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Space Debris and Its Threat to National Security

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Space Debris and Its Threat to National Security: A Proposal for a Binding International Agreement to Clean Up the Junk

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ABSTRACT

In 2007, a Chinese anti-satellite missile destroyed an aging weather satellite, creating millions of pieces of space debris. In 2009, the collision of two satellites created thousands more. By 2010, more than 95 percent of all man-made objects in Earth's orbit were debris. Such a sudden and massive addition to the space debris environment since 2007 poses a direct threat to operational satellites and continued space access. This in turn threatens U.S. national security, to which space access and use is vital. Unfortunately, future increases in the number of space-faring nations and corresponding launches will only exacerbate this space debris threat. Some experts now fear that a chain reaction of space debris collisions threatening sustainable space access for centuries is unavoidable unless international action to minimize and remove the debris is soon taken. This Article argues that such international action should come in the form of a binding international space debris agreement, and puts forth the draft agreement at Annex A as a starting point for discussion.

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> *[A]lthough the current hazard to most space activities from debris is low, growth in the amount of [space] debris threatens to make some valuable orbital regions increasingly inhospitable to space operations over the next few decades. Indeed, some experts at NASA believe that collisions between space assets and larger pieces of debris will remain rare only for the next decade, although there is ongoing discussion about this assessment.*[1]

> *[D]ecades of space activity have littered Earth's orbit with debris; and as the world's space-faring nations continue to increase activities in space, the chance for a collision increases correspondingly.*[2]

I. INTRODUCTION

In 1986, the Soviet representative to the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) "was of the view that the space debris problem affecting the space environment must be dealt with immediately."[3] Almost twenty-five years later, the international community still has not sufficiently dealt with the problem. Sadly, space debris continues to threaten the survivability of space-based assets and manned spaceflight. On March 12, 2009, space debris forced astronauts aboard the International Space Station to take shelter in an escape capsule out of fear that debris would collide with the station.[4] Based on the current space debris environment and the very real threat it poses, it is now time for the international community to heed the Soviet representative's advice and deal with the space debris problem. The solution to that problem needs to come in the form of a binding international agreement.

Without a binding international agreement, the problem will only continue to worsen. According to scientists at the National Aeronautics and Space Agency (NASA), more than 5,500 tons of space debris orbited Earth in 2006.[5] Unfortunately, the space debris

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1. SPACE SECURITY 2010, at 31 (Cesar Jaramillo et al., eds. 2010) (footnotes omitted) (internal quotation marks omitted).

2. OFFICE OF SCI. & TECH. POLICY, EXEC. OFFICE OF THE PRESIDENT, NATIONAL SPACE POLICY OF THE UNITED STATES OF AMERICA 2 (2010), http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf (outlining President Barack Obama's 2010 space policy).

3. David Tan, *Towards a New Regime for the Protection of Outer Space as the Province of All Mankind*, 25 YALE J. INT'L L. 145, 153 (2000) (internal quotation marks omitted).

4. Traci Watson, *Space Junk Forces Crew to Scram: Astronauts Enter Escape Pod in Case Debris Hit Station*, USA TODAY, Mar. 13, 2009, at 2A.

5. *See* J.-C. Liou & N. L. Johnson, *Risks in Space from Orbiting Debris*, SCIENCE, Jan. 20, 2006, at 340, 340 (noting that five million kilograms are tracked by U.S. space surveillance).

problem has worsened drastically in the years since.[6] During 2007, the explosion of a Russian rocket and the Chinese destruction of one of its own weather satellites during an anti-satellite (ASAT) mission created potentially millions of new pieces of space debris.[7] In February 2009, a collision between a defunct Russian communications satellite and a privately owned Iridium telecommunications satellite created possibly thousands more.[8] This recent creation of so much space debris is unprecedented, and the wreckage could soon damage or destroy other working satellites.[9]

Such a sudden and massive addition to the space debris environment is cause for concern. In fact, some experts fear that we have reached the point that space is so cluttered with debris that a chain reaction of collisions, severely jeopardizing sustainable space access, is unavoidable unless international action is taken soon.[10] This Article argues that international action must be in the form of a binding international agreement on space debris. The agreement at Annex A provides a starting point for discussion.

Without legal consequences, including appropriate international sanctions for treaty violations, little international influence exists to compel space-faring nations to find a viable solution to this problem. Moreover, space debris threatens the durability and survivability of the space assets on which the United States so heavily depends for its national security.[11] It is therefore in the United States' best interest to support a binding international agreement to deal with the removal and mitigation of space debris.

To demonstrate the urgency of the problem and highlight the need for a binding international agreement on space debris, this Article first examines the amount of space debris currently in

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6. *See, e.g.*, SPACE SECURITY 2010, *supra* note 1, at 30–35 (noting the trend of increasing orbital space debris).

7. *See* David Bond, *Debris Decision*, AVIATION WK. & SPACE TECH., Feb. 26, 2007, at 23, 23 (discussing the Russian rocket explosion); Frank Morring, Jr., *Worst Ever; Chinese Anti-Satellite Test Boosted Space-Debris Population by 10% in an Instant*, AVIATION WK. & SPACE TECH., Feb. 12, 2007, at 20, 20 (discussing the ASAT mission).

8. Traci Watson, *Two Satellites Collide 500 Miles Over Siberia*, USA TODAY, Feb. 12, 2009, at 9A.

9. *Id.*

10. *See* SPACE SECURITY 2010, *supra* note 1, at 31 (discussing the increasing trend of orbital space debris); *see also* William J. Broad, *Orbiting Junk, Once a Nuisance, Is Now a Threat*, N.Y. TIMES, Feb. 6, 2007, at F1 (noting that the number of objects in orbit had surpassed a "critical mass").

11. *See, e.g.*, Craig Covault, *Space Control: Chinese Anti-Satellite Weapon Test Will Intensify Funding and Global Policy Debate on the Military Uses of Space*, AVIATION WK. & SPACE TECH., Jan. 22, 2007, at 24, 24 (discussing the import of space assets to national security); Jean-Michel Stoullig, *Rumsfeld Commission Warns Against "Space Pearl Harbor,"* SPACE DAILY, Jan. 11, 2001, http://www.spacedaily.com/news/bmdo-01b.html (discussing how the United States is more dependent on space than any other nation).

existence and the predictions for future additions. It then discusses the United States' reliance on the unhindered use of space for national security and demonstrates why a space debris threat to American space assets presents an immediate and serious concern to the United States. The Article then analyzes the 1967 Outer Space Treaty,[12] the 1972 Liability Convention,[13] and the 1975 Registration Convention[14] to show that these treaties are, by their terms, insufficient to deal with the space debris problem. Next, the Article illustrates why no other international agreement adequately addresses or demands the removal of space debris currently in Earth's orbit.

Consequently, to better preserve and protect the national security interests of the United States by assuring access to space and the freedom to operate there, the United States must pursue a binding international agreement with real consequences, and it must persuade the international community to follow its lead. Definitions for both "space" and "space debris" are needed in such an agreement. Additionally, countries must be required to do at least three things: (1) minimize the creation of space debris; (2) make efforts to rid the space environment of the debris they create or have already created; and (3) notify each other when they cause space debris. The proposed agreement at Annex A addresses each of these issues. An agreement is necessary because of both the gloomy future presented by an unresolved space debris problem and the lack of adequate international law in this area.

II. THE MEASURABLE PROBLEM OF SPACE DEBRIS

The phrase "space debris" is generally described as "a blanket term for any man-made artifact discarded, or accidentally produced, in space, either in orbit around a planetary body (when it is also known as orbital debris) or on a trajectory between planetary bodies."[15] Space debris typically consists of fragments of older satellites and rocket boosters resulting from explosions or collisions.[16] Space debris, however, also includes "dead satellites, spent rocket stages, a camera, a hand tool and junkyards of whirling debris left

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

13. Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention].

14. 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].

15. MARK WILLIAMSON, SPACE: THE FRAGILE FRONTIER 46 (2006).

16. 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 (2007).

over from chance explosions and destructive tests."[17] In addition to the space debris created during the satellite collision of February 10, 2009,[18] some of the newest space debris includes a $100,000 set of grease guns and other tools that Space Shuttle Endeavour astronaut Heidemarie Stefanyshyn-Piper lost during a space walk on November 19, 2008.[19]

These recent additions to the space debris population intensify a problem that began on October 4, 1957, when the former Soviet Union launched the first satellite, Sputnik 1, into space.[20] Since that date, space-faring nations have launched objects into space at a frenetic pace. Those launches have, in turn, created a considerable amount of space debris.[21]

In October 2010, Air Force Space Command's (AFSPC) Space Surveillance Network was tracking over 21,000 man-made objects orbiting Earth that were larger than ten centimeters.[22] Unfortunately, fewer than 5 percent of those 21,000 man-made objects are operational satellites; the rest are debris.[23] Even worse, scientists currently estimate "that there are over 300,000 objects with a diameter larger than one centimeter, and several million that are smaller," orbiting in space, and a large majority of these objects are man-made space debris.[24]

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17. Broad, *supra* note 10, at F1.

18. Watson, *supra* note 8, at 9A.

19. Mark Carreau, *Astronaut Who Lost Tool Kit Focuses on Today's Outing, Will Double-Check Every Little Thing*, HOUS. CHRON., Nov. 20, 2008, at A3; John Schwartz, *Tool Bag Is Lost During Spacewalk*, N.Y. TIMES, Nov. 19, 2008, at A23.

20. *E.g.*, WILLIAMSON, *supra* note 15, at 8 tbl.1 (giving dates for various "space firsts").

21. For a visual representation of the current space debris problem, see *Space Debris: Evolution in Pictures*, EUROPEAN SPACE OPERATIONS CENT.—EUROPEAN SPACE AGENCY, http://www.esa.int/SPECIALS/ESOC/SEMN2VM5NDF_mg_1_s_b.html (last visited Apr. 11, 2011). According to the European Space Agency's website, the space debris objects shown in the images "are an artist's impression based on actual density data"; however, the debris objects depicted are not to scale. *Id.*

22. SPACE–TRACK, http://www.space-track.org/perl/boxscore.pl (last updated Apr. 4, 2011); *see also* SPACE SECURITY 2010, *supra* note 1, at 30–31 (discussing the U.S. Space Surveillance Network system and its ability to catalogue objects that are greater than ten centimeters); *Satellite Box Score*, ORBITAL DEBRIS Q. NEWS (Nat'l Aeronautics and Space Admin. [NASA], Hous., Tex.), Oct. 2010, at 4, 10 (providing satellite box scores as of Oct. 6, 2010, for countries and organizations); *Orbital Debris Frequently Asked Questions*, NASA ORBITAL DEBRIS PROGRAM OFF., http://orbitaldebris.jsc.nasa.gov/faqs.html (last visited Mar. 17, 2011) (noting that large orbital debris (> 10 cm) are tracked routinely by the U.S. Space Surveillance Network). In November 2003, space surveillance responsibility transferred from NASA to AFSPC. Press Release, Captain Angie Blair, Air Force Space Command News Serv., New AFSPC Website Provides Worldwide Space Surveillance Support (Jan. 3, 2005), *available at* http://www.space-track.org/afspc_pa.html.

23. SPACE SECURITY 2010, *supra* note 1, at 31; SPACE–TRACK, *supra* note 22.

24. SPACE SECURITY 2010, *supra* note 1, at 13, 29–31.

Historically, explosions have been the biggest cause of space debris.[25] That fact, however, is about to change. Due to the amount of space debris that currently exists, several NASA computer "models predict that more [space] debris will be generated by collisions, rather than explosions, in the future."[26] As a result of this outer space clutter, Earth's orbital region has become, in just over fifty years, "the junkyard of the solar system."[27]

This orbital junkyard is already hindering our utilization of outer space. In recent years, the vast amount of space debris has affected space launch schedules and caused in-space collision-avoidance maneuvering. On March 12, 2009, the near collision of space debris with the International Space Station (ISS) caused the ISS crew to temporarily evacuate into a Russian escape capsule docked with the station.[28] This was the second time in less than a year that space debris threatened the ISS,[29] and it highlighted a list of nine 2009 space debris collision-avoidance maneuvers by satellites under NASA's control.[30] Since February 2009, over thirty-two collision-avoidance maneuvers have been reported, including one by China.[31] Concerns with space debris also threatened a space shuttle launch in fall 2008, as NASA warned that the risk of a catastrophic collision between space debris and the shuttle exceeded the norm.[32] Earlier that year, in order to ensure that an Atlas V rocket carrying a secret payload into space did not collide with space debris, the United States was forced to delay the rocket's launch for two weeks.[33] Additionally, in 2005, a spacecraft that is a major part of NASA's

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25. *See, e.g.*, WILLIAMSON, *supra* note 15, at 48 (noting that explosions—mostly of rocket stages—account for nearly 40 percent of all cataloged space debris).

26. T. Hanada, K. Sakuraba & J.-C. Liou, *Three New Satellite Impact Tests*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Oct. 2007, at 4, 4.

27. Taylor, *supra* note 16, at 1.

28. Watson, *supra* note 4, at 2A.

29. *ISS Maneuvers to Avoid Russian Fragmentation Debris*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Oct. 2008, at 1, 4.

30. *Avoiding Satellite Collisions in 2009*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Jan. 2010, at 1, 2; *see also* Stew Magnuson, *New Satellites to Keep Watch Over Space-Based Systems*, NAT'L DEF. MAG., June 2009, at 29, 29 (explaining a proposed satellite monitoring system).

31. SPACE SECURITY 2010, *supra* note 1, at 37.

32. Traci Watson, *Space Debris Could Hinder Next Shuttle Mission*, USA TODAY, Sept. 9, 2008, at 4A. The October launch was initially scheduled for Hubble Space Telescope repairs, but was delayed until February 2009 due to problems with the Hubble Telescope itself. Dan Vergano & Traci Watson, *Hubble Repair Delayed Until 2009*, USA TODAY, Sept. 30, 2008, at 5D. On February 2, 2009, however, a failure of Hubble's command and data-handling system presented a problem that the Shuttle astronauts had not been trained to address, and the launch was delayed until 2010. *NASA Delays Shuttle Hubble Mission*, ABC NEWS, Feb. 4, 2009, http://abclocal.go.com/wabc/story?section=news/technology&id=6383411.

33. *Satellite Fallout Delays Rocket Launch: Secret Mission Held Up to Avoid Possible Debris, Manufacturer Says*, MSNBC, Feb. 28, 2008, http://www.msnbc.msn.com/id/23391366.

