Regulating the void: In-orbit collisions and space debris

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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 US 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 above Siberia, of the "defunct" Russian satellite Kosmos 2251 with Iridium 33, a privately-owned US satellite.[3] The crash occurred at a relative velocity of 10 kilometers/second, destroyed both satellites and reportedly created a very large field of new

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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*, German Journal of Air and Space Law (*Zeitschrift fur Luft und Weltaumerecht (ZLW)*), 230, 232 (2010).

debris.[4] As discussed below, there remains significant scope for debate over who if, anyone, is liable for in-orbit collisions from "space debris."

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] Aviation is likewise a false analogy; debris from aircraft does not linger in the atmosphere but instead falls to 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. 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]

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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) (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).

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).

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 Ariane rocket.[11] 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 space station activities when there is a projected possibility of a debris collision.[13] The "weaponization" of space, including the use and

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[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").

[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 (1989) (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 Ariane rocket collided with a French *Cerise* spy satellite).

[12] *See* Leinberg, *supra* n. 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).

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:

- "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

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[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 n. 13, at 600-01.

[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.

[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.

- "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. The low earth orbit (LEO) is closest to the atmosphere,[22] medium earth orbit is between 5,600 to 36,000 kilometers (often used for navigational satellites),[23] while geosynchronous orbit (GEO)—the very valuable orbit utilized by many communications satellites—is a higher orbit.[24] Debris in LEO is more likely to be dragged down to the atmosphere and thus may diminish over time, but travels at enormous speed relative to other objects.[25] Orbital debris in 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]

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

[22] Taylor, *supra* n. 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* n. 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).

[25] *See* Beck, *supra* n. 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* n. 22, at 10; *see also* Steven A. Mirmina, *Reducing the Proliferation of Orbital Debris: Alternatives to a Legally Binding Instrument*, 99 A.J.I.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.").

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." According to the insurer Swiss Re, there are operating satellites worth "hundreds of millions of dollars" that are "in or near these locations."[27]

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.[28] One writer explains:

> 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.[29]

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[27] Swiss Re, *Space Debris: On 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).

[28] *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.

[29] Bird*, supra* n. 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 Envtl. 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* n. 13, at 597-99.

On this theory, the "collisional cascading" process will "pose a greater risk to spacecraft than the natural debris population of meteoroids."[30] 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."[31]

The risks posed from space debris have attracted attention from the insurance sector. In a recently-published study, Swiss Re observed that 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."[32]

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 adopted by the United Nations Inter-Agency Space Debris Coordination Committee (IADC) and NASA[33], as well as the reporting and tracking of existing space junk.

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30 Weeden, *Saving Earth's Orbit*, *supra* n. 28.

31 *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).

32 Swiss Re Report, *supra* n. 27, at 1.

33 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.

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Other mitigation practices include the de-orbiting of inactive satellites (if in LEO), or (if in GEO) their removal from active orbit of inactive satellites and their placement in 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."[34] Commentator Brian Weeden has called for the introduction of an enhanced, more comprehensive debris tracking system and other technologies to reduce debris.[35] Others have called for the creation of a "superfund" or multilateral treaty system to subsidize remediation efforts/research,[36] as well as bans of particular kinds of material (*e.g.*, nuclear fuel) in orbit.[37] A possible variant is the creation of "market share" or polluter-pays system where space users are required to "purchase" the ability to create debris.[38]

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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* n. 27, 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* n. 29, 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 F.R. 54581 (Sept. 9, 2004).

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

[35] *See* Brian Weeden, *Billiards in Space*, 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").

[36] Joseph S. Imburgia, *supra* n. 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).

[37] As a result of Cold War era technology, there reportedly are 1500kg of radioactive materials orbiting Earth. Pusey, *supra* n. 29, 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* n. 1, at 90.

[38] *See* Taylor, *supra* n. 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*

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Other more ambitious projects would include the recapture of defunct satellites, perhaps aided by a maritime-style "salvage" regime.[39] Technologically, however, the options are limited:

> 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.[40]

On this view, "currently there are no economically or technically feasible ways to remove space debris from space."[41]

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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).

