

SPACE COMMUNICATIONS

Chapter 7 of the book addresses “Space Communications.” It begins with basic technical information describing the elements of a radio system and the nature of the radio magnetic spectrum. Haley then included a substantial section describing the various uses of space communication technologies and the attendant need for international cooperation to obtain and maintain order in the use of the radio magnetic spectrum. Haley traced the history of the efforts, in many of which he was directly involved, to accomplish internationally agreed allocations for space communications. The chapter then explored trends and requirements of future developments in space communications and the enabling technologies emerging. Haley described the recently adopted *Communications Satellite Act of 1962* and explained its rationale and limitations. What emerges from a reading of this chapter is a clear awareness that Haley, by experience and interest, had gained more information about the interactions and interdependence of space law and satellite communications than any comparable topic or area addressed by this book. Haley knew more about the communications issues and the communication laws than he ever did about any other area of demanding, immediate problems emerging in the space field. The more than 70 pages of Chapter 7 constitute a remarkably thorough primer on the technology of space radio as well as a broad and detailed presentation of the existing and the needed provisions of national and international laws to permit

States Parties to the Treaty undertake not to place in orbit around the earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.

The Moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the moon and other celestial bodies shall also not be prohibited.

orderly progress to occur. Discussion in Chapter 7 eventually focuses on the legal aspects of communications by satellite. This is a topic area to which Haley had apportioned a great deal of his professional time and energy. From early in the 1950s Haley was urging the U. S. and other governments to pay attention to the absolute need, in fact the *enabling need* for clear, internationally agreed radio frequency allocations to permit interference free space flight and activities in outer space.

In his early insistence on the need to establish international agreement relating to radio usage, Haley was absolutely correct. He was instrumental during his lifetime in proposing and obtaining international agreement to numerous space-related radio allocations and regulations. Haley wrote extensively about these matters. In early 1966, shortly before his death, he personally compiled many of his relevant articles and papers concerning satellite communications, and produced them as a self-published book, entitled *Satellite Communications*. As the senior partner of the law firm Haley, Bader and Potts, Haley would from time to time employ law clerks in the firm to assemble and prepare materials for publication. His book on satellite communications, containing descriptions of all his earlier work on satellite communication matters, was a limited publication with hard covers binding duplicated papers and article reprints expediently assembled in an Acco fastener binding. The book is an impressive and comprehensive collection on which publication processing time ran out, because of his rapidly failing health. Andrew Haley died September 10, 1966, shortly after he released his final book, *Satellite Communications*.

LIABILITY FOR DAMAGES

Chapter 8 of *Space Law and Government* is devoted to issues of "Liability for Personal and Property Damages in Space Activities." In the author's Preface, Haley notes that he was assisted by Ibrahim Shihata of Harvard University, a specialist in liability issues, who prepared a draft describing liability and personal property issues existing in 1963 and anticipated for the future. This chapter of the book is undoubtedly the most thoroughly researched and documented legal discussion in the work.

In a book review of *Space Law and Government* I wrote in 1965,²⁰ I noted that this chapter was the only one in the book, which I believed then and still do believe, could stand on its own merit as a legal treatise of a relevant subject area of space law.

FORENSICS, JURISPRUDENCE AND CONTAMINATION

Haley then turned in Chapter 9 to “Space Medical Jurisprudence.” The opening sentence of the preamble to the chapter reads: “[t]he development of forensic medicine in space has been a seriously neglected topic in space literature.” It was Haley’s intention with this chapter to heighten the sensitivity of not only space travelers, but that of the eventual authorities who will be required to deal with forensic medical issues in space in due course.

The chapter is largely reportorial, describing a good deal of fascinating history, looking back into the annals of medicine for millennia. A future need for forensic medicine in space is postulated, but there are no specific recommendations of action to accomplish necessary means to provide forensic space medicine. The chapter also discussed at some length the issues of contamination and back contamination and the attendant requirements of decontamination of artifacts to be sent to space, and the careful handling and quarantine required for artifacts or materials returned from space. In connection with control of contamination Haley offered eight recommended courses of action to obtain and insure sterilization of objects and seven supplementary actions, all intended to avoid contamination, including recommendations for dealing with newly discovered life forms. The chapter then described international actions up to 1963, including the establishment of the *ad hoc* Committee on Contamination by Extraterrestrial Exploration (CETEX) by the International Council of Scientific Unions (ICSU) in March 1958. Shortly thereafter, in 1959, ICSU established its standing Committee on Space Research (COSPAR), as an institution to follow-up and further develop the international cooperation in

²⁰ Stephen E. Doyle, book review, *Space Law and Government*. By Andrew G. Haley. New York: Appleton-Century-Crofts, 1963. Pp. xvii, 584, 1965 DUKE L. J. 214, 217 (1965).

space related activities initiated during the 66-nation cooperative International Geophysical Year (IGY) of 1957-58. COSPAR assumed the jurisdiction of the contamination issues formerly assigned to CETEX. Haley's international focus is then brought to the questions of personal injury and criminal behavior in space. Observing the total lack of useful experience to deal with such issues, Haley concluded that: "[f]inally, with respect to the criminal aspects of space medical jurisprudence, in all probability new methods of detecting and proving criminal offenses involving human beings will have to emerge, through further scientific investigation and refinement of methods." One could fairly question today, in 2013, if we have come very much further than Haley was in 1963 in our understanding of or willingness to address the topic of space medical jurisprudence.

INTERGOVERNMENTAL ORGANIZATIONS

For several years during the 1950s Haley served on and as chairman of the International Astronautical Federation's (IAF) Committee on International Relations. He assumed a responsibility, diligently pursued, to bring the IAF into formal relationships with many of the existing international organizations with an interest in astronautical affairs. In identifying the organizations in the international community which he sought to work with, he also tells of his efforts to achieve cooperation. Chapter 10 contains a history and description of Haley's work to engage intergovernmental organizations with interests in astronautics into working relationships with the IAF. Within the United Nations Organization he described the General Assembly and the Economic and Social Council (ECOSOC), and went on to describe his efforts with the Educational, Scientific and Cultural Organization (UNESCO), the international Civil Aviation Organization (ICAO), the International Telecommunication Union (ITU), and the World Meteorological Organization (WMO). Haley concluded this section of the work addressing the United Nations Committee on the Peaceful Uses of Outer Space, including the initial *ad hoc* committee, as well as the creation and early growth of the permanent committee on outer space.

Other organizations are described and discussed briefly, including the International Council of Scientific Unions (ICSU) and its Committee on Space Research (COSPAR), and Haley concluded this tour of governmental organizations with discussion of the National Aeronautics and Space Administration, its associated National Aeronautics and Space Council, and the Congressional committees assigned oversight of astronautics in the U. S. House of Representatives and the Senate. There was still relatively little else to report of a governmental or intergovernmental nature, because the eventual emergence of the International Telecommunications Satellite Organization (INTELSAT); the International Maritime Satellite Organization (INMARSAT); and regional organizations such as the Arab Satellite Telecommunications Corporation (ARABSAT), the European Space Agency (ESA), and International Communications Satellite Organizations among the then Communist countries (INTERSPUTNIK) were yet to be formed as of 1963.

