A. International Space Body

One possible proposition is the formation of an 'International Space Body' (ISB), which should be a separate, independent legal entity which functions as a part of the United Nations and is accorded the status of a specialized agency. under the garb of the United Nations. Just like the General Assembly, all the nations must be its members. These members must in turn elect a panel of experts and must lay down the powers and functions of the panel. The panel must then formulate rules and regulations applicable to whole range of activities that exploitation of celestial bodies would consist of. The panel will decide which asteroid must be mined out of several viable options, with their decision based on several factors such as the risk involved, demand in the market, possible adverse effects on the market or individual consumers etc. The ISB must also formulate a way of issuing licenses for mining of asteroids. It must also consider any liability arising for any damage caused to a third party or the space environment as a result of any activity related to asteroid mining. The panel must also create a dispute settlement mechanism. Their aim must be the benefit of people at large. Only once the panel adopts the above-mentioned rules should it start the process of allocating asteroids.

Private companies and Government bodies should be encouraged to apply via tenders based on their plan, financial strength and resources and a license may then be granted to the most capable enterprise or government agency. The ISB must also establish conditions and terms according to which exploitation must be carried out, the duration, the location, the right of licensee, third parties rights, etc. The rights of the licensee to obtain property rights over the extracted minerals must be laid down.[42] The ISB must also have the power to revoke the license and impose fines in cases of non-compliance of the terms and conditions by the licensee. In return the licensee must have undisturbed access of the select asteroid mentioned in the license for the purpose and time period specified.

The body must be given the power to have a final say on the execution of the mining process. The ISB must determine the prices

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[42] *Id.* at 245.

of mined products in a way that enables companies to make profits, but not supernatural profits.

Funding of an asteroid mining project could be done in two major ways-either the official, elected government of member States or private companies could finance it. Two or more private companies/ governments may collaborate to make a bid. The most popular way to raise money seems to be crowd funding. The only asteroid mining companies today-Planetary Resources and Deep Space Industries, which are still in a nascent stage, have not yet revealed their funding plans. Space Tourism could emerge as a possible source of revenue for asteroid mining. Companies like Virgin Galactic where over 700 tickets valued at over $250,000 have been sold for space tourism can definitely enter the asteroid mining race[43]. In addition, in this decade alone, a private citizen has paid $20 million dollars to travel to space, while eight other citizens have also undertaken the same journey, with many more to certainly follow.[44].[45] Space Adventures suggests that this number could increase fifteen-fold by 2020[46]. Even companies like Blue Origin, Boeing, Space X and Sierra Nevada Corporation are in the fray to start their own space tourism expeditions. The Russian Space agency also has plans to take space tourists to the International Space Station from 2018[47]. This only goes to show that Space Tourism is a goldmine waiting to be utilized.

Appointment of Experts: The following factors must be considered while appointing experts to the panel:[48]

- Panels shall be composed of well-qualified governmental and/or non-governmental individuals, including persons

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[43] Virgin Galactic.com, *Why We Go: Exploring Space Makes Life Better on Earth,* http://www.virgingalactic.com/why-we-go/, (last visited July 27, 2016).

[44] Pete Spotts, *A Space Tourism Trip to the Moon? It Could Happen by 2015,* The Christian Science Monitor, May 6, 2011, http://www.csmonitor.com/USA/2011/0506/A-space-tourism-trip-to-the-moon-It-could-happen-by-2015.

[45] The BBC, *Profile: Tito the Spaceman,* http://news.bbc.co.uk/2/hi/science/nature/1297924.stm, (last visited July 16, 2016).

[46] Spotts, *supra* note 44.

[47] TASS-Russian News Agency, *Russian Space Agency to Resume Regular Tourist Flights to ISS as of 2018*, http://tass.ru/en/russia/784497, (last visited July 27, 2016).

[48] World Trade Organization, *Understanding on Rules and Procedures Governing the Settlement of Disputes- Uruguay Round Agreement-Article 8*, https://www.wto.org/english/docs_e/legal_e/28-dsu_e.htm, (last visited July 27, 2016).

who have served on or presented a case to a panel, served as a representative of a Member or of a contracting party to the International Space Body. Member countries may make their recommendations for the constitution of the panel.

- Panel members should be selected with a view to ensuring the independence of the members, a sufficiently diverse background and a wide spectrum of experience.
- Citizens or representatives of those countries, whose asteroid mining rights and interests are to be decided by the panel, will not serve as members for that particular decision to ensure independence and fairness.
- Panelists shall serve in their individual capacities and not as government representatives, nor as representatives of any organization. Members shall therefore not give them instructions nor seek to influence them as individuals with regard to matters before a panel.
- Panelists must have representation from different professional backgrounds. For example, Economists, Space Scientists, Lawyers, NGO's, etc.

B. Dispute Settlement

1. Appeal To The International Court of Justice (ICJ)

As stated above, the decision of the panel of experts with regard to any proposed asteroid mining expedition is to be final and binding on all parties concerned. However, in the interests of justice and fair play, contingencies have to be made which would allow an appeal to a duly authorized international adjudicatory body like the International Court of Justice. Taking inspiration from the Arbitration & Conciliation Act, 1996[49] an appeal can be preferred by any of the parties on the following grounds:

i If the party furnishes proof that any expert on the panel has acted under some incapacity, or in a biased or prejudiced manner;

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[49] Indian Arbitration & Conciliation Act Ch.VII §34 (1996).

ii If the decision of the panel is not valid or in in conflict with international law, or the law to which the parties are subject;

iii The decision of the panel is based on grounds which were not part of the original proposal made to it, or if it contains decisions on matters which prima facie fall outside its authority;

iv The composition of the panel or appointment of experts was not in accordance with the procedure laid down and agreed to by all member countries;

v Any other ground on which the ICJ is of the opinion that an appeal should be allowed based on the facts and circumstances of the case, in light of the principles of justice, equity and good conscience.

2. The Concept Of A Multi-Door Courthouse

Though parties would be advised and would rightly so stick to a proven dispute resolution mechanism like the ICJ, it is worth mentioning the novel idea of the Multi-Door Courthouse that may be the future of dispute resolution in all forms, and not only for asteroid mining.

A multi-door courthouse is a means of directing cases filed in court to various "dispute resolution doors" or options.[50] Parties are referred to different dispute resolution options in an effort to select that option which best suit the needs of their particular dispute. The dispute resolution options include mediation, arbitration, conciliation, case evaluation and finally adjudication. In the multi-door courthouse system, trained intake workers inform the parties of the various alternative dispute resolution programs available and direct the parties towards the most appropriate process or series of processes based on factors such as the relationship of the parties, the nature of the dispute, the amount at stake, and the type of relief sought. The goal of the multi-door courthouse is to streamline the court process and afford parties various options to resolve their dis-

[50] GERARDINE MEISHAN GOH, DISPUTE SETTLEMENT IN INTERNATIONAL SPACE LAW: A MULTI-DOOR COURTHOUSE FOR OUTER SPACE, Studies in Space Law, 270, 297 (Martinus Nijhoff Publishers, 2007).

putes beyond the standard option of litigation. Multi-door courthouse programs have been in place in several states for many years and have proven an effective means of channeling cases to alternate options for dispute resolution to meet the specific needs of a case.