[39] *See* James Dunstan & Berin Szorka, B*eware of Space Junk*, forbes.com (Dec. 17, 2009 11.55 am ET) ("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."), http://www.forbes.com/2009/12/17/space-junk-environment-global-opinions-contributors-berin-szoka-james-dunstan.html; *see also* Glenn Reynolds, *Space Junk and the Law of Space Collisions*, Popular Mechanics (Oct. 1, 2009 12.00 am) (arguing that there should be a "salvage law [which would] give a shot in the arm to commercial space efforts"), *available at* http://www.popularmechanics.com/science/space/4303567.

[40] Taylor, *supra* n. 31, at 43-44 (footnotes omitted).

[41] *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 (Apr. 1, 2012), http://www.satellitetoday.com/via/globalreg/38524.html. Oberst also notes that "many if not most, technical proposals for debris removal have some overtones of military applications." *Id.*

III. Do the OST and Liability Convention regulate space debris?

A. The Legal Framework

The Outer Space Treaty of 1967 (OST)[42] 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 OST provides that space is the "province of all mankind";[43] that the "exploration and use of outer space [shall be conducted] in accordance with international law,"[44] that states are generally responsible for the activity of their nationals in outer space;[45] that states "shall retain jurisdiction and control" over "objects launched into outer space"[46] and shall generally be "liable for damage" from such objects;[47] and that states shall avoid "harmful contamination" of space and activities that interfere with other states' rights and exploration.[48]

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[42] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 18 U.S.T. 2410 (*opened for signature* Jan. 26, 1967) (hereinafter "OST"). As at the present date, 101 states have ratified, and a further 26 states have signed, the OST. *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).

[43] OST, art. I.

[44] *Id.*, art. III.

[45] *Id.*, art. V.

[46] *Id.*, art. VIII.

[47] *Id.*, art. VII.

[48] *Id.*, arts. IX, XI.

In a Liability Convention signed in 1972,[49] contracting states agreed to create absolute liability for damage on the surface of the earth (or to aircraft) "caused by its space object[s],"[50] 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."[51] Inter-state claims may be resolved through "Claims Commissions"; a quasi-arbitral procedure.[52]

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 OST:

> 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. [53]

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[49] Convention on International Liability for Damage Caused by Space Objects (*opened for signature* Mar. 29, 1972) (hereinafter "Liability Convention"). The Liability Convention has been adopted by 88 countries, with 23 further signatories. *See, generally*, Hertzfeld, *supra* n. 3, at 233.

[50] Liability Convention, art. II; *see also id.* 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").

[51] *Id.*, art. III.

[52] *Id.*, arts. XIV-XX.

[53] Roberts, *supra* n. 26, at 1124 (footnotes omitted).

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.[54] Thus, arguments for state liability for space debris have often been based upon the more general statements contained in the OST, 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.[55]

As all space debris originates from materials launched into outer space, it might be argued that any piece of space debris is an "object[s] launched into space" and that collisions involving such "objects" trigger the international liability provisions of Article VII of the OST. The "liability" on states established by Article VII is fortified by Article VIII, providing for states to "retain jurisdiction and control" over "objects launched into outer space,"[56] as well as Article VI, providing that states are generally responsible for the activities of *all* of their nationals—public or private—occurring in space.[57] Indeed, although Article VI's reference to

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[54] Diaz, *supra* n. 10, at 377; Baker, *supra* n. 17, at 86.

[55] OST, art. VII; *see also* Hertzfeld, *supra* n. 3, at 233.

[56] OST, art. VIII.

[57] *Id.*, art. VI.

responsibility is somewhat "vague,"[58] 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.[59] 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.[60]

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" includes "component parts of a space object as well as its launch vehicle and parts thereof,"[61] were viewed as including the *remnants* of all launched objects,[62] then states may be potentially liable for damage caused by debris that could be traced back to it. Things, however, are not that simple.

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

[59] Specifically, Article VI 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 OST. OST, Art. VI. 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 Atcivities in the Area*, Advisory Opinion ¶¶ 110-25 (ITLOS, Sea-Bed Dispute Chamber, (Feb. 1, 2011) (hereinafter "*Sea Bed Advisory Opinion*"). This issue is discussed further in a customary international law context, *see infra* n. 110.