NONGOVERNMENTAL ORGANIZATIONS CONCERNED WITH ASTRONAUTICS

Chapter 11 takes up “Nongovernmental Organizations.” This portion of the book expands on an earlier record of the involvement of Haley in the founding, promotion and development of international organizations and programs of cooperation in astronautics. In an earlier book, published in 1958,²¹ Haley told not only of his international efforts to establish the International Astronautical Federation, but also his leadership roles in the American Rocket Society and other nongovernmental forums such as the American Bar Association. Haley’s writings on astronautics from the outset in the 1950s placed heavy emphasis on the need for international attention to the needs of and international cooperation in realizing the benefits of astronautics. After he left the Aerojet Engineering Corporation in California and returned to law practice in Washington, D. C., Haley assumed continually increasing roles in the American Rocket So-

²¹ ANDREW G. HALEY, *ROCKETS AND SPACE EXPLORATION: THE INTERNATIONAL STORY* (Van Nostrand, 1958).

ciety (ARS), serving during the 1950s sequentially as Vice President, President, as a Director, as General Counsel and as Chairman of the Board of the ARS. His senior positions in the ARS management structure facilitated his early involvement in the founding of the International Astronautical Federation (IAF). He also served in the 1950s as a Vice President, the President, and the General Counsel to the IAF. Among Haley's crowning achievements in the international field, he was instrumental in creating the International Academy of Astronautics in 1960 and in founding the International Institute of Space Law the same year.

Today, it cannot be denied that the benefits of astronautics are shared among the nations of the Earth through the efforts of multiple international organizations; organizations which Haley never named in particular, but organizations Haley projected as essential to bring the benefits of space endeavors to humanity. As significant example of relevant international organizations we can name the European Space Agency (ESA), the International Telecommunications Satellite Organization (INTELSAT), the International Maritime Satellite Organization (INMARSAT), the Arab Communication Satellite Corporation (ARABSAT), the European Telecommunication Satellite Organization (EUTELSAT), The European Meteorological Satellite Organization (EUMETSAT), and the *International Space Station* (ISS) consortium, among others.

There are in addition numerous regional cooperative ventures and bilateral cooperative programs, as well as a thriving international competitive market in the provision and sale of rocket launch services, purchased from among nations in an open competitive market. There are also internationally competitive services for imaging and remote sensing of the Earth, and for navigational services covering most of the Earth's surface. This extensive expanse of international cooperative activities are certainly not attributable to Andrew Haley, but without his vision and efforts in the 1950s it is likely that much of what we collectively enjoy from astronautics today could not have been so readily realizable in so short a period.

METALAW

Chapter 12 presents Haley's proposal of 'Metalaw,' subtitled "The Possibility of other World's with Intelligent Life." This subject has been extensively discussed by other authors in the intervening years since 1963, and another paper in the current number of this Journal is addressing the topic thoroughly.²² Consequently we will not spend time or effort here, which would only duplicate the work of others.

A REFERENCE LIBRARY ON ASTRONAUTICS FROM 1963

Space Law and Government concluded with more than 110 pages of texts gathered in Appendices, which are well worth considering in their individual significance and importance to astronautics, as well as to Haley. The Appendices include:

I. International Conventions, Agreements, Resolutions and Proposals

- A. The Antarctic Treaty of 1959.
- B. Int'l. Telecommunication Union, Radio Regulations (Geneva, Dec, 1959)
- C. Radio Frequency allocations proposed by the International Astronautical Federation (1959)
- D. Federation (1959)
- E. Extracts of a Kennedy/Khrushchev letter Exchange (March 1962)
- F. Joint Communique on US/Soviet Talks (June 1962)
- G. Significant Recent United Nations Documents: eight are included.
- H. Preliminary Views of the US for Frequency Allocations for Space Radio Communications (extracts)
- I. Proposed Program for Preparation for the ITU 1963 Extraordinary Radio Advisory Conference (EARC, Geneva, 1963).
- J. Was left blank.

²² George S. Robinson, *The Biochemical Foundations of Evolving Metalaw: Moving at a Glance to the Biological Basis of Sentient "Essence"*, 39(1) J. Space L. 181 (2013).

- K. United States and International Action in the International Consultative Committee on Radio (CCIR) and International Telecommunication Union on Space Telecommunications.

II. United States Laws

- A. National Aeronautics and Space Act of 1958, as amended.
- B. Communications Satellite Act of 1962

III. International Organizations

- A. Constitution and Member List of the International Astronautical Federation
- B. Statutes and Structure of the International Academy of Astronautics
- C. Statutes of the International Institute of Space Law
- D. Charter of the Committee on Space Research of ICSU
- E. CCIR Study Groups of the ITU

IV. Miscellaneous

- A. Definitions of "Atmosphere" and "Air"
- B. Abbreviations and Acronyms

V. Bibliography

- A. Bibliographies of Space Legal Literature
- B. Selected and Partial Bibliography of the works of the Author

SUMMARY AND CONCLUSION

In the author's Preface Haley gave credit to the editorial assistants he had working in his firm on the texts of chapters 1, 2, 3, 5, 10, and 11.²³ He also gave explicit recognition to his assistant in developing Chapter 8.²⁴ By implication, it is quite clear that Haley considered himself the lead author and editor of chapters 4, 6, 7, 9 and 12. Much of his original thinking and projections of problems and solutions are found in that latter list of chapters.

²³ SPACE LAW AND GOVERNMENT, *supra* note 1, at xv.

²⁴ *Id.* at xvi.

Throughout *Space Law and Government* one finds that the lawyer Haley is also the industrialist Haley, the technician Haley, and the historian Haley. The title of the book does not reflect the extensive content of useful background of history and technology in each topic area. From our perspective of 50 years later in time, this 1963 book remains a valuable reference source, as well as a broad and reliable picture of the state of law and government related to outer space activities in 1963.