With respect to asteroid mining, this process can be used, where instead of referring a dispute to the ICJ directly, alternatively a dispute can be sent to a multi-door courthouse which would have to be set up under the International Space Body with the agreement of all members. The courthouse would then decide which process would best suit the issue at hand.

3. Asteroid Mining Legislation: The United States Commercial Space Law Competitiveness Act (2015)

While establishing a legal framework fit to deal with asteroid mining activities is of paramount importance, and is what has been proposed in this paper, it is pertinent to take on record that the United States through the U.S. Commercial Space Law Competitiveness Act[51] which was signed by President Obama in 2015, has become one of the first nations to take a step in this direction by enacting a law that encourages the commercial exploitation of asteroid resources, and also recognizes the right of a U.S. citizen to own the resources so obtained[52]. It also rakes a significant step forward by actually defining the terms 'asteroid resource' and 'space resource' The progressive legislation becomes a hugely important step towards advancing space exploration and by doing so the U.S has become the first nation to enact a law that deals exclusively with Asteroid Mining.

VI. CONCLUSION

The law can only be effective when it learns from the past, works on the present, and keeps one eye on the future. To ensure the scales of justice are always balanced, the law must always be

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[51] U.S. Space Launch Commercial Competitiveness Act, Pub. L. 114-90, § 51302, 129 Stat. 704 (2015).
https://www.congress.gov/bill/114th-congress/house-bill/2262.

[52] Planetary Resources-The Asteroid Mining Company, *President Obama Signs Bill Recognizing Asteroid Resource Property Rights in Law*
http://www.planetaryresources.com/2015/11/president-obama-signs-bill-recognizing-asteroid-resource-property-rights-into-law/, (last visited July, 16, 2016).

rigid enough to enable enforcement, but flexible enough too to meet the needs of changing times. Truth be told, times today are changing faster than they were ever before. Asteroid mining, as we have explained, is not only set to become a reality very soon, but will change the global economy and guarantee large steps in scientific progress unlike anything ever seen before. Even if all we provided is glance on how mining will take place in the future, the possible legal implications and the need for an international regulatory body, we hope to have taken a step in the right direction. If an idea can be judged by its potential for change, the world as a whole is sitting on one major breakthrough. As the late Neil Armstrong said when we took our first small steps into the moon in 1969-"That's one small step for man, one giant leap for mankind", he too would be proud to see how far we have come if we mine that asteroid.

REGULATING THE VOID: IN-ORBIT COLLISIONS AND SPACE DEBRIS

Timothy G. Nelson[*]

Space flight has been a reality for barely fifty years, and yet there have already been several notable incidents involving de-orbiting spacecraft. In 1978, the Soviet satellite *Kosmos 954* crashed in northern Canada, scattering nuclear material across parts of the Arctic and requiring an extensive cleanup operation.[1] In 1979, the U.S. space station *Skylab* satellite landed in rural Western Australia, without causing significant damage.[2]

Many collisions occur within space itself. A recent example was the January 2009 collision, in Low Earth Orbit (LEO) above Siberia, of the "defunct" Russian satellite *Kosmos 2251* with *Iridium 33*, a privately-owned U.S. satellite.[3] The crash occurred at a relative velocity of 10 km/second, destroyed both satellites, and reportedly created a very large field of new debris.[4] As discussed below, there remains significant scope for debate over who if, anyone, is liable for in-orbit collisions from "space debris."

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[*] B.A. L.L.B. (UNSW 1990), B.C.L. (Oxon. 1997). Mr. Nelson is a Partner in the International Litigation and Arbitration practice group of Skadden, Arps, Slate, Meagher & Flom LLP. The views expressed herein are solely those of the author and are not those of his firm or the firm's clients. This paper reflects comments delivered at the ABILA/ASIL International Law Weekend on October 27, 2012. The author thanks his fellow panelists Henry Hertzfeld and Amber Charlesworth for their comments and insights during that session.

[1] *See* Alexander F. Cohen, *Cosmos 954 and the International Law of Satellite Accidents,* 10 YALE J. INT'L L. 78, 79-80 (1984-85). *See also* Protocol on Settlement of Canada's Claim for Damages Caused by "Cosmos 954," Apr. 2, 1981, Can.-U.S.S.R., 20 I.L.M. 689 (1981).

[2] *See Skylab's Spectacular Death*, TIME, July 23, 1979, at 35.

[3] *See* Henry Hertzfeld & Ben Basely-Walker. *A Legal Note on Space Accidents*, 2010 ZEITSCHRIFT FUR LUFT UND WELTAUMERECHT (ZLW) 230, 232 (2010).

[4] *See id.*; *see also* Jared B. Taylor, *Tragedy of the Space Commons: A Market Mechanism Solution to the Space Debris Problem*, 50 COLUM J. TRANSN'L L. 253, 261 (2011)

Fascinating though it may be to the disinterested legal observer, a legal "debate" is not necessarily good news for industry participants. In a capital-intensive industry where the entry costs are high (literally so), and where long-term investment is key, any form of uncertainty can prove problematic. Likewise, from a government standpoint, uncertainty over the legal implications of orbital debris is worrying: orbital space represents a shared environment in which numerous governmental actors participate – and thus have a vested interest in cooperating together and avoiding collisions, both literal and figurative. Finally, from an environmental standpoint, the world community has an interest in minimizing the impact of orbital debris. One does not need to be a wholesale subscriber to the "cascade effect" theory of infinite, domino-like orbital collisions and destruction arising from a single crash (as featured in the movie *Gravity*) to believe that floating space junk should be minimized. All of these factors mean that the international legal community, and the community of space users, have an interest in improving the current system of space debris regulation. This article does not attempt to propose a comprehensive solution; it does, however, attempt to frame and define the current situation, including the gaps in regulation, in the hope that future policymakers may fill them.

I. THE PHENOMENON OF SPACE DEBRIS

Space debris, or space junk, is a shorthand reference for any man-made objects lingering in space, as a (sometimes inevitable) byproduct of space activities. Science fiction writers sometimes liken space flight to seafaring; however, the analogy is flawed: ships wrecked on the high seas typically sink, with no long-term impact on other surface traffic.[5] Air-flight is likewise a false analogy. Debris from aircraft does not linger in the atmosphere; it falls to

(noting the *Kosmos 2251/Iridium* crash reportedly created "402 pieces of new orbital debris").

[5] *See* Brian Beck, *The Next, Small Step for Mankind: Fixing the Inadequacies of the International Space Law Treaty Regime to Accommodate the Modern Space Flight Industry*, 19 ALB. L.J. SCI. & TECH. 1, 9 (2009).

earth.[6] In space, by contrast, as a simple matter of Newtonian physics, particles in a weightless environment will continue on their current trajectories indefinitely unless or until they collide with other particles, just as the defunct *Kosmos 2251* satellite collided with *Iridium 33*. Moreover, due to the kinetic force of high-velocity objects, even a tiny particle can cause enormous damage. "A 0.5 mm paint chip travelling at 35,000 km/hr (10 km/sec) could puncture a standard space suit."[7] A one centimeter fragment can damage a space station.[8]

Of course, the remnants of these explosions themselves became space debris.[9] The 1981 destruction of the Soviet *Kosmos 1275* remains unexplained, but was possibly due to space debris,[10] and the same may be true of the 1986 explosion of an Arianne rocket.[11]

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[6] Many also do not appreciate the harshness of space and the short lifespan of some satellites. *See* Michael W. Taylor, Orbital Debris: Technical & Legal Issues and Solutions, 2-3 (Aug. 1, 2006) (unpublished LL.M. thesis, McGill University), *available at* http://www.fas.org/spp/eprint/taylor.pdf. (noting that the "science fiction" view of space often ignores the "unique physical properties" of space – space is a "harsh environment" limiting the functioning life of satellites to an average of 15 years).