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

[61] Liability Convention, art. I(d).

[62] 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 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).

C. Legal uncertainties concerning launch state liability for debris

At the most basic level, there remains uncertainty over the meaning of "space object"/"object launched into space" for purposes of the OST and the Liability Convention. [63] 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."[64] 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."[65] Thus, on an expansive view, even "non-functional space objects" remain "space objects."[66] "[S]hattered fuel tanks or flakes of paint from space objects" will be treated as "space objects."[67] So, according to Cheng, will "refuse generated in space."[68]

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[63] *See* Hertzfeld, *supra* n. 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* n. 17, at 63; *see also* Imburgia, *supra* n. 13, at 616-18.

[64] Leinberg, *supra* n. 8, at 99.

[65] Bin Cheng, Studies in International Space Law 506 (1997).

[66] *Id.*

[67] *Id.*

[68] *Id.* Existing precedent, in the form of the Soviet government's voluntary settlement of the *Kosmos 954* matter with Canada, might imply that the reactor and components of a satellite were "space objects" under I(d) of the Liability Convention, but 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"?[69] Cheng considers that they might be, but also considered that states may disclaim ownership in discarded or disused objects, rendering them owner-less, or *res derelicta*.[70] But this remains controversial.[71] Baker, while noting the United States position that "space refuse" is potentially a "space object" for purposes of the Liability Convention and OST, nevertheless considers the issue to be "unclear" [72] 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.[73]

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."[74] But it is silent on the

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69 Pusey, *supra* n. 29, at 436.

70 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* n. 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.

71 *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*)).

72 Baker, *supra* n. 17, at 62-63.

73 *Id.* at 64.

74 Liability Convention, art. III.

standard for determining "fault" with regard to a particular object, and thus silent on how "fault" can be ascribed for space debris (assuming this to be a space "object").[75] Some might argue that the "gap" is filled by the IADC Guidelines establishing standards with respect to debris mitigation,[76] 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 US (per Article VII of the OST), determining the applicable "fault" standard remains problematic.[77] 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."[78]

Furthermore, although the OST "imputes" private actions to states, there is some doubt as to whether this rule holds true for the Liability Convention, which "does not specifically

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[75] Baker, *supra* n. 17, at 80; *see also* Limperis, *supra* n. 10, at 331; Smith, *supra* n. 12, at 58; Christol, *supra* n. 61, at 368-69; Swiss Re Report, *supra* n. 27 at 24. This "lacuna" in the Liability Convention was a "conscious decision of the negotiators." *Id.* at 369.

[76] *See* Hertzfeld, *supra* n. 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").

[77] 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.

[78] *See id.* at 236.

incorporate the Outer Space Treaty's doctrine of imputability."[79] 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."[80]

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."[81] Article VIII(1) permits "[a] State which suffers damage, or whose natural or juridical persons suffer damage" to make claims,[82] 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.[83]

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

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79 Firestone, *supra* n. 57, 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)).

80 *Id.* at 760.

81 Liability Convention, art. I(a).

82 *Id.*, art. VIII(1).

83 *Id.*, art. IX.

not being used for farming or industrial use. Although the Soviet Union eventually paid around half of the C$6 million 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.[84] This "illustrate[d] one of the Liability Convention's main weaknesses: its definition of damages is too vague."[85]

It has been argued that space debris triggers Article IX of the OST, which obligates states to avoid "harmful contamination" of space.[86] 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.[87] 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.[88] Similarly, while Article V of the

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[84] *See* Cohen, *supra* n. 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").

[85] Van C. Ernest, Note: *Third Party Liability of the Private Space Industry: To Pay What No One Has Paid Before*, 41 Case W. Res. 503, 526 (1991); *see also* Swiss Re Report, *supra* n. 27, 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).

[86] OST, art. IX; *see also* Cheng, *supra* n. 65, 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* n. 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* Lucinda Roberts, *supra* n. 58, at 618-19.