“SPACE TRASH”: LESSONS LEARNED (AND IGNORED) FROM SPACE LAW AND GOVERNMENT

James E. Dunstan *

Then, too, the Soviet Union and the United States have already sent into outer space many vehicles which are not controllable. A collision in which two orbital bodies would hit and exfoliate, but continue in some irregular orbit for many more hundreds of years, would constitute a threat to life and property in outer space-and many similar threats are possible. Objects have been placed in orbit-both satellite vehicles and spent rocket stages-that could come back to earth at almost any place. Such objects might land on the Kremlin, on the Vatican, or on Buckingham Palace; as far as the dispersion factor is concerned, we still do not know enough. We do know that satellites do not come back as small particles or completely exfoliated, because they would burn up; but objects in space may come back as great chunks if they were large enough to start with and if they are not brought down in a controlled re-entry. Finding answers to these problems, naturally, is not easy. Ideally, however, no objects should be allowed to go into outer space without a code of law requiring that they be controllable; they should be earth-returnable, or capable of being projected into orbits around the sun or into

* James E. Dunstan began his legal career in 1983, joining Andrew G. Haley's firm Haley, Bader & Potts upon graduation from the Georgetown University Law Center, where he was the first chairman of the Georgetown Space Law Group. Jim matured as a young lawyer steeped in stories of the exploits of "Uncle Andy" (since Andrew G. Haley was the uncle of Michael Haley Bader, then the senior partner at Haley Bader & Potts, along with Bill Potts, who writes separately in this edition of the *Journal of Space Law*). Jim became a partner at Haley Bader & Potts in 1988, and served at its Finance Partner for ten years until the members of Haley Bader & Potts joined Garvey Schubert Barer in 2000, where Jim served as head of the Telecommunication and Information Technology group for five years. Jim left Garvey in 2010 to found Mobius Legal Group, PLLC. Dunstan first wrote about Haley's *Space Law and Government* in 1987, in "Space Law and Government: A Generation Later," Proceedings of the Eighth Princeton/Space Studies Institute Conference on Space Manufacturing (AIAA, 1987). The author wishes to thank Ryan T. Noble for assisting in the research and retrieval of key original source materials that went into this article.

*some other area where they could not be injurious to life, property, and near-terrestrial navigation.*¹

Absent the outdated reference to the Soviet Union and its iconic seat of power, the Kremlin, the quote above is as true today, in 2013, as it was in 1963, when it appeared in Andrew G. Haley's seminal work, *Space Law and Government*. Fifty years after Haley warned of the dangers of "space trash,"² we now face a reality of tens of thousands of pieces of orbital debris spinning over our heads,³ a permanently manned space station that regularly must alter its orbit to avoid the possibility of a collision,⁴ and expert opinions that range from a prediction that some orbits may soon be dangerously cluttered, to others who claim that we may already be experiencing the beginnings of the "Kessler Syndrome,"⁵ wherein an ever-increasing cascade of orbital collisions renders parts of space unusable.

If "space trash" was identified by Haley as a potential problem back in 1963, what happened (or didn't happen) in the intervening fifty years to put us in the current position where billions of dollars of space assets⁶ are at risk of loss and we have scant hope of solving the problem within the next decade? This article will assess the current problem of orbital debris, analyze what Haley said about the problem (and potential solutions) in 1963, track the development of international law and policy in this area over the past half-century, and in the end propose potential actions that could be taken at the domestic and international level to deal with the orbital debris problem.

¹ ANDREW G. HALEY, *SPACE LAW AND GOVERNMENT* 11 (Meredith Press, 1963).

² *Id.* at 206. "As we must deal with the conservation and safety of life and property, a second and more serious long-range problem must also be considered, namely, the continued orbiting of man-made space vehicles for periods of undetermined length-extending even to centuries or millennia. This uncontrollable 'space trash' will constitute a hazard to safety of life and property in outer space as long as it continues in orbit."

³ *See infra*, Section I.

⁴ *Id.*

⁵ *Id.*

⁶ The total "space economy" in 2009 was estimated to be between \$150 and \$165 billion dollars per year, much of that generated by the space assets in orbit. *See* OECD, *Executive Summary*, in *THE SPACE ECONOMY AT A GLANCE 2011* (OECD Publishing, 2011).

I. THE MAGNITUDE OF THE CURRENT ORBITAL DEBRIS PROBLEM

Space is big, there can be no doubt of that. For instance, the total area of the 800 kilometer orbital sphere⁷ encompasses 664 million square kilometers (or 411 million square miles) of area. Were the approximately 1000 currently operating satellites all bunched in this one orbit (which they obviously are not), each would have some 664,000 square kilometers (411,000 square miles) in which to operate.⁸ The mindset of many in the early years of spaceflight was that space was so vast that the likelihood of two objects actually colliding was so remote as to not be worth worrying about, and certainly not worth taking into consideration when planning space activities. This became known as the “Big Sky” theory of space operations.⁹ Recent debris generating collisions (both accidental and intentional) have demonstrated, however, that the days of the “Big Sky” theory are relegated to the pages of history, if the theory ever had any validity to begin with. Today satellites must operate in orbits that not only contain 1000 other operating satellites, but 50

⁷ The 800 kilometer orbit was chosen for this calculation because it is considered one of the more crowded orbits. *See infra*, Section I.

⁸ This calculation is a significant oversimplification since in addition to assuming that the approximately 1000 operating satellites all occupy the 800 kilometer orbit, the calculation assumes that all are exactly orbiting on the surface of a perfect sphere 800 kilometers above the mean surface of the Earth (and hence 7271 kilometers above the center of the Earth). Therefore, it only calculates the square kilometers surface area of the sphere. Since satellites don’t operate at exactly the same orbital altitude, even within a designated orbit, and since orbits aren’t entirely circular (the apogee – or high point – of an orbit is usually slightly different than the perigee – or low point), to be more accurate the calculation should be made using a three dimensional slice of sphere centered around 800 kilometers above the surface of the Earth, making the amount of “Big Sky” surrounding each satellite appear much larger. However, what also makes the calculation incorrect is the assumption that somehow all of satellites are flying “in formation,” while in reality, they are orbiting in a variety of directions (predominately West to East, North to South (polar) or South to North (polar)), such that their orbits cross each other.

⁹ The origin of the term “Big Sky” is unknown. Most likely it comes from aviation traffic modeling where the assumption is that two randomly flying bodies are unlikely to collide because of the size of the three dimensional space in which they operate. The earliest reference this author can find to such a theory being applied to space is the SURVEY OF SPACE LAW, STAFF REPORT OF THE SELECT COMMITTEE ON ASTRONAUTICS AND SPACE EXPLORATION, H. R. DOC. NO. 89, 86TH CONG., 1ST SESS., at 7 (1959) [hereinafter SURVEY OF SPACE LAW] (where Dr. John P. Haden, the director of Project Vanguard is quoted as saying “space is a very big area”).

years' worth of rocket bodies, derelict satellites, and the flotsam and jetsam caused by on-orbit explosions¹⁰ and even routine space deployment activities, where pieces just float away from a vehicle while deploying payloads or during normal operation.¹¹

The United States Strategic Command's (USSTRATCOM's) Joint Space Operations Center (JSpOC) is tasked with tracking all objects in space.¹² According to its website,¹³ since Sputnik was launched by the Soviets in 1957, JSpOC has cataloged more than 39,000 man-made objects in space, and it is currently tracking more than 16,000 objects orbiting Earth.¹⁴ Of these, only five percent (5%), or approximately 800, are functioning payloads or satellites, eight percent (8%) are rocket bodies, and the other 87 percent are either debris or inactive satellites.¹⁵ This translates into a situation where at most, only five percent of the objects currently being tracked have the ability to take any action (such as changing orbits) to avoid a potential collision, even if notified in time to take action. The remaining 15,000 objects, ranging in size from bus-size down to bullet-sized (or smaller), whiz around the earth at more than 17,500

¹⁰ Between 1961 and 1995, for instance, 124 fragmentation events were cataloged. See Office of Science and Technology Policy, *Interagency Report on Orbital Debris*, 12 (Nov. 1995), available at <http://orbitaldebris.jsc.nasa.gov/library/references.html>.

