Note

"You're Not Actually Going *into* an Asteroid Field?"—The Threat of Man-Made Space Debris, and a Proposal to Extend Existing Law to Prevent it

Justin Moor[∗]

"I hate space."[1]

I. Introduction

Directed by Alfonso Cuarón, *Gravity* is the highest-grossing movie ever released in the months of September or October.[2] The plot's catalyst is a Russian missile strike on an old satellite, which creates a large cloud of debris that travels at a deadly speed.[3] The debris cloud destroys an American space shuttle and satellite, killing much of the crew.[4] The two surviving astronauts, played by Sandra Bullock and George Clooney, are left to find their way back to Earth.[5] This may seem like a scenario firmly planted in the realm of science-fiction, but the threat of orbiting debris to spacecraft and satellites is very real.[6] The National Aeronautics and Space Administration (NASA) estimates that there are hundreds of millions of pieces of man-made debris in orbit, and "even the smallest of these items has the ability to put future launches. . . or one of the 1,000 or so operational satellites in orbit at risk."[7] Satellites fulfill a number of needs, including communications, navigation, data transmission, surveillance, weather forecasting, and more. Any threat to these spacecraft must be taken seriously.

The debris problem is worsening, as debris-caused collisions produce yet more debris and increase the chance of future collisions.[8] Currently, no effective international framework is in place to prevent the spread of debris. Unfortunately, removal of orbital debris is at the moment technologically impossible.[9] To confront this threat to national and commercial interests, the international community must thus focus

∗ JD expected, 2015 University of Minnesota Law School.

1. GRAVITY (Warner Bros. Pictures 2013).

2. Ray Subers, *'Gravity' Dominates Disappointing October*, BOXOFFICEMOJO.COM (Nov. 1, 2013), http://www.boxofficemojo.com/news/?id=3746&p=.htm. The movie is still in theaters as of this writing.

3. Robyn Johnston, *The Space Junk Disaster in 'Gravity' is a Real Threat*, BUSINESSINSIDER.COM (Oct. 28, 2013, 12:49 PM), http://www.businessinsider.com/the-space-junk-disaster-in-gravity-is-a-real-threat-to-earth-2013-10.

4. GRAVITY (Warner Bros. Pictures 2013).

5. *Id.*

6. *Id.*

7. *Id.*

8. *Id.*

9. MATTHEW J. KLEIMAN, THE LITTLE BOOK OF SPACE LAW at 82–83 (2013).

squarely on debris prevention. This Note argues that, until debris removal becomes possible, a relatively simple extension of the Convention on International Liability is a significant step toward solving the problem.

Part II of this article gives an overview of modern space law, a description of space debris and why it is a problem, and what measures the international community is currently taking to address the issue. Part III explains why these efforts have fallen short, and suggests a simple amendment to the Convention on International Liability to discourage debris-creating behavior.

II. Background

The Law of Space

On October 4, 1957, the Soviet Union launched a modified intercontinental ballistic missile into space called Sputnik.[10] Sputnik in Russian means 'travelling companion.'[11] It contained no cameras, sophisticated computing equipment, solar panels, or method of propulsion after reaching orbit.[12] Sputnik's main and only function was to transmit a radio signal providing pressure and temperature readings, as well as the reassurance that the satellite had not yet been hit by a meteorite, natural space debris.[13] Despite it being a global event, the legality of Sputnik's launch was questionable. International air law could not govern Sputnik. If it did, Sputnik would be illegally infringing on multiple foreign states' air space by orbiting over them.[14]

To resolve this, the United Nations in 1958 formed the Committee on the Peaceful Uses of Outer Space (COPUOS).[15] Now a permanent body with seventy-six members,[16] COPUOS has drafted most of the major international space-law treaties. This subsection will summarize the three agreements most pertinent to space debris: the Outer Space Treaty, the Convention on International Liability, and the Convention on Registration.

The Outer Space Treaty of 1967

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies ("Outer Space Treaty"), is the first and, arguably the most significant space law document.[17] As of January 1, 2013, one hundred and two states (including North Korea) are party to the Outer Space Treaty. Twenty-six more have signed the treaty but not ratified it.[18]

---

10. Ron Cowen, *Sputnik + 50: Remembering the Dawn of the Space Age*, 172 SCI. NEWS 216, 218 (2007).

11. *Id.* at 216.

12. *Id.*

13. *Id.*

14. Kleiman, *supra* note 7, at ix.

15. *History and Overview of Activities*, U.N. OFF. FOR OUTER SPACE AFF., http://www.unoosa.org/oosa/en/COPUOS/cop_overview.html (last visited Oct. 4, 2013).

16. *Id.*

17. Heidi Keefe, *Making the Final Frontier Feasible: A Critical Look at the Current Body of Outer Space Law*, 11 *SANTA CLARA COMPUTER & HIGH TECH. L.J.* 345, 349 (1995).

18. Comm. on the Peaceful Uses of Outer Space, Legal Subcomm, Rep. on its 52nd

The Treaty states that outer space "shall be free for exploration and use by all States,"[19] and cannot be conquered as it "is not subject to national appropriation by claim of sovereignty."[20] More recent articles have forbidden the use or placement of weapons of mass destruction in space.[21] Articles 6, 7, and 9 are most important with regard to space debris. These hold, respectively, that states are responsible for their own activities in space, even if conducted by private parties; that states are liable for damage caused by objects launched into space from within their territory; and that states have an obligation to avoid 'harmful contamination' of outer space and celestial bodies.[22]

Key terms, including "harmful contamination" and "space object,"[23] are not defined, causing enforcement issues with the treaty.[24] This will be discussed later in this Note. Nevertheless, the Outer Space Treaty remains the most significant source of law for operations above (or at the outer reaches of) the Earth's atmosphere.

The Liability Convention of 1972

The Convention on International Liability and Damage Caused by Space Objects (the "Liability Convention") took effect in 1973, and expands on Article 7 of the Outer Space Treaty.[25] As of October 2010, ninety states have adopted and twenty-three more have signed the Liability Convention.[26] According to the Convention's terms, launching countries are strictly liable for damage occurring on the ground or to aircraft.[27] Countries that cooperate in the launch of a space object may be jointly liable.[28] There is a one-year statute of limitations on damages claims, which begins after "the occurrence of the damage or the identification of the launching State which is liable."[29]

Article 3 could be a source of space debris regulation. For damage caused in space by another state's space object, liability falls on the launching state "only if the damage is due to its fault or the fault of

---

Sess., Apr. 18–19, 2013, U.N. Doc. A/AC.105/C.2/2013/CRP.5 (Mar. 28 2013).

19. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies art. 1, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205.

20. *Id.* at art. 2.

21. *Id.* at art. 4.

22. *Id.* at art. 6–7, 9 ("States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter.").

23. 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, 614–615 (2011).

24. For instance, legal scholars continue to disagree on whether or not debris constitutes a 'space object.' *See id.*; *see also infra*, pp. 23–25.

25. *See* Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389, T.I.A.S. No. 7762, 961 U.N.T.S. 205 [hereinafter Liability Convention].