Earth Observing System successfully performed a small collision-avoidance maneuver to ensure that it did not collide with space debris.[34]

Unfortunately, the space debris problem is not limited to near misses. On February 10, 2009, five hundred miles above Siberia, a Russian communications satellite collided with a privately owned Iridium telecommunications satellite "in an unprecedented orbital accident that would have been visible from the Earth."[35] If defunct, the Russian satellite would be properly considered "space debris"[36]; however, there is some skepticism as to whether the satellite was truly "defunct."[37] According to former Department of Defense space consultant Taylor Dinerman, the "possibility the Russians were testing a pre-positioned space mine is very plausible."[38] Russian Major General Leonid Shershnev, however, claims that the United States deliberately caused the collision.[39]

Whoever is to blame, one thing is certain: the collision caused more space debris. On February 23, 2009, the United States reported to the United Nations that it was tracking over seven hundred new pieces of debris larger than ten centimeters.[40] The collision is also believed to have created thousands of smaller pieces of debris.[41]

Other space debris collisions have also occurred. For example, in 1986 the third stage of an Arianne rocket, launched by the European Space Agency, exploded in outer space, "generating over 700 fist-sized debris fragments."[42] In 1996, ten years after that Arianne rocket exploded, debris from its explosion struck the French reconnaissance satellite *Cerise*[43] and severed its stabilization boom.[44] Scientists were able to control the satellite and maintain its function in orbit, but the severed piece of the boom subsequently orbited Earth as debris until the boom reentered Earth's atmosphere in 2000.[45] Another space debris collision occurred in 2005, when pieces from a U.S. rocket, used to launch a satellite in 1974, collided with debris from a Chinese

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34. *Collision Avoidance Maneuver Performed by NASA's Terra Spacecraft*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Jan. 2006, at 1, 1.

35. Watson, *supra* note 8, at 9A.

36. *See supra* notes 15–17 and accompanying text.

37. SPACE SECURITY 2010, *supra* note 1, at 32.

38. Editorial, *Strike From Space?*, WASH. TIMES, Mar. 6, 2009, at A18.

39. *Id.*

40. Press Release, U.N. Info. Serv., Outer Space Scientific and Technical Subcommittee Concludes Its 46th Session in Vienna, U.N. Press Release UNIS/OS/377 (Feb. 23, 2009), *available at* http://www.unis.unvienna.org/unis/pressrels/2009/unisons377.html.

41. Watson, *supra* note 8, at 9A.

42. WILLIAMSON, *supra* note 15, at 66.

43. *Id.*; *see also* SPACE SECURITY 2010, *supra* note 1, at 13 (noting that the *Cerise* collision has increased awareness of space debris as a significant threat).

44. WILLIAMSON, *supra* note 15, at 66–67.

45. *Id.*

launch vehicle that exploded in space in 2000.[46] The collision produced three new marble-sized pieces of debris.[47]

These incidents and others like them[48] exemplify the significance of the space debris crisis. Many scientists even believe that without removal actions, a space debris disaster is unavoidable.[49] That disaster is more accurately illustrated by what has become known as the "cascade effect."

A. *The Cascade Effect*

The "cascade effect" is "the greatest fear of those who study the problem of orbital debris."[50] Even before the February 2009 satellite collision, many scientists agreed "that the number of objects in orbit had surpassed a critical mass,"[51] the point at which "orbital debris would collide with other space objects, which in turn would create new debris that would cause [a chain reaction of] even more collisions."[52] This "chain reaction" is often referred to as the cascade effect.[53]

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46. *Id.* at 67.

47. *Id.*

48. Additional instances of space debris collisions also exist. For example, the first thirty-three space shuttle flights sustained debris damage to some of the tiles on the shuttle's undersides. JESSICA WEST ET AL., SPACE SECURITY 2008, at 28 (2008). Additionally, in July 1981, the Russian Kosmos 1275 military navigation satellite experienced an unexpected breakup, generally thought to have been a result of space debris. *Id.* In December 1991, fragmented debris from two defunct Russian navigation satellites collided, creating even more debris. WILLIAMSON, *supra* note 15, at 67. Space debris also likely disabled a Japanese climate observation satellite in the summer of 1997. Peter J. Limperis, *Orbital Debris and the Spacefaring Nations*, 15 ARIZ. J. INT'L & COMP. L. 319, 319 (1998). Closer to home, the Hubble Space Telescope currently has a three-fourths-inch hole in its antenna that was created by space debris, and NASA's Long Duration Exposure Facility, a school bus-sized satellite in Low Earth Orbit (LEO), recorded more than 30,000 hits by debris or meteoroids during six years in orbit. WEST ET AL., *supra*, at 28. For more concerns about space debris, see, for example, ANTONY MILNE, SKY STATIC: THE SPACE DEBRIS CRISIS 81–85 (2002) (discussing the economic concern space debris poses to the existing and growing number of commercial and scientific satellites). *See also* Lubos Perek, *Ex Facto Sequitor Lex: Facts Which Merit Reflections in Space Law in Particular with Regard to Registration and Space Debris Mitigation*, *in* ESSENTIAL AIR AND SPACE LAW 2: SPACE LAW: CURRENT PROBLEMS AND PERSPECTIVES FOR FUTURE REGULATION 29, 40–44 (Marietta Benkö & Kai-Uwe Schrogl eds., 2005) (discussing the practical and legal problems of space debris).

49. *See* SPACE SECURITY 2010, *supra* note 1, at 39 (stating that debris mitigation alone is not enough, the "active removal of debris from orbit—debris remediation—is necessary").

50. Taylor, *supra* note 16, at 18.

51. Broad, *supra* note 10, at F1.

52. Taylor, *supra* note 16, at 18.

53. The cascade effect is the oft-used phrase to describe this phenomenon; however, the "Kessler Syndrome," named after NASA scientist Donald Kessler, is also used. Christopher D. Williams, *Space: The Cluttered Frontier*, 60 J. AIR L. & COM.

Some experts believe that once space debris collisions begin, they will be impossible to stop.[54] The fear is that these cascading "collisions will eventually produce an impenetrable cloud of fragmentation debris that will encase Earth[, making] space travel . . . 'a thing of the past' and . . . obstruct[ing] our dream of colonizing outer space."[55] Experts warn that if the cascade effect occurs, space will be unusable for centuries due to the time it will take for all of the debris to eventually disintegrate in Earth's atmosphere.[56]

If space debris is not immediately countered by preventative and removal measures, the cascade effect could occur in little more than a decade.[57] In February 2008, Dr. Geoffrey Forden, a Massachusetts Institute of Technology physicist and space programs expert, stated that the United States is "in danger of a runaway escalation of space debris."[58] He argued that the danger of a cascade effect is a greater threat to U.S. space assets than the threat of anti-satellite (ASAT) weapons.[59]

NASA scientists have warned about the threat of the cascade effect since the late 1970s.[60] In the decades since, experts have worried that collisions caused by the cascade effect "would expand for centuries, spreading chaos through the heavens"[61] and multiplying space "debris to levels threatening sustainable space access."[62] "Today, next year or next decade, some piece of whirling debris will start the cascade, experts say."[63] According to Nicholas L. Johnson,

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1139, 1145 n.31 (1995); *see, e.g.*, Mark J. Sundahl, Note, *Unidentified Orbital Debris: The Case for a Market-Share Liability Regime*, 24 HASTINGS INT'L & COMP. L. REV. 125, 132 (2000) (noting that increased space activity may bring about the Kessler effect); Carl Hoffman, *Battlefield Space*, POPULAR MECHANICS, July 2007, at 76, 76 (using the Kessler Syndrome to describe the space where China had decided to blow up one of its own satellites); *see also* Broad, *supra* note 10, at F1 ("[A] kind of orbital crisis might ensue that is known as the Kessler Syndrome . . . .").

54. Sundahl, *supra* note 53, at 132.

55. *Id.* (quoting Jennifer M. Seymour, *Containing a Cosmic Crisis: A Proposal for Curbing the Perils of Space Debris*, 10 GEO. INT'L ENVTL. L. REV. 891, 914 (1998)).

56. *Id.*

57. Marietta Benkö, *The Problem of Space Debris: A Valid Case Against the Use of Aggressive Military Systems in Outer Space?*, *in* ESSENTIAL AIR AND SPACE LAW 2, *supra* note 48, at 155, 159. Marietta Benkö serves as the Legal Advisor in the German Delegation to the UN Commission on the Peaceful Uses of Outer Space (COPUOS). *Id.* at 303.

58. John Johnson, Jr., *Scientists Cite Growing Peril of Space Junk*, L.A. TIMES, Apr. 16, 2008, at A10.

59. *Id.*

60. *See* Broad, *supra* note 10, at F1 (discussing how, in 1978, Donald J. Kessler and Burton G. Cour-Palais, two NASA scientists, warned about an exponential increase in the number of space debris that over time would create a belt of debris around Earth).

61. *Id.*

62. SPACE SECURITY 2010, *supra* note 1, at 31.

63. Broad, *supra* note 10, at F1.

NASA's chief scientist for orbital debris, the cascade is now "inevitable" unless something is done to remove the debris.[64] Experts believe that if nothing is done to address the space debris problem, the amount of orbiting space debris greater than ten centimeters in size will increase to over 50,000 objects in the next fifty years.[65] Considering that the number of objects in orbit has increased drastically since the beginning of 2007, the problem is, unfortunately, only worsening.

B. *The Problem Is Getting Worse*

The fundamental dilemma with "space debris" is that "[g]rowth in the debris population increases the probability of inter-debris collision[s]" that have the potential to create even more debris.[66] This problem is only exacerbated by the increased demand for space use by both the public and private sectors. The decades to follow will only result in increased use of space and, therefore, increased space debris.[67]

From 2004 to 2010, the annual growth rate of tracked debris increased every year except 2008.[68] At the beginning of 2010, Earth's orbit held 2,347 more space debris objects measuring more than ten centimeters in size than it held at the beginning of 2009, a 15.6 percent increase.[69] The greatest annual increase in space debris to date occurred in 2007.[70] At the beginning of 2008, Earth's orbit held 2,507 more space debris objects measuring more than ten centimeters than it held at the start of 2007.[71] This marked a 20.12 percent increase in the space debris population in just one year.[72] A large portion of this increase is attributable to China and Russia, as discussed in the following subparts.

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64. *Id.*

65. *NASA and DARPA Sponsor International Debris Removal Conference*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Jan. 2010, at 1, 1 (depicting, graphically, the increase in space debris over the next 50–100 years).

66. SPACE SECURITY 2010, *supra* note 1, at 31.

67. *See, e.g.*, WEST ET AL., *supra* note 48, at 14 ("In the long term, an increased number of satellites launched into outer space will also add pressure to the problem of space debris.").

68. SPACE SECURITY 2010, *supra* note 1, at 13, 34.

69. *Id.* at 33.

70. *Id.*; Frank Morring, Jr. & Amy Butler, *Second Thoughts: China Appears to Be Regretting Last Year's ASAT Weapon Test*, AVIATION WK. & SPACE TECH., May 12, 2008, at 35, 35; Watson, *supra* note 32, at 4A.

71. WEST ET AL., *supra* note 48, at 30.

72. *Id.*

1. China's 2007 Intentional Obliteration of an Old Weather Satellite

On January 11, 2007, China launched a small ballistic missile with a kinetic kill vehicle 537 miles into space to destroy its aging weather satellite, the *Fengyun-1C*.[73] The resulting explosion and destruction sent thousands of destructive pieces of debris from both the satellite and the missile into various orbital planes around Earth, "ranging in altitude from 3,800 km [2,361 miles] on the high end down to about 200 km [124 miles] at the lowest."[74] Worse yet, because the fragmentation debris was ejected in a variety of initial directions and high velocities, the debris orbits rapidly spread out in a toroidal debris cloud[75] that eventually surrounded the globe.[76] After only six months, the debris cloud from the *Fengyun-1C* ASAT mission had already rapidly dispersed into various orbits around Earth.[77] By January 2009, the debris cloud had completely surrounded Earth.[78]

The unprecedented space debris that the Chinese ASAT mission created was "described as the worst satellite fragmentation event in the 50-year history of spaceflight."[79] At the outset, scientists estimated that the explosion instantly increased the space debris population by 10 percent.[80] After analyzing the problem for over a year, however, NASA scientists quickly realized that the problem was much worse than their initial predictions.[81] By the end of 2007, NASA identified over 250 additional pieces of debris larger than ten centimeters.[82]

In March 2010, the United States was tracking 2,841 fragments from the ASAT mission that measured greater than five centimeters

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73. Covault, *supra* note 11, at 24.

74. Morring, *supra* note 7, at 20.

75. *See* GEORGE GLEGHORN ET AL., ORBITAL DEBRIS: A TECHNICAL ASSESSMENT 25–26 (1995) (describing a toroidal, or doughnut-shaped, debris cloud's evolution in Earth's orbit over time).

76. *Detection of Debris from Chinese ASAT Test Increases*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Jan. 2007, at 2, 3 ("The debris orbits are rapidly spreading . . . and will essentially encircle the globe by the end of the year.").

77. *Id.* at 2. For a visual representation of what the debris cloud from the *Fengyun-1C* spacecraft looked like six months after break-up, see Figure 2 on page 2.

78. *Fengyun-1C Debris: Two Years Later*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Jan. 2009, at 1, 2. For a visual representation of what the debris cloud from the *Fengyun-1C* spacecraft looked like two years after break-up, see Figure 2 on page 2.

79. Morring & Butler, *supra* note 70, at 35.

80. Morring, *supra* note 7, at 20.

81. *Fengyun-1C Debris: One Year Later*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Jan. 2008, at 1, 3–4.

82. *Id.*

in diameter, plus another 500 fragments that had not yet been cataloged.[83] NASA estimates the population of debris larger than one centimeter from the explosion to be greater than 150,000.[84] Worse yet, scientists speculate that the explosion increased the space debris population by millions of undetectable pieces of debris.[85] By the end of 2008, less than 2 percent of the ASAT mission's debris population had reentered the atmosphere.[86] Consequently, the debris population far exceeds NASA's initial predictions, and unless something is done to remove it, Earth will have to deal with the resultant wreckage for years, perhaps even thousands of years, to come.[87] According to NASA's Nicholas Johnson, due to the altitude at which the satellite was destroyed, much of the debris will be "in orbit for 100 years or more .... Some will come down earlier, but the majority will be up there for a very long time."[88]

The actual length of time that this debris will continue to move uncontrollably around Earth depends on "its altitude, mass, size, and the amount of solar activity."[89] Although numerous Earth orbits exist, "Low Earth Orbit (LEO) and Geosynchronous Earth Orbit (GEO) are the two most heavily used and, therefore, the most significant" to the space debris problem.[90] A pertinent discussion of both LEO and GEO is necessary to explain just how long the Chinese ASAT debris will remain a space nuisance.

2. Low Earth Orbit

LEO "is typically defined as any orbit up to around 5500 kilometers [3418 miles] in altitude."[91] Generally, "[s]atellites in LEO circle the Earth approximately once every ninety minutes and can be in any inclination, or orbital plane."[92] The majority of the world's

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83. *Update on Three Major Debris Clouds*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Apr. 2010, at 2, 4.