¹¹ One of the earliest and most publicized pieces of space debris was NASA astronaut Ed White's glove, which he lost on the first American spacewalk during the Gemini 4 flight (June 3, 1965). See National Aeronautics and Space Administration, *Gemini 4*, <http://nssdc.gsfc.nasa.gov/nmc/masterCatalog.do?sc=1965-043A> (last visited Sept. 12, 2013). Fortunately, the Gemini 4 capsule was orbiting at a relatively low altitude (166 x 290 km orbit), such that the glove reentered the atmosphere within a month. For a look at eight interesting (tagged as "weird") pieces of orbital debris, see Clara Moskowitz, *Lost in Space: 8 Weird Pieces of Space Junk*, WIRE (Feb. 13, 2013), <http://www.wired.com/wiredscience/2009/02/spacestuff/>.

¹² See *Threats From Space: A Review of U.S. Government Efforts To Track and Mitigate Asteroids and Meteors* (Mar. 19, 2013) (testimony of General William L. Shelton before the U.S. House of Representatives Committee on Science, Space and Technology), available at <http://www.hq.nasa.gov/legislative/hearings/2013%20hearings/3-19-2013%20SHELTON.pdf>.

¹³ U.S. Strategic Command, *USSTRATCOM Space Control and Space Surveillance*, http://www.stratcom.mil/factsheets/USSTRATCOM_Space_Control_and_Space_Surveillance/ (last visited Sept. 12, 2013).

¹⁴ *Id.* In comparison, in 1995, when the first comprehensive study of orbital debris was conducted by the United States government, U.S. Space Command was tracking less than 8,000 objects. See *Interagency Report on Orbital Debris*, *supra* note 10, at 5.

¹⁵ *Id.*

miles per hour without the ability of anyone to control their orbits.

The Union of Concerned Scientists (UCS) also keeps a database of functioning space objects, and as of December 1, 2012, lists 1,046 operating satellites (about 25 percent more than appear in the JSpOC database).¹⁶ As discussed below, the impact of orbital debris is truly global in nature. The oldest satellite still operating, according to the UCS database, is the AMSAT/OSCAR 7 satellite, launched November 15, 1974.¹⁷ Of the 1046 operating satellites cataloged by UCS, 455 are operated by the United States, 110 by Russia, and 107 by China, leaving 374 satellites in the hands of other countries. Indeed, a review of the database reveals that 47 countries currently exclusively or jointly control operating satellites.¹⁸ Given that there are 192 member countries in the United Nations,¹⁹ this means that nearly 25 percent of all UN members currently have operating satellites in orbit (before even including nations that have access to satellite assets and operations through their membership in international organizations and consortia).²⁰ In

¹⁶ Union of Concerned Scientists, UCS Satellite Database, http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html (last visited Sept. 12, 2013). As discussed more fully in this section, the disparity between the number of satellites cataloged by the Union of Concerned Scientists and JSpOC raises questions, if not significant concerns, as to which of these lists is accurate, and why the databases differ so significantly.

¹⁷ *Id.*

¹⁸ *Id.* The UCS database lists the following countries as either individually or jointly operating satellites (which does not include international consortia): Algeria (1), Argentina (10), Australia (5), Belarus (1), Belgium (2), Brazil (9), Canada (22), Chile (1), Denmark (1), Egypt (3), France (16), Germany (21), Greece (3), Hungary (1), India (28), Indonesia (7), Iran (1), Israel (9), Italy (14), Japan (43), Kazakhstan (1), Luxembourg (17), Malaysia (5), Mexico (4), Morocco (1), the Netherlands (10), Nigeria (3), Norway (5), Pakistan (2), Philippines (1), Saudi Arabia (10), Singapore (3), South Korea (5), Spain (10), Sweden (4), Switzerland (2), Taiwan (8), Thailand (4), Turkey (4), Ukraine (1), United Arab Emirates (5), United Kingdom (21), Venezuela (2), Vietnam (2). In addition, the UCS database lists 52 satellites as operated by "Multinational," including those operated by the Arab Satellite Communications Organization (ASCO), the European Telecommunications Satellite Consortium (EUTELSAT), and the Regional African Satellite Communications Organization (RASCOM). Because of the joint operation of a number of satellites and 17 satellites listed under the European Space Agency, the total number listed above exceeds the total of 1046 currently operating satellites as of December 1, 2012.

¹⁹ UN, *Member States*, <http://www.un.org/en/members/> (last visited Sept. 12, 2013).

²⁰ *See supra*, note 14.

contrast, the United Nations, which is tasked under the Registration Convention²¹ to keep a registry of objects launched into space, lists only 42 nations as having notified them of placing an object into orbit above Earth.²² On the UCS list but not on the United Nation list are nine countries: Belarus, Belgium, Indonesia, Iran, Morocco, Norway, Singapore, Taiwan, and Vietnam. Of these, five are not signatories to the Registration Convention (Iran, Morocco, Singapore, Taiwan and Vietnam). The only country on the UN list but not on the UCS list is Poland, whose notification to the UN indicated that its PW-Sat, launched February 13, 2012, was launched under French and ESA auspices.

There is also a significant difference between the JSpOC-identified number of 16,649 tracked objects,²³ and the number of tracked objects cited by NASA's Orbital Debris Program Office,²⁴ which reports that more than 21,000 pieces of orbital debris larger than 10 centimeters are "known to exist."²⁵ In addition, NASA's Orbital Debris Program Office ("ODPO") estimates that there are approximately 500,000 objects between 1 and 10 cm,

²¹ Convention on Registration of Objects Launched into Outer Space, *opened for signature* Jan. 14, 1975, 28 U.S.T. 695, T.I.A.S. 8480 (hereinafter Registration Convention). See *infra*, section III(A).

²² See UNOOSA, *Convention on Registration of Objects Launched into Outer Space, Notifications from States & Organizations*, <http://www.oosa.unvienna.org/oosa/en/SORegister/docsstatidx.html> (last visited Sept. 12, 2013). The United Nation list of notifications including the following countries (ESA and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) are omitted): Algeria, Argentina, Australia, Brazil, Canada, Chile, China, Czech Republic (includes information from Czechoslovakia), Democratic People's Republic of Korea (North Korea), Denmark, Egypt, France, Germany (includes information from the Federal Republic of Germany), Greece, Hungary, India, Israel, Italy, Japan, Kazakhstan, Luxembourg, Malaysia, Mexico, The Netherlands, Nigeria, Pakistan, Philippines, Poland, Republic of Korea (South Korea), Russian Federation (includes information from the Union of Soviet Socialist Republics), Saudi Arabia, Spain, Sweden, Thailand, Turkey, Ukraine, United Arab Emirates, United Kingdom of Great Britain and Northern Ireland, United States of America, and Venezuela.