26. Imburgia, *supra* note 23, at 616.

27. Liability Convention, *supra* note 25, at art. 2.

28. *Id.* at art. 5.

29. *Id.* at art. 10.

persons for whom it is responsible."[30] While "space object" is defined in the treaty,[31] the term "fault" is not.[32] Because the treaty does not define fault, the international community has generally interpreted 'fault' as "legal fault in the sense that the responsible party acted negligently by violating an established duty of care."[33] This definition creates significant problems when attempting to enforce the treaty.[34]

The Convention does have a defined procedure for resolving these disputes. First, "[a] claim for compensation for damage shall be presented to a launching State through diplomatic channels."[35] If this is not possible, the harmed state "may also present its claim through the Secretary-General of the United Nations."[36] In the event that parties are unable to settle, they must appoint a Claims Commission to resolve the dispute.[37] This Commission is comprised of three members: one nominated by each country, plus one member chosen jointly by both countries.[38] However, the decision of the Claims Committee is not binding, unless both parties agree that it is, and no state ever created a Claims Commission.[39]

The Convention on Registration of 1975

The Convention on Registration of Objects Launched into Outer Space,[40] or 'Registration Convention,' is potentially useful in deterring debris-creating behavior. It requires any state launching a space object to keep a detailed registry of that object, including an identifying registration number, when and from where the object was launched, the object's general purpose, and basic information about the object's orbit.[41] States must give this information to the United Nations (U.N.) "as soon as practicable."[42] The U.N. then enters this information into a publicly-accessible registry.[43]

The convention permits, but does not require, states to update the

---

30. *Id.* at art. 3.

31. "The term 'space object' includes component parts of a space object as well as its launch vehicle and parts thereof." *Id* at art. 1.

32. Ezra J. Reinstein, *Owning Outer Space*, 20 NW. J. INT'L L. & BUS. 59, 59 (1999).

33. Kleiman, *supra* note 9, at 74.

34. *See infra* pp. 25–26.

35. Liability Convention, *supra* note 25, at art. 9.

36. *Id.*

37. *Id.* at art. 14.

38. *Id.* at art. 15.

39. Lauren Bressack, *Addressing the Problem of Orbital Pollution: Defining a Standard of Care to Hold Polluters Accountable*, 43 GEO. WASH. INT'L L. REV. 741, 759–760 (2011). This may be because a Claims Committee's decision is not automatically binding. It may also be because Claims Committees have no specific delegated powers other than the ability to make a final judgment, and thus may not be able to adequately acquire or analyze evidence. *See* Liability Convention, *supra* note 22, at art. 15–20. Note also that only one case has been resolved under the liability convention, and that case ended in settlement. *Id.* at 760 n.128.

40. Convention on Registration of Objects Launched into Outer Space, Jan. 14 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15 (*hereinafter* "Registration Convention").

41. *See id.*

42. *Id.* at art. 4.

43. *Id.*

information in this registry.[44] If a space object breaks apart into debris, the launching state has no duty to tell the U.N. Countries often do not even report launches. Between 2001 and 2003, states registered only seventy five percent of all launches at both the national and international level.[45] Thus, the Registration Convention is far from a bastion of enforcement and adherence that can help deter debris creation.

Space Debris since Sputnik: Where Debris Comes From, and Why it Poses a Threat

Since Sputnik in 1957, nearly every spacecraft has created some sort of debris, be it small pieces that break away from the main craft, or whole components such as used rockets or fuel tanks.[46] Even paint chips can be a potential hazard.[47] While functional spacecraft have evasive maneuver capabilities to avoid collisions with debris,[48] inert debris cannot avoid collisions with other debris. This results in debris-on-debris collisions that result in a substantially increased amount of debris, each piece of debris smaller than before but still potentially dangerous.[49] The frequency of these 'fragmentation events' has increased over the last half-century.[50] Experts estimate that there are currently over "500,000 man-made objects larger than a centimeter, and millions of objects smaller than a centimeter" in orbit around Earth.[51] Only about 1,000 of those objects larger than a centimeter are functional spacecraft.[52]

The Fragmentation Events of 2007 and 2009

Two events in the past six years substantially increased the amount of debris in orbit. The first was a Chinese anti-satellite missile test conducted in 2007.[53] The Chinese government chose a defunct, one-metric-ton weather satellite as their target.[54] Upon striking the satellite, the missile obliterated it.[55] This test was the largest fragmentation event on record, resulting in over 150,000 pieces of debris larger than one

---

44. *Id.* Note, though, that states do have to inform the U.N. once their space objects leave orbit.

45. Imburgia, *supra* note 23, at 618 n.243.

46. *See* Jordan Olliges, *The Impact of Orbital Debris*, ILLLUMIN (Sept. 9, 2013), http://illumin.usc.edu/printer/16/the-impact-of-orbital-debris/.

47. Lawrence D. Roberts, *Addressing the Problem of Orbital Space Debris: Combining International Regulatory and Liability Regimes*, 15 B.C. INT'L & COMP. L. REV. 51, 55 (1992) [hereinafter Roberts, *Addressing the Problem of Orbital Space Debris*] (highlighting an example of the hazards of space debris).

48. *See* Kadhim Shubber, *US Budget Cuts Force Debris-Tracking Space Fence Offline*, WIRED (Aug. 14, 2013), http://www.wired.co.uk/news/archive/2013-08/14/space-fence-shutdown.

49. *See generally* Roberts, *Addressing the Problem of Orbital Space Debris*, *supra* note 43.

50. Olliges, *supra* note 46.

51. Kleiman, *supra* note 9, at 71.

52. *Id.* at 71.

53. *See* T.S. Kelso, *Chinese ASAT Test*, CELESTRAK, http://celestrak.com/events/asat.asp (last updated Sept. 25, 2013).

54. Nat'l Aeronautics & Space Admin., *Fengyun 1-C Debris: One Year Later*, ORBITAL DEBRIS Q. NEWS (Jan. 2008), *available at* http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv12i1.pdf [hereinafter NASA].

55. *Id.*

centimeter.[56] Scientists estimate that 80% of this debris will still be in orbit in 2107.[57] This single incident makes China responsible for almost half of all tracked satellite breakup debris.[58]

The second recent fragmentation event occurred when a defunct Russian satellite collided with an active U.S. commercial satellite.[59] This was the worst accidental collision on record, producing thousands more pieces of debris.[60] The U.S. commercial satellite belonged to a private telephone company called Iridium, and not the U.S. government.[61] The collision caused only a small interruption in Iridium's phone service.[62] However, since the satellite was launched from the United States, the Liability Convention implies that the U.S. government may be liable for damage caused by its debris.[63]

The Physics and Orbital Dynamics of Space Debris

Objects in orbit around the Earth travel very, very quickly, and space debris is no exception. Orbital velocities of debris range from 11,000 to 35,000 kilometers per hour,[64] up to twenty-eight times the speed of sound. A piece of debris weighing only two grams and traveling 35,000 kilometers per hour could hit a spacecraft with the force of one thousand tons of TNT.[65]

While larger pieces of debris strike with greater force, even near-microscopic debris can pose a serious threat.[66] Tiny chunks of debris—such as paint chips—can, and have, caused damage to spacecraft.[67] In fact, a one-centimeter piece of debris could be enough to penetrate the

---

56. *Id.*

57. Kelso, *supra* note 50.

58. NASA, *supra* note 49. Note that only a small portion of total debris is tracked.

59. *See* Veronika Oleksyn, *What a Mess! Experts Ponder Space Junk Problem*, USA TODAY, (Feb. 19, 2009), http://usatoday30.usatoday.com/tech/science/space/2009-02-19-space-junk_n.htm.