[7] Robert C. Bird, *Procedural Challenges to Environmental Regulation of Space Debris*, 40 AM. BUS. L.J. 635, 641 (2003).

[8] *Id.*; *see also* Gunnar Leinberg, *Orbital Space Debris*, 4 J.L. & TECH. 93, 98 (1989) ("A 3 mm piece of space debris traveling at 10 km/sec has as much kinetic energy as a 12 lb bowling bowl travelling at 60 mph"); Adrian Taghdiri, *Note: Flags of Convenience and the Commercial Space Flight Industry: the Inadequacy of Current International Law to Address the Opportune Regulation of Space Vehicles in Flag States*, 19 B.U. J. SCI. & TECH. L. 405, 420 (2013) (noting that space debris may remain in orbit for "over a century").

[9] *See* Tariq Malik, *Satellite Debris Tracked Near Space Station*, SPACE.com (Mar. 19, 2009, 1.21 pm ET) (reporting that NASA was tracking *Kosmos 1275*'s remains to ensure that the International Space Station was not threatened); Leinberg, *supra* n. 8 at 97 (noting the 1986 Arianne rocket explosion increased the debris population by 7%, and involved 500 large pieces of debris).

[10] *See id.* Some consider the breakup in the 1970s of the US "PAGEOS" satellite may have been due to debris. *Id. a*t 95; *see also* Daria Diaz, *Trashing the Final Frontier: An Examination of Space Debris from a Legal Perspective*, 6 TUL. ENVTL. L.J. 369, 371-72 (1993) (noting that "[i]n 1984, the Solar Max satellite was permanently disabled after it collided thousands of times with what may have been nearly invisible pieces of rocket fuel or satellite fragments. Scientists who examined the aforementioned debris also discovered microscopic shards of human urine.") (footnote omitted); Peter T. Limperis, *Note: Orbital Debris and the Space Faring Nations: International Law Methods for Prevention and Reduction of Debris; and Liability Regimes for Damage Caused by Debris*, 15 ARIZ. J. INT'L & COMP. L. 319, 319 (1998) (noting "possibility that space debris disabled a Japanese climate observation satellite named *Midori* in the summer of 1997").

[11] *See id.* (noting reports that the Arianne rocket collided with a French *Cerise* spy satellite).

Then there are the seemingly mundane (but in fact potentially deadly) encounters with small bits of debris, such as the paint fleck that struck the Space Shuttle *Challenger* in 1983 and caused $50,000 worth of damage,[12] plus the disruption caused to launches and *International Space Station* activities when there is a projected possibility of a debris collision.[13] The "weaponization" of space, including the use and testing of anti-satellite weaponry, may also increase the amount of fragmentation debris.[14] The 2007 Chinese anti-satellite test in LEO may have created "a cloud of more than 3,000 pieces of space debris."[15] During the Cold War, the intentional destruction of satellites for national security reasons may have had a similar effect.[16]

In an exhaustive 1989 study, Howard Baker identified four categories of space debris:

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[12] *See* Leinberg, *supra* note 8, at 95 (noting that the *Challenger* collision with a 0.2 mm paint fleck "le[ft] a crater approximately 2.4 mm across and 0.63 mm deep that cost $ 50,000 to replace"); *see also id.* (noting that in 1987, "a cosmonaut's life was jeopardized in an attempt to remove a plastic 'baggie' that was preventing the Soviet craft Kvant from docking with the Mir"); Delbert D. Smith, "The Technical, Legal and Business Risks of Orbital Debris," 6 N.Y.U. Envt'l L.J. 50, 53-54 (1997-98) (noting that as at the late 1990s, "the Shuttle Orbiter ha[d] experienced an increased frequency of orbital debris damage" and that impacts "as a result of particles greater than one millimeter occurred during each of four recent missions").

[13] *See* Joseph S. Imburgia, *Space Debris and Its Threat To National Security: A Proposal for a Binding International Agreement to Clean Up the Junk*, 44 VAND. J. TRANSNAT'L L. 589, 595 (2011) (noting instances where rocket launches were delayed, or the ISS crew placed on evacuation alert, due to specific threats of debris collision).

[14] *See* He Qizhi, *Towards International Control of Environmental Hazards of Space Activities*, *in* INT'L INST. OF SPACE LAW, PROCEEDINGS OF THE THIRTIETH COLLOQUIUM ON THE LAW OF OUTER SPACE, 138, 140 (warning "intentional explosion, such as tests of ASAT [might] intensify the seriousness of the [debris] situation by producing hundreds of thousands of debris and particles").

[15] Brian Weeden, "2007 Chinese Anti-Satellite Test Fact Sheet" (Nov. 23, 2010), http://swfound.org/media/9550/2007%20chinese%20asat%20test%20factsheet.pdf; Imburgia, supra note 13, at 600-01; *see also* Jesse Oppenheim, *Danger at 700,000 Feet: Why the United States Needs to Develop a Kinetic Anti-Satellite Missile Technology Test-Ban Treaty*, 38 BROOKLYN J. INT'L L. 761, 761-63 (2013) (noting effects of the Chinese 2007 ASAT test; further noting that a United States military test of 2008, "Operation Burnt Frost," involved a sea-launched missile that destroyed *US-193*, a 5,000-pound U.S. spy satellite orbiting at an altitude of 193 nautical miles).

[16] The Former Soviet practice was to explode inactive satellites. David E. Reibel, *Environmental Regulation of Space Activity: The Case of Orbital Debris*, 10 STAN. ENVIR'L L.J. 97, 105 (1991). These satellites, however, were usually in LEO, *id.*, meaning that atmospheric drag may have eliminated much of this material.

- "inactive payloads" – "former active payloads which can no longer be controlled by their operators"; a category that includes spent orbital satellites and probes;[17]

- "operational debris," i.e., "objects associated with space activities" that remain in space, mostly comprising "launch hardware" but also other man-made materials discarded in the course of space exploration.[18] Hardware items include rocket bodies, orbital transfer vehicles, kick motors, nose cones, payload separation hardware, "exploded restraining bolts," "fairings," "exploded fuels tanks and insulation" and "window and lens covers";[19]

- "fragmentation debris" caused when objects break up after explosions;[20] and

- "micro particulate matter" between 1 and 100 microns wide, including particulates from solid-fuel transportation systems.[21]

The nature of the problem varies according to orbit. LEO is closest to the atmosphere,[22] the medium earth orbit (MEO) is between 5,600 km to 36,000 km (often used for navigational satellites),[23] while the Geosynchronous Orbit (GEO) – the very valuable orbit utilized by many communications satellites – is a higher orbit.[24] Debris in the LEO is more likely to be dragged down to the

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[17] HOWARD A. BAKER, SPACE DEBRIS: LEGAL AND POLICY IMPLICATIONS 4 (1989).