84. *Fengyun-1C Debris: Two Years Later*, *supra* note 78, at 2.

85. *See* Broad, *supra* note 10, at F1 ("Federal and private experts say that early estimates of 800 pieces of detectable debris from the shattering of the satellite will grow to nearly 1,000 as observations continue by tracking radars and space cameras.").

86. *Fengyun-1C Debris: Two Years Later*, *supra* note 78, at 2.

87. *Fengyun-1C Debris: One Year Later*, *supra* note 81, at 3.

88. Morring, *supra* note 7, at 20.

89. *See* Taylor, *supra* note 16, at 6 (detailing how to calculate lifetime of debris in LEO).

90. Taylor, *supra* note 16, at 5; *see also* HEINRAD KLINKRAD, SPACE DEBRIS: MODELS AND RISK ANALYSIS 1, 5–18 (2006) (discussing the launch history and resulting orbital environment of space debris since the launch of Sputnik–1 in 1957).

91. Taylor, *supra* note 16, at 5.

92 Taylor, *supra* note 16, at 5–6 (footnote omitted).

satellites operate in LEO.[93] Consequently, the majority of Earth's space debris can also be found there.[94] Unfortunately, in some LEO altitude regimes, "the production rate of new debris due to collisions exceeds the loss of [space debris] objects due to orbital decay."[95] Considering the increasing amount of debris in these LEO altitude regimes, unless space debris is removed, these orbits could soon become unusuable because of fears that the debris there will quickly damage or destroy vehicles that enter this space.

Exact amounts of debris in LEO are impossible to calculate, because countries generally cannot consistently detect or track LEO space debris "smaller than ten centimeters and [can] only continuously track objects thirty centimeters and larger."[96] The U.S. Space Surveillance Network (SSN), "a network of radar and optical sensors strategically located at more than two dozen sites worldwide," is the network that most consistently tracks and catalogs orbital debris greater than ten centimeters in size.[97] Although not reliably tracked, scientists estimate that debris as small as two millimeters threaten spacecraft security.[98]

The amount of time that space debris remains in LEO depends, in large part, on its altitude within that orbit. Space debris orbiting between 200 and 400 kilometers (124 to 249 miles) above Earth may last for only a few months, because the debris will eventually deorbit into Earth's atmosphere and burn up.[99] However, for debris orbiting between 400 and 900 kilometers (249 to 559 miles) above Earth, orbital lifetimes "could range from years to hundreds of years depending on the mass and area of the [debris]."[100] In fact, one U.S. satellite, launched in 1958 and defunct since 1964, continues to orbit in this type of LEO, and it may continue to orbit Earth as a piece of space debris for another two hundred years.[101]

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93. GLEGHORN ET AL., *supra* note 75, at 18; *see also* Bill Gertz, *U.S. Halts China Space Ventures; Missile Testing Violated Pact*, WASH. TIMES, Feb. 2, 2007, at A1 (discussing the Chinese ASAT additions to the LEO).

94. *See* SPACE SECURITY 2010, *supra* note 1, at 30 (noting that LEO is the most congested area for space debris)

95. Liou & Johnson, *supra* note 5, at 340.

96. Taylor, *supra* note 16, at 5; *see also* Comm. on the Peaceful Uses of Outer Space, Scientific & Technical Subcomm., Rep. on its 33d Sess., Feb. 12–23, 1996, ¶ 134, U.N. Doc. A/AC.105/637/Corr.1 (Mar. 4, 1996) [hereinafter 33d STS Report] (discussing effects of small debris objects on the operation of space systems).

97. SPACE SECURITY 2010, *supra* note 1, at 48.

98. *Id.* at 29.

99. OFF. OF SCI. & TECH. POLICY, EXEC. OFF. OF THE PRESIDENT, INTERAGENCY REPORT ON ORBITAL DEBRIS 6 (1995), http://orbitaldebris.jsc.nasa.gov/library/IAR_95_Document.pdf.

100. *Id.*

101. GLEGHORN ET AL., *supra* note 75, at 22 (discussing the 1.5 kilogram Vanguard 1 satellite).

Debris orbiting in the higher altitudes of LEO will remain in orbit for thousands of years. For China's ASAT debris thrown into an orbit 3,800 kilometers (2,361 miles) above Earth, the orbital lifespan could reach 20,000 years.[102] Unfortunately, debris thrust into GEO will last even longer.

3. Geosynchronous Earth Orbit

"Unlike LEO satellites, which complete many orbits in a day, satellites in GEO orbit Earth once a day."[103] The most common type of "GEO is geostationary, which is a circular orbit around the equator at an altitude of 35,786 kilometers."[104] Spacecraft in a geostationary orbit generally stay in the same spot above Earth throughout their orbit.[105] The amount of space debris in GEO is unknown because at that altitude, debris needs to be about one meter in size before the SSN can effectively track its location.[106] Because Earth's "atmospheric drag will not naturally remove objects in GEO," some "[e]xperts estimate that orbital debris in GEO will last anywhere from 1 million to 10 million years."[107]

4. China Is Not the Only Culprit; Russia and the United States Are Also to Blame

Although China drastically increased the space debris population through its 2007 ASAT mission, it is certainly not the only originator of space debris. As evidenced by the February 2009 satellite collision, Russia and the United States are also responsible.[108] With its January 2007 ASAT mission, China is the number one space polluter per satellite in terms of the ratio of space debris created to satellites launched.[109] However, the United States and Russia rank second and third respectively.[110]

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102. *See* Taylor, *supra* note 16, at 6 ("For debris 2000 kilometers above Earth, the lifespan is approximately 20,000 years.").

103. DAVID WRIGHT ET AL., THE PHYSICS OF SPACE SECURITY: A REFERENCE MANUAL 43 (2005).

104. *Id.*

105. GLEGHORN ET AL., *supra* note 75, at 18.

106. *Id.* at 34–35.

107. *Id.* at 7.

108. *See* Watson, *supra* note 8, at 9A (noting the collision was between a defunct Russian communications satellite and a satellite owned by Iridium—a privately owned U.S. company).

109. Erin McCarthy, *Anatomy of a Destroyed Satellite*, POPULAR MECHANICS (Oct. 1, 2009), http://www.popularmechanics.com/science/space/4303476.

110. Irene Klotz, *China Top of Orbital Garbage Heap, Study Shows*, Discovery News, Aug. 13, 2010, http://news.discovery.com/space/china-top-of-orbital-garbage-heap-study-shows.html.

Russia, like China, is responsible for generating space debris through ASAT missions. There are reportedly over three hundred pieces of space debris still in orbit from Soviet ASAT tests conducted in the 1970s and 1980s.[111] During February 2007, a failed Russian Breeze-M upper stage rocket exploded in LEO.[112] A NASA space debris newsletter called this incident "a 'very serious' accident."[113] Notably, that explosion created over 1,200 pieces of new debris.[114]

The United States' contributions to the current space debris environment have also been noteworthy. In addition to the February 2009 satellite collision and the November 2008 loss of $100,000 worth of tools during a space walk,[115] the United States temporarily, but intentionally, added to the space debris problem when it shot down an aging spy satellite.[116] On February 14, 2008, the United States launched an Aegis-LEAP SM-3 interceptor missile from the *USS Lake Erie* to destroy the *USA-193* spy satellite's toxic hydrazine fuel propellant tank, which officials said could be hazardous if it crashed back to Earth.[117] To prevent that from happening, the United States destroyed the satellite in LEO, just before it fell out of orbit.[118]

Some experts worried that "the impact would blast [more] debris into orbit around Earth, threatening the space station" and other space-based systems.[119] However, the Pentagon and NASA planned for the created space debris to quickly disintegrate in Earth's atmosphere.[120] Indeed, the "majority of the debris fell to Earth within an hour of the break-up, and the remaining debris was left in short-lived orbits."[121] According to General Kevin Chilton,

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111. WEST ET AL., *supra* note 48, at 25.

112. Bond, *supra* note 7, at 23.

113. Watson, *supra* note 32, at 4A.

114. Hoffman, *supra* note 53, at 81; *see also* Bond, *supra* note 7, at 23 ("[China's] Jan. 11 anti-satellite weapon test created more debris than any previous event.").

115. Carreau, *supra* note 19, at A3; Schwartz, *supra* note 19, at A23; Watson, *supra* note 8, at 9A.

116. *Missile Hits Spy Satellite, Pentagon Says*, CHI. TRIB., Feb. 21, 2008, at C3.

117. *Id.* The ASAT mission drew criticism from abroad over concerns about the militarization of space, and whether the U.S. concern over hydrazine was simply a pretext to respond to the Chinese ASAT mission with its own ASAT mission. *See, e.g.*, Jack Gillum & David Wichner, *How Satellite Shot Went Down*, ARIZ. DAILY STAR, Apr. 13, 2008, at D1. This debate prompted a State Department cable to be sent out to all U.S. embassies abroad. "Diplomats were told to draw a clear distinction between the [U.S. ASAT mission] and [2007's] test by China of a missile specifically designed to take out satellites, a test that was criticized by the United States and other countries." *Id.*

118. *Satellite Breakups During First Quarter of 2008*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Apr. 2008, at 1, 1–2.

119. *Missile Hits Spy Satellite, Pentagon Says*, *supra* note 116, at C3.

120. *Id.*

121. *Satellite Breakups During First Quarter of 2008*, *supra* note 118, at 2.

Commander, United States Strategic Command, no debris from that ASAT mission currently remains in orbit.[122]

This ASAT mission, however, was not the United States' first. Although most of America's space debris "comes from the upper stages of [satellite] launch vehicles,"[123] until 2002, the United States was also responsible for over 250 pieces of space debris, ten centimeters or larger, that it created during a 1985 ASAT test.[124] Some of this debris orbited less than 1.3 kilometers (0.80 miles) from the ISS.[125] The last piece of debris ultimately deorbited in 2002, seventeen years after the United States conducted its test.[126]

These examples from China, Russia, and the United States show just how much explosions in space affect the space environment. Such missions create space debris that can pose problems for several generations to come. Regrettably, the more recent debris additions have made the current space environment unpredictable and unstable, and it is likely only to worsen.[127]

5. The Problem with Models

In January 2006—a year before the China ASAT mission and Russian rocket explosion, and three years before the recent satellite collision—NASA scientists predicted an instability in the then-existing, but severely less-cluttered, orbital debris population.[128] At that time, J.C. Liou and Nicholas Johnson of the NASA Orbital Debris Program Office reviewed space debris and space environment projection models conducted between 1991 and 2001.[129] They concluded that, unless removed, the large amount of debris in LEO would cause instability in some LEO altitudes, resulting in space debris collisions becoming the dominant debris-generation mechanism due to the cascade effect.[130] The two scientists stated that even "if space launches were halted [in 2005], the collection of debris would continue growing as items already in orbit collide and break into more pieces."[131] According to Liou, the most debris-

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122. Jim Wolf, *U.S. Satellite Shootdown Debris Said Gone from Space*, REUTERS, Feb. 27, 2009, http://www.reuters.com/article/2009/02/27/us-space-usa-china-idUSTRE51Q2Q220090227.

123. Hoffman, *supra* note 53, at 81.

124. WEST ET AL., *supra* note 48, at 28.

125. *Id.*

126. *Id.*

127. *See* Broad, *supra* note 10, at F1 (noting that because the satellites orbit was high, the debris will remain in space for "tens, thousands or even millions of years").

128. *Instability of the Current Orbital Debris Population*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Jan. 2006, at 1, 2.

129. *Id.*

130. *Id.*

131. *Sky Isn't Falling, Just Cluttered*, CHI. TRIB., Jan. 20, 2006, at 11.

crowded area was at an altitude between 550 and 625 miles above Earth.[132] This orbital regime is in the upper altitudes of LEO[133] and in the same general area in which the recent satellite collision took place.[134] Although still significant, the risk of space debris collisions below that altitude is slightly reduced, posing a lower risk to space shuttle missions, which typically orbit between 250 miles and 375 miles above Earth, and missions to the ISS, which orbits at around 250 miles above Earth.[135]

Liou and Johnson's modeling, which predicted a threefold increase in the amount of space debris ten centimeters and larger and a tenfold increase in space debris collision probability over the next two hundred years, made one key assumption: that there would be no more launches after January 1, 2005.[136] That assumption was clearly unrealistic, but the study on which it was based nevertheless provided a starting point for discussions about the debris environment and the problem it presents.[137] In reality, the future debris environment will be far worse than the study suggested.[138] The past three years have already proved that to be true. In addition to all of the debris created over the last three years, since the beginning of 2008, a total of 202 known satellites have been launched into space.[139] The United States also has seven launches scheduled for 2011.[140]

Additionally, more countries are vying to become space-faring nations. Algeria, Brazil, Chile, Egypt, India, Iran, Malaysia, Nigeria, North Korea, South Africa, and Thailand have all placed a priority on space utilization.[141] China has discussed the possibility of traveling to the Moon, and the United States has recently discussed the

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132. *Id.*

133. *See supra* notes 91–103 and accompanying text.

134. Watson, *supra* note 8, at 9A.

135. *Sky Isn't Falling, Just Cluttered*, *supra* note 131, at 11.

136. Liou & Johnson, *supra* note 5, at 340.

137. *Instability of the Current Orbital Debris Population*, *supra* note 128, at 2.

138. *Id.*

139. SPACE LAUNCH REP., http://www.spacelaunchreport.com (last visited Mar. 17, 2011). Russia and Ukraine jointly lead the way with thirty-two launch attempts. China had a record eleven launches, India had three, the European Space Agency had five, and the United States had fifteen. Japan and Israel accounted for the remainder. *Id.*

140. *Shuttle and Rocket Launch Schedule*, NASA, http://www.nasa.gov/missions/highlights/schedule.html (last visited Mar. 17, 2011); SPACE LAUNCH REP., *supra* note 139.

141. WEST ET AL., *supra* note 48, at 14; *see also* Blaine Harden, *N. Korea Puts Launch in Innocuous Terms*, WASH. POST, Feb. 24, 2009, at A11 (discussing North Korea's plan to launch a satellite despite U.S. warnings). For a discussion about Iran's space aspirations, see Thomas Erdbrink, *Nuclear Just Part of Tehran's Science Goals*, CHI. TRIB., June 8, 2008, at C19; *Iran Launches Homegrown Satellite*, BBC NEWS, Feb. 3, 2009, http://news.bbc.co.uk/2/hi/middle_east/7866357.stm.

possibility of traveling to Mars.[142] In 2007, the space budgets for both India and Russia increased.[143] In 2009, India, Iran, Japan, Europe, Australia, China, Russia, and the United States all expressed a greater interest in military uses of space to support national security.[144] Currently, even North Korea is increasing its space efforts, announcing its plan to launch a "communications satellite" into space and fueling debate over its intention to develop long-range ballistic missiles.[145] These outer space plans lend credence to the predictions that the space debris problem will be worse than the 2006 models suggested. In fact, those predictions have already come to fruition.