60. Traci Watson, *Two Satellites Collide 500 Miles over Siberia*, USA TODAY, (Feb. 12, 2009), http://usatoday30.usatoday.com/tech/science/space/2009-02-11-satellites_N.htm.

61. *Id.*

62. *Id.*

63. *See infra* notes 146–156 and accompanying text.

64. Roberts, *Addressing the Problem of Orbital Space Debris*, *supra* note 47, at 55. Speed depends heavily on how close the object's orbit is to the Earth.

65. *See generally* Lucinda R. Roberts, *Orbital Debris: Another Pollution Problem for the International Community*, 11 FL. J. INT'L L. 613, 615–16 (1997). The damage such a collision would cause depends on several factors, the first being the relative velocities of the debris and the spacecraft. If the craft is moving in the opposite direction of the debris, the force on impact could double, analogous to a head-on automobile collision. Damage inflicted will also vary with the angle of impact and how close the impact site is to the spacecraft's center of mass. *See* Meghan R. Plantz, *Orbital Debris: Out of Space*, 40 GA. J. INT'L & COMP. L. 585, 595 (2012).

66. *See supra* note 47 and *infra* note 67 and accompanying text.

67. *See* Robert C. Bird, *Procedural Challenges to Environmental Regulation of Space Debris*, 40 AM. BUS. L.J. 635, 640 (2003) (noting that in 1983, a 0.2 mm paint chip stuck a window of the space shuttle *Challenger*, causing $50,000 in damage and requiring a replacement window).

International Space Station and kill its crew.[68] Debris of this size cannot be effectively detected or avoided.[69] Large numbers of small collisions can cause damage or corrosion, which can wear down important observational equipment,[70] or even render spacecraft inoperable.

According to several NASA scientists, the number of pieces of debris will continue to increase even without any additional spacecraft being launched:

> Even without new launches, collisions will continue to occur in the LEO [low-Earth orbit] environment over the next 200 years, primarily driven by the high collision activities in the region between 900-and 1000-km altitudes, and will force the debris population to increase. In reality, the situation will undoubtedly be far worse because spacecraft and their orbital stages will continue to be launched.[71]

This prediction came in 2006, *before* the Chinese missile test and the Russo-U.S. satellite collision. Those events have accelerated the debris-propagation process. Further compounding the problem, debris tends to remain in orbit for many years (depending on what level of orbit it originated in) before its orbit decays and it begins an atmospheric descent or drifts into outer space.[72] Based on the present level of debris, some estimate that it would take anywhere from one to ten million years for space in Earth's orbit to clear entirely.[73]

Lastly, it is worth noting that collisions and discarded parts are not the only sources of debris. Satellites at the end of their life cycle are often simply left in crowded orbits.[74] These crafts "cannot realistically carry enough extra propellant to move into an atmospheric disposal orbit at the end of their useful lives."[75] Crafts may be able to move themselves into a less-populated orbit,[76] decreasing the chance that they will collide with any active craft or break up into debris. Nevertheless, evidence shows that most satellite operators simply do not do this.[77] The European Union found that in 2009, only 11 of 21 satellites at the end of their lifespan were actually relocated to a higher, less-popular orbit.[78] As discussed below, this happens despite non-binding international guidelines that

---

68. *Id.* at 641.

69. Plantz, *supra* note 65, at 596.

70. Roberts, *Addressing the Problem of Orbital Space Debris*, *supra* note 47, at 55–56.

71. J.C. Liou & N.L. Johnson, *Risk in Space from Orbiting Debris*, 311 SCIENCE 340, 340 (2006).

72. *See infra* note 73 and accompanying text.

73. Mary Button, *Cleaning up Space: The Madrid Protocol to the Antarctic Treaty as a Model for Regulating Orbital Debris*, 37 WM. & MARY ENVTL. L. & POL'Y REV. 539, 547 (2013).

74. Kleiman, *supra* note 9, at 81–82.

75. *Id.* at 82. Atmospheric disposal orbit is defined as an orbit that would cause the spacecraft to harmlessly break up in the atmosphere. *Id*.

76. *Id.* at 82.

77. *See infra* note 78 and accompanying text.

78. *See* R. Choc and R. Jehn, *Classification of Geosynchronous Objects*, 12 EUR. SPACE AGENCY (2010) *available at* http://lfvn.astronomer.ru/files/COGO-issue12.pdf.

require satellite removal.[79] Whether by collision-caused fragmentation, abandonment of defunct spacecraft in orbit, or just paint chipping off of satellites, the amount of space debris in orbit is rapidly increasing, and it will all stay in orbit for potentially a million years or more.[80]

Space in Earth's Orbit is Limited

Outer space is vast, perhaps infinitely large; however the space around Earth in which satellites can actually be useful is finite.[81] Orbital paths around the Earth are primarily differentiated by their speed and distance from the Earth's surface,[82] so satellites are placed in different orbits depending on their purpose. A satellite designed for taking high-resolution photographs requires a comparatively low orbit, whereas a higher orbit will better serve a telecommunications satellite in order to draw line of sight to more of the Earth's surface.[83] There are three commonly used orbital paths.[84] They are known as low-Earth orbit (LEO), medium-Earth orbit (MEO), and geosynchronous Earth orbit (GEO).[85]

GEO requires a brief explanation. While in GEO, a spacecraft orbits Earth at the same speed Earth turns.[86] Spacecraft in GEO thus remain above a fixed point on the Earth's surface. This feature, combined with the height of the orbit, makes it useful for telecommunications satellites.[87] Space within this orbit is limited, because satellites must maintain a precise distance (22,236 miles) from the Earth's surface.[88]

Though half of all active satellites are in LEO,[89] GEO is the most regulated, and comes under the purview of the International Telecommunications Union (ITU), a 193-member U.N. agency.[90] The ITU's process is complicated, but essentially they assign discrete orbital 'slots' to ITU member states who apply for them, and those states cannot launch more spacecraft once their 'slots' are used up.[91] The regulatory details show that orbital space is finite, and that there has been some regulatory success at limiting the number of *active* spacecraft in orbit.[92]

---

79. *See infra* notes 122–125, 129–136 and accompanying text.

80. *See supra* notes 64–75 and accompanying text.

81. *See infra* notes 82–88 and accompanying text.

82. Kleiman, *supra* note 9, at 51.
83. *Id.*
84. *See infra* note 85 and accompanying text.

85. Kleiman, *supra* note 9, at 51.
86. *Id.* at 53.
87. *Id.* at 53.
88. *Id.*
89. *Id.* at 52.
90. *Id.*

91. *See id.* at 61–62.
92. *See supra* notes 86–91 and accompanying text.

