United Nations Charter*, Article 33.

general rule be referred by the parties to the International Court of Justice ..."[44] If the dispute cannot be resolved and the dispute endangers the maintenance of international peace and security, then Article 37 requires the parties to refer the matter to the UN Security Council.[45] The Security Council may agree and direct, or at least allow, the requesting State to effecting the removal, without the consent of the registering space-faring State.

### *Non-cooperative removal is lawful if the hazardous derelict satellite or space object has been "abandoned" by the launching State.*

As a second approach, some think that a maritime and admiralty law analogy should be pursued to achieve a solution. As noted by Baker, in maritime law, "abandonment" arises where no personnel remain on board a vessel and there is no intent to return and reactivate it. Such an object would thus be considered a "derelict" and subject to salvage. In space law, a "derelict space object" would be

> one which is abandoned and deserted by those who were in charge of it, without hope on their part of recovering it and without intention of returning to it. Thus, manned spacecraft, abandoned by the crew without intention of returning to or recovering it, would be derelict. Unmanned satellites and other objects with an 'active lifespan' would be considered derelict when this active lifespan is terminated, that is, in a permanent inactive state...[46]

The test for this "permanent inactive state" could involve ascertaining whether or not the space-faring State can exert "effective physical control" of the space object.[47] If it could not, the satellite would be considered abandoned.

As noted by Dunstan and Werb, the maritime *Law of Finds* and the *Law of Salvage* go back at least 500 years, and allow for the recovery and ownership of abandoned property found on the seas (*Law of Finds*), or for the recovery and right of possession of ships and cargo in peril (*Law of Salvage*).[48] Whether an analogous Space *Law of Finds* or the *Law of Salvage* for space debris applies would turns on a determination on whether a space object has been "abandoned." A space-faring nation seeking to clean space should take the position that orbital debris and derelict (dead or defunct) satellites constitute abandoned property, and thus are "fair game" for removal or in-orbit recycling.

### *Non-cooperative removal is lawful if the hazardous derelict satellite or space object poses a hazard to space navigation by other launching States.*

As a third approach, Baker suggests that "consent of the State of registration may be unnecessary if (1) the possibility exists that persons or property of innocent third-party States may be injured, lost or damaged; (2) the hazard threatens the safety of spaceflight; or harm to Earth."[49] These arguments provide the basis for a strong exception to the absolute jurisdiction and control and ownership of the State of registration.

Article IX of the Outer Space Treaty provides, in pertinent part:

> In the exploration and use of outer space...States Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the

[44] *Ibid.*, Article 36(3). See also the *Statute of the International Court of Justice.*

[45] *Ibid.*, Article 37.

[46] Baker, *Space Debris*, *supra*, p. 70, citing D.M. Wanland, "Hazards to Navigation in Outer Space: Legal Remedies and Salvage Law," at 30.

[47] R.C. Hall, "Comments on Salvage and Removal of Man-Made Objects from Outer Space," 9 *Colloquium Law of Outer Space* 177 (1966) at 119.

[48] Dunstan and Werb, "Legal and Economics...," *supra.*

[49] Baker, *Space Debris*, *supra*, p. 70.

corresponding interests of all other States Parties to the Treaty.[50]

Given the threat posed by the growing space debris problems to continued manned and unmanned spaceflight by the globe's space-faring States, the obligations to co-operate, provide mutual assistance and have due regard for the corresponding interests of other States should limit the perceived absolute nature of the provisions of Article VIII. Accordingly, a feckless or willful failure to remove a hazardous space object or consent to such removal should be considered contrary to the corresponding interests of other space nations.

The *Outer Space Treaty* provides for competing interests, and some might think it may be arguably in the freedom interests of launching States to leave inactive satellites in orbit if it were too expensive to remove them. Given the growing threat this freedom should not easily prevail against the rights of space-faring nations to safe navigation.

It is in all space-faring nations' interests to have outer space free from navigational hazards.[51]

### *Non-cooperative removal of the hazardous derelict satellite or space object is lawful if the removing space-faring State attempts to undertake international consultation with launching State pursuant to the provisions of the Outer Space Treaty, Article IX.*

As a fourth approach, removing the hazardous space object or derelict satellite to protect the interests of the space-faring nations of globe would be entirely consistent with the *Lotus Principle,* or *Lotus Approach. Lotus* provides that sovereign States may act in any way they wish so long as said acts do not contravene an *explicit* prohibition.[52] Indeed, the Outer Space Treaty does not completely prohibit activities in space that may adversely affect the interests of others. Article IX provides, in pertinent part:

> If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space... would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space... it shall undertake appropriate international consultations before proceeding with any such activity or experiment.[53]

Applying Article IX, a party seeking to perform a removal maneuver merely needs to attempt to undertake appropriate international consultation before proceeding. The removal would appear to be permitted as long as the Article IX provisions are followed in good faith, especially given the greater good effected for the space-faring community, and notwithstanding the provisions of Article VIII which provide a launching State may exercise *jurisdiction and control* of the object or defunct satellite. Since there is some ambiguity, the *Lotus Principle* would apply.

### *Concluding Thoughts*

Unrestrained growth in the amount of space debris is leading to alarming safety of flight concerns for the global space community. These threats must be addressed, and space removal technologies have begun to mature to the point where removal actions can be considered because they are technically and financially feasible. These technologies can be used to clear increasingly crowded orbital corridors, especially derelict satellites located in low Earth or geosynchronous orbits that are no longer functioning but pose a frightening danger of adding to the population of in-orbit debris via destructive collision with other objects.

According to Article VIII of the *Outer Space Treaty*, a State retains *jurisdiction and control* over

[50] *Outer Space Treaty,* Article IX.

[51] Baker, *Space Debris, supra,* p. 71.

[52] The *Lotus Principle* is considered one foundation of international law. See *The Case of the S.S. "Lotus,"* PCIJ, Ser. A., No. 10, 1927. http://www.worldcourts.com/pcij/eng/decisions/1927.09.07_lotus/

[53] *Outer Space Treaty,* Article IX.

its space objects. Unless this right is relinquished, some argue that peacetime retrieval, alteration of orbit, or any other form of interference with foreign space objects would be unlawful without prior consent, no matter how desirable the end result. In circumstances where feckless and irresponsible States refuse to avail themselves of the opportunities to move satellites that pose dangers to other operational space systems, this paper has presented four approaches that can be employed to support removal of the object in accord with international law and protect the interests of the global space-faring community.

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