[87] See Tatsuzawa, *supra* n. 71, 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* n. 10, at 377 (noting that there is no clear definition of what constitutes "harmful contamination" for purposes of Article IX of OST); Imburgia, *supra* n. 13, at 614-15.

[88] Taylor, *supra* n. 22, at 41. *See also* Taylor, *supra* n. 31, at 25.

OST 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.[89] Furthermore, Article IX's obligation to "consult" with other users about activities that might cause causing "harmful interference" the use of outer space is hardly an "absolute injunction" against such activities,[90] 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).[91]

There are serious practical issues in actually identifying the source of a collision, especially for fragmentary debris.[92] 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

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89 *See* Leinberg, *supra* n. 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* n. 12, at 56.

90 Pusey, *supra* n. 29, at 437; *see also* Limperis, *supra* n. 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).

91 Smith, *supra* n. 12, at 57.

92 Weeden notes that the tracking of the launching state for a piece of debris can be "extremely challenging." Brian Weeden, *The Numbers Game,* 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; and 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, art. II(1), 28 U.S.T. 695 (opened for signature Jan. 14, 1975). Even assuming full compliance with the Registration Convention, however, this does not solve the technological impediments to tracking debris. However, 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/.

the disaster and identify it."[93] This problem, combined with the absence of a fault standard, can "make recourse under the Liability Convention largely futile."[94] The same can be said of Article VII of the OST, which "does not indicate what recourse a participating State has if the damaging debris is unidentifiable."[95]

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.[96] 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.[97]

In sum, the OST and Liability Convention provide "minimal specific guidance to the drafters of a space debris framework."[98] One observer has said that "'it is apparent that any

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[93] Beck, *supra* n. 5*, at* 28; *see also* Leinberg, *supra* n. 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").

[94] James P. Lampertius, Note: *The Need for an Effective Liability Regime for Damage Caused by Debris in Outer Space*,; *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 states for debris, it "is virtually impossible to identify the source of any particular piece of debris"); Beck, *supra* n. 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).

[95] Limperis, *supra* n. 10, at 331.

[96] Liability Convention, art. XI(2).

[97] 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* n. 27, at 26.

[98] Bird, *supra* n. 7, at 655; *see also* Imburgia, *supra* n. 13, at 618; Swiss Re Report, *supra* n. 27, at 35 (concluding that the existing legal framework leaves liability "shrouded in uncertainty").

prohibition on the generation of space debris could only be found in the spirit of the treaty and not in its text.'"[99]

D. Calls for legal reform

Many have called for a better-defined treaty regime to govern space debris.[100] 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*,"[101] *and that there is an urgent need to* define "space object" "to make clear that it applies to orbital debris."[102] He further argues that, although voluntary mitigation is commendable, "[t]he current *lacuna* of international law concerning orbital debris needs to be filled with enforceable rules and definitions that provide certainty and accountability."[103] A new regime, he acknowledges, might involve collective and individual sacrifices (in terms of fuel carrying, mission life, other costs), but considers these justified in the interests of a safer environment.[104]

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[99] Seymour, *supra* n. 7, at 900. .

[100] Lampertius, *supra* n. 90, at 466 (urging "multilateral approach" to debris control in order to "fill the gaps" in Liability Convention); *see also* Hertzfeld, *supra* n. 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."); Smith, *supra* n. 12, at 67-71.

[101] Taylor, *supra* n. 22, at 80 (emphasis added).

[102] *Id.* at 95.

[103] *Id.* at 98; *see also* Imburgia, *supra* n. 13, at 634 (calling for treaty to "preserve the near-Earth space environment, and the U.S. space-based national security interests that reside there"); *id.* at 636-41 (setting forth terms of draft treaty to research problem assets and fund solutions).

[104] Taylor, supra n. 22, at 98; *see also* Seymour, *supra* n. 89, at 914 (urging that "it is imperative that techniques . . . be employed as soon and as widely as possible" to address space debris).