The Impact of Space Debris: The Kessler Syndrome and other Less-Severe Predictions

Access to Earth's orbit is important for a variety of reasons. Satellite telecommunications companies comprise a $180 billion-dollar-per-year global industry,[93] and therefore damage to satellites could have major economic consequences. Apart from the loss of corporate revenues, losing telecom satellites harms the people who rely on them both in their career and in their lives. The 2009 satellite collision provides a good example of an incident that could have had far harsher consequences. Iridium, the company whose satellite was destroyed, provided phone service to workers on offshore oil platforms.[94] Those workers rely on satellites to communicate with the outside world. The 2009 collision temporarily interrupted phone service, but a series of such collisions could have resulted in longer communication failures with the outside world.[95] If the rate of collisions increases, people in similarly isolated areas could see their communications equipment malfunction as well. Data transmission via the internet could also be harmed. Even people in densely populated areas might have to resort to slower, shorter-ranged methods of communication.

Many developed states, the U.S. in particular, depend on satellites for national security.[96] Satellites are vital to modern military intelligence-gathering and navigation. Satellite-powered GPS guidance is vital to ensuring that guided missiles and bombs hit their targets.[97] In a 2006 hearing, members of Congress addressed the issue of satellites and national security:

Lieutenant General C. Robert Kehler, then the Deputy Commander, United States Strategic Command, stated that "space capabilities are inextricably woven into the fabric of American security." He added that these space capabilities are "vital to our daily efforts throughout the world in all aspects of modern warfare" and discussed how integral space capabilities are to "defeating terrorist threats, defending the homeland in depth, shaping the choices of countries at strategic crossroads and preventing hostile states and actors from acquiring or using WMD."[98]

The U.S. and the international community at large have a vested interest in keeping debris from crowding satellites out of orbit. Scholars have provided several scenarios that detail the gravity of the situation, and how conditions may develop if present policies remain in place.[99]

The Kessler Syndrome: The Worst-Case Scenario

---

93. Kleiman, *supra* note 9, at 60.

94. Watson, *supra* note 60.

95. *See supra* notes 59–61 and accompanying text.

96. *See* Imburgia, *supra* note 23, at 608–12.

97. *See generally id*.

98. *Id.* at 609–10 (quoting Space and U.S. Nat'l Power: Hearing Before the Subcomm. on Strategic Forces of the H. Comm. on Armed Servs., 109th Cong. (2006) (statement of Lt. Gen. C. Robert Kehler, Deputy Commander, U.S. Strategic Command)) (footnotes omitted).

99. *See infra* notes 100–112100 and accompanying text.

The Cascade Effect, more popularly known as the Kessler Syndrome, comes from a 1978 paper by NASA scientist Donald Kessler.[100] The basic hypothesis is that, initially, most of the debris in orbit will be made up of larger objects.[101] Those objects will collide, producing more and more fragmentation, which in turn makes subsequent collisions more likely.[102] Since debris stays in orbit for over a million years there will be exponential growth in the amount of orbital debris, as more collisions create more debris, which in turn creates more collisions.[103] This could "eventually produce an impenetrable cloud of fragmentation debris that will encase Earth," making space travel nearly impossible.[104]

In a 2010 paper, Kessler and several NASA scientists revisited these predictions using more advanced mathematical models. They concluded that the Cascade Effect is still a substantial threat to spacecraft in orbit, even with no additional spacecraft launches.[105] Their models suggest that, over the next fifty years, the number of major collisions could triple that of the last fifty years, with further increases still possible.[106] The timeframe for the gradual increase in space collisions is very uncertain, with some predictions holding that the collision cascade could begin as soon as in a decade.[107] Therefore, actions must be taken now in order to mitigate the risk of a collision cascade and its consequences.

Other Predictions are Less Severe, but Still Dire

The Inter-Agency Space Debris Coordination Committee (IADC), an organization comprised of members of government space agencies from around the globe, recently published a summary of multiple predictive models for debris growth.[108] Using optimistic assumptions,[109] six different governmental agencies (including NASA, the European Space Agency, and the United Kingdom Space Agency) submitted predictive models.[110] All models returned similar results, and generally predicted a thirty percent increase in the debris population over the next

---

100. Donald J. Kessler et al., *The Kessler Syndrome: Implications to Future Space Operations*, 33d Annual AAs Guidance and Control Conference, Paper AAS 10-016, at 1 (Feb. 2010), *available at* http://webpages.charter.net/dkessler/files/Kessler%20Syndrome-AAS%20Paper.pdf.

101. *See id.* at 2 ("[T]he two objects will eventually collide and break up into a number of smaller fragments.").

102. *See id.* at 2–8 (creating a model for calculating the rate of collision and explaining the consequences of collisions).

103. *See generally id.* at 2 (explaining the concept of collisional cascading effect).

104. Mark J. Sundahl, *Unidentified Orbital Debris: The Case For a Market-Share Liability Regime*, 24 HASTINGS INT'L & COMP. L. REV. 125, 132 (2000).

105. Kessler, *supra* note 100, at 6.

106. *Id.* at 6.

107. Imburgia, *supra* note 23, at 598.

108. J.C. Liou et al., *Stability of the Future LEO Environment*, IADC–12–08 INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE 1 (2013), *available at* http://www.iadc-online.org/Documents/IADC-2012-08,%20Rev%201,%20Stability%20of%20Future%20LEO%20Environment.pdf.

109. For instance, all models assumed a 90% compliance rate with guidelines for removing defunct satellites from orbit. *Id.* at 2. Of course, the actual compliance rate with those procedures is more like 50%. *See* Choc, *supra* note 78, at 126.

110. Liou et al., *supra* note 108, at 2.

two hundred years, with catastrophic (spacecraft-disabling) collisions occurring every five to nine years.[111] These models made unrealistic assumptions about compliance with debris-mitigation guidelines. The study itself concluded that "-[t]he 90%-compliance assumption made in the simulations is certainly higher than the current reality. If the international community cannot reach this level soon, future debris population growth will be far worse than the AI 27.1 study results."[112] Without urgent action, even conservative models predict dire consequences for spacecraft in orbit.

Current Efforts to Mitigate Space Debris

In general, there are three types of programs currently underway to prevent the impact of space debris. Those programs are debris tracking, debris prevention, and debris removal.

Debris Tracking

Debris tracking focuses on monitoring the location of debris so as to avoid collisions with active spacecraft. The U.S. maintains the most effective debris-tracking program in the world. The U.S. program is capable of tracking objects five centimeters in diameter and larger in LEO, and objects one meter in diameter or larger in GEO.[113] The U.S. makes most of this data publicly available, so corporations or other states can also use it to avoid collisions.[114] The European Union (EU) is putting together a space-monitoring program of its own. Several private organizations have also agreed to share debris-tracking data to preserve their satellites.[115] These orbital monitoring programs are helpful, but far from perfect.