The drastic additions to the space debris environment caused Nicholas Johnson, one of the two NASA scientists involved in the 2006 modeling, to predict the inevitability of the cascade effect.[146] Other scientific experts agree with Johnson and say that the cascade effect will start sooner than predicted in the 2006 modeling.[147] In short, scientists currently say that the space debris issue is now "a very big problem."[148] A report to the United Nations in October 2008—before the 2009 satellite collision—added to the ominous feeling, stating that the unhindered increase in space debris will, within ten to fifty years, create a cascade of collisions threatening sustainable space access.[149]

If the cascade effect actually occurs, it will put "billions of dollars' worth of advanced satellites at risk and eventually threaten to limit humanity's reach for the stars."[150] But is the cascade actually inevitable? Can this cascading effect be prevented, or at least mitigated by an international agreement? The United States' national security may depend on such efforts.

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142. SPACE SECURITY 2010, *supra* note 1, at 90.

143. WEST ET AL., *supra* note 48, at 14.

144. SPACE SECURITY 2010, *supra* note 1, at 77–82; Erdbrink, *supra* note 141, at C19; *Iran Launches Homegrown Satellite*, *supra* note 141.

145. Harden, *supra* note 141, at A11. In late February 2009, North Korea announced its plan to launch a "communications satellite" into space. Many North Korean experts, however, believed that the declaration served only as a cover for North Korean military plans to test a long-range ballistic missile. A UN resolution currently bans the country from such ballistic missile activity. The announcement threatened regional security, resulting in debate over whether to destroy any launched missile in flight. *Id.*

146. Broad, *supra* note 10, at F1.

147. *Id.*; *see also* Johnson, *supra* note 58, at A10 (predicting that even with no additions to space, there will still be an increase of space debris by a factor of three in the next two hundred years due to collisions).

148. Johnson, *supra* note 58, at A10.

149. *Increase in Space Debris Threatens Safe Space Fight*, SASKATOON STARPHOENIX, Oct. 25, 2008, at C17.

150. Broad, *supra* note 10, at F1.

III. THE NATIONAL SECURITY IMPACT

These gloomy prognostications about the threats to our space environment should be troubling to Americans. The United States relies on the unhindered use of outer space for national security.[151] According to a space commission led by former Secretary of Defense Donald Rumsfeld, "[t]he [United States] is more dependent on space than any other nation."[152] According to Robert G. Joseph, former Undersecretary for Arms Control and International Security at the State Department, "space capabilities are vital to our national security and to our economic well-being."[153] Therefore, a catastrophic collision between space debris and the satellites on which that national security so heavily depends poses a very real and current threat to the national security interests of the United States.

Since "the [1991] Gulf War, the [United States] military has depended on satellites for communications, intelligence and navigation for its troops and precision-guided weapons."[154] Satellites are also used for reconnaissance and surveillance, command and control, and control of Unmanned Aerial Vehicles.[155] According to the United States Space Command's Fact Sheet:

> Satellites provide essential in-theater secure communications, weather and navigational data for ground, air and fleet operations and threat warning.
>
> Ground-based radar and Defense Support Program satellites monitor ballistic missile launches around the world to guard against a surprise missile attack on North America. Space surveillance radars provide vital information on the location of satellites and space debris for the nation and the world. Maintaining space superiority is an emerging capability required to protect our space assets.[156]

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151. *See, e.g.*, OFFICE OF SCI. & TECH. POLICY, *supra* note 2, at 3, 5, 14 (declaring the free access to space as vital to national interests and outlining the details and defense of such access); Covault, *supra* note 11, at 24 (describing the United States' space capabilities as vital to national security and to the economy); Andrea Stone, *"Space Assets" Face Threat Panel: Satellites Are Vulnerable*, USA TODAY, Jan. 11, 2001, at 1A (suggesting that the government should make efforts to protect space assets for military and commercial reasons).

152. Stoullig, *supra* note 11.

153. Covault, *supra* note 11, at 24.

154. Stone, *supra* note 151, at 1A.

155. *See, e.g.*, *Air Force Space Command Factsheet*, U.S. AIR FORCE (Dec. 28, 2010), http://www.af.mil/information/factsheets/factsheet.asp?id=155 (noting satellite use for command and control); *MQ–1 Predator Factsheet*, U.S. AIR FORCE (July 20, 2010), http://www.af.mil/information/factsheets/factsheet.asp?fsID=122 (describing satellite use in unmanned aircraft systems that provide reconnaissance and surveillance); *MQ–9 Reaper Factsheet*, U.S. AIR FORCE (Aug. 18, 2010), http://www.af.mil/information/factsheets/factsheet.asp?id=6405 (same).

156. Air Force Space Command Factsheet, *supra* note 155.

With the modern speed of warfare, it has become difficult to fight conflicts without the timely intelligence and information that space assets provide. Space-based assets and space-controlled assets have created among U.S. military commanders "a nearly insatiable desire for live video surveillance, especially as provided from remotely piloted vehicles like the Predator and now the Reaper."[157] Moreover, military forces have become so dependent on satellite communications and targeting capabilities that the loss of such a satellite would "badly damage their ability to respond to a military emergency."[158]

In fact, the May 2008 malfunction of a communications satellite demonstrates the fragile nature of the satellite communications system.[159] The temporary loss of a single satellite "effectively pulled the plug on what executives said could [have been] as much as 90 percent of the paging network in the United States."[160] Although this country's paging network is perhaps not vital to its national security, the incident demonstrates the possible national security risks created by the simultaneous loss of multiple satellites due to space debris collisions.

Simply put, the United States depends on space-based assets for national security, and those assets are vulnerable to space debris collisions. As Massachusetts Democratic Congressman Edward Markey stated, "American satellites are the soft underbelly of our national security."[161] The Rumsfeld Commission set the groundwork for such a conclusion in 2001, when it discussed the vulnerability of U.S. space-based assets and warned of the Space Pearl Harbor.[162] Congress also recognized this vulnerability in June 2006, when it held hearings concerning space and its import to U.S. national power and security.[163] In his June 2006 Congressional Statement, Lieutenant General C. Robert Kehler, then the Deputy Commander, United States Strategic Command, stated that "space capabilities are

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157. Thom Shanker, *Air Force Plans an Expanded Role in Iraq*, N.Y. TIMES, July 29, 2008, at A12.

158. David A. Fulghum, *New Colors of War: Fused Sensors Stalk the Electromagnetic Spectrum for Extra Information*, AVIATION WK. & SPACE TECH., June 25, 2007, at 52, 52.

159. *Wayward Satellite Wreaks Havoc*, WIRED (May 20, 1998), http://www.wired.com/science/discoveries/news/1998/05/12414.

160. *Id.*

161. Craig Covault et al., *Aftermath: Chinese ASAT Test Raises the Prospects for Space-Control Spending—Eventually*, AVIATION WK. & SPACE TECH., Jan. 29, 2007, at 28, 28.

162. Stoullig, *supra* note 11.

163. *See, e.g., Space and U.S. Nat'l Power: Hearing Before the Subcomm. on Strategic Forces of the H. Comm. on Armed Servs.*, 109th Cong. (2006) (opening statement of Rep. Terry Everett, Chairman, H. Comm. Armed Servs. Subcomm. on Strategic Forces), *available at* http://www.globalsecurity.org/space/library/congress/2006_h/index.html (asking witnesses to discuss vulnerabilities of space systems).

inextricably woven into the fabric of American security."[164] 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."[165]

Because so much of the United States' security depends on satellites, these integral space-based capabilities would, therefore, be costly to lose. That loss would be felt in more than just the security arena. Due to the steep price tags attached to some of the national space security platforms, the economic loss of a satellite due to space debris would also be significant. For example, a pair of new Global Positioning Satellites (GPS), which provides valuable targeting and battle space awareness to military commanders, costs $1.5 billion.[166] Accordingly, if a piece of space debris destroys one of these satellites, $750 million could be lost instantly. Additionally, NASA invests billions of dollars annually in space assets. Congress provided NASA with $18.3 billion to spend on space utilization and exploration for fiscal year 2010, and it provided $17.7 billion for fiscal year 2011.[167] Air Force General (retired) Ronald E. Keys, former Commander of Air Combat Command, summed it up best, stating that a great deal "rides on space-borne satellites."[168] Because these space capabilities are so costly yet so vital to the United States' national security and economic well-being, the preservation of these space capabilities should also be vital.

Unfortunately, as the Rumsfeld Commission noted, "the threat to the [United States] and its allies in and from space does not command the attention it merits."[169] This problem was echoed when, on April 28, 2010, experts from NASA, the U.S. military, industry, and academia provided testimony to the U.S. House of Representatives Subcommittee on Space and Aeronautics.[170] "According to subcommittee Chairwoman Gabrielle Giffords of Arizona, the general

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164. *Id.* (statement of Lt. Gen. C. Robert Kehler, Deputy Commander, U.S. Strategic Command).

165. *Id.* at 3.

166. Per the May 2008 award of the contract to Lockheed Martin. *See, e.g.*, Gayle S. Putrich, *Lockheed Wins GPS III*, DEF. NEWS, May 15, 2008, http://www.defensenews.com/story.php?i=3532006 (noting that the contract for two satellites is worth $1.5 billion and is expected to grow).

167. *See* OFFICE OF MGMT. & BUDGET, EXEC. OFFICE OF THE PRESIDENT, BUDGET OF THE UNITED STATES GOVERNMENT: FISCAL YEAR 2011, at 132 (2010), http://www.whitehouse.gov/sites/default/files/omb/budget/fy2011/assets/nasa.pdf (budgeting $18.33 billion in 2010 and $17.68 billion in 2011 for NASA funding).

168. Covault et al., *supra* note 161, at 28.

169. Stoullig, *supra* note 11.

170. SPACE SECURITY 2010, *supra* note 1, at 39.

conclusion of the hearing was that the problem is serious and the world needs to take concrete steps to address it."[171] To rectify this problem from a legal standpoint, and to immediately counter the national security threat that space debris presents, there must be a fundamental shift in how the United States and the international community perceive space debris. Rather than thinking about space debris in terms of its overall increase to the amount of man-made material in space, we must look at space debris in terms of the considerable risk that it poses to national security.

Toward that end, the international community needs aggressive space debris removal and reduction efforts on a global scale, and it can effectuate the necessary change through international law. Without a collective international legal effort to induce a reduction in space debris, it will only be a matter of time before the free use of space is severely imperiled, if not forever lost.[172]

IV. THE HISTORICAL LEGAL FRAMEWORK

The devastating consequences described in the previous Part could be avoided through the implementation of a binding international agreement on space debris. Such an agreement must require, among other things, that countries make efforts to rid the space environment of the debris that they produce. The agreement must also require countries to create cost-effective methods to solve the current space debris problem, rather than simply mitigating future additions to the problem. To explain the necessity of such an agreement, however, it is important to first discuss why current international law on this issue is insufficient to address the monumental space debris predicament. Simply put, "there is no legal concept of 'space debris' under international space law and thus no mechanisms to regulate it."[173] The discussion centers around how space, and subsequently space debris, is defined.

A. *Space Debris v. Air Debris*

Currently, there is no international consensus on where a nation's airspace ends and space begins.[174] Although the UN

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171. *Id.*

172. *See, e.g.*, Sundahl, *supra* note 53, at 132 (explaining that it is only a matter of time before there is enough space debris to cause a collision that will trigger a cataclysmic chain reaction).

173. Steven Freeland, *Up, Up and . . . Back: The Emergence of Space Tourism and Its Impact on the International Law of Outer Space*, 6 CHI. J. INT'L L. 1, 20 (2005).

174. *See* U.N. Secretariat, Comm. on the Peaceful Uses of Outer Space, *Historical Summary on the Consideration of the Question on the Definition and*

Committee on the Peaceful Uses of Outer Space (COPUOS) has considered this issue since 1959, it remains unresolved.[175] In fact, the general feeling that COPUOS expressed in 1959—that "the determination of precise limits for airspace and outer space [does] not present a legal problem calling for priority consideration at this moment"[176]—remains true today.[177]

Despite the lack of a precise definition for outer space, several approaches to defining that term have emerged over the years. One predominant approach sets the upper limits of airspace at about 100 kilometers (sixty-two miles).[178] As an organization with a vested interest in declaring where outer space begins, the World Air Sports Federation (FAI) picked this limit in the 1950s to keep track of the aeronautical record book.[179] On March 28, 1979, the Soviet Union became the first country to submit that the 100-kilometer standard should be used to define where outer space begins.[180] Although never legally accepted, many international agencies and organizations have adopted the 100-kilometer standard.[181] In fact, NASA uses the FAI's 100-kilometer figure to determine who gets astronaut ratings.[182]

However, the FAI's 100-kilometer limit is "fairly arbitrary."[183] A more functional approach sets the upper limits of airspace at the lowest possible orbiting altitude for satellites.[184] This delimitation is established at roughly 275,000 feet (just under eighty-four kilometers), which is believed to be the "point where aerodynamic lift yields to centrifugal force."[185] This point, however, is not constant, as

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Delimitation of Outer Space, ¶¶ 3–25, U.N. Doc. A/AC.105/769 (Jan. 18, 2002) (describing decades-long attempts to reach a definition, with no agreement).

175. SPACE SECURITY 2010, *supra* note 1, at 60.

176. Rep. of the Ad Hoc Comm. on the Peaceful Uses of Outer Space, U.N. Doc. A/4141 (1959).

177. *See, e.g.*, U.N. Secretariat, *supra* note 174, ¶ 25 (concluding that included information could eventually provide a basis for a resolution, but noting no urgency).

178. *See, e.g.*, SPACE SECURITY 2010, *supra* note 1, at 60 (noting this 100-kilometer boundary, but pointing out that many states refuse to acknowledge a need for it); Dan Kois, *Where Does Space Begin?*, SLATE (Sept. 30, 2004), http://www.slate.com/id/2107381 (noting that the creators of the Ansari X Prize set the "border of space" at 100 kilometers because it is a "nice round number" used by the World Air Sports Federation (FAI)).

179. Kois, *supra* note 178.

180. Stanley B. Rosenfield, *Where Air Space Ends and Outer Space Begins*, 7 J. SPACE L. 137, 138 (1979).

181. Kois, *supra* note 178.

182. *Id.* ("The U.S. Air Force, however, awards astronaut wings to rated officers who fly higher than 50 miles (or about 80 kilometers) above sea level.").

183. Even the FAI's Secretary General Max Bishop admitted, in 2004, that the FAI's 100-kilometer limit was "fairly arbitrary." *Id.*

184. *See, e.g.*, WILLIAMSON, *supra* note 15, at 29 ("A more scientific reason for choosing 100 km is that spacecraft cannot complete an orbit below this altitude because friction with the atmosphere causes them to reenter.").