Others warn that this is not a "realistic possibility," given the slow-moving nature of the UN's space law committees.[105] For its part, the United States took the position in 2004 that it was "premature" for the UN subcommittee to consider the legal aspects of space debris.[106]

IV. Customary international law

Treaties represent but one source of law; existing alongside "international custom, as evidence of a general practice accepted as law," as well as "the general principles of law recognized by civilized nations."[107] To prove customary international law as to a particular proposition the proponent must generally show the existence of a rule of law, as evidence by "extensive and virtually uniform" practice of states, "including that of States whose interests are specially affected," that show conformity to the rule in question, accompanied by *opinio juris*, i.e., that the states have conducted themselves "in such a way as to show a general recognition that a rule of law or legal obligation is involved").[108]

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[105] Mirmina, *supra* n. 26, at 661.

[106] *Id.* at 652 n. 19 (quoting 2006 United States spokesman).

[107] Statute of the International Court of Justice, art. 38(1).

[108] *North Sea Continental Shelf (Ger. v. Den.; Ger. v. Neth.)*, Judgment, 1969 I.C.J. 3, ¶ 74, at 43 (Feb. 20); *accord Continental Shelf (Libya v. Malta)*, 1985 I.C.J. 13, ¶ 27, at 29 ("[T]he material of customary international law is to be looked for primarily in the actual practice and *opinio juris* of states . . . ."); *Military and Paramilitary Activities in and Against Nicaragua (Nicar. v. U.S.)*, Merits, 1986 I.C.J. 14, ¶207, at 108-09 (June 27) ("For a new customary rule to be formed, not only must the acts concerned 'amount to settled practice,' but they must be accompanied by the *opinio juris sive necessitatis*.' Either the States taking such action or other States in a position to react to it, must have behaved so that their conduct 'is evidence of a belief that this practice is rendered obligatory by the existence of a rule of law requiring it.'" (citations omitted)). Moreover, although past international decisions "are not a source of international law," Hersch Lauterpacht, The Development of International Law by the International Court, 20-21 (1958), they may, however, "serve as illustrations of customary international law if they involve an examination of customary international law, as opposed to a treaty-based, or autonomous, interpretation." *Glamis Gold, Ltd. v. United States*, ¶ 605 (UNCITRAL, June 8, 2009), *available at* http://www.state.gov/documents/organization/125798.pdf. This will only be the case, *(cont'd)*

Some treaties have been held to represent a codification of law;[109] other treaties, if drafted by a wide membership of the international community, may be viewed as "binding upon all members of the international community" even prior to ratification "because [they] embod[y] or crystallize a pre-existing or emergent rule of customary law".[110] In this vein, commentators such as Cheng have viewed the OST's terms, except the "registry" requirement, are "declaratory of general international law." [111] Moreover, Article III of the OST, requiring states to carry on the exploration and use of space "in accordance with international law," may further indicate that the rules of customary international law, as they apply between states, extend to space activities.

Customary international law has been said to impose an obligation "'not to allow knowingly [a state's] territory to be used for acts contrary to the rights of other States.'"[112] This

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however, where the award in question has the necessary persuasive force. *See, e.g., Ahmadou Sadio Diallo (Guinea v. Dem. Rep. Congo)*, Preliminary Objections, 2007 I.C.J. 582, ¶¶ 89-91, at 615 (May 24) (holding that a particular series of past arbitral decisions did not represent customary international law on espousal of diplomatic claims).

[109] *See, e.g.*, *Dispute Regarding Navigational and Related Rights (Costa Rica v. Nicar.)*, 2009 I.C.J. 214, ¶ 47, at 237 (July 13) (holding, with respect to Articles 31 and 32 of the 1969 Vienna Convention on the Law of Treaties, that those provisions were a "reflect[ion]" of "customary international law on the subject"); *Sovereignty over Pulau Ligitan & Pulau Sipadan (Indon. v. Malay.)*, 2002 I.C.J. 625 ¶ 37, at 645 (Dec. 17) (similar holding); *Maritime Delimitation and Territorial Questions between Qatar and Bahrain (Qatar v. Bahr.)*, 2001 I.C.J. 40 ¶ 185, at 97 (Mar. 16) (holding that certain provisions of the 1982 Convention on the Law of the Sea concerning delimitation of the territorial sea are reflective of customary international law)..