First, recent budget cuts have forced the U.S. to shut down important parts of its monitoring network. Most significant was the shutdown of the Air Force Space Surveillance System, known as the 'space fence,' which was recently deactivated to save fourteen million dollars per year.[116] Unlike other radar systems, which must be tasked to look at specific areas of space, the space fence could simultaneously track debris over several extremely large areas.[117] It was considered a "key part"[118] of the U.S. surveillance program, important for general awareness of the debris environment in Earth orbit. The fence was shut down on September 1, 2013.[119] The extent of damage to U.S. efforts to detect and avoid debris caused by the shutdown is unclear.

---

111. *Id.* at 17.

112. *Id.*

113. *Space Debris and Human Spacecraft*, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (Sept. 27, 2013), http://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

114. Kleiman, *supra* note 9, at 76.

115. *Id.* at 76–77.

116. Kadhim Shubber, *US Budget Cuts Force Debris-Tracking Space Fence Offline*, WIRED.CO.UK (Aug. 14, 2013), http://www.wired.co.uk/news/archive/2013-08/14/space-fence-shutdown (last visited Sept. 8, 2013).

117. *Id.*

118. *Id.*

119. *Space Fence Discontinued, Spaceweather.com (Sept. 1, 2013), http://spaceweather.com/archive.php?view=1&day=01&month=09&year=2013.*

The second problem is that current surveillance cannot detect most debris. The U.S. system currently tracks twenty two thousand pieces of debris.[120] Yet, scientists estimate that there are over five hundred thousand pieces of debris larger than a centimeter in orbit.[121] Since even small pieces of debris can inflict severe damage on spacecraft, it is clear that current monitoring systems are helpful, but nowhere near effective enough to make orbit entirely safe.

Debris Mitigation

There exist both domestic and international 'codes of conduct' aimed at preventing additional space debris. The U.S. was the first country to issue such domestic guidelines.[122] The Orbital Debris Mitigation Standard Practices outline a number of goals, including selecting safe flight profiles, and safely disposing of defunct spacecraft.[123] Since the U.S. created these regulations in the late 1990s, other countries, including the EU and Russia, have adopted similar regulations.[124] These regulations have helped curb debris-related damages. However, since any state's space operations indirectly affect those of all other states, an international regime is necessary to regulate space effectively.[125] Differing domestic regulations complicate dispute resolution, and make it difficult to answer several questions. Could states be liable for debris-related damages if they violated the victim state's regulations? Or would they only be liable for breaking their own regulations? What administrative bodies would have jurisdiction over these disputes? Furthermore, individual states cannot solve the problem on their own—all spacefaring countries need to regulate their behavior.[126]

International mitigation guidelines do exist, and they mostly originate from the IADC. The IADC implemented its own guidelines in 2002.[127] These same guidelines, with very minor alterations, were adopted by the full U.N. General Assembly in 2007.[128] These guidelines set out seven generic recommendations which are non-binding, such as "limit the probability of accidental collision in orbit" and "avoid international destruction and other harmful activities."[129] Evidence indicates that compliance with these recommendations is quite

---

120. Kleiman, *supra* note 9, at 71.

121. *Id.* at 71.

122. *Id.* at 77.

123. *See* U.S. GOVERNMENT ORBITAL DEBRIS MITIGATION STANDARD PRACTICES 1–3, *available at* http://orbitaldebris.jsc.nasa.gov/library/USG_OD_Standard_Practices.pdf.

124. Kleiman, *supra* note 9, at 78.

125. *See* Button, *supra* note 65, at 557–58 ("A nation cannot put an object into space without at least a possibility that it could come into contact with an object from another nation.").

126. *Id.*

127. Kleiman, *supra* note 9, at 78.

128. G.A. Res. 62/217, ¶ 26, U.N. Doc. A/RES/62/217 (Dec. 22, 2007).

129. Rep. of the Comm. on the Peaceful Uses of Outer Space, 50th Sess., June 6–15, 2007, at 49, U.N. Doc. A/62/20; GAOR, 62d Sess., Supp. No. 20 (2007), *available at* http://www.oosa.unvienna.org/pdf/gadocs/A_62_20E.pdf.

infrequent.[130]

Debris Removal

Effective debris removal is not possible with current technology.[131] Large pieces of debris, such as defunct satellites, could be removed individually by a revival of the Space Shuttle program, or the Russian Soyuz.[132] However, such an endeavor would be both time-consuming and costly. Debris smaller than five inches in diameter is undetectable to the U.S. space-monitoring network, and thus impossible to remove in any organized manner. Even if these fragments were detectable, with the sheer number of them, removal would require a massive expansion of international space operations. Other proposals, such as building "ground-based 'laser brooms' to sweep debris from orbit,"[133] are even less feasible. Until technology improves, the world cannot fix its past mistakes—it can only avoid making them again.

III. Analysis

Current Law Fails to Prevent Debris Buildup and Avert Collisions

Given the current impossibility of debris removal, debris mitigation and detection are the only ways to preserve Earth's orbit for future use. Current debris mitigation and monitoring programs are well-intentioned, but ultimately ineffective.

Most Debris Mitigation Standards are Non-Binding

The debris-mitigation standards adopted by the U.N. are useful, and could well work if they were enforceable. The IADC estimates that, with a ninety percent compliance rate with these mitigation guidelines, the orbital debris population will grow by only about thirty percent over the next two hundred years.[134] This is not ideal, but such measures would allow for continued space operations, and would partially stave off what the Kessler Syndrome predicts. But the U.N. standards are guidelines, not rules.

Even states that openly approve of these guidelines do not always follow them. In 2009, Russia left three defunct satellites to drift in GEO, and in 2008, the U.S. and Russia each left one satellite in GEO.[135] Even

---

130. *See* Liou et al., *supra* note 91, at 17 ("The 90%-compliance assumption made in the simulations is certainly higher than the current reality. . . If the international space community cannot reach this level soon, future debris population growth will be far worse. . . ."); *see also* European Space Agency, *supra* note 69 at 126 ("Only 11 were reorbited more than 250 km above GEO and complied with the IADC reorbiting guidelines.").

131. Imburgia, *supra* note 23, at 626–29; *see generally* Kleiman, *supra* note 9, at 82–83.

132. Imburgia, *supra* note 23, at 627.

133. Kleiman, *supra* note 9, at 82. These 'laser brooms' would entail "focusing a mid-powered laser through a telescope to shine on pieces of orbital debris that look like they're on a collision course," which could nudge the debris sufficiently to avert collisions or even get it out of orbit entirely. Lisa Grossman, *NASA Considers Shooting Space Junk with Lasers*, WIRED.COM (Mar. 15, 2011), http://www.wired.com/wiredscience/2011/03/lasering-space-junk/ (last visited June 9, 2014).

134. Liou et al., *supra* note 71, at 17.

135. *Drifting in GEO*, 14 Orbital debris Q. News 3, at 3 (2010), *available at* http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv14i3.pdf..

if these satellites never collide with other space objects, they take up valuable GEO ‘slots.’ This data also shows that the U.S. often fails to follow its *own* regulations, which require responsible disposal of satellites. Globally, only one in three satellites in GEO is put into a graveyard orbit.[136] If the U.S. often fails to comply with the U.N. guidelines, imagine what compliance rates will be like for countries that are more cavalier in their approach to space operations, such as China, the state that deliberately destroyed a satellite in orbit.