185. Rosenfield, *supra* note 180, at 139.

it often changes with changes in atmospheric density.[186] Because solar activity can cause atmospheric expansion, it is generally believed that the 100-kilometer standard is a better point to arbitrarily determine where outer space begins.[187] Due to atmospheric friction and gravitational pull, most objects orbiting below this altitude cannot sustain orbit.[188] Although the 100-kilometer limit is gaining acceptance, "there is still no internationally agreed, or legally binding, definition regarding the boundary between Earth and space."[189]

The term "space debris" also lacks an internationally agreed upon and legally binding definition. Some scholars argue that the vague terminology in the 1967 Outer Space Treaty, the 1972 Liability Convention, the 1975 Registration Convention, and any other international agreement discussing space is enough to encompass the phrase "space debris."[190] Nothing in these treaties, however, precisely or adequately defines the term.[191] In a careful examination of these treaties, one theme stands out: in "any future international agreement designed to control debris, the term 'space debris' will have to be defined."[192]

B. *The 1967 Outer Space Treaty*

The first treaty to deal with outer space issues was the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.[193] This treaty, more commonly referred to as the "Outer Space Treaty," is generally believed to be the most important treaty governing space.[194] Scholars have described the treaty as "the

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186. WILLIAMSON, *supra* note 15, at 29.

187. *Id.*

188. *Id.*

189. *Id.*; *see also* U.N. Secretariat, *supra* note 174, ¶ 25 (noting that no agreement on the delimitation of outer space is apparent).

190. *See, e.g.*, Taylor, *supra* note 16, at 27 (arguing that under the treaties, every object launched into space has the potential to become space debris).

191. *Compare* Outer Space Treaty, *supra* note 12, art. I (referring to the "use of outer space, including the Moon and other celestial bodies," but providing no further definition), *with* Liability Convention, *supra* note 13, art. I (referring only to a "space object" as an object launched), *and* Registration Convention, *supra* note 14, art. II(1) (referring only to objects launched into "Earth orbit or beyond").

192. Gunnar Leinberg, *Orbital Space Debris*, 4 J.L. & TECH. 93, 101 (1989).

193. Outer Space Treaty, *supra* note 12.

194. *See, e.g.*, Adam G. Quinn, *The New Age of Space Law: The Outer Space Treaty and the Weaponization of Space*, 17 MINN. J. INT'L L. 475, 479, 487 (2008) (considering the Outer Space Treaty as the "foundation" and "cornerstone" of space law); *see also* 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, 370 (2002) ("[T]he Outer Space Treaty is the most important.").

foundation of the international legal order in outer space"[195] and "the Magna Carta for space activities."[196] These descriptions generally ring true, as the "Outer Space Treaty was the first attempt to regulate outer space and establish broad guidelines for space exploration."[197] As of October 1, 2010, the Outer Space Treaty had been ratified by one hundred countries, including the United States, Russia, China, and North Korea.[198] An additional twenty-six countries, including Iran, have signed but not ratified the treaty.[199]

Pertinent to the space debris discussion, the Outer Space Treaty states that "Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty."[200] Article I states that the "exploration and use of outer space . . . shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind."[201] Moreover, this treaty demands that outer space be "free for exploration and use by all States."[202]

To ensure the free use of space by all nations, Article IX of the treaty states that the exploration of outer space shall be conducted so as to avoid its "harmful contamination" and that, where necessary, signatories to the treaty shall "adopt appropriate measures for this purpose."[203] The problem with applying this obligation to the space debris debate is that the treaty fails to define what "harmful contamination" actually is.[204] The absence of a definition of this term raises questions as to whether it encompasses space debris, because

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195. Nandasiri Jasentuliyana, *A Survey of Space Law as Developed by the United Nations*, *in* PERSPECTIVES ON INTERNATIONAL LAW 349, 359 (Nandasiri Jasentuliyana ed., 1995). Dr. Jasentuliyana is President-Emeritus of the Paris-based International Institute of Space Law.

196. Eilene Galloway, *Expanding Space Law into the 21st Century*, 35 PROC. COLLOQUIUM L. OUTER SPACE 49, 52 (1992).

197. Quinn, *supra* note 194, at 480.

198. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, UNITED NATIONS OFFICE OUTER SPACE AFF., http://www.oosa.unvienna.org/oosa/en/SpaceLaw/outerspt.html (last visited Mar. 17, 2011). For the list of signatories and ratifications, click on "Treaty Status Index" hyperlink and then enter drop down fields for "treaty" and "status."

199. *Id.*

200. Outer Space Treaty, *supra* note 12, art. IX.

201. *Id.* art. I.

202. *Id.*

203. *Id.* art. IX.

204. *See id.* arts. I–XVII (providing no definition or explanation for "harmful contamination"); *see also* Nandasiri Jasentuliyana, *Space Debris and International Law*, 26 J. SPACE. L. 139, 141 (1998) (noting that the treaties do not indicate what "harmful contamination" means).

there "is no generally accepted definition of . . . 'harmful contamination' . . . and the treaty does not provide any guidance."[205] One legal scholar suggested "that harmful contamination does not include space debris and refers only to astronauts and spacecraft."[206] Another argument based on a plain-language reading of the provision is that "harmful contamination" refers only to contamination resulting from the introduction of extraterrestrial matter, not debris created from fragmented Earth objects.[207] Regardless of these arguments, the definitions of "space" and "space debris" represent important aspects of space law development that the international community needs to address in any space debris treaty.[208]

Another uncertain term mentioned in the Outer Space Treaty is "space object." Arguably, this term could encompass space debris; however, a complete and adequate definition of "space object" cannot be found anywhere in international law.[209] Article VII of the Outer Space Treaty mentions this concept in the context of liability, extending international liability to a launching state for the damage that its space "object or its component parts" cause to another nation's objects "in outer space."[210] Unfortunately, the treaty defines neither "space object" nor "component parts."[211]

A former Soviet lawyer once defined "space object" as something launched into space and controlled from a ground control center.[212] Certainly, this definition would not include space debris. One can also legitimately argue that the drafters of the Outer Space Treaty meant for space objects to be operational objects and "regarded only 'component parts' [such as rocket boosters] and not all 'parts' [such as debris fragments] of a space object as being subject to the constraints" of the treaty.[213] Scholars have yet to agree on whether space debris should be considered a space object,[214] and some notable legal scholars "maintain that space debris is not to be considered a space object."[215] Dr. Nandasiri Jasentuliyana, President-Emeritus of the

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205. Williams, *supra* note 53, at 1156.

206. *Id.* (citation omitted).

207. *See* Outer Space Treaty, *supra* note 12, art. IX (declaring that parties conduct space exploration "so as to avoid their harmful contamination").

208. Stephen Gorove, *Toward a Clarification of the Term "Space Object"—An International Legal and Policy Imperative?*, 21 J. SPACE L. 11, 11–12 (1993).

209. *Id.* at 12.

210. Outer Space Treaty, *supra* note 12, art. VII.

211. Outer Space Treaty, *supra* note 12, arts. I–XVII.

212. Leinberg, *supra* note 192, at 101.

213. Gorove, *supra* note 208, at 13–14.

214. *Id.* at 15; *see also* Comm. on the Peaceful Uses of Outer Space, Scientific and Technical Subcomm., Rep. on its 44th Sess., Feb. 12–23, 2007, Annex IV ¶ 1, U.N. Doc. A/AC.105/890 (Mar. 6, 2007) [hereinafter 44th STS Report] (attempting to again provide a separate definition for space debris).

215. Gorove, *supra* note 208, at 15. Stephen Gorove was a leader among space law scholars and "among the first to tackle the legal angles of the conquest of space."

Paris-based International Institute of Space Law, supports the assertion that the term "space debris" is not adequately covered by current space law.[216] He argues that the terms in the Outer Space Treaty and subsequent space treaties, such as the 1972 Liability Convention and the 1975 Registration Convention, "are just not definite enough to handle the complex issue of space debris."[217]

C. *The 1972 Liability Convention*

The terminology in the 1972 Convention on International Liability for Damage Caused by Space Objects,[218] more commonly referred to as the "Liability Convention," does nothing to clarify the question of whether the term "space debris" falls within the ambit of outer space treaty provisions. Enacted to address the damage that space objects may cause,[219] this treaty "clarifies and amplifies the liability regime established by Article VII of the Outer Space Treaty."[220] As of October 1, 2010, the Liability Convention had ninety ratifications and twenty-three signatures.[221] North Korea is a nonparty, but ratifications include the United States, Russia, China, and even Iran.[222]

Article I of the Liability Convention defines "space object" to include "component parts of a space object as well as its launch vehicle and parts thereof."[223] Because the treaty fails to define what a "component part" of a "space object" actually is, or whether either term includes "space debris," the applicability of this treaty to space debris is far from established.[224] Additionally, with the increase in space commercialization, both private industry and, to some degree, state actors have a monetary interest in ensuring that the terms used in space treaties remain as vague as possible in order to avoid

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Wolfgang Saxon, *Stephen Gorove, 83, Leader in Field of Space Law*, N.Y. TIMES, Sept. 1, 2001, at C15. His international space law efforts paved the way for the establishment of the NASA-financed National Remote Sensing and Space Law Center located at the University of Mississippi. *Id.*

216. Jasentuliyana, *supra* note 204, at 141.

217. *Id.*

218. Liability Convention, *supra* note 13.

219. *Id.* pmbl.

220. Taylor, *supra* note 16, at 26.

221. *Convention on International Liability for Damage Caused by Space Objects*, UNITED NATIONS OFFICE OUTER SPACE AFF., http://www.oosa.unvienna.org/oosa/en/SpaceLaw/liability.html (last visited Mar. 17, 2011). For the list of signatories and ratifications, click on "Treaty Status Index" hyperlink and then enter drop down fields for "treaty" and "status."

222. *Id.*

223. Liability Convention, *supra* note 13, art. I.

224. Jasentuliyana, *supra* note 204, at 142.

potential liability for damage caused by the space debris they create.[225]

More importantly, even if the terms of the Liability Convention do encompass space debris, it does nothing to deter debris creation, because the Liability Convention requires fault before liability can be assessed. Article III of the Liability Convention states that when a launching state causes damage in space to a space object or to persons on board that space object, the state causing the damage "shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible."[226] Accordingly, absent fault, which can be difficult to prove in the space environment, no liability attaches when space debris unintentionally causes damage in space. Therefore, from a liability cost–benefit analysis, the Liability Convention provides little motivation for space-faring nations to minimize space debris or to clean up the debris currently in existence.

Moreover, the "Liability Convention speaks only of damage to persons or property, but not for damage caused to the outer space environment."[227] Article I(a) defines "damage" to mean "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."[228] Nothing in the Liability Convention mandates the prevention of space debris that does not cause physical damage to other objects or persons.[229] Therefore, the Liability Convention does nothing to force nations to remove the existing space debris that fails to cause physical damage, even though it causes launch delays or collision-avoidance maneuvers. Instead, the Liability Convention serves "only as a limited deterrent to States' generation of space debris."[230]

Finally, the Liability Convention fails to "provide any specific mechanism for establishing the identity of space objects launched into outer space, or the associated debris that might" be created.[231] Instead, the Liability Convention operates under the assumption that the launching state of any given space object will be easily identifiable.[232] With space debris, however, "[t]his is quite clearly not the case."[233] Accordingly, even if the Liability Convention did apply to space debris, "[l]iability for damage caused by space debris [would

225. *Id.* at 143.
226. Liability Convention, *supra* note 13, art. III.
227. Jasentuliyana, *supra* note 204, at 143; *see also* Liability Convention, *supra* note 13, art. II (creating liability only for damage "on the surface of the earth or to aircraft flight").
228. Liability Convention, *supra* note 13, art. I.
229. Jasentuliyana, *supra* note 204, at 313.
230. *Id.*
231. *Id.*
232. *Id.*
233. *Id.*

be] difficult to establish, as it [would be] difficult to determine the specific source of a piece of debris, particularly when it is a small piece that has not been cataloged."[234] The Liability Convention therefore leaves "too many gaps to be very useful regarding the problem of [space] debris."[235]

D. *The 1975 Registration Convention*

The 1975 Convention on Registration of Objects Launched into Outer Space,[236] commonly referred to as the "Registration Convention," does little to remedy the problem of ascertaining which nation is responsible for a particular piece of space debris. As of October 1, 2010, this treaty had been ratified by fifty-four states, including the United States, Russia, China, and even North Korea.[237] Additionally, four countries, including Iran, have signed but not ratified the Registration Convention.[238]

Article I of the Registration Convention requires a launching state to register any space object launched into space "by means of an entry in an appropriate registry which it shall maintain."[239] Each launching state must "inform the Secretary-General of the United Nations of the establishment of such a registry."[240] The UN Secretary-General shall be notified "as soon as practicable" after the space launch occurs.[241]

There is no set length of time deemed "practical" for proper notification to the Secretary-General, and a "lack of timelines for UN registration remains a shortcoming of the Registration Convention."[242] In fact, from 1980 to June 2006, at least 225 known payloads launched into space went completely unregistered.[243]

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234. SPACE SECURITY 2010, *supra* note 1, at 61.

235. Lucinda R. Roberts, *Orbital Debris: Another Pollution Problem for the International Legal Community*, 11 FLA. J. INT'L L. 613, 621 (1997).

236. Registration Convention, *supra* note 14.

237. *Convention on Registration of Objects Launched into Outer Space*, UNITED NATIONS OFFICE OUTER SPACE AFF., http://www.oosa.unvienna.org/oosa/SORegister/index.html (last visited Mar. 17, 2011). Additionally, "two international intergovernmental organizations (the European Space Agency and the European Organization for the Exploitation of Meteorological Satellites) have declared their acceptance of the rights and obligations provided for in the Convention." *Id.* For the list of signatories and ratifications click on "51 States have ratified, 4 have signed," then click on "searchable online treaty status," and enter drop down fields for "treaty" and "status."

238. *Id.*

239. Registration Convention, *supra* note 14, art. II(1).

240. *Id.*

241. *Id.* art. IV.

242. SPACE SECURITY 2010, *supra* note 1, at 62.

243. WEST ET AL., *supra* note 48, at 50. Registration of space objects at both the national and international levels between 2001 and 2003 occurred only 75 percent of the time, down from 91 percent in 1991. *Id.* at 49.