[110] *Continental Shelf (Tunisia/Libya)*,1982 I.C.J. Rep. 18 ¶ 24, 38 (Feb. 24).

[111] Bin Cheng, *supra* note 65, at 466-67; *see also* P. Malanczuk, *Space Law as a Branch of International Law*, 1994 Neth Y.B. Int'l L. 143, 159 (1995) (observing that the it is appropriate to treat OST as reflecting custom where its "essential principles . . . have been accepted by all States active in outer space by practice and with *opinio juris* after ratification, and where no evidence of dissenting practice on the part of non-ratifying States is available"); Christol, *supra* n. 62, at 353.

[112] Taylor, *supra* n. 31, at 29 (citation omitted); *see also* Taylor, *supra* n. 22, at 49 (citation omitted).

doctrine, known by some as the "transboundary rule," was expressed as follows in the *Trail Smelter* arbitration:

> [N]o state has the right to use or permit the use of its territory in such a manner as to cause injury… in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence.[113]

The ICJ in *Corfu Channel*, finding Albania liable for minefields placed in its territorial waters, likewise referred to "every State's obligation not to allow knowingly its territory to be used for acts contrary to the rights of other States."[114] In a similar vein, the 1972 Stockholm Declaration called upon states to "ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.[115] In the 2009 *Pulp Mills* case, the ICJ, after reaffirming the *Corfu Channel* principle of prevention, held:

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[113] *Trail Smelter (U.S. v. Can.)*, 3 R.I.A.A. 1905, 1965 (*ad hoc* Arbitral Tribunal Mar. 11, 1941). The *Trail Smelter* case involved alleged transboundary pollution from a Canadian factory in British Columbia that caused damage to landowners in the nearby U.S. state of Washington. In the same vein, in the *Lac Lanoux* arbitration between Spain and France -- a case concerning riparian rights over the Carol River -- in the it was held that an upstream state could not divert the waters of a river in such a manner as would cause injury to the interests of a downstream state. *Lac Lanoux (France v. Spain)*, 12 R.I.A.A. 281 (*ad hoc* Arbitral Tribunal Nov. 16, 1957).

[114] *Corfu Channel (U.K. v. Alb.)*, 1949 I.C.J. 4, 22 (Apr. 9).

[115] "States have . . . the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction." Declaration of the United Nations Conference on the Human Environment, Principle 21, June 16, 1972, U.N. Doc. A/CONF.48/14/Rev.1 (1972), *reprinted in* 11 I.L.M. 1416 (1972) [hereinafter Stockholm Declaration]; *accord* Rio Declaration on Environment and Development, Principle 2, June 14, 1992, U.N. Doc. A/CONF.151/5/Rev.1 (1992), *reprinted in* 31 I.L.M. 876 (1992). By 1989, some commentators considered that this had been "accepted as a rule of customary international law." Baker, *supra* note 17, at 73; Christol, *supra* note 62, at 353.

> A State is thus obliged to use all the means at its disposal in order to avoid activities which take place in its territory, or in any area under its jurisdiction, causing significant damage to the environment of another State. This Court has established that this obligation "is now part of the corpus of international law relating to the environment".[116]

In his study on space debris, Baker tied this principle to the provisions of the OST.[117] Article VI, he observed, extends state responsibility to activities "carried on by non-government entities" and requires states to "assur[e] that national activities are carried out in conformity with the provisions" of the OST, including through "authorization and continuing supervision" by the applicable states.[118] These may support a "heightened duty to protect other States"; thus, he argued, "the effect of Articles II and VI of the [OST] is to apply the *Corfu Channel* and *Trail Smelter* principles to governmental and non-governmental activity in outer space and to heighten a State's duty of due diligence.[119] Put another way:

> "In the absence of any specific agreement to the contrary, there is a customary rule of international law which provides that States, either individually or together with other States in international organizations, are liable for damages caused to other States through acts committed within their jurisdiction, particularly where