[18] *Id.*

[19] Other items include "raw propellant inadvertently dumped during fuel transfers," "a camera from an Apollo mission," an "astronaut's glove," lost screws, "food wrappers" from Soviet cosmonauts and "'transient bits of frozen sewage'" from a Space Shuttle mission. *Id.*

[20] *Id.* at 4-5.

[21] *Id.* at 8-9.

[22] Taylor, *supra* note 6, at 10.

[23] *Id.* at 10 (noting that the US Navstar and Russian Glonass satellites used Medium Earth Orbit).

[24] *Id.* Geosynchronous orbit, at 36,000 km above Earth, is the "second most widely used Earth orbit," and allows "orbital periods of 24 hours" and "[s]implified communications." Limperis, *supra* note 10, at 321-22. On the value of geosynchronous orbit within the GEO, *see* Joel Stroud, *Space Law Provides Insights on How the Existing Liability Framework Responds to Damages Caused by Artificial Outer Space Objects*, 37 REAL PROP. PROB. & TR. J. 363, 371 (2002).

atmosphere, and may diminish over time, but it travels at enormous speed relative to other objects.[25] Orbital debris in the GEO, which "moves in an enormous doughnut shaped ring around the equator as the gravitational forces of the Sun, Moon and Earth pull on the objects," is "not naturally removed from orbit by atmospheric drag," and thus is "estimated to last anywhere from a million to 10 million years."[26]

Moreover, it has been estimated that collision risk in the GEO "is not uniform by longitude," but instead is "seven times greater in regions centered around the so-called 'geopotential wells' which exert a gravity pull on drifting satellites and other debris."[27] According to the insurer Swiss Re, there are operating satellites worth "hundreds of millions of dollars" that are "in or near these locations."[28]

Some scientists have warned that the risks posed by space debris may grow – perhaps exponentially – as the use of space increases. One theory, developed by NASA Scientists John Gabbard and Donald Kessler (and dubbed "the Kessler Syndrome"), posits that the population of human-generated space debris might hit a critical mass.[29] One writer explains:

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[25] *See* Beck, *supra* note 5, at 28 (noting atmospheric drag has effects that continue for hundreds of kilometers, meaning that satellites in LEO need propellant to keep their orbit).

[26] Taylor, *supra* note 22, at 10; *see also* Steven A. Mirmina, *Reducing the Proliferation of Orbital Debris: Alternatives to a Legally Binding Instrument*, 99 AM. J. INT'L L. 649, 650 (2005) (making similar observation). On the other hand, collision velocities in the GEO may be lower than in the LEO. *See* Lawrence D. Roberts, *A Lost Connection: Geostationary Satellite Networks and the International Telecommunication Union*, 15 BERKELEY TECH. L.J. 1095, 1125 (2000) ("Differential velocities among active spacecraft and debris tend to be lower, both because the absolute velocity of objects in geosynchronous orbit are lower and because uses of the geosynchronous orbit tend to confine the direction and orbital angle of working satellites, derelicts, and other forms of debris to similar vectors.").

[27] *Id.*

[28] Swiss Re, *Space Debris: On a Collision Course for Insurers*, available at http://media.swissre.com/documents/Publ11_Space+debris.pdf (hereinafter "Swiss Re Report"); *see also id.* at 6-7, 11-13 (discussing technical factors driving collision risk and GEO orbital characteristics).

[29] *See* Brian Weeden, *Saving Earth Orbit, One Piece of Junk at a Time,* SPACE NEWS BLOG (Aug 11, 2010), http://www.spacenews.com/article/guest-blog-saving-earth-orbit-one-piece-junk-time.

> Proponents of the cascade effect hypothesize that large space debris pieces will increasingly collide, break apart, and fill the orbit with smaller and more numerous bits of debris. These smaller pieces of debris will further collide and break apart, creating more fragments and increasing the chance of new impacts. When the space debris population reaches a certain threshold, collisions between objects will create so much new debris that it will increase independently of further space operations. Left unchecked, this self-generation could actually create a debris belt around the Earth.[30]

On this theory, the "collisional cascading" process will "pose a greater risk to spacecraft than the natural debris population of meteoroids."[31] Indeed, some consider that debris is already expanding at an "astonishing" rate, and that without proper mitigation "[e]arth's orbit, and eventually the entire solar system, will become an unusable wasteland of dangerous debris."[32]

The risks posed from space debris has attracted attention from the insurance sector. In a recently-published study, Swiss Re observed that orbital debris had doubled over the last 20 years, and warned that "debris has the potential to damage or destroy high-value, operational satellites with resulting revenue losses in the billions of dollars or euros.[33]

II. CALLS FOR ACTION AND POLICY PROPOSALS

The principal response to the "debris" issue has been "mitigation" – the adoption of guidelines to modify spacecraft design to reduce the amount of space debris created in flight, such as those

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[30] Bird, *supra* note 7, at 643; *see also* Natalie Pusey, *The Case for Preserving Nothing: The Need for a Global Response to the Space Debris Problem*, 21 COLO. J. INT'L ENVT'L. L. & POL'Y 425, 432 (2010) (noting that "if humans add no additional debris to Earth orbit, but also fail to remediate the problem, the amount of debris in orbit could still grow exponentially"); Imburgia, *supra* note 13, at 597-99.

[31] Weeden, *Saving Earth's Orbit*, *supra* note 28.

[32] *See* Michael W. Taylor, *Trashing the Solar System One Planet at a Time: Earth's Orbital Debris Problem*, 20 GEO. INT'L ENVTL L. REV. 1, 1, 59 (2007); *see also id.* at 1 (noting 32% increase in orbital objects during the first two months of 2007).

[33] Swiss Re Report, *supra* note 28, at 1.

adopted by the United Nations Inter-Agency Space Debris Coordination Committee ("IADC") and NASA[34] – as well as the reporting and tracking of existing space junk. Other mitigation practices include the de-orbiting of inactive satellites (if in LEO), or, if in GEO, the removal from active orbit of inactive satellites to retirement orbits.

Some call for more vigorous action. Writing in 1990, Albert Gore stated that "[o]rbital debris [was] already a problem of considerable importance; consequently, laws to control further proliferation will be needed."[35] Commentator Brian Weeden has called for the introduction of an enhanced, more comprehensive debris tracking system and other technologies to reduce debris.[36] Others have called for the creation of a "superfund" or multilateral treaty system

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[34] The UN guidelines, developed through the Inter-Agency Debris Committee, call for a series of vehicle-design and operational measures to reduce the extent of space debris produced by space vehicles. They also call for disposal of defunct satellites orbiting in the LEO and the adoption, for defunct satellites in the GEO, of retirement orbits above the GEO. *See* United Nations Office for Outer Space Affairs, *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space* (2010), *available at* http://orbitaldebris.jsc.nasa.gov/library/Space%20Debris%20Mitigation%20Guidelines_COPUOS.pdf.