Non-mandatory provisions such as these *could* “become binding customary law through repeated practice over time,”[137] but this is unlikely in a world where states do not actually follow them. The EU in 2008 proposed a binding code of conduct, which would, among other things, require states to do two things. First, it would require states to not intentionally destroy orbital objects. Second, it would require states to implement policies to comply with the IADC guidelines.[138] The U.N. supported adoption of the code, but the U.S., though initially favoring adoption, reversed its position in 2012.[139] U.N. negotiations on a revised version of the EU code have begun,[140] but may not make much progress. Chinese resistance is a daunting obstacle, as China has classified the issue of space debris as a “low priority”, especially given its position that “the behavior encouraged by the Code of Conduct would seem to run contrary to current Chinese interests.”[141]

Binding Treaties are Imprecise, Unclear, and Often Unenforceable

The Outer Space Treaty is the most important source of space law.[142] Article 9 of that Treaty prescribes that states have an obligation to avoid “harmful contamination” of space.[143] This provision could be construed to mitigate the effects of space debris. On the other hand, “harmful contamination” could have several alternate meanings.

Some legal scholars believe that it might refer to harmful contamination of the Earth, and thus bans bringing back harmful extraterrestrial material.[144] This is unlikely. The passage in question reads: “States Parties to the Treaty shall . . . conduct exploration of [outer space, including the moon and other celestial bodies] so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter . . . .”[145] This provision specifically refers to changes in the Earth’s environment, which would seem to include contamination of the

---

136. Plantz, *supra* note 65, at 608.
137. Imburgia, *supra* note 23, at 625.
138. Kleiman, *supra* note 9, at 79.
139. *Id.* at 80.
140. *Id.*
141. Michael Listner, *Code of Conduct: Corrections, Updates, and Thoughts Going Forward*, The Space Rev. (June 18, 2012), www.thespacereview.com/article/2101/1.
142. *See generally* Outer Space Treaty, *supra* note 19.
143. *See id.* at art. 9.
144. Imburgia, *supra* note 23, at 615.
145. Outer Space Treaty, *supra* note 19, at art. 9.

Earth's surface. Therefore, unless the reference to "harmful contamination" is redundant with the 'Earth's environment' clause, it must mean something different than contamination of the Earth's surface. These competing interpretations show how confusing the Outer Space Treaty can be. At least one legal scholar even suggests that "harmful contamination" may not include debris at all, and refers only to astronauts and active spacecraft.[146]

Article 7 of the Outer Space Treaty states that a State Party launching a space object "is internationally liable for damage to another State Party to the [Outer Space] Treaty or to its natural or juridical persons by such object or its component parts . . . ."[147] The two critical terms in this Article—"object" and "component parts"—are undefined.[148] "Object" could include debris, or could include active spacecraft and astronauts only. "Component parts" could include debris as well—any and all fragments of a space object. The treaty uses the word "component" rather than some clearer descriptor such as "all," and thus the term may simply refer to larger sections of spacecraft such as rocket boosters or fuel tanks.[149] Because Article 7 of the Outer Space Treaty mentions both "objects" and "component parts," the two terms presumably have different meanings. Nonetheless, there are no legally-binding authorities on what those meanings might be. There has never been any "litigation over damage caused by space debris and other objects in outer space,"[150] and consequently there is no relevant case law to draw upon. The all-important Outer Space Treaty, marked by a distinct lack of definitive terms, has limited use to the international community in addressing space debris.

Furthermore, the Outer Space Treaty would actually hinder active debris removal, should technology ever allow such efforts. Article 8 prescribes that States Parties maintain control over their launched objects and their component parts forever.[151] Hence, states would not be legally able to remove another state's debris without asking for specific permission.[152] This would make removal efforts even more costly and time-consuming, and possibly transform such efforts into another arena for international politics. A country could, for instance, only allow other states to remove its space debris if they made certain political concessions. This provision should at some point be revised, but this is not an immediate priority, because the international community currently lacks the technology to remove orbital debris under any legal regime.

The Liability Convention has problems similar to those of the Outer Space Treaty.[153] The Liability Convention defines "space object" to

---

146. *See* Imburgia, *supra* note 23, at 615 (citing Christopher D. Williams, *Space: The Cluttered Frontier*, 60 J. AIR L. & COM. 1139, 1145 n.31 (1995))..

147. Outer Space Treaty, *supra* note 19, at art. 7.

148. *See* Imburgia, *supra* note 23, at 615. *See generally* Outer Space Treaty, *supra* note 19.

149. *See* Imburgia, *supra* note 23, at 615.

150. KLEIMAN, *supra* note 9, at 73.

151. *See* Outer Space Treaty, *supra* note 19, at art. 8.

152. KLEIMAN, *supra* note 9, at 83.

153. *See generally* Liability Convention, *supra* note 25.

include “component parts of a space object as well as its launch vehicle and parts thereof.”[154] However, like the Outer Space Treaty, the Liability Convention fails to define the term “component parts.”[155] This means that a “component part” might only be a major component, such as a rocket booster, or it could include any small piece of an object which might break away. A more important problem with the Liability Convention is its use of the term “fault.”[156] The Liability Convention imposes strict liability on states whose space objects cause damage on the ground or in the Earth’s atmosphere.[157] However, it requires a determination of fault before assigning liability for damage to other objects in space.[158] The Liability Convention does not define the term “fault,” but it is understood to mean a breach of a legal duty.[159] This fault-based liability scheme becomes problematic when no specific legal duties exist. States have no way of knowing when they will be at fault, or what behaviors they must follow to avoid liability. The codes of conduct described earlier in this Note do set standards of behavior,[160] but none of them are linked in any legal way to the Liability Convention.

The Liability Convention has proved toothless even in egregious cases, such as the 2007 Chinese missile test. Despite that test’s devastating and predictable consequences for the debris population, no charges have been brought, and no action has been taken. In fact, the Liability Convention has only been used once.[161] A Soviet satellite crashed in Canada in 1978, and the Canadian government used the Liability Convention to bring a lawsuit.[162] The suit settled a few years later for three million Canadian dollars.[163] The Liability Convention thus does have some utility, but it has never been used to hold a state accountable for damage caused to objects in space.

Another issue is that the Liability Convention only applies to damage dealt directly to people or objects.[164] This became relevant in the case of the above mentioned Soviet satellite crash. Upon impact, the Soviet satellite did not harm any people or objects—the damage done

---

154. *Id.* at art. 1(d).

155. *See id.* at art. 1.

156. *See generally id.* at arts. 3, 4.

157. *See id.* at art. 2 (“A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight.”).

158. *See id.* at art. 3 (“In the event of damage being caused elsewhere than on the surface of the-earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault of the fault of persons for whom it is responsible.”).

159. Bressack, *supra* note 39, at 757.

160. *See* supra Part III.A.1.