Moreover, many military-related launches go unregistered: no launched satellite has ever been registered as having a military function.[244] Therefore, failure to register a satellite presents a huge obstacle to subsequent identification of any piece of space debris from or caused by that satellite. Moreover, the Registration Convention does not "require a launching state to provide appropriate identification markings for its spacecraft and its component parts."[245] As a result, the Registration Convention is not a very useful tool for addressing the problem of space debris.[246]

Another major debris-related drawback to the Registration Convention is the lack of clarity as to whether "only active satellites are required to be registered, or whether additional information on such things as inactive satellites, failed missions, and space object breakup might also be required, all of which could increase the amount of space debris in outer space."[247] On its face, there does not appear to be an affirmative duty for nations to register the space debris that they create.[248] As such, even if the Liability Convention did apply to space debris, enforcing its provisions against the offending state through either bilateral negotiations or the Claims Commission established by that treaty[249] would be almost impossible due to a lack of adequate recording under the Registration Convention.

To its credit, the Registration Convention does create a data-sharing duty to assist in the tracking of space objects, but the duties under that obligation are not absolute and are likely inapplicable to space debris.[250] Article VI of the Registration Convention states:

> Where the application of the provisions of this Convention has not enabled a State Party to identify a space object which has caused damage to it or to any of its natural or juridical persons, or which may be of a hazardous or deleterious nature, other States Parties, including in particular States possessing space monitoring and tracking facilities, shall respond to the greatest extent feasible to a request by that State Party, or transmitted through the Secretary-General on its behalf, for assistance under equitable and reasonable conditions in the identification of the object.[251]

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244. *Id.* at 49.

245. *Id.*

246. Jasentuliyana, *supra* note 204, at 144.

247. *Id.*

248. Registration Convention, *supra* note 14, art. II(1) (requiring registration of space objects, but making no specific mention of space debris).

249. *See* Liability Convention, *supra* note 13, arts. XIV–XX (describing the procedure for enforcing claims).

250. *See* Registration Convention, *supra* note 14, art. VI (describing the data-sharing duty).

251. Registration Convention, *supra* note 14, art. VI.

The phrase "to the greatest extent feasible" raises questions of how much data must be shared. Moreover, as with the Outer Space Treaty and the Liability Convention, the term "space object" is not precisely defined and likely was not intended to include "space debris."[252] In fact, UN action over the last sixteen years clearly demonstrates that space debris remains an uncertain term and an unresolved problem.[253] The international community therefore needs a more specific treaty regarding space debris.

V. UNITED NATIONS DRIVES NONBINDING FRAMEWORK TO DEAL WITH SPACE DEBRIS

Due to the international concerns surrounding the space debris problem, the UN General Assembly sought to formally address the issue through a 1993 resolution.[254] This resolution essentially marked the formal beginning of the modern international space debris discussion. In its resolution, the General Assembly specifically noted that "space debris" was "an issue of concern to all nations"[255] and called upon the Scientific and Technical Subcommittee (STS) to COPUOS to make the issue of space debris a formal agenda item.[256] Moreover, the General Assembly mandated that the STS consider the problem of space debris "on a priority basis."[257] The General Assembly considered it "essential that Member States pay more attention to the problem of . . . space debris."[258]

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252. *See* Jasentuliyana, *supra* note 204, at 144 (noting that the convention's narrow definition of "space object" conceivably excludes many debris objects).

253. *See, e.g.*, Comm. on the Peaceful Uses of Outer Space, Scientific & Technical Subcomm., Technical Rep. on Space Debris, ¶¶ 6–7, U.N. Doc. A/AC.105/720 (1999) [hereinafter Technical Rep. on Space Debris] (stating that "there is still no consensus agreement on the definition" of "space debris"); *see also* Gorove, *supra* note 208, at 11–12 (noting that despite achievements in the drafting of five space treaties, the term "space object" remains undefined and remains an impediment); Jasentuliyana, *supra* note 204, at 140–41 ("Unfortunately, there is no definition of what comprises an 'object or its component parts,' thus it is uncertain whether all space debris would fall within the ambit of this provision."); Taylor, *supra* note 16, at 26–27 (discussing the lack of clear definitions of "space objects" and "objects launched into outer space").

254. G.A. Res. 48/39, U.N. Doc. A/RES/48/39 (Dec. 10, 1993).

255. *Id.* ¶ 6.

256. *Id.* ¶ 8.

257. *Id.* ¶ 10(a)–(b)(i).

258. *Id.* ¶ 27.

A. *COPUOS Makes Space Debris an Agenda Item*

Space debris was subsequently included in the STS's agenda at its February 1994 session.[259] The STS "agreed that consideration of space debris was important and that international cooperation was needed to evolve appropriate and affordable strategies to minimize the potential impact of space debris on future space missions."[260] At its next session, in February 1995, the STS made the consideration of space debris a priority, as called for by the 1993 General Assembly resolution.[261]

During that 1995 session, the STS also attempted to define "space debris" in order to "have a common understanding of the term."[262] The discussion centered around the notion that the term would encompass "all man-made objects, including their fragments and parts, in Earth orbit or reentering the dense layers of the atmosphere that are non-functional with no reasonable expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be authorized."[263] Unfortunately, there is still no consensus space debris definition.[264] In fact, even the STS tinkered with its definition the following year, adding the phrase "whether their owners can be identified or not" to the previous year's definition.[265]

1. STS Discusses Measurements of Space Debris

In addition to changing the definition of space debris, the 1996 STS also focused on how to measure space debris.[266] It was during this session that "large debris objects" were defined to be objects "larger than 10 centimeters in size."[267] The STS settled on this size because such objects were capable of being easily tracked.[268] Moreover, debris of this size can be very harmful to other space objects because it can carry "the kinetic energy of a 35,000-kg truck

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259. Jasentuliyana, *supra* note 204, at 146.

260. Comm. on the Peaceful Uses of Outer Space, Scientific and Technical Subcomm., Rep. on its 31st Sess., Feb. 21–Mar. 3, 1994, ¶ 64, U.N. Doc. A/AC.105/571 (Mar. 10, 1994).

261. Jasentuliyana, *supra* note 204, at 146.

262. Comm. on the Peaceful Uses of Outer Space, Scientific & Technical Subcomm., Rep. on its 32d Sess., Feb. 6–16, 1995, ¶ 95, U.N. Doc. A/AC.105/605 (Feb. 24, 1995).

263. *Id.*

264. *See supra* note 255.

265. 33d STS Report, *supra* note 96, ¶ 143.

266. *Id.* ¶ 95.

267. *Id.* ¶ 133.

268. *Id.*

traveling at up to 190 km per hour."[269] Scientists estimate that debris as small as two millimeters threaten spacecraft security.[270] This potential damage, combined with the amount of debris currently in Earth's orbit, mandates the mitigation and removal of space debris.

2. STS Discusses Space Debris Mitigation Measures

The STS addressed that concern in 1998, when it formally discussed space debris mitigation and removal options.[271] During that session, representatives of France, Germany, Japan, Russia, the United Kingdom, and the United States presented information on the topic.[272] Additionally, some "delegations expressed the view that the elimination of the existing space debris was one of the most important mitigation measures," and they added that even if the removal of space debris was "not technically and economically feasible[,] . . . the international community should not neglect the efforts to develop adequate technologies to cleanse outer space in the future."[273] Moreover, some delegates laid the foundation for a discussion concerning the establishment of an "international fund for space debris to tackle the space debris issue."[274] Unfortunately for the legal aspects of the space debris problem, many delegates "expressed the view that it would not be appropriate to discuss the issue of space debris in the Legal Subcommittee [to COPUOS] unless sufficient progress had been made on that issue in the [STS]."[275] The STS ultimately agreed that draft space debris mitigation measures should be included in its subcommittee report, but it deferred adoption of any mitigation measures until 1999 in order to allow such measures to be further analyzed.[276]

During its 1999 session, the STS adopted the 1998 draft space debris mitigation measures.[277] Once adopted, the STS widely distributed the draft measures to several scientific communities, as well as COPUOS's Legal Subcommittee, for review and comment.[278]

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269. Space SECURITY 2010, *supra* note 1, at 29.

270. *Id.* at 27.

271. *See* Comm. on the Peaceful Uses of Outer Space, Scientific & Technical Subcomm., Rep. on its 35th Sess., Feb. 8–20, 1998, ¶¶ 26–32, U.N. Doc. A/AC.105/697 (Feb. 25, 1998) [hereinafter 35th STS Report] (analyzing the effectiveness of different mitigation and removal strategies).

272. *Id.* ¶ 89.

273. *Id.* ¶ 100.

274. *Id.* ¶ 103.

275. *Id.* ¶ 104.

276. *Id.* ¶ 95.

277. Comm. on the Peaceful Uses of Outer Space, Scientific & Technical Subcomm., Rep. on its 36th Sess., Feb. 22–26, 1999, ¶ 35, U.N. Doc. A/AC.105/719 (Mar. 18, 1999).

278. *Id.*

The STS also produced a separate *Technical Report on Space Debris*, the aim of which "was to establish a common understanding of the nature of space debris that could serve as a basis for further deliberations."[279] Regrettably, even with intermittent UN focus and an STS space debris working group,[280] the ensuing review process took over seven years to complete.[281]

B. *COPUOS's 2007 Nonbinding Guidelines for Space Debris Mitigation*

Finally, in 2007, COPUOS provided nonbinding guidelines for mitigating man-made space debris to the UN General Assembly for consideration and potential implementation.[282] In an annex to their 2007 committee report, COPUOS stated that ever since the publication of "its *Technical Report on Space Debris* in 1999, it ha[d] been a common understanding that the current space debris environment poses a risk to spacecraft in Earth orbit."[283] COPUOS recognized that as "the population of debris continues to grow, the probability of collisions that could lead to potential damage will consequently increase," and it accepted that absent removal methods, space debris collisions would be a significant source of space debris in the future.[284]

COPUOS thoroughly understood the benefit of having international and widely accepted space debris guidelines.[285] As a result, COPUOS provided the UN General Assembly with the following seven nonbinding guidelines for the mitigation of space debris:

> Guideline 1: Limit debris released during normal operations;
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> . . . .
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> Guideline 2: Minimize the potential for break-ups during operational phases;
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> . . . .
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> Guideline 3: Limit the probability of accidental collision in orbit;
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> . . . .

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279. Technical Rep. on Space Debris, *supra* note 254, ¶ 10.

280. *See* U.N. Comm. on the Peaceful Uses of Outer Space, Scientific & Technical Subcomm., Rep. on its 42d Sess., Feb. 12–23, 2007, Annex II ¶¶ 1–2, U.N. Doc. A/AC.105/848 (Feb. 25, 2005) (discussing a space debris working group).

281. 44th STS Report, *supra* note 214, Annex IV. COPUOS did not adopt and submit a finalized version of the STS's 1999 draft measures until 2007.

282. *Id.*

283. *Id.* ¶ 1 (emphasis added).

284. *Id.*

285. *Id.* ¶ 2.

> Guideline 4: Avoid intentional destruction and other harmful activities;
>
> . . . .
>
> Guideline 5: Minimize potential for post-mission break-ups resulting from stored energy;
>
> . . . .
>
> Guideline 6: Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission; and
>
> . . . .
>
> Guideline 7: Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission.[286]

COPUOS considered the immediate implementation of these measures "a prudent and necessary step towards preserving the outer space environment for future generations."[287]

In creating these seven nonbinding space debris mitigation measures, COPUOS also attempted to define the term "space debris" again. This definition included "all man-made objects, including fragments and elements thereof, in Earth orbit or reentering the atmosphere, that are non-functional."[288] Unfortunately, like the mitigation measures themselves, this definition of "space debris" is nonbinding and, by the specific terms of the report, limited to the purpose of that document.[289]

C. *UN General Assembly Adopts Nonbinding Mitigation Guidelines*

In February 2008, the UN General Assembly, by resolution, endorsed and adopted COPUOS's seven nonbinding space debris mitigation measures.[290] The General Assembly also recognized that its member states need to pay more attention to the problem of space debris.[291] In addition, the United Nations called for continued national and international research, including research and development into means to better track and remove debris, compile debris data, and disseminate that information.[292]

The biggest problem with these seven space debris mitigation guidelines, however, is that they are nonbinding. Although

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286. *Id.* ¶ 4.
287. *Id.* ¶ 1.
288. *Id.*
289. *Id.*
290. G.A. Res. 62/217, ¶¶ 26–28, U.N. Doc. A/RES/62/217 (Feb. 1, 2008).
291. *Id.* ¶ 28.
292. *Id.*

nonbinding guidelines can become binding customary law through repeated practice over time,[293] the space debris challenge needs to be met now. Additionally, for these guidelines to actually become customary international law, the guidelines must develop into "a settled practice . . . carried out in such a way as to be evidence of a belief that this practice is rendered obligatory by the existence of a rule of law requiring it."[294] Moreover, "the state practice must be 'extensive and virtually uniform,' particularly with respect to states whose interests are 'specially affected.'"[295]

Customary international law on space debris is never likely to develop. The first problem is that "the prevailing, but not universal, state practice among the specially affected states is to limit the creation of new orbital debris when it is cost-effective and can be accomplished without negative mission impact."[296] Since the space race began, "states abandoned satellites in space and made no effort to minimize the creation of new debris."[297] Incidents such as the Chinese ASAT mission, and even the United States' destruction of its own satellite, "provide additional evidence that consistent state practice has not yet solidified" regarding space debris mitigation, and even if it has, states do not feel obligated to follow that practice.[298]

Furthermore, the guidelines require member states and international organizations to "voluntarily take measures, through national mechanisms or through their own applicable mechanisms, to ensure that [the space debris mitigation] guidelines are implemented."[299] This obligation applies only to "the greatest extent feasible."[300] Consequently, binding international law clearly has not been and cannot be created by these guidelines. No *opinio juris* or legal obligation to follow the guidelines exists.[301] As such, even with these guidelines, customary international law does not govern space debris.[302]

More worrisome is the fact that the nonbinding guidelines fail to truly address the immediate problem of debris removal. Although mitigation measures are definitely needed, removal measures are needed now to prevent the cascade effect that will occur if space

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293. *See* North Sea Continental Shelf (F.R.G./Den. & F.R.G./Neth.), 1969 I.C.J. 3, 44 (Feb. 20) (citing this possibility, but noting that it did not happen in this case).

294. *Id.*

295. Taylor, *supra* note 16, at 28 (discussing the North Sea Continental Shelf cases).

296. *Id.*

297. *Id.*

298. *Id.*

299. 44th STS Report, *supra* note 214, Annex IV ¶ 3.

300. *Id.*

301. *See* Taylor, *supra* note 16, at 29 (explaining how this practice does not satisfy *opinio juris* requirements).

302. *Id.*

debris is left uncontrolled. Therefore, despite the noblest of mitigation efforts, the guidelines fall short to the extent that they fail to address the need to remove the space debris currently in existence and the space debris that will inevitably be created in the future.