²³ 17(2) ORBITAL DEBRIS Q. NEWS (NASA) 10 (Apr., 2013) (citing U.S. Space Surveillance Network data), <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv17i2.pdf>.

²⁴ NASA Orbital Debris Program Office, *About Us*, <http://orbitaldebris.jsc.nasa.gov/faqs.html#3> (last visited Sept. 12, 2013).

²⁵ NASA Orbital Debris Program Office, *Orbital Debris Frequently Asked Questions #3* (Mar. 2012), <http://orbitaldebris.jsc.nasa.gov/faqs.html#3>. The difference in number may be explained by the fact that NASA may know of the existence of more objects than JSpOC actually tracks in real-time, or publicly reports.

and more than 100 million objects smaller than 1 centimeter.²⁶ Orbital debris is concentrated mainly in Low Earth Orbit (LEO), with the most congested (and dangerous) areas being polar orbits around 800 kilometers.²⁷ A second band of orbital debris exists in the Geostationary (or Clarke) Orbit (GEO).²⁸

Of the JSpOC-tracked orbital debris, the source of such debris is not uniform across operating countries, as depicted in Table 1 below:

²⁶ Even small objects can cause damage or destruction to a satellite, given that the relative impact speed of two bodies in orbit are on the order of 10 kilometers a second (or close to 20,000 miles per hour). NASA Orbital Debris Program Office, *Orbital Debris Frequently Asked Questions #7* (Mar. 2012), <http://orbitaldebris.jsc.nasa.gov/faqs.html#7>. Items as small as paint flecks have been known to cause damage in space (including requiring the replacement of a Space Shuttle window after STS-7 was struck while on-orbit. NASA, *International Space Station*, http://www.nasa.gov/mission_pages/station/news/orbital_debris.html (last visited Sept. 12, 2013).

²⁷ J. Liou and N. Johnson, *A Sensitivity Study of the Effectiveness of Active Debris Removal in LEO*, IAC-07-A6.3.05 (2007), http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20070013702_2007011170.pdf. Polar orbits present the highest likelihood of “conjunctions” because each satellite crosses the North and South Pole on each orbit. These “choke points” above the poles increase dramatically the chances that two satellites flying at the same altitude could collide. See J. PELTON, *SPACE DEBRIS AND OTHER THREATS FROM OUTER SPACE 70* (International Space University, 2013).

²⁸ *Id.*

Table 1: Payloads and Debris By Contributing Country

Country of Origin	Payload	Rocket Bodies & Debris	Total	Percent of all Payloads in Space	Percent of Orbital Debris Generated	Ratio of Debris to Payload ²⁹	Ratio of Debris to Payloads (minus major accidents) ³⁰
China	140	3612	3752	3.90%	27.65%	25.80	5.37
ESA	42	46	88	1.17%	0.35%	1.10	1.10
France	56	442	498	1.56%	3.38%	7.89	7.89
India	49	125	174	1.37%	0.96%	2.55	2.55
Japan	125	83	208	3.48%	0.64%	0.66	0.66
Russia	1427	4830	6257	39.77%	36.98%	3.38	1.63
USA	1134	3804	4938	31.61%	29.12%	3.35	1.15
Other	615	119	734	17.14%	0.91%	0.19	0.19
	3588	13061	16649	100.00%	100.00%		

As can be seen from this list, there is a significant difference in the amount of debris created per satellite orbited depending on which country is analyzed. To be slightly more fair to China, Russia and the United States, the large debris numbers associated with each is attributable to two major space incidents, as described by NASA's ODPO:

Prior to 2007, the principal source of debris was from explosions of old launch vehicle upper stages left in orbit with stored energy sources, e.g., residual propellants and high pressure fluids. The intentional destruction of the Fengyun-1C weather satellite by China in 2007 and the accidental collision of American and Russian communications satellites in 2009

²⁹ This represents the ratio of debris created to payloads orbited. So in the instance of China, while they currently are operating 140 payloads (satellites) in orbit, they have created 3,612 trackable pieces of debris, or 25 pieces of debris created for each payload orbited.

³⁰ For this calculation, the debris created by China by its Fengyun FY-1C ASAT test is removed from the equation, as are the debris created by the collision of the Iridium 33 and COSMOS 2251 satellites, both discussed more fully below.

greatly increased the number of large debris in orbit and now represent one-third of all cataloged orbital debris.³¹

More specifically, China's very high debris numbers in Table 1 are a result of its anti-satellite "test" conducted January 11, 2007, when the Chinese used a kinetic kill vehicle to destroy its nearly one-metric ton Fengyun FY-1C weather satellite, which was in a polar orbit of 865 kilometers, resulting in at least 2,300 new pieces of orbital debris that is being currently tracked, and an estimated 150,000 pieces larger than 1 centimeter,³² very little of which had reentered the atmosphere.³³ Indeed, a piece of FY-1C was reported to have struck the Russian BLITS ("Ball Lens in The Space") laser-ranging satellite, which weighed only 7.35 kg, on January 22, 2013, splitting BLITS into at least two pieces (and thus creating even more orbital debris).³⁴

The second event that underscores the discrepancy between payloads and debris for both the United States and Russia was the collision between the Iridium 33 (a U.S. Commercial satellite with a mass of 560 kg) and retired (derelict) Cosmos 2251 (a Russian satellite with a mass of 950 kg), on February 10, 2009, at an altitude of 789 km. NASA experts now believe the collision created another 2,500 trackable objects.³⁵ On October 31, 2012, the International Space Station was forced to make a debris avoidance maneuver (DAM), to avoid a fragment from Iridium 33.³⁶

Yet even when these two debris-causing incidents are removed, there remains a significant disparity between the major spacefaring nations in terms of debris generation, ranging from

³¹ *Orbital Debris Frequently Asked Questions #3*, *supra* note 25.

³² 13(1) ORBITAL DEBRIS Q. NEWS (NASA) (Jan. 2009), <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv13i1.pdf>.

³³ 12(1) ORBITAL DEBRIS Q. NEWS (NASA) (Jan. 2008), <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv12i1.pdf>.

³⁴ Karl Tate, *Russian Satellite Crash with Chinese ASAT Debris Explained (Infographic)*, SPACE.COM (Mar. 08, 2013), <http://www.space.com/20145-russian-satellite-chinese-debris-crash-infographic.html>.

³⁵ 17(1) ORBITAL DEBRIS Q. NEWS (NASA), 4 (Jan. 2013), <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv17i1.pdf>.

³⁶ *Id.* at 3.

a 0.19 payload to debris ratio for the 40-odd “Other” countries to a high of 7.89 payload to debris ratio for France. Again, the numbers and ratios used in this analysis are less important than the demonstration of the fact that orbital debris is a global issue, both in terms of who is creating debris, as well as who might be affected by a future collision in space.