161. Plantz, *supra* note 65, at 606 (citing 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, 15 (2009)).

162. Button, *supra* note 73, at 553–54.

163. *See id.*

164. *See* Imburgia, *supra* note 23, at 617 (quoting Nandasiri Jasentuliyana, *Space Debris and International Law*, 26 J. SPACE L. 139, 143 (1998)). *See generally* Liability Convention, *supra* note 25, at art. 2.

was exclusively to the Canadian landscape.[165] The only costs incurred by the Canadian government were clean-up costs, but these were quite substantial, amounting to fourteen million Canadian dollars.[166] Canada likely settled for three million Canadian dollars simply because it was unsure that the Liability Convention would actually hold the Soviet Union accountable for debris-related damage.[167] Debris in orbit can also indirectly cause injuries or additional expenses, such as "launch delays or collision-avoidance maneuvers."[168] These are expensive and inconvenient, but the Liability Convention would not help states recover damages for these injuries alone.

Lastly, the Liability Convention requires effective surveillance to function, because a party that sustains damage must know where the debris that harmed it came from. As discussed above, most debris is too small to be detected.[169] Collisions are often unexpected, almost by definition. Most spacecraft can move out of the way of a piece of oncoming debris if the spacecraft's controlling organization has enough warning. In the aftermath of a collision, it may be impossible to tell which piece of debris caused it. Even with that information in hand, the aggrieved state would then have to find out what country created the precipitating debris. This is difficult,[170] which is why the Liability Convention may only be effective at assigning blame for collisions caused by large, easily-monitored debris.

Potentially, the Registration Convention can ensure enforcement of the Liability Convention, because catalogued debris will facilitate investigation as to which state's debris caused what collision.[171] Unfortunately, the Registration Convention has its own difficulties. First, there are no penalties for not registering launches or other space operations with the UN.[172] This may create a perverse disincentive to registration. It is much harder to hold states accountable for any debris they create if they do not register their launches and other space operations. Indeed, most states do not fully comply with the Convention, and many spacecraft or parts thereof go unregistered.[173] States *can* request the aid of other states in identifying certain pieces of debris.[174] However, in light of the limits of debris monitoring, this is unlikely to be

---

165. Plantz, *supra* note 65,, at 606 (citing Beck, *supra* note 161, at 15).

166. *See id.*

167. *Cf. id.* (stating that the Soviet Union paid Canada C$3 million, and that there was uncertainty whether the Soviet Union was liable under the Liability Convention).

168. *See* Imburgia, *supra* note 23, at 617.

169. *See supra* Part II.E.1.

170. *See* Imburgia, *supra* note 23, at 617 (quoting Jasentuliyana, *supra* note 164, at 313) ("[The assumption that the launching state of any given space object will be easily identifiable] is quite clearly not the case.").

171. *See generally* Registration Convention, *supra* note 40.

172. Button, *supra* note 73, at 554 (quoting JAMES E. DUNSTAN & BOB WERB, LEGAL AND ECONOMICS IMPLICATIONS OF ORBITAL DEBRIS REMOVAL: COMMENTS OF THE SPACE FRONTIER FOUNDATION, 5 (2009), *available at* http://www.scribd.com/doc/23379988/Legal-and-Economics-Implications-of-Orbital-Debris-Removal).

173. *See id.*

174. *See* Registration Convention, *supra* note 40, at art. 6.

of much help.[175]

Even when states comply with the Registration Convention, it may not be effective at preventing debris. The Registration Convention requires registration "as soon as practicable,"[176] but never defines when that is.[177] Spacecraft could be in orbit for some time before they are registered, even if the launching country does eventually comply with the Registration Convention. Furthermore, the Convention is unclear on whether or not states need to register anything beyond active spacecraft.[178] States can thus essentially choose how and when they comply with the Registration Convention, further limiting its effectiveness.

A Potential Solution: Establish Strict Liability for All Damage Caused by Space Operations by Modifying the Liability Convention.

As the above Section demonstrates, space debris is a complicated problem with no quick or easy solutions. No one proposal can solve everything. As the predictions above show, even stopping all future spacecraft launches would do little to mitigate the dangers of current debris, and would not do much to clear the Earth's orbit, at least not quickly. The international community must focus on practical, albeit imperfect, policies that limit debris growth until a way to remove debris can be found.

Perhaps the simplest solution is to amend the Liability Convention so that "fault" is no longer required for liability for damage in space.[179] States would be strictly liable for all damage their debris causes, whether that damage happens in orbit or on the ground. This was actually proposed when the Liability Convention was being drafted, but it was met with "universal disapproval."[180] This idea was disfavored in the 1990s, because it seemed politically impossible.[181] Discussion of such a solution has abated in the last ten to fifteen years. Given the current severity of the problem, now is the time to revisit this admittedly harsh option.

Faultless Strict Liability acts as a Deterrent, Promoting Caution among States Engaged in Space Operations

Should the treaty be amended to remove the fault requirement, all participating states will have the motivation to act cautiously in their handling of space operations. Satellites and spacecraft are expensive, and so the financial burden of replacing a damaged or destroyed spacecraft would be very heavy. Debris creation would become a risky activity. Since debris is impossible to control, states would have to focus on

---

175. *See* Button, *supra* note 73, at 554.

176. *See* Registration Convention, *supra* note 40, at art. 6.

177. *See* Imburgia, *supra* note 23, at 618. *See generally* Registration Convention, *supra* note 40.

178. *See* Imburgia, *supra* note 23, at 619.

179. *E.g.*, 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. 447, 460–61 (1992) (discussing the imposition of strict liability, and citing to commentators who have made this proposal).

180. *Id.* at 461.

181. *See id.* at 463.

minimizing the amount of debris that they create. Unlike current international law, concrete financial incentives would ensure satellites go into a declining orbit, and are not simply left in high-traffic orbital lanes. Participating countries would have to carefully weigh the costs and benefits of each individual space operation, and may abandon those launches that create or risk creating substantially more debris.

This would also encourage states to monitor private parties that come under their sovereign rule. The Liability Convention already holds countries accountable for the actions of private parties within their borders. States which host large satellite telecommunications businesses, such as the United States, would have strong incentives to force those companies to abide by debris-mitigation guidelines. Companies could perhaps move their launches to countries with laxer regulations, in what game theorists have termed a *race to the bottom*. This is unlikely, though, because the only states with the infrastructure necessary to support such launches are large, developed countries, most of which tend to obey international law.

Strict Liability Encourages Investment in Debris-Monitoring and Debris-Removal Technologies

Debris monitoring is useful, but extremely limited, and debris removal is effectively impossible. Strict liability would give countries several distinct incentives to enhance their debris-monitoring efforts. First, monitoring their own debris can help countries avoid liability for collisions. If a country sees that their debris may soon collide with a spacecraft of another country, the two countries can work together to avoid that collision—and thus avoid any liability. Because wealthier countries—such as the United States—are responsible for most of the existing debris, they will have the most motivation to step up their monitoring efforts. In this way, the monitoring costs may be borne by those most able to bear them.

As one commentator has argued, "[a]lthough the current orbital debris problem is a result of international production, the primary responsibility must rest squarely on the spacefaring states who launch the greatest number of objects into space."[182] This liability scheme would move toward that goal. Certainly, the United States would be less likely to continue shutting down large debris-monitoring radar arrays in the name of cost reductions.