The United States has adopted similar guidelines. *See* NASA, "Orbital Debris Mitigation," *available at* http://orbitaldebris.jsc.nasa.gov/mitigate/mitigation.html (last visited Jan. 25, 2013); Swiss Re Report, *supra* note 28, at 28. The International Telecommunications Union similarly encourages mitigation, advocating "disposal" or "graveyard orbits" 300 km above GEO for otherwise non-functional or derelict satellites. Pusey, *supra* note 30, at 428. Also relevant are the regulations of the Federal Commissions Commission of the United States, which in 2004 issued a requirement that satellite operators must, as part of the licensing process, provide information on their debris mitigation strategies, as well as "end-of-life" assurances that their satellites will be repositioned to a disposal orbit. *See* Federal Communications Commission, "Mitigation of Orbital Debris," 69 FED. REG. 54581 (Sept. 9, 2004).

[35] Albert Gore, Jr., *Outer Space, The Global Environment, and International Law: Into The Next Century*, 57 TENN. L. REV. 329, 334 (1990).

[36] *See* Brian Weeden, *Billiards in Space*, THE SPACE REVIEW (Feb. 23, 2009), *available at* http://www.thespacereview.com/article/1314/1 (arguing it would be "criminal" not to devote the "rather low amount of resources" to tracking debris, given the "hundreds to thousands of close approaches among the entire satellite catalog every day").

to subsidize remediation efforts/research,[37] as well as bans of particular kinds of material (*e.g.*, nuclear fuel) in orbit.[38] A possible variant is the creation of a "market share" or polluter-pays system where space users are required to "purchase" the ability to create debris.[39]

Other more ambitious projects would include the recapture of defunct satellites, perhaps aided by a maritime-style "salvage" regime.[40] Technologically, however, the options are limited:

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[37] Joseph S. Imburgia, *supra* note 13, at 654 (proposes new Space Treaty to mandate prevention/mitigation and establish a Space Sustainability Authority with power to effect removal of space debris); Agatha Akers, Note and Comment: *To Infinity and Beyond: Orbital Space Debris and How to Clean it Up*, 33 U. LA VERNE L. REV. 285 , 311-13 (2012) (arguing in favor of a space access fee of $5 million per unmanned object launched and a $1 million fee per manned launch, modeled after California's Electronic Waste Recycling Fee, to fund an orbital maintenance program); *see also* Taghdiri, *supra* note 8 at 430 (calling for greater regulation; arguing that space debris risks are increasing due to risks of growing space tourism, "lax" regulation and/or the use of "flags of convenience"; calling for treaties to be amended to include "comprehensive compliance regimes," possibly featuring "an international space tribunal, international space safety regulations, and a mandatory international insurance plan"); Oppenheim, *supra* note 15 at 794-95 (arguing for a ban on kinetic anti-satellite missile tests, among other things, to reduce risks of orbital debris); Elise Epperson Crow, Note & Comment: *Waste Management in Space: Addressing the Challenge of Orbital Debris*, 18 SW. J. INT'L L. 707, 716-20 (2012) (calling for reform of the treaty system, including burden-shifting rules "to shift the burden of proof of negligence to the debris-creating states," as well as laws to promote space salvage).

[38] As a result of Cold War era technology, there reportedly are 1500kg of radioactive materials orbiting Earth. Pusey, *supra* note 30, at 432. In 1978, President Carter called for a ban on nuclear satellites in the wake of the *Kosmos 954* crash, but this failed to come to fruition. *See* Cohen, *supra* note 1*,* at 90.

[39] *See* Taylor, *supra* note 1, at 279 (arguing for a tradable allowance scheme). For a trenchant criticism of the "market share liability" school, *see* Allen Rostron, *Beyond Market Share Liability: A Theory of Proportional Share Liability for Nonfungible Products*, 52 UCLA L. REV. 151, 201-02 (2004) (noting problems with compiling reliable data about orbital debris as well as the varying properties of debris based on location and velocity).

[40] *See* James Dunstan & Berin Szorka, *Beware of Space Junk*, FORBES.COM, http://www.forbes.com/2009/12/17/space-junk-environment-global-opinions-contributors-berin-szoka-james-dunstan.html (Dec. 17, 2009) ("While maritime law encourages the cleanup of abandoned vessels as hazards to navigation, space law discourages debris remediation by failing to recognize debris as abandoned property, and making it difficult to transfer ownership of, and liability for, objects in space even junk. By adapting maritime precedents, space law could make orbital debris removal feasible, once the right economic incentives are in place. Entrepreneurs may even find ways to recycle and reuse on orbit the nearly 2,000 metric tons of space debris, which includes ultra-high grade aerospace aluminum and other precious metals."),; *see also* Glenn Reynolds, *Space Junk and the Law of Space Collisions*, POPULAR MECHANICS (Oct. 1, 2009) *available at*

> One involves sending a satellite to known debris and either capturing the debris or attaching a device (tether or engine) that would enable the debris to reenter Earth's atmosphere. The primary problem with this concept is that the propellant expenditure to visit more than one piece of debris per launch is enormous. . . . The only other potential remediation measure involves using ground-based lasers to perturb the orbit of debris and cause it to reenter the Earth's atmosphere more quickly. However, the tracking ability of lasers, the ability to discriminate among active satellites and debris, and the high energy levels required to have any noticeable effects makes this proposal currently impractical.[41]

On this view, "currently there are no economically or technically feasible ways to remove space debris from space."[42]

III. DO THE OUTER SPACE TREATY AND LIABILITY CONVENTION REGULATE SPACE DEBRIS?

A. The Legal Framework

The Outer Space Treaty of 1967[43] articulates a series of governing principles about the use and exploration of space that, while extremely important to space law generally, do not directly address the status of space debris. Among other things, the Outer Space

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http://www.popularmechanics.com/science/space/4303567 (arguing that there should be a "salvage law [which would] give a shot in the arm to commercial space efforts").

[41] Taylor, *supra* note 32, at 43-44 (footnotes omitted).

[42] *Id.* at 79. A physical removal regime might also trigger legal problems, especially as many satellites are subject to national security claims. For example, Gerry Oberst notes that the United States "ITAR" Regulations still apply to in-orbit objects meaning that "taking control of debris could technically be an 'export' subject to all the ITAR rules." Gerry Oberst, *Legal Issues for Space Debris Removal*, SATELLITE TODAY, http://www.satellitetoday.com/via/globalreg/38524.html (Apr. 1, 2012). Oberst also notes that "many if not most, technical proposals for debris removal have some overtones of military applications." *Id.*

[43] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, *opened for signature* Jan. 26, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty]. As at the present date, 101 states have ratified, and a further 26 states have signed, the Outer Space Treaty. *See Status of International Agreements Relating to Activities in Outer Space*, U.N. Office for Outer Space Affairs, jhttp://www.oosa.unvienna.org/oosa/en/SpaceLaw/treatystatus/index.html (last visited Jan. 26, 2013).

Treaty provides that space is the "province of all mankind";[44] that the "exploration and use of outer space [shall be conducted] in accordance with international law";[45] that states are generally responsible for the activity of their nationals in outer space;[46] that states "shall retain jurisdiction and control" over "objects launched into outer space"[47] and shall generally be "liable for damage" from such objects;[48] and that states shall avoid "harmful contamination" of space and activities that interfere with other states' rights and exploration.[49]

In the 1972 Liability Convention,[50] contracting states agreed to create absolute liability for damage on the surface of the earth (or to aircraft) "caused by its space object[s],"[51] and further imposes "fault"-based liability on states for damages "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."[52] Inter-state claims may be resolved through "Claims Commissions"; a quasi-arbitral procedure.[53]

These presuppose that governments are responsible for many facets of space travel and that the principal claims arising in space law will be government-to-government in nature. This is a product of the era in which they were negotiated. As one commentator remarked of the Outer Space Treaty:

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[44] Outer Space Treaty, Art. I.