This issue also impacts more than the potential loss of a space asset. NASA has been required to execute maneuvers of the *International Space Station* (ISS) on a regular basis to avoid the chance of a collision (any situation where the conjunction analysis indicates greater than a 1 in 10,000 chance of collision).³⁷ According to NASA’s Orbital Debris Program Office:

For the first dozen years of its existence, the ISS averaged only one collision avoidance maneuver per year. However, in the past 12 months (April 2011 to April 2012), the ISS was forced to execute four collision avoidance maneuvers and would have conducted two additional maneuvers if the warnings had come sooner.³⁸

Obviously, such maneuvers require substantial propellant to be carried out, which must be resupplied from the ground (currently from Russian resupply rockets which NASA must pay for). So there is a very real cost to coping with the current orbital debris problem in LEO.

Finally, and most importantly, the orbital debris situation is not static. While a certain number of pieces of debris reenter the atmosphere each year, countries continue to launch vehicles and create more debris on a yearly basis. Yet this accounts for a relatively slow and somewhat manageable increase in orbital debris. This steady state ecosystem of junk is upset, however, whenever there is a major collision incident, which as discussed above, interjects between 2,500 and 3,500 new trackable pieces of junk per incident. The fear, which is not yet predictable, is if such major collision events continue, there may be a cascading

³⁷ See NASA Orbital Debris Program Office, *Orbital Debris Frequently Asked Questions* (Mar. 2012), <http://orbitaldebris.jsc.nasa.gov/faqs.html>.

³⁸ 16(2) ORBITAL DEBRIS QUARTERLY NEWS (NASA), 1 (Apr. 2012), <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv16i2.pdf>.

effect dubbed “the Kessler Syndrome,” whereby collision events and new debris occur at exponentially increasing rates creating huge clouds of debris and rendering certain orbits useless because of the clutter.³⁹

Heretofore this introduction section outlining the problem presented by orbital debris has only addressed the danger of the potential collision between two physical objects in space. Another danger posed to satellites is from unintentional radiofrequency interference caused by an uncontrollable satellite, whose operator is unable to turn off its radio transmissions.⁴⁰ The most recent example of this hazard was posed by the Galaxy 15 satellite operated by Intelsat. It originally occupied the 133° West geostationary position. On April 5, 2010, Intelsat lost control of the satellite, and it began to wander eastward across the geostationary arc, and soon became dubbed the “Zombiesat.”⁴¹ There was not a significant probability that it would actually collide with another satellite, but in losing control of the satellite, Intelsat also was unable to turn off its 24 C-Band and 2 L-Band transponders.⁴² As Galaxy 15 slowly drifted from the 133° West position ultimately to the 93° West position, it had the potential to significantly interfere with the operation of other C-

³⁹ The “Kessler Syndrome” is named after (and not directly by), retired NASA engineer Donald J. Kessler. According to Kessler, the term was coined by a colleague, John Gabbard, a NORAD analyst. See Donald J. Kessler, *The Kessler Syndrome* (Mar. 8, 2009), <http://webpages.charter.net/dkessler/files/KesSym.html>. See also Donald J. Kessler & Burton G. Cour-Palais, *Collisional Frequency of Artificial Satellites: The Creation of a Debris Belt*, Paper 8A0210, 83(A6) J. GEOPHYSICAL RES., 2637 (June 1, 1978); Donald J. Kessler, *Collisional Cascading: The limits of population growth in low earth orbit*, 11(12) ADVANCES IN SCIENCE RES., 63-66 (1991). See also James Rendleman, *Space Traffic Management – Private Regulation*, in PROC. OF THE AIAA SPACE 2012 CONF. & EXPO., n. 6, AIAA 2012-5124 (Sept. 2012), <http://arc.aiaa.org/doi/abs/10.2514/6.2012-5124>. For a fascinating PBS interview with Donald Kessler about orbital debris and the “Kessler Syndrome,” see <https://www.youtube.com/watch?v=LaKz8VDkDkI> (last visited Sept. 29, 2013).

⁴⁰ As discussed *infra*, Section II, Haley thought that radiofrequency interference from derelict spacecraft posed the greatest immediate danger to space operations.

⁴¹ See Peter B. de Selding, *Attempt to Shut Down Zombie Satellite Galaxy 15 Fails* (May 05, 2010) <http://www.space.com/8344-attempt-shut-zombie-satellite-galaxy-15-fails.html> (concerning Galaxy).

⁴² The C-Band consists of frequencies between 4 and 8 GHz, of which the range between 3.7 to 4.2 GHz used for space-to-Earth communications (downlinks) and 5.925 to 6.425 are used Earth-to-space communications (uplinks). See B. ELBERT, INTRODUCTION TO SATELLITE COMMUNICATION 31 (Artech House, Inc., 2008).

Band transponders in the area (not to mention the loss of commercial service provided by Galaxy 15 at the 133° West position). The largest single interference impact was to the SES World Skies AMC-11 satellite, which provides a significant amount of the cable television programming fed to cable systems in the United States.⁴³ To avoid this interference, SES began maneuvering the AMC-11 satellite on May 26, 2010, to the eastern edge of its 131° West slot, and maneuvered its SES-1 satellite to follow behind Galaxy 15 to take over the transmissions for AMC-11 as it was maneuvered back into position in the center of the 131° West “box.”⁴⁴ Ultimately, Intelsat regained control of Galaxy 15 on December 23, 2010, and the satellite was successfully moved back to its 133° West position.

From the analysis above, it is very clear that orbital debris is a significant problem, and a problem that is costing the space-faring nations real money in terms of lost assets and station-keeping fuel to conduct avoidance maneuvers. It is also clear that this is not a problem impacting only the relatively few nations that actually have launch capabilities. With fully one-quarter of the nations of the world operating space assets, and virtually every country benefitting from the services delivered from space assets (everything from communications, to weather data to environmental remotes sensing to location services), orbital debris is an international problem of the highest order. The question then becomes, did this problem sneak up on the world, or was it simply ignored and the hard questions avoided during the first fifty years of spaceflight? For this, we must turn back to *Space Law and Government*, to see what Andrew

⁴³ See Jeff Hill, *Intelsat Wins GAO CBSP Decision; Warns Galaxy 15 May Drift into AMC 11 Orbit* (May 13, 2010), SATELLITETODAY.COM, <http://www.satellitetoday.com/st/topnews/34137.html>.

⁴⁴ For an excellent animation of the maneuver, see <http://www.youtube.com/watch?v=wVp8UNnG3YE>. This author has discussed the maneuver with a number of aerospace engineers familiar with geostationary satellite operations, and they estimate that the maneuver required between one and six months of station-keeping fuel for AMC-11. Thus, while there was no direct cost to any satellite operator of the Galaxy 15 “Zombiesat,” the useful life of AMC-11 may be cut short by as much as half a year, and for a satellite that was placed into service in 2004 and well into the second half of its estimated 15 year useful life, potential lost revenues from an early termination of AMC-11 could be significant.