A second incentive to develop better monitoring capabilities is that doing so would enhance a state's ability to provide evidence when bringing claims under the Liability Convention. With sufficient monitoring capabilities, a state would only need to prove that (1) a damaging collision occurred, and (2) the debris that caused the collision came from one specific country. Debris monitoring would thus become a way to defend a state's investment in a space object. Close monitoring for liability purposes could mean that proof of a country's liability, and

---

182. Peter T. Limperis, *Orbital Debris and the Spacefaring 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, 336 (1998).

thus its responsibility to cover damages, becomes readily available.

Strict liability creates similar incentives to invest in debris removal. Given the inexorable increase in the debris population, even without the launch of new spacecraft, removal is the only long-term way to stabilize the debris environment. As long as debris collisions produce more debris, countries' exposure to liability will increase. The threat of liability may encourage research on debris removal methods and related technologies. It is not possible to chart the course of technological advancement today, and it is equally impossible to guess when a solution to the problem of debris removal will be available. But the process must begin as soon as possible. The threat of strict liability could serve to kick-start the required research.

Perhaps the most powerful argument *against* strict liability is that it does not protect against debris that is too small to monitor, or debris of unknown origin.[183] That is a troublesome shortcoming, and doubtless there will be many collisions caused by unidentified debris. Debris cascades may worsen this. Imagine, for example, that object A collides with object B, creating debris which collides with object C, which in turn breaks up and damages object D. This chain of events could be very difficult to monitor. However, the incentives described above partially mitigate this issue—if countries can create better monitoring programs in order to "defend"' their spacecraft, and if the incentives to share data are sufficiently strong, then monitoring could become much more effective than it is today.

Strict Liability Minimizes Transaction Costs, Making Debris Lawsuits More Likely

For this regime to have any force within the international community, litigation must be a credible threat. With a fault-based system, disputes could drag on for prolonged periods of time, and aggrieved states bear a substantial risk of losing on the fault question itself. These costs could deter litigation. With strict liability, an easily interpreted legal standard would emerge, and the evidence needed to win would be objective and fact-based. If the accused state created the precipitating piece of debris, it is liable. This leaves less room for legal maneuvering, and facilitates efficient adjudication. Faster judgments are not always a good thing, but are at least partially justified by the "abnormally dangerous or ultra-hazardous character of space activities."[184] There may be rare cases in which an innocent country is forced to pay for damages, but the severe consequences of ignoring the debris problem compensate for this eventuality. Provided they have the monitoring data, even poorer countries should be able to bring and win a lawsuit over debris-related damages in space.

The costs of writing the amendment are also worth considering. Changing a few words in the Liability Convention could be done cheaply and quickly. Any other solution would likely require creating an entirely

---

183. *Cf.* Button, *supra* note 73, at 550 (calling the idea of states being accurately held liable for all debris they create "laughable," because debris often cannot be traced to its source).

184. Lampertius, *supra* note 179, at 462.

new regulatory regime. Pursuing other avenues may lead to a very lengthy negotiation and drafting process, even before debates on ratification begin. Because space debris must be dealt with immediately, the speed and ease of a strict liability amendment are major advantages.

Strict Liability is Now More Politically Viable

Twenty years ago, a commentator concluded that "although a strict liability system theoretically may be a good idea, it is doubtful that it could generate the acceptance necessary for its implementation."[185] However, the situation is not what it was two decades ago. Since then, the debris population has massively increased, the Kessler Syndrome has been reaffirmed, and states and other actors have created debris-mitigation guidelines.[186] The existence of the NASA and IADC guidelines, and the continuing negotiations on expanding those guidelines, show an increasing willingness to make some sacrifices in the name of regulating debris. None of these existing regimes are as severe as strict liability, but they reflect an increased awareness of the scope of the problem. During his 2008 election campaign, then-Senator Obama even supported "an international approach to minimizing space debris."[187] With strong leadership from the United States, this amendment may garner international support.

China and Russia are the amendment's most likely opposition. Russia's Cold War legacy would leave it responsible for a large quantity of debris, and China would be responsible for the effects of their 2007 missile test. Yet there is some hope of persuading these countries. Most of the debris currently in orbit is not tracked, and so even if that debris is located again, there would be no way to determine its country of origin. Establishing liability for collisions caused by already-existing debris would, in practice, be almost impossible. This weakens the strict liability regime, but makes it more palatable for China and Russia. They will be held accountable for what they do from now on, but likely will not be held responsible for their past acts. If necessary, the strict liability amendment could explicitly not be retroactive—strict liability would then only attach to debris created after ratification.

An Alternate Solution: Define "Fault" as "Not Complying with the IADC Debris-Mitigation Guidelines."

As mentioned earlier, the IADC guidelines are very useful—the problem is that many states ignore them. Amending the Liability Convention to define "fault" as "not complying with the IADC guidelines" would force states to abide by them, or risk liability for damage caused by their debris. This is not a new idea.[188] Because such standards now exist, and have the potential to be effective if enforced, writing them in as a defined standard of care would be easier than ever before.

185. *Id.* at 463.

186. NASA created the world's first such guidelines in 1995. Kleiman, *supra* note 9, at 77.

187. *See* Imburgia, *supra* note 23, at 632.

188. *See generally* Lampertius, *supra* note 179, at 464–65 (arguing in favor of a defined standard of care).

The arguments in favor of this approach are similar to those in favor of strict liability. There would still be deterrence, and there would still be incentive to develop more effective debris monitoring. These effects would likely be weaker, however, because the odds of losing a liability dispute under this code of conduct would presumably be lower than losing such a dispute under a strict liability regime. Transaction costs would also be higher, and disputes would take longer to resolve, because determining compliance with the code could require a lengthy legal debate.

Advantages of a code of conduct over strict liability are obvious. Countries would be more likely to support it, because they would less likely to be found liable for damages. Modifying such a code in the future would be easier and less disruptive than attempting to "modify" a strict and absolute standard such as strict liability. And a code of conduct is inherently more flexible in its enforcement, and therefore there should be fewer instances of false-positives. Strict liability seems overall more effective at combating debris, but a code of conduct would be superior to the current regime.

IV. Conclusion

To the casual observer, space debris does not appear to be a pressing problem. The international community has known of the threat it poses at least since Donald Kessler's 1978 paper on the Cascade Effect. However debris has not thus far caused any major calamities. Unlike in the movie *Gravity*, no human lives have yet been lost. Satellites do not fall from the sky with regularity. But "[i]f the international community waits until the serious consequences of the space debris cascade manifest themselves, it will be too late."[189] Orbital debris creates more of itself, and because it cannot currently be removed from orbit, the problem will only get worse. Many estimates say it will worsen quickly.

If the international community does not take action now, space may be largely inaccessible to humankind in as little as a century. The solutions proposed in this Note are drastic, but drastic solutions are needed if we expect future generations to enjoy the myriad benefits of satellites and other spacecraft. No one policy can solve the entire problem, but countries the world over must start evaluating their options as soon as possible. One thing is certain: the most damning course of action the international community could take would be to do nothing.

---

189. Imburgia, *supra* note 23, at 634–35.