[45] *Id.* at Art. III.

[46] *Id.* at Art. V.

[47] *Id.* at Art. VIII.

[48] *Id.* at Art. VII.

[49] *Id.* at Arts. IX, XI.

[50] Convention on International Liability for Damage Caused by Space Objects, *opened for signature* Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention]. The Liability Convention has been adopted by 88 countries, with 23 further signatories. *See generally*, Hertzfeld, *supra* note 3, at 233.

[51] Liability Convention, Art. II; *see also id.* at Art. I(a) (defining "damage" as "loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations").

[52] *Id.* at Art. III.

[53] *Id.* at Arts. XIV-XX. For a criticism of the current claims commission structure, *see* Dan St. John, *The Trouble with Westphalia in Space: The State-Centric Liability Regime*, 40 DENV. J. INT'L L. & POL'Y 686, 696 (2012) (arguing that the current state-centric structure is a "vestige" of the Westphalian system of international law, in which private actors must enlist the cooperation of their home states to bring a claim).

> Because it was drafted at a time when space activity meant rare and expensive government forays, little attention was paid to the possibility of pollution of the space environment. Instead the provisions of the treaty focused on ensuring freedom of access and forestalling the exercise of national control, not operational efficiencies.[54]

B. Arguments in Favor of Liability for Launching States

None of the space treaties contains a "per se" ban on "[l]ittering the outer space environment" or specific rules about space debris.[55] Thus, arguments for state liability for space debris have often been based upon the more general statements contained in the Outer Space Treaty, particularly Article VII, which provides:

> 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.[56]

As all space debris originates from materials launched into outer space, it might be argued that any piece of space debris is an "object[] launched into space" and that collisions involving such "objects" trigger the international liability provisions of Article VII of the Outer Space Treaty. Those who urge such a theory of liability on states under Article VII may argue that such liability is fortified by Article VIII, providing for states to "retain jurisdiction and control" over "objects launched into outer space,"[57] as well as Article VI, providing that states are "bear international responsibility for national activities in outer space . . . whether such activities are

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[54] Roberts, *supra* note 26, at 1124 (footnotes omitted).

[55] Diaz, *supra* note 10, at 377 and Baker, *supra* note 17, at 86.

[56] Outer Space Treaty, Art. VII (emphasis added). *See also* Hertzfeld, *supra* note 3, at 233.

[57] Outer Space Treaty, Art. VIII.

carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the [Outer Space Treaty]."[58]

Indeed, although Article VI's reference to responsibility is somewhat "vague,"[59] its terms state that the "activities" of "non-governmental entities" in outer space are to remain subject to "authorization and continuing supervision" of the appropriate state parties.[60] On this view:

> Because non-governmental entities may conduct activities in outer space only with the authorization of and under the supervision of the appropriate nation, any liability of such an entity is imputed to the nation-state which authorized its space activities. In this way, article VI renders the nation-state liable for the activities of non-governmental entities.[61]

A similar line of argument could be made with respect to the Liability Convention, using its fault-based liability for in-orbit collisions. If its definition of "space object," which includes "component parts of a space object as well as its launch vehicle and parts thereof,"[62] were viewed as including the *remnants* of all launched objects,[63] then states could arguably become liable for damage

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[58] *Id.* at Art. VI.

[59] Lucinda R. Roberts, *Orbital Debris: Another Pollution Problem for the International Legal Community*, 11 FLA. J. INT'L L. 613, 618 (1997).

[60] Specifically, Article VI of the Outer Space Treaty provides that "States Parties to the Treaty shall bear international responsibility for national activities in outer space," regardless of whether such activities are carried out by "governmental agencies or by non-governmental entities," and imposes a further duty to "assur[e] that national activities are carried out in conformity with" the Outer Space Treaty. An analogy in this regard could be made to the responsibility of states for the activities of its nationals who operate mining activities on the sea-bed floor; a topic recently explored by the Sea-Bed Disputes Chamber of the International Tribunal for the Law of the Sea. *See generally* Responsibilities & Obligations of States Sponsoring Persons & Entities with Respect to Activities in the Area, Advisory Opinion, ITLOS Sea-Bed Dispute Chamber, ¶¶ 110-25 (Feb. 1, 2011) (hereinafter Sea Bed Advisory Opinion). This issue is discussed further in a customary international law context. *See infra* note 111.

[61] Marc S. Firestone, *Problems in the Resolution of Disputes Concerning Damage Caused in Outer Space*, 59 TUL. L. REV. 747, 751-52 (1985)

[62] Liability Convention, Art. I(d).

[63] At the time of ratification, the United States Senate was told by the State Department that "payload" in the Liability Convention meant "the space object, its component parts, and all property on or within the space object . . . even those parts which are not

caused by debris that could be traced back to it. Things, however, are not that simple.

C. Legal Uncertainties Concerning Launch State Liability for Debris

1. Uncertainty over the Meaning of "Space Object"

At the most basic level, there remains uncertainty over the meaning of "space object"/"object launched into space" for purposes of the Outer Space Treaty and the Liability Convention.[64] Manfred Lachs reportedly considered that "a space object is any object to be placed in orbit as a satellite of the earth, the moon or any other celestial body to traverse some other course to, in or through outer space."[65] Cheng considered that a space object is anything launched into space, even "a lump of rock launched into outer space for no reason at all but the fun of it."[66] Thus, on an expansive view, even "non-functional space objects" remain "space objects."[67] "[S]hattered fuel tanks or flakes of paint from space objects" will be treated as "space objects."[68] So, according to Cheng, will "refuse generated in space."[69]

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intended to go into orbit or beyond" may be considered payload. Carl Q. Christol, *International Liability for Damage Caused by Space Objects*, 74 AM. J. INT'L .L. 346, 357 (1980).

[64] *See* Hertzfeld, *supra* note 3, at 234 (discussing uncertainty over whether things like component parts are space objects, as well as past uncertainty over whether explosive bolts should be regarded as space objects). In this regard, there is a possible gap between the definition of "space object" in Article I(d) of the Liability Convention (specifically defined as including the launch vehicle and its component parts) and the potentially vaguer concept of "objects launched into outer space" appearing in Article VIII of the OST. *See* Baker, *supra* note 17, at 63; *see also* Imburgia, *supra* note 13, at 616-18.

[65] Leinberg, *supra* note 8, at 99.

[66] BIN CHENG, STUDIES IN INTERNATIONAL SPACE LAW 506 (1997).

[67] *Id.*

[68] *Id.*

[69] *Id.* The Soviet government's voluntary settlement of the *Kosmos 954* matter with Canada could be argued to reflect an implicit recognition of its potential treaty liabilities. In turn, this might be said to support the view that a satellite's reactor, and other components of a satellite, are "space objects" under I(d) of the Liability Convention. Ultimately, however, the no-admission nature of the settlement prevents us from drawing firm conclusions. *Id.* at 656.