G. Haley had to say about the potential problem, and the logical solutions to avoid the situation we now face.

II. HALEY'S ANALYSIS OF THE 'SPACE TRASH' PROBLEM IN 1963 AND PROPOSED SOLUTIONS

Haley covered a wide variety of legal issues in *Space Law and Government*, and "space trash" was not one of main foci of the book. Yet the analysis he undertook on a variety of issues related to space law (e.g., where does space begin,⁴⁵ freedom of overflight,⁴⁶ liability for accidents,⁴⁷ and even *metalaw*⁴⁸) provides keen insight as to the state of space law just six years into the space age. While many agree that *Space Law and Government* was the first comprehensive text on the law of outer space, Haley spent a substantial portion of the book documenting the efforts underway at that early stage of spaceflight to address significant legal issues, and cited to significant international⁴⁹ and U.S. government efforts to catalog and analyze space law issues.⁵⁰ Yet in noting this work, Haley understood the politics of the time, and that space could become the "high ground" of the Cold War. His strong reaction to this is best quoted in its entirety here, because it presages the development of international policy on orbital debris, without Haley even knowing it.

It is unfortunate too, that the work of the United Nations Legal Committee, the Committee on the Law of Outer Space of the American Bar Association, and the USSR Juridical Committee on Cosmic Law, should thus far be encyclopedic in nature-with the result that these great forums are failing to con-

⁴⁵ See SPACE LAW AND GOVERNMENT, *supra* note 1, at 75-117.

⁴⁶ *Id.* at 40-61.

⁴⁷ *Id.* at 233-265.

⁴⁸ *Id.* at 394-424.

⁴⁹ See, e.g., *id.* at 314-333 (discussing the 1959 report on the U.N.'s then-ad hoc Committee on the Peaceful Uses of Outer Space, U.N. Doc. A/4141 (1959) (hereinafter 1959 COPUOS Study), which addressed many of the issues discussed in *Space Law and Government*. Interestingly, that 1959 report did not specifically identify orbital debris as a potential issue with which the international community should be concerned.)

⁵⁰ See, e.g., SPACE LAW AND GOVERNMENT, *supra* note 1, at 130, n. 40 (citing SURVEY OF SPACE LAW, *supra* note 9); see also SPACE LAW AND GOVERNMENT, *supra* note 1, 386 (citing Leon Lipson, Nicholas Katzenbach, *Report to NASA on the Law of Outer Space*, 61 COLUM. L. REV. 1074 (1961) (hereinafter the Katzenbach Report)).

tribute in an effective manner to the wealth of thinking on the law of outer space.

Indeed, it appears now that to avoid the slowing process of political haggling this urgent and even critical task must be undertaken by non-governmental international organizations such as the International Institute of Space Law of the International Astronautical Federation. It is a pity that purely national committees and official international bodies have so far been incapable of synoptic thinking!

The United Nations, having taken a look at the issues presented and the solutions offered, has commenced the piecemeal and stop-gap solution which the author predicted, several years ago, would be adopted. The advocates of the U.N. and U.S. Government "wait and see" policy will undoubtedly point to the General Assembly Resolution of December 20, 1961 and ask, "What more do you want?" However, as we have pointed out earlier, what is needed is not the broad meaningless language that "international law ... applies to outer space" and "celestial bodies are free for exploration and use by all states in conformity with international law and are not subject to national appropriation." The invitation which immediately follows these quoted statements is what was needed in 1955, not in 1961: "The General Assembly ... Invites the Committee on Peaceful Uses of Outer Space to study and report on the legal problems which may arise from the exploration and use of outer space."

Negatively phrased sweeping generalizations are not contributing to the solution of the immediate problems. We now need agreement on what men *may* do, what effect their actions *will* have, where they *may* go and how they *may* travel. Listing in vague terms what outer space is, or is not, will not serve the purpose; and to say that outer space and its celestial bodies "are not subject to national appropriation" is only the temporary means of putting off the question of what may be done. This single limitation does not prevent the use of other means to secure control. Processes and practices other than "national appropriation" still exist unrestrained, and we have not even

yet agreed upon what constitutes "national appropriation" here on earth.⁵¹

Haley's demand that the international law and policy community move forward to work on a solution to the key issues facing space operations is justified by his prediction of the alternative future, where "wait and see," has become an unmovable dead weight with no inertia.

In contrast to the ominous chords struck above, Haley was actually optimistic that many of the issues raised in *Space Law and Government* could be solved through a combination of international treaty, bilateral agreement between nations, and especially the use of customary international law,⁵² which Haley found to be of critical importance in analyzing space law issues, notwithstanding the human species had launched its first satellite into orbit only six years before the publication of *Space Law and Government*, and only a dozen humans had been sent into space, with the longest U.S. flight to date lasting 34 hours and 22 orbits.⁵³

So while Haley was concerned about space trash, as discussed below, he saw a fairly clear path to address and prevent

⁵¹ SPACE LAW AND GOVERNMENT, *supra* note 1, at 131 (footnotes omitted, emphasis in original).

⁵² Haley's analysis and justification for the use of customary international law in establishing and interpreting international space laws is detailed and persuasive, but beyond the scope of this article (indeed this section of *Space Law and Government* warrants an article of its own). Haley himself teed up the issue of freedom to orbit above a nation in 1955 by writing several articles and making speeches all over the world positing that if any nation did orbit a satellite during the upcoming International Geophysical Year (IGY), held in 1957-1958, and no country objected to the overflight, the right of free overflight would be established. See SPACE LAW AND GOVERNMENT, *supra* note 1, at 62. Countering academic arguments that, like the law of adverse possession, establishment of international law through custom required years if not generations, Haley concluded otherwise, saying that "The present situation, however, is entirely different. An earth satellite will pass over numerous countries in a period of hours and these nations are immediately aware of the launching. Knowledge of the impending launching may even have been available for a considerable time prior to the actual event. In view of this, the nations could be expected to express their consent-or non-consent-in a timely manner." *Id.* at 60-61.

⁵³ Mercury 9, piloted by Gordon Cooper, launched May 15, 1963, landed May 16, 1963. See NASA, Human Space Flight: A Record of Achievement, 1961-1998, <http://www.hq.nasa.gov/office/pao/History/40thann/humanspf.htm#mercury> (last visited Sept. 12, 2013).

actual damage to the orbital environment going forward. As it turned out, however, the quote at the beginning of this article became a poignant prediction of what would happen in the future if the nations of the world failed to consider the issue of disposing of satellites at the end of their useful lives.

When it came to the issue of orbital debris and the activities that could negatively impact the ability of other satellites to function, Haley was first and foremost concerned with radiofrequency interference between satellites and ground stations, mainly caused by the fact that most early satellites had no "off" switch.

In the context of communications, it cannot be emphasized too often that radio controls, guidance, tracking, and scanning are essential elements in the use and safety of space travel. Abuses of allocations leading to confusion of radio commands could result in extensive losses and irreparable damage. This fundamental tool of the space scientist must be kept in working condition, and the lawyers and diplomats at the council tables must be constantly aware that the burden is upon them to create and enforce workable laws and rules of the road for the use of radio in space travel.