VI. COPUOS'S LEGAL SUBCOMMITTEE MUST PROPOSE A BINDING AGREEMENT

The United Nations seemed to recognize these problems with the nonbinding space debris mitigation efforts. In its February 2008 resolution, the General Assembly highlighted the need for COPUOS's Legal Subcommittee to look at the issue of space debris.[303] The General Assembly discussed the need for the Legal Subcommittee to reconvene its working group designed to ascertain whether the UN treaties on outer space apply to space debris, or whether a new agreement on space debris is necessary.[304]

The United Nations has given the Legal Subcommittee a substantial opportunity to create much-needed international law regarding space debris, an opportunity that the Legal Subcommittee should quickly seize. The Legal Subcommittee needs to declare that the UN treaties on outer space are insufficient to deal with the problem of space debris, and it needs to propose a binding international agreement on this topic. In doing so, the Legal Subcommittee must demand a treaty that defines, regulates, and mandates the removal of space debris. Toward this end, the Legal Subcommittee would be prudent to revive the STS's 1998 arguments that (1) emphasize and prioritize the import of space debris removal, regardless of whether such removal is yet "technically and economically feasible"; and (2) call for the creation of an international fund to finance research and development into space debris removal methods.[305] Finally, in order to provide countries with a better space situational awareness, the Legal Subcommittee should demand a treaty that requires the tracking and sharing of data related to space debris, a measure which the 1975 Registration Convention lacks.

A. *Cleaning Up the Junk*

Undoubtedly, technological accomplishments in the area of space debris removal are necessary to solve this problem. "Despite natural clearing, deorbiting, and debris mitigation measures, the [space

303. G.A. Res. 62/217, *supra* note 290, ¶ 6.
304. *Id.* ¶ 5.
305. *See* 35th STS Report, *supra* note 271, ¶ 103.

debris] population is growing and so is the risk of collisions."[306] NASA scientists J.C. Liou and Nicholas Johnson believe that space debris mitigation measures will not be enough to constrain Earth's space debris population.[307] Instead, they argue that only "the removal of existing [space debris] can prevent future problems for research in and commercialization of space."[308] The European Space Agency agrees. According to its 2009 "Key Findings from the 5th European Conference on Space Debris," the European Space Agency believes that space debris mitigation is not enough to maintain a safe space debris environment; active debris removal from orbit is the necessary next step.[309] Because removal of debris is the only long-term solution, implementing a binding international treaty on this issue can only assist in drawing attention to the need for cost-effective debris-removal techniques.[310] Legal necessity can sometimes be the mother of invention.

Currently, there are few cost-effective ways to remove space debris,[311] but NASA and the Defense Advanced Research Projects Agency are working on viable solutions.[312] Retrieval by the U.S. Space Shuttle or Russian Soyuz could be a viable solution for old satellites in LEO.[313] An easier and less costly way to remove defunct satellites from LEO is to limit the time that those satellites remain in orbit: after its effective life, a satellite could disperse enough residual fuel to allow it to deorbit for a destructive reentry or a controlled

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306. WILLIAMSON, *supra* note 15, at 79.

307. Liou & Johnson, *supra* note 5, at 341.

308. *Id.*

309. *Key Findings from the 5th European Conference on Space Debris*, EUROPEAN SPACE AGENCY (Apr. 2, 2009), http://www.esa.int/esaCP/SEMKO5EH1TF_index_0.html.

310. *See generally* AM. INST. OF AERONAUTICS & ASTRONAUTICS, SPECIAL PROJECT REP. NO. SP–016–1992, ORBITAL DEBRIS MITIGATION TECHNIQUES: TECHNICAL, LEGAL, AND ECONOMIC ASPECTS 6 (1992) (discussing the legal aspects of the space debris problem that existed in 1992).

311. *See, e.g.*, *id.* (noting the need to implement more cost-efficient approaches); WILLIAMSON, *supra* note 15, at 76–79 (noting various proposed solutions and the difficulties with funding these projects); *see also* Liou & Johnson, *supra* note 5, at 341 ("[N]o single remediation technique appears to be both technically feasible and economically viable.").

312. *NASA and DARPA Sponsor International Debris Removal Conference*, ORBITAL DEBRIS Q. NEWS (NASA, Hous., Tex.), Jan. 2010, at 1, 1–2. NASA and the Defense Advanced Research Projects Agency jointly sponsored the first of its kind—the International Conference on Orbital Debris Removal, which was held in Chantilly, Virginia December 8–10, 2009. *Id.*

313. *See* Warren E. Leary, *4th Endeavour Flight Pursues European Satellite*, N.Y. TIMES, June 22, 1993, at C5 (discussing the 1993 shuttle Endeavor's mission to retrieve the 9,800 pound European Space Agency's satellite EURECA through the use of the shuttle's robotic arm as practice for repair and retrieval of the Hubble telescope); *see also* WILLIAMSON, *supra* note 15, at 260 (discussing the Russian Soyuz' ability to ferry people and objects in and out of space).

disposal over the ocean.[314] The cost for this "residual fuel" technique is estimated to be low.[315] Adding extra fuel to the satellite, however, would increase the launch costs due to increases in total mass at launch.[316] Another option is to increase the drag on a satellite by attaching tethers that can be deployed at the end of the satellite's effective life to cause a corresponding increase in atmospheric drag that would subsequently result in atmospheric reentry.[317] These postmission deorbiting options are currently "advocated by the major space-faring nations and organizations of the world, including NASA, the Department of Defense, the Department of Transportation, and the Federal Communications Commission in the United States."[318]

Unfortunately, it is not yet possible to effectively deorbit satellites in GEO.[319] The only cost-effective option is to move defunct GEO satellites into "graveyard orbits" where "dead" GEO satellites can move and stay until the requisite technology is developed to collect them.[320] This solution would require the satellite to have and save enough fuel to accomplish the transfer, and that additional fuel would also increase launch costs.[321] Moreover, this solution fails to offer long-term relief; it only rearranges the chairs on the deck of the titanic space debris problem.[322] *LiveScience* speculated on a few futuristic alternative methods to clean up space debris.[323] The online magazine discussed such solutions as "giant NERF balls, space lasers and cosmic collection vehicles among other imaginative ways to tackle the growing problem."[324] According to NASA Scientist Nicholas

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314. *See* AM. INST. OF AERONAUTICS & ASTRONAUTICS, *supra* note 310, at 5 tbl. (proposing the venting of residual fuel as the most preferable solution); WILLIAMSON, *supra* note 15, at 76 (referencing plans to deorbit the SPOT-5 satellite using its remaining fuel).

315. AM. INST. OF AERONAUTICS & ASTRONAUTICS, *supra* note 310, at 5.

316. *Id.* at 3–5; *see also* Liou & Johnson, *supra* note 5, at 340 (noting that an addition of devices to remove space debris would incur excessive costs compared to the benefits).

317. AM. INST. OF AERONAUTICS & ASTRONAUTICS, *supra* note 310, at 3–5; WILLIAMSON, *supra* note 15, at 76; Liou & Johnson, *supra* note 5, at 340; Morring, *supra* note 7, at 20.

318. Liou & Johnson, *supra* note 5, at 340. The Inter-Agency Space Debris Coordination Committee, the European Space Agency, and the Japan Aerospace Exploration Agency also advocate such post-mission deorbiting options. *Id.*

319. *See* WILLIAMSON, *supra* note 15, at 76 (noting that the spacecraft orbits are too high to allow them to return to LEO).

320. Williams, *supra* note 53, at 1187.

321. *Id.*

322. The phrase "rearrange the chairs on the deck of the *Titanic*" is generally attributed to Joseph Eger. *See* Joseph Eger, *Listening to the Vibes*, N.Y. TIMES, May 15, 1971, at 34.

323. *E.g.*, Jeanna Bryne, *Cosmic Clean-Up: Wild Ideas to Sweep Space*, SPACE.COM (Mar. 19, 2008), http://www.space.com/5135-cosmic-clean-wild-ideas-sweep-space.html.

324. *Id.* The "NERF ball" concept essentially employs a soft, gel-like sphere that would field the orbiting debris and apply a coat to it as the debris passed through,

Johnson, however, none of these solutions "meet all the requirements for a viable remediation technique."[325]

B. *Spreading the Cost to Fix the Problem*

Because a cost-effective method to remove space debris is needed to effectively address the problem, the required international agreement on space debris must create a way for the space-faring nations to fund further scientific research. Some nations may express concern that such a plan is not in their economic interest. Dealing with the problem now, however, would ultimately be less costly and less difficult than waiting until the cascade effect occurs. Moreover, as the amount of space debris increases, the economic barrier to space exploration also increases. Spacecraft will need thicker shielding, "making them heavier and more costly."[326] At some point, it could become too expensive to use and explore space unless the international community effectively deals with the removal of space debris.[327]

To help pay for a cost-effective method of space debris removal, an international treaty must impose upon all space-faring nations the responsibility, upon ratification or accession, to contribute money to an international fund. An international organization, created in the treaty and directed by COPUOS, would maintain that fund and be solely responsible for the collection and distribution of the revenues. Monies collected would be redistributed into a research and development process, subsequently aiding in actual mitigation and removal activities. The state contribution amount should be based on market-share responsibility for the debris currently in orbit.

Similar proposals have been made before.[328] By forcing contributions based on each nation's contribution to the space debris problem, market-share contributions provide the only fair and effective solution to the space debris problem.[329] Similarly, for any hostile attack in space,[330] the aggressive nation would be required to

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causing the debris to gain mass, lose energy, and fall back to Earth more quickly. The "laser idea" would employ directed-energy that could perturb orbit and push the debris to lower altitudes so it would fall back to Earth quicker. Finally, "cosmic collection vehicles" would use specially designed rendezvous vehicles to attach a propulsion system or drag augmentation device onto debris to accelerate its descent to Earth. *Id.*

325. *Id.* (internal quotation marks omitted).

326. Broad, *supra* note 10, at F1.

327. *Id.*

328. *See* WILLIAMSON, *supra* note 15, at 270 (noting the previous proposal to create an international fund to support "clean-up operations in outer space"); *See generally* Sundahl, *supra* note 53, 138–47 (proposing a solution based on market-share liability).

329. Sundahl, *supra* note 53, at 138.

330. A hostile attack should not be interpreted to include an act of self-defense or of anticipatory self-defense. *See, e.g.*, DEPT. OF DEF., NATIONAL SECURITY SPACE

pay the cost of debris removal. If two objects collide, akin to the February 2009 satellite collision, the parties involved would be jointly and severally liable to pay for the clean up if fault cannot be established.

This solution to the problem would place the greatest financial obligation on the nations that have created, and continue to create, the most space debris. Moreover, every future space launch should include an additional fee that will be sent to the space debris removal and mitigation fund. "Although initially this would increase the cost of space access, which no one wants, it would be preferable to having *no space access* should an orbit become unusable."[331]

This type of international treaty would be economically burdensome on the United States in the short term. However, for the reasons previously discussed,[332] investment in the removal of space debris is in the long-term national security interest of the United States. The United States has consistently led the way in space debris mitigation, and it should continue to do so. In 1987, the Department of Defense (DoD) addressed the debris issue for the first time: "[The] DoD will seek to minimize the impact of space debris on its military operations. Design and operations of DoD space tests, experiments and systems will strive to minimize or reduce accumulation of space debris consistent with mission requirements."[333] President Ronald Reagan's 1988 Presidential Directive on National Space Policy also called for "all space sectors [to] minimize the creation of space debris . . . consistent with mission requirements and cost effectiveness."[334] President George W. Bush's 2006 National Space Policy echoed this directive, [335] as does President Barack Obama's 2010 National Space Policy,[336] which states,

> For the purposes of minimizing debris and preserving the space environment for the responsible, peaceful, and safe use of all users, the United States shall . . . [l]ead the continued development and adoption

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STRATEGY, UNCLASSIFIED SUMMARY 11 (2011), www.dni.gov/reports/2011_national securityspacestrategy.pdf (explaining the need to develop the capability to "defeat attacks" against the United States in space).

331. WILLIAMSON, *supra* note 15, at 270.

332. *See supra* Part III.

333. Taylor, *supra* note 16, at 32.

334. *Id.* (quoting F. Kenneth Schwetje, *Current U.S. Initiatives to Control Space Debris, in* 30 PROC. COLLOQUIUM L. OUTER SPACE 163, 168 (1988)).

335. OFFICE OF SCI. & TECH. POLICY, EXEC. OFFICE OF THE PRESIDENT, U.S. NATIONAL SPACE POLICY 9 (2006), http://www.fas.org/irp/offdocs/nspd/space.pdf (outlining President George W. Bush's 2006 space policy). The policy stated that because "[space] debris poses a risk to continued reliable use of space-based services and operations," the "United States shall seek to minimize the creation of orbital debris by government and non-government operations in space in order to preserve the space environment for future generations." *Id.*

336. OFFICE OF SCI. & TECH. POLICY, *supra* note 2, at 7.

> of international and industry standards and policies to minimize debris, such as the United Nations Space Debris Mitigation Guidelines.[337]

Existing NASA and DoD policy reflect the presidential directives. NASA's current policy is also to limit the generation of orbital debris.[338] DoD's policy is very similar, directing that debris creation should be minimized "consistent with mission requirements and cost effectiveness."[339] Because both NASA and DoD are already required to minimize space debris, the United States' interests would be better served if an international agreement required other nations to do the same.

Without question, any treaty creating an international space debris fund will be difficult to get through the Senate's advice and consent process,[340] especially in the current global financial crisis. The space debris problem, however, has placed America at a crossroads regarding the future security of space. Some experts predict the inevitability of the cascade effect if space debris is not removed, and others predict that space debris may cause the start of World War III.[341] As a result, the path that the United States chooses next may determine its future security.[342]

To preserve and protect its national security, the United States must therefore pursue and compel a binding international agreement regarding space debris, and the Senate must give its bilateral consent to the ratification of that agreement. Something must be done now or the current costs involved in contributing to the proposed fund will be trivial compared to the costs, both to the United States' economy and to its national security, of a space debris cascade. Unless space debris is removed, it will essentially control space and space access.[343] If the cascade effect is "inevitable" unless space debris is removed—a prognostication made even before the February 2009 satellite collisions[344]—supporting an international fund to ensure the removal of space debris should be a "no brainer."

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337. *Id.*

338. NASA PROCEDURAL REQUIREMENTS FOR LIMITING ORBITAL DEBRIS GENERATION (W/ CHANGE 1) 4, ¶ P.1.1 (May 14, 2009).

339. DEPT. OF DEF., DIR. 3100.10, SPACE POLICY 13, ¶ 4.11.5 (1999).

340. *See* U.S. CONST. art. II, § 2, cl. 2 (enumerating the steps the President must take to pass a treaty).

341. Schwetje, *supra* note 334, at 166 (fearing that "the Archduke Francis Ferdinand of World War III may well be a critical U.S. or [Russian] satellite hit by space junk during a crisis").

342. Theresa Hitchens, *Debris, Traffic Management, and Weaponization: Opportunities for and Challenges to Cooperation in Space*, 14 BROWN J. WORLD AFF. 173, 174 (2008).