But *space debris* creates additional problems. While it could be argued that an intact (but non-functioning) satellite is a "space object," can the same be said of an exploded satellite? Are "fragments from a space object" a "space object"?[70] Cheng considers that they might be, but also considers that states may disclaim ownership in discarded or disused objects, rendering them owner-less, or *res derelicta*.[71] But this remains controversial.[72] Baker, while noting the United States position that "space refuse" is potentially a "space object" for purposes of the Liability Convention and Outer Space Treaty, nevertheless considers the issue to be "unclear."[73] He further observes:

> . . . The status of inactive satellites and spacecraft is uncertain, since Article I(d) [of the Liability Convention] gives no indication as to whether a payload must be active to qualify as a "space object." If, however, "space object" is defined as an object "designed *for use* in outer space," then inactive payloads would not be included.[74]

2. Problems with the "Fault" Standard in the Liability Convention

Article III of the Liability Convention imposes liability upon states for in-orbit collisions that are "its fault or the fault of persons for whom it is responsible."[75] But it is silent on the standard for determining "fault" with regard to a particular object, and thus silent on how "fault" can be ascribed for space debris (assuming this

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[70] Pusey, *supra* note 30, at 436.

[71] Cheng considers that the jurisdiction and ownership rules "do not appear to preclude States from abandoning those of their space objects which have outlived their usefulness," Cheng, *supra* note 65, at 466, arguing that states should only be liable for non-disowned space objects (and that such a rule would aid in addressing the space debris problem by removing legal obstacles to the removal of space debris). *Id.* at 509.

[72] *See generally* Kunihiko Tatsuzawa, *The Protection of Space Environment: the Problem of Space Wreckages*, in INT'L INST. OF SPACE LAW, PROCEEDINGS OF THE THIRTY-SECOND COLLOQUIUM ON THE LAW OF OUTER SPACE, 173, 174-76 (1989) (noting disagreement among commentators over whether objects in space can be abandoned or disowned (*res derelicta*)).

[73] Baker, *supra* note 17, at 62-63.

[74] *Id.* at 64.

[75] Liability Convention, Art. III.

to be a space "object").[76] Some might argue that the "gap" is filled by the IADC Guidelines establishing standards with respect to debris mitigation,[77] but this is not a universal consensus and the guidelines by no means resolve all controversies.

This is exemplified by the academic debate over the *Kosmos 2251/Iridium* crash of 2009 (an incident that, officially at least, does not seem to have given rise to any liability claims at this date). Even assuming Iridium's activities were attributable to the U.S. (per Articles VI and/or VII of the Outer Space Treaty), determining the applicable "fault" standard remains problematic.[78] As for *Kosmos 2251*, some might criticize Russia for failing to de-orbit this satellite when it became inactive in 1995. But although under *today's* remediation standards, it may be appropriate to de-orbit a defunct satellite, this was arguably not the case in 1995, when *Kosmos 2251* ceased to be active. Indeed, in 1995, "nations routinely abandoned unused or decommissioned satellites."[79]

Furthermore, although the Outer Space Treaty "imputes" private actions to states, there is some doubt as to whether this rule holds true for the Liability Convention, which "does not specifically incorporate the Outer Space Treaty's doctrine of imputability."[80] Some have therefore argued that it is "unclear whether a respondent under the Liability Convention will be liable for damage caused by its nationals under the Outer Space Treaty."[81]

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[76] Baker, *supra* note 17, at 80. *See also* Limperis, *supra* note 10, at 331; Smith, *supra* note 12, at 58; Christol, *supra* note 62, at 368-69; Swiss Re Report, *supra* note 28 at 24. This "lacuna" in the Liability Convention was a "conscious decision of the negotiators." *Id.* at 369.

[77] *See* Hertzfeld, *supra* note 3, at 236 n.28 (noting that the IADC guidelines, while "not binding law, . . . are likely to become customary practice among responsible nations and therefore could be found to be a reasonable standard of care").

[78] Although Iridium was launched from Kazakhstan, it was subsequently acquired by U.S. private interests. *Id.* at 235. Arguably, "in the final analysis, the United States *should* be the logical state responsible for [Iridium]." *Id.* at 236. Hertzfeld notes that it might be argued that the U.S. was at "fault" for failing to track alternative routes for Iridium and for not providing satellite tracking information to the private operators. *Id.* at 237-38.

[79] *See id.* at 236.

[80] Firestone, *supra* note 58, at 759 (citing Foster, *The Convention on International Liability for Damage Caused by Space Objects,* 10 CAN. Y.B. INT'L L. 137, 165 (1972)).

[81] *Id.* at 760.

3. The Definition of "Damage"

Article I(a) of the Liability Convention defines "damage" as "loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations."[82] Article VIII(1) permits "[a] State which suffers damage, or whose natural or juridical persons suffer damage" to make claims,[83] and Article XII calls for compensation to be

> determined in accordance with international law and the principles of justice and equity, in order to provide such reparation in respect of the damage as will restore the person, natural or juridical, State or international organization on whose behalf the claim is presented to the condition which would have existed if the damage had not occurred.[84]

But beyond those general statements, the Convention does not indicate clearly whether "damage" extends to the costs of environmental remediation or of other injury that did not directly affect life or economic property. This became evident during the *Kosmos 954* episode, where the main "damage" claimed was the cost of environmental cleanup to property that was not being used for farming or industrial use. Although the Soviet Union eventually paid around half of the C$6m claimed by Canada as part of a voluntary settlement, the Canadian side was initially concerned that the Soviets might deny the existence of any "damage" under the Liability Convention.[85] This "illustrate[d] one of the Liability Convention's main weaknesses: its definition of damages is too vague."[86]

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[82] Liability Convention, Art. I(a).

[83] *Id.* at Art. VIII(1).

[84] *Id.* at Art. IX.

[85] *See* Cohen, *supra* note 1, at 89 n. 72 ("It was not clear that the radioactive remnants . . . injured Canada under the Liability Convention's definition of injury . . . . Canadian elites were relieved that the U.S.S.R. chose not to avoid payment on these grounds").

[86] Van C. Ernest, Note: *Third Party Liability of the Private Space Industry: To Pay What No One Has Paid Before*, 41 CASE W. RES. L. REV. 503, 526 (1991). *See also* Swiss Re Report, *supra* note 28, at 25 (noting that the provisions of Article XII of the Liability Convention, which refer generally to the principle of compensation to "restore" the injured party to its former position, remain unclear); St. John, *supra* note 53, at 703-04 (noting the uncertainty over whether the definition of damage includes "lost profits" or "indirect" damage: conventions provide "no clear guidance[,] and a staggering amount of

4. Debris as "Harmful Contamination"?

It has been argued that space debris triggers Article IX of the Outer Space Treaty, which obligates states to avoid "harmful contamination" of space.[87] Others, however, maintain that Article IX refers only to *biological* contaminants, with the result that it applies only to materials that could affect astronauts and spacecraft – not debris.[88] Some have argued that "debris" was not intended to be regarded as "harmful contamination," because it is "impossible to operate in space without creating some amount of debris," and thus it would have been odd for Article IX to have applied to a seemingly inevitable byproduct of space exploration.[89] Similarly, while Article V of the Outer Space Treaty requires states to report "phenomena" that may be "a danger to the life or health of astronauts," some question whether space debris is a "phenomenon" for purposes of this article.[90]

Furthermore, Article IX's obligation to "consult" with other users about activities that might cause causing "harmful interference" with activities of other states is hardly an "absolute injunction"

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indirect damage could potentially be attributed to a state," noting as an example the debate over a 2005 expression of concern by Canada that "a Titan IV rocket booster launched from Cape Canaveral" might "fall near an oil platform in Newfoundland," possibly causing significant financial loss).