One important requirement, to be discussed in detail in Section 7-7 *infra*, is the control of the radio transmitter on an earth-circling vehicle so that it will not continue to operate indefinitely. At present, radio engineers throughout the world are possessed of the unpleasant knowledge that for indeterminate periods certain frequencies are being in a sense usurped for satellite operation to the possible detriment of assigned frequency usage. The radio spectrum is limited, and the frequencies involved are extremely valuable; they may be quite essential to some other services. Accordingly, there must also exist a radio command or other device capable of silencing these earth-circling vehicle radio transmitters.⁵⁴

Haley went out of his way not to criticize the Soviets,⁵⁵ yet pointed out that Sputnik's transmit frequency (20 MHz) was

⁵⁴ SPACE LAW AND GOVERNMENT, *supra* note 1, at 172.

⁵⁵ *Id.* at 169.

commonly used by scientists all around the world, and many of those scientists reported receiving interference from Sputnik’s transmissions.⁵⁶ Haley then turned to the problem presented by the Vanguard I satellite (launched March 17, 1958 by the Naval Research Lab), which was powered by solar cells and again had no “off” switch. Haley predicted that because of its much higher orbit than Sputnik (654 x 3,969 kilometers), the 108 MHz radio could transmit for between 200 and 1000 years.⁵⁷ Haley was partially correct. Vanguard I remains the oldest man-made object in space, and it will likely stay in orbit for another 200 years. Its radio ceased operating (or at least ground stations could no longer receive the gradually weakening signal), after May, 1964 (within a year of when *Space Law and Government* was published).⁵⁸

Haley had been preaching on this subject for a number of years, dating back to at least 1952,⁵⁹ and his solution for the problem was simple. The International Telecommunication Union (ITU), already chartered by the United Nations and having been in operation for nearly 100 years (as opposed to the United Nations, which in 1959 was barely over a decade old), was Haley’s choice for resolving the interference issues. The ITU had to step in and begin allocating frequencies for space use before any more satellites “usurped” frequencies, according to Haley. Actually, by the time *Space Law and Government* was published, the ITU was well on its way to solving this part of the “space pollution” puzzle by allocating frequencies for Earth-to-space and space-to-Earth operations as early as 1959.⁶⁰

The reader might conclude from this discussion that Haley was setting up a “straw man” by spending dozens of pages of *Space Law and Government* on an issue that had largely been solved. The reader might also question why this author is even discussing a problem long ago solved. The reason is two-fold: First, as discussed *supra*, the problem of a rogue or derelict sat-

⁵⁶ *Id.* at 170.

⁵⁷ *Id.* at 179.

⁵⁸ See SSDD, *Vanguard I*, <http://code8100.nrl.navy.mil/about/heritage/vanguard.htm> (last visited Sept. 12, 2013).

⁵⁹ See SPACE LAW AND GOVERNMENT, *supra* note 1, at 173.

⁶⁰ *Id.* at 174.

ellite interfering with the operations of other satellites has not been completely solved, as demonstrated by the case of Galaxy 15. The ability that SES had to avoid the interference and maneuver its AMC-11 satellite as Galaxy 15 encroached its GEO orbital position was directly related to the ITU frequency allocation process and various national licensing regimes, such that SES knew exactly what frequencies Galaxy 15 was transmitting on, and where Galaxy 15 was licensed to operate, and it could take steps to mitigate the interference that Galaxy might cause to its AMC-11 satellite. The second, and more important reason to discuss this issue in its historical context is because Haley had faith that the same sort of international regulatory regime could be established to ensure that satellites themselves would not pose a danger to space navigation, because an international organization could be established to require that nations remove their old satellites and debris.

As we must deal with the conservation and safety of life and property, a second and more serious long-range problem must also be considered, namely, the continued orbiting of man-made space vehicles for periods of undetermined length—extending even to centuries or millennia. This uncontrollable “space trash” will constitute a hazard to safety of life and property in outer space as long as it continues in orbit.

It is quite clear that the radio command problem is simple of solution, whereas the disposal of “space trash” is most difficult to solve, and the latter problem is really the most serious by far. Certainly, the “probabilities” of collision and all aspects of threats to safety over the next century should be the subject of a searching study under the supervision of NASA by such organizations as the Rand Corporation.⁶¹

Haley’s solution to the “serious” future problem of orbital debris was similar to his solution to the frequency pollution issue: Establish international norms requiring nations to register their space vehicles and dispose of them at end-of-life, and stand up an international organization to police this registry to ensure

⁶¹ *Id.* at 206.

that nations remained in compliance. Unlike the solution for radio pollution, however, Haley was not so naïve as to think that this part of the puzzle would be easy to solve, so he began with the need to register all objects sent into space.

Registration of vehicles-their weight, payload, trajectory, function, expected life, and all other pertinent data-could obviously involve matters of national security. But there is apparently no reason why all those facts that are relevant but not necessarily crucial in nature could not be disclosed, e.g., the time of a launch, the trajectory or expected orbital path, the vehicle weight, and matters of similar import, which are frequently released to the press for publication.

If an international commission were functioning, this material could be carefully logged and efficiently kept in readily accessible sources. A uniform system of reporting activities would slowly come into being, and smaller, later-arriving astronautical powers would come into an existing framework of registration, with precedent to act as guide and a centralized office to be notified. As the numbers of vehicles increase, the work of this office would grow in importance.

Many relevant facts will be made available through a system of registration. The source of damage-causing vehicles, for example, will be internationally identifiable. Indeed, the sources of all existing vehicles will be on permanent record. Vehicles violating communications or other regulations will be identifiable, together with the country that launched them, and measures can then be taken to prevent further abuses. As long as only two or three nations are actively involved in space activities these may seem naive observations, but when there are eight or ten different nations continually launching vehicles into space, the problem of numbers alone will be acute.

Whatever the systems of recordation hitherto employed by American and Soviet space scientists and officials, a uniform system should be agreed upon for the future. An international agency, preferably within the U.N., should be established to localize and formalize the registration activity. The longer we

wait to tackle this problem, the greater its dimensions become and the more difficult of solution.⁶²

But Haley went further, concluding that registration alone was not going to be enough, that vehicles and satellites needed to be *licensed* by some international authority.⁶³ Haley also fully understood that registration and licensing by themselves would be insufficient unless the regulating entity had the power to enforce its rules. He noted with a certain disdain the history of the ITU's inability to actually force nations to abide by its frequency allocation determinations.

Yet merely to create a series of specialized agencies is not enough. In communications, for example, the International Telecommunication Union, affiliated with the U.N., is now the primary source of determination of frequency allocations. When these allocations are violated, as they have been in the past, some agency within the international structure will have to have authority to apply sanctions to such violations. At present, no such sanctioning body exists, and there is no more effective sanction available than irate expressions of disdain for the violator. Situations of this kind will multiply in space activity as regulations are developed, and unless the specialists can support their regulations by the application of sanctions, the violations of rules will go on.⁶⁴

Haley also recognized the difficult political path this presented at the height of the Cold War. While Haley himself enjoyed access to people and places deep inside the Soviet sphere of influence because of his position with various international organizations,⁶⁵ he also knew first-hand, as a former Army officer and in the General Counsel's office of the