343. *Id.*

344. Broad, *supra* note 10, at F1.

The United States must lead in this regard. President Obama stated that he intends to restore "U.S. leadership in space"[345] and address "threats to U.S. satellites."[346] His June 2010 National Space Policy speaks of responsible behavior in space and calls on the United States to strengthen "measures to mitigate orbital debris."[347] President Obama is also open to the possibility of space treaties, so long as they improve national security.[348] If he and his administration are truly committed to those statements, a space debris treaty is the perfect place to start.

On the election trail, the President supported the development of "an international approach to minimizing space debris."[349] That support could be the catalyst needed to effectuate an international treaty on this issue. President Obama also supported funding research and development related to space missions.[350] That research and development money could be combined with other nations' contributions to the international space debris fund to create the debris removal mechanisms necessary to rectify the problem.

C. *Space Situational Awareness*

In addition to an international space fund, the treaty should also include space situational awareness provisions. Whenever space debris is created, the responsible country should be required to provide notice and information about the debris to other space-faring nations. On the election trail, President Obama supported "enhancing capabilities for space situational awareness."[351] Because the United States owns and operates the SSN, space situational awareness is not necessarily a problem from the United States' perspective;[352] however, any mandated global exchange of such information would only add to the United States' actionable data and increase its space awareness.

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345. Turner Brinton, *Obama Space-Weapon Ban Draws Mixed Response*, FOX NEWS, Feb. 5, 2009, http://www.foxnews.com/story/0,2933,488127,00.html.

346. Andrea Shalal-Esa, *Obama's Bid to Ban Space Weapons May Prove Tricky*, REUTERS, Jan. 25, 2009, http://www.reuters.com/article/newsOne/idUSTRE50O15X20090125.

347. OFFICE OF SCI. & TECH. POLICY, *supra* note 2, at 4.

348. *Id.* at 7; Brinton, *supra* note 345.

349. *Barack Obama: Advancing the Frontiers of Space Exploration*, SPACEREF (Aug. 16, 2008), http://www.spaceref.com/news/viewsr.html?pid=28880. The original information was located at Barack Obama's website (www.barackobama.com) during the 2008 presidential election.

350. *Id.*

351. *Id.*

352. John A. Tirpak, *Space and Counterspace: Space Superiority Cannot Be Taken for Granted, So the Air Force Is Making Plans to Defend It*, A.F. MAG., June 2006, at 42, 45.

Any information exchange must include the location and size of the space debris, as well as potential orbital paths through which the debris may transgress. To avoid the compromise of operational security, national secrets, or proprietary technology, such data should be limited to that amount of information necessary for other countries to become aware of the new debris and to take appropriate measures to avoid collisions with their assets. Some international data sharing already occurs in accordance with the Registration Convention, but it is intermittent and not reliably accomplished where space debris is concerned.[353] As a result, a treaty obligation on space situational awareness would add needed stability in this area.

D. *Enforcement Mechanisms*

Finally, any treaty must have teeth in the form of sound enforcement mechanisms. Because the law of the sea, like the law of space, is concerned with a province of all mankind, the dispute resolution and enforcement mechanisms in any space debris treaty ought to be similar to the provisions contained in the 1982 UN Convention on the Law of the Sea.[354] Accordingly, any space debris treaty should require state parties to settle disputes peacefully in accordance with Article 2, paragraph 3, of the UN Charter and to seek a solution by the means indicated in Article 33, paragraph 1, of the UN Charter.[355] Moreover, the treaty should establish an International Tribunal for the Law of Outer Space to hear disputes that may arise.[356] In enforcing treaty violations, states need to be free to choose among various dispute settlement forums, including the proposed International Tribunal for the Law of Outer Space, the International Court of Justice, or an appropriate arbitral tribunal constituted in accordance with the treaty.[357] Moreover, in accordance with Article 33, paragraph 2, of the UN Charter, the Security Council shall always have the power to call upon the parties to settle their

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353. *See, e.g.*, Diane Howard, *Achieving a Level Playing Field in Space-Related Public-Private Partnerships: Can Sovereign Immunity Upset the Balance?*, 73 J. AIR L. & COM. 723, 730–31 (2008) (discussing sharing between the public and private sector); Matthew Schaefer, *Conference on Security and Risk Management in a New Space Era: Military, Commercial, and Tourism Dimensions*, 86 NEB. L. REV. 396, 399 (2007) (introducing a symposium agenda which will include the potential for using informal mechanisms to fill the current regulatory gap).

354. U.N. Convention on the Law of the Sea, *opened for signature* Dec. 10, 1982, 1833 U.N.T.S. 397.

355. *Id.* art. 279.

356. *See, e.g., id.* Annex VI (Statute of the International Tribunal for the Law of the Sea).

357. *See id.* art. 287 (listing similar options).

dispute by any means or to enforce, through binding resolutions or sanctions, the treaty's provisions.[358]

VII. CONCLUSION

Global problems require global solutions, and such a global solution, in the form of a binding international agreement, is required to deal with the ever-increasing problem of space debris. "Any move to change the status quo, in any walk of life, is problematic, and any initiative to protect the space environment would be no exception."[359] However, a binding international agreement on space debris is needed to preserve the near-Earth space environment, and the U.S. space-based national security assets that reside there, from the potential devastation of the cascade effect. The resultant disruption or destruction from such a catastrophic event would eliminate the United States' ability to use and exploit space and space-based assets. These devastating consequences could be avoided, or at least minimized, through the implementation of a binding agreement that defines "space" and "space debris," provides the economic means to remove space debris, provides the legal measures to mandate its elimination and mitigation, and establishes the data-sharing responsibilities necessary to effectively monitor the threat throughout the international community.

Although it will be difficult to force countries to stop polluting outer space or to clean up the debris that is already there, "the question is not whether law is enforceable or even effectively enforced; rather, [the question should be] whether law is observed, whether it governs or influences behavior, whether international law reflects stability and order."[360] Because the area of space debris presents "an unregulated vacuum, devoid of law, responsibility, and common sense,"[361] a binding international agreement is needed to provide stability and order, to influence the behavior of space-faring nations, to provide legally enforceable provisions, and to preserve mankind's access to and through space. Because of the Chinese and Russian additions to the space debris population in 2007, the February 2009 additions from the collision of two communications satellites, and the corresponding acceleration of a predicted cascade, an international agreement is needed immediately. If the

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358. *See, e.g.*, U.N. Charter art. 33, para. 2 ("The Security Council shall, when it deems necessary, call upon the parties to settle their dispute by such means.").

359. WILLIAMSON, *supra* note 15, at 270.

360. LOUIS HENKEN, HOW NATIONS BEHAVE: LAW AND FOREIGN POLICY 26 (2d ed. 1979).

361. WILLIAMSON, *supra* note 15, at 272.

international community waits until the serious consequences of the space debris cascade manifest themselves, it will be too late.

ANNEX A

DRAFT INTERNATIONAL AGREEMENT ON SPACE DEBRIS[362]

The Subscribing States,

Recalling the initiatives aiming at promoting a peaceful, safe and secure outer space environment through international cooperation;

Recognizing the common interest of all mankind in the long-term sustainability of outer space activities;

Recognizing that the long-term sustainability of outer space activities is an issue that needs to be addressed by all nations interested in the future utilization of outer space;

Desiring to contribute to broad international cooperation in the scientific as well as the legal aspects of sustaining the long-term sustainability, exploration and use of outer space for peaceful purposes;

Taking into account that space debris could constitute a threat to outer space activities and potentially limit the effective deployment and exploitation of associated space capabilities;

Believing that only international cooperation will contribute to the long-term sustainability of space activities;

Noting that it is in the best interests of all States to actively contribute to the mitigation and removal of space debris;

Desiring to both minimize and remove space debris to preserve the space environment for the responsible, peaceful, and safe use of all users;

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362. This draft agreement is by no means comprehensive, and is meant only to generate discussion and critical thinking on what form a potential agreement in this area should take. Some of the text in this draft is borrowed from the European Union's *Draft Code of Conduct for Outer Space Activities.* Council Conclusions of September 27 2010 Concerning the Revised Draft Code of Conduct for Outer Space Activities (EC) No. 14455/10, *available at* http://www.spacepolicyonline.com/pages/images/stories/EU_revised_ draft_code_of_conduct_Oct_2010.pdf.

Reaffirming their commitment to resolve any conflict concerning actions in space by peaceful means;

Recognizing that a comprehensive approach to safety and security in outer space should be guided by the following principles: (i) freedom of access to space for all for peaceful purposes, (ii) preservation of the security and integrity of space objects in orbit, and (iii) due consideration for the legitimate defense interests of States;

Have agreed on the following:

Article 1

For the purposes of this Agreement:

(a) The term "damage" means 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; the term "damage" also includes the loss of space access that results from a State's creation of space debris;

(b) The term "space" includes that portion of Earth's atmosphere beginning at 100 kilometers above sea level, and any portion of outer space beyond that point;

(c) The term "space debris" includes all man-made objects, including fragments and elements thereof, in Earth orbit or reentering the atmosphere, that are non-functional, regardless of whether the debris is created accidentally or intentionally; the term includes, but is not limited to, fragments of older satellites and rocket boosters resulting from explosions or collisions, as well as any non-functional space object, such as dead satellites, spent rocket stages or other launch vehicles, or component parts thereof;

(d) The term "long-lived space debris" includes space debris that will not deorbit into Earth's atmosphere within 25 years of the creation of such debris.

Article 2

The Subscribing States will, in conducting outer space activities, refrain from any intentional action which will or might bring about, directly or indirectly, the damage or destruction of outer space objects unless such action is conducted to reduce the creation of outer space debris and/or justified by imperative safety considerations and/or national security concerns.

Article 3

In order to limit the creation of space debris and reduce its impact in outer space, the Subscribing States will:

(a) Refrain from intentional destruction of any on-orbit space object or other harmful activities which may generate long-lived space debris unless such action is justified by imperative safety considerations and/or national security concerns; in any event, the creation of long-lived space debris should be only an option of last resort;

(b) Limit debris released during normal operations;

(c) Minimize the potential for break-ups during operational phases;

(d) Limit the probability of accidental collision in orbit;

(e) Avoid intentional destruction and other harmful activities;

(f) Minimize potential for post-mission break-ups resulting from stored energy;

(g) Limit the long-term presence of spacecraft and launch vehicle orbital stages in the Low-Earth Orbit (LEO) region after the end of their mission;

(h) Limit the long-term interference of spacecraft and launch vehicle orbital stages with the Geosynchronous Earth Orbit region after the end of their mission;

(i) Engage in good faith efforts to remove, to the greatest extent scientifically and economically feasible, any space debris it creates or is in any way responsible;

(j) Take all other measures necessary to limit the amount of space debris its space missions create, and remove any space debris its space missions create;

(k) Actively contribute to the research, development and implementation of space debris mitigation and removal methods through both domestic and international programs;

(l) Pay a fee to the organizational body established in Article 8 below upon the launch of any future space object, which will be used

to fund research, development and implementation of space debris mitigation and removal methods;

(m) To the greatest extent feasible, maintain a registry of all space debris for which it is responsible for creating that includes the location and size of the space debris, and make this registry readily available to the other States Parties.

Article 4

A launching State shall be absolutely liable to pay compensation for damage caused by the space debris it creates. In the event of a collision of space objects or debris in space, the States involved shall be jointly and severally liable to pay compensation for damage caused by the space debris created as a result of the collision. In all cases of joint and several liability, the burden of compensation for the damage shall be apportioned between the applicable States in accordance with the extent to which they were at fault. If the extent of the fault of each of these States cannot be established, the burden of compensation shall be apportioned equally between them. Such apportionment shall be without prejudice to the right of a State to seek the entire compensation due from any or all of the launching States which are jointly and severally liable.

Article 5

Whenever two or more States jointly launch a space object, they shall be jointly and severally liable for taking appropriate steps to remove any space debris created.

Article 6

The Subscribing States resolve to share, where feasible, immediate information on:

(a) Procedures to prevent and minimize the possibility of accidents, collisions or other forms of harmful interference caused by space debris;

(b) Procedures to successfully minimize the creation of space debris, or remove space debris already created;

(c) The space debris they create; included in any information exchange must be the location and size of the space debris, as well as potential orbital paths through which the debris may transgress.

Article 7

States Parties, including in particular States possessing space monitoring and tracking facilities, shall provide information and assistance under equitable and reasonable conditions in the identification of space debris and the danger such debris may pose to space activities of other States Parties.

Article 8

An international organization called the "Space Sustainability Authority" is hereby established and will operate under COPUOS direction. All States Parties are *ipso facto* members of the Space Sustainability Authority.

Article 9

The Space Sustainability Authority will maintain an account and be solely responsible for the collection and distribution of the revenues. The main purpose of the account will be to aid in actual space debris mitigation and removal activities. The following will apply to this account:

(a) The contributions referred to in Article 3, subparagraph (l), shall be paid into this account;

(b) The administrative expenses of the Space Sustainability Authority shall be a first call upon those funds;

(c) Those funds which remain after payment of administrative expenses will be used to further research, development and implementation of space debris mitigation and removal methods;

(d) The Space Sustainability Authority shall have the power to borrow funds;

(e) To the extent States Parties to this Agreement fail to engage in good faith efforts to remove, to the greatest extent scientifically and economically feasible, any space debris it creates or is in any way responsible for, the Space Sustainability Authority will have the authority to impose market-share contributions to this fund equitably based on the amount of debris the State Party is responsible for creating and the anticipated cost of removal;

(f) Upon becoming a State Party to this Agreement, a State Party will provide a previously agreed upon contribution to this account, which will be an amount fairly and equitably established in

accordance with an agreed scale of assessment that primarily takes into account the amount of space debris for which the State Party is then responsible;

(g) The Space Sustainability Authority will have the authority to assess and publicly report on the contributions of members to the budget of the Space Sustainability Authority.

Article 10

States Parties shall settle any dispute between them concerning the interpretation or application of this Agreement by peaceful means in accordance with Article 2, paragraph 3, of the Charter of the United Nations and, to this end, shall seek a solution by the means indicated in Article 33, paragraph 1, of the Charter. Nothing in this Article impairs the right of any States Parties to agree at any time to settle a dispute between them concerning the interpretation or application of this Agreement by any peaceful means of their own choice.

Article 11

When signing, ratifying or acceding to this Agreement or at any time thereafter, a State shall be free to choose, by means of a written declaration, one or more of the following means for the settlement of disputes concerning the interpretation or application of this Agreement:

(a) The International Tribunal for the Law of Outer Space established in a separate document;

(b) The International Court of Justice;

(c) An appropriate arbitral tribunal.

The Security Council shall also, in accordance with Article 33, paragraph 2, of the Charter of the United Nations, always have the power to call upon the parties to settle their dispute by any means, or to enforce, through binding resolutions or sanctions, the treaty's provisions.

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