[87] Outer Space Treaty, art. IX. S*ee also* Cheng, *supra* note 66, at 506 (opining that "deliberate and harmful release" of refuse or debris "would doubtless come under Article IX of the Space Treaty . . . relating to harmful contamination"); Baker, *supra* note 17, at 62 (considering that "inactive satellites" are capable of being regarded as "contamination" for purposes of article IX of the OST). A related questions is whether Article IX's provisions about "the introduction of extraterrestrial matter" to the "environment of the Earth" might apply to space debris; this, however, would require an interpretation that includes orbital areas as within the Earth's "environment." *Id.*; *see also* Roberts, *supra* note 59, at 618-19.

[88] See Tatsuzawa, *supra* note 72, at 175 (quoting Professor Reijnen as contending that "contamination" is merely one particular kind of pollution, and denotes damage having a "'medico-biological'" effect, and thus is inappropriate to littering in space); Diaz, *supra* note 10, at 377 (noting that there is no clear definition of what constitutes "harmful contamination" for purposes of Article IX of OST); and Imburgia, *supra* note 13, at 614-15.

[89] Taylor, *supra* note 22, at 41. *See also* Taylor, *supra* note 32, at 25.

[90] *See* Leinberg, *supra* note 8, at 102 ("[O]rbital debris probably does not qualify as 'phenomena.'"). Others have argued that the obligation in Article IX to avoid harmful contamination "apparently applies only to those activities directed at the study and exploration of space," because the word "use" is "omitted" – thus implying that non-exploratory "use" of space is not subject to Article IX. Smith, *supra* note 12, at 56.

against risky activities,[91] and, in any event it only applies to "future planned space activities," not "activities already completed," meaning that Article IX, even if applicable, may be of little utility in dealing with space debris (which usually is created through past activities).[92]

5. Other Issues

There are serious practical issues in actually identifying the source of a collision, especially for fragmentary debris.[93] For example, "[i]f a piece of debris one centimeter in diameter destroys a space station, it would be nearly impossible to find that piece of debris after the disaster and identify it."[94] This problem, combined with the absence of a fault standard, can "make recourse under the Liability Convention largely futile."[95] The same can be said of Article VII of the Outer Space Treaty, which "does not indicate what

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[91] Pusey, *supra* note 30, at 437. *See also* Limperis, *supra* note 10, at 331 (noting uncertainties in Article IX with respect to space debris); Jennifer M. Seymour, Note: *Containing the Cosmic Crisis: A Proposal for Curbing the Perils of Space Debris*, 10 GEO. INT'L ENVTL. L. REV. 891, 899 (1998) (similar observation).

[92] Smith, *supra* note 12, at 57.

[93] Weeden notes that the tracking of the launching state for a piece of debris can be "extremely challenging." Brian Weeden, *The Numbers Game,* THE SPACE REVIEW (July 13, 2009), *available at* http://www.thespacereview.com/article/1417/1. He also notes that there are discrepancies between the 14,800 objects in orbit according to the Space Track website and the over 19,000 figure being quoted by "military and NASA officials" – due in part to "uncataloged" objects. *Id.* Notably, the United Nations has since 1962 maintained a registry of objects launched into outer space. *See Registration of Objects Launched into Outer Space*, U.N. Office for Outer Space Affairs, http://www.oosa.unvienna.org/oosa/SORegister/index.html. The 56 parties to the Registration Convention are required, by Article II(1) thereof, to maintain a register of space objects launched by them into outer space, and to inform UN Secretary General of the existence of the registry. *See* Convention on Registration of Objects Launched into Outer Space, *opened for signature* Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15, art. II(1) [hereinafter Registratiob Convention]. Even assuming full compliance with the Registration Convention, however, this does not solve the technological impediments to tracking debris. One privately funded organization that has collected significant data on satellite orbits, and which is dedicated to assisting in space safety and debris mitigation, is the Space Data Association, *see* http://www.space-data.org/sda/.

[94] Beck, *supra* note 5, at 28. *See also* Leinberg, *supra* note 8, at 97 (noting that the U.S. government's Colorado Springs tracking station "cannot detect space debris smaller than 10cm at altitudes of 500 km and higher").

[95] James P. Lampertius, Note: *The Need for an Effective Liability Regime for Damage Caused by Debris in Outer Space*, 13 MICH. J. INT'L L. 445, 447 (1991). *See also* Christopher D. Williams, *Comment: Space: the Cluttered Frontier*, 60 J. AIR L. & COM. 1139, 1153-54 (1995) (even assuming Articles VI and VII of the OST create "responsibility" of

recourse a participating State has if the damaging debris is unidentifiable."[96]

The Liability Convention's dispute resolution provisions, which envisage state-to-state dispute resolution, are expressed as being without prejudice to a private party's ability to bring claims in the "national courts" or agencies of contracting states.[97] In the absence of legislation or precedent on the issue, however, it is far from clear how the world's various national courts would handle the matter.[98]

In sum, the Outer Space Treaty and Liability Convention provide "minimal specific guidance to the drafters of a space debris framework."[99] One observer has said that "'it is apparent that any prohibition on the generation of space debris could only be found in the spirit of the treaty and not in its text.'"[100]

D. Calls for Legal Reform

Many have called for a better-defined treaty regime to govern space debris.[101] Taylor, for example, argues forcefully that the jurisdictional and control rule in Article VIII arguably is "an impediment to proposed solutions for the orbital debris problem,"[102] and that there is an urgent need to define "space object" "to make clear that it applies to orbital debris."[103] He further argues that, although

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states for debris, it "is virtually impossible to identify the source of any particular piece of debris") and Beck, *supra* note 5, at 28 (arguing that the existing space treaty regime "provides no incentive for launching state or companies to limit space debris" because of the uncertain fault standard and difficulty in identifying the source of debris).

[96] Limperis, *supra* note 10, at 331.

[97] Liability Convention, Art. XI(2).

[98] The Swiss Re Report constructs a hypothetical litigation scenario between a UK and US operator, and suggests that the outcome of a claim in the California courts would be difficult to predict. Swiss Re Report, *supra* note 28, at 26.

[99] Bird, *supra* note 7, at 655. *See also* Imburgia, *supra* note 13, at 618; Swiss Re Report, *supra* note 28, at 35 (concluding that the existing legal framework leaves liability "shrouded in uncertainty").

[100] Seymour, *supra* note 7, at 900.

[101] Lampertius, *supra* note 91, at 466 (urging "multilateral approach" to debris control in order to "fill the gaps" in Liability Convention). *See also* Hertzfeld, *supra* note 3, at 240 ("As space becomes increasingly utilized and future space accidents occur, it remains to be seen if the current approach to space law will be able to withstand the legal, economic and diplomatic challenges of the future.") and Smith, *supra* note 12, at 67-71.

[102] Taylor, *supra* note 22, at 80 (emphasis added).

[103] *Id.* at 95.