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[116] *Pulp Mills on the River Uruguay (Argentina v. Uruguay),* Judgment, 2010 I.C.J. 14 ¶ 101 at 44-45 (Apr. 20) (quoting (*Legality of the Threat or Use of Nuclear Weapons*, Advisory Opinion, 1966 I.C.J. Reports 226 ¶ 29, at 242 (July 8)); *see also id.* ¶ 139, at 56 (speaking of obligation "to prevent any significant transboundary harm which might be caused by potentially harmful activities planned by either one of them."); *Sea Bed Advisory Opinion* ¶ 135 (commenting on "precautionary approach" and noting "a trend towards making this approach part of customary international law"); *see also, generally* Duncan French, *From the Depths: Rich Pickings of Principles of Sustainable Development & General International Law on the Ocean Floor – he Seabed Disputes Chamber's 2011 Advisory Opinion*, 26 Int'l J. of Marine and Coastal Law 525 (2011) (discussing the general implications of the *Sea-Bed Advisory Opinion* on the law relating to the sustainable use of shared resources).

[117] Baker, *supra* n. 62, at 73; *see also* Christol, *supra* n. 62, at 349-50 (arguing that the Stockholm Declaration is applicable to outer space).

[118] OST, art. VI.

[119] Baker, *supra* n. 17, at 73; *see also* Christol, *supra* n. 62, at 353-54 (expressing similar view).

> those acts are committed with a high degree of State participation and supervision. Launching of space objects would appear to fall within that kind of category."[120]

This proposition will remain hotly debated (and, indeed, the concept of "jurisdiction" may be hard to translate to a space context). The closest there has been to an acknowledgment of such a rule was the Soviet Union's acceptance of financial responsibility in the Kosmos 954 incident of 1978 in response to Canada's claim under both the 1972 Convention and "general" principles of international law.[121] Even then, the eventual payment, made grudgingly, was expressed as voluntary and without admission – meaning its status remains debatable.[122]

It remains difficult to ascertain the precise boundaries of the OST or Liability Convention as regards space debris, and equally difficult to ascertain customary international law (if any) on the same topic. This uncertainty, however, cuts both ways, because it clouds future investments in space and complicates the process of insuring space risks.[123] Beyond the continuation and

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[120] *Id.* at 352-53. Any such duty (if it exists), might not be absolute, and may also remain at all times highly context-specific. In the *Sea-Bed Advisory Opinion,* in addressing Article 139 of the Law of the Sea Convention and related provisions (imposing on states a "responsibility to ensure" their nationals' activities complied with the treaty's provisions), the Chamber stated:

> The sponsoring State's obligation "to ensure" is not an obligation to achieve, in each and every case, the result that the sponsored contractor complies with the aforementioned obligations. Rather, it is an obligation to deploy adequate means, to exercise best possible efforts, to do the utmost, to obtain this result. To utilize the terminology current in international law, this obligation may be characterized as an obligation "of conduct" and not "of result", and as an obligation of "due diligence".

Sea Bed Advisory Opinion ¶ 110.

[121] *See* Beck, *supra* n. 5, at 15 (noting that although the Soviet Union only paid 50% of the amount claimed by Canada, "[t]he Cosmos 954 incident appeared to validate an international norm that underlies the Liability Convention: nations have some responsibility to compensate states that are damaged by their fallen spacecraft").

[122] *See id.*; Cohen, *supra* n.1, at 88; Ernest, *supra* n. 84, at 626; Swiss Re Report, *supra* n. 27, at 25.

[123] *See, generally*, Swiss Re Report, *supra* n. 27, at 35.

broadening of existing mitigation guidelines, a case can thus be made for some kind of reform that will limit and/or cap the liability of space users who have observed certain basic precautionary practices, either in design or deployment of spacecraft.[124]

The existing uncertainty ought to incentivize all users of space—states and private entities alike—to remain focused upon the issue and to work together to find a more definite and predictable means of addressing it. Unlike space, the law abhors a vacuum.

[124] *See id.* at 641 (arguing in favor of a new treaty and statutory regime "to increase the uniformity and predictability of litigation," with a "cap on damages in order to further advance uniformity and predictability"; this would "reduce uncertainty and reserve the limited amount of insurance available on the world market for compensation of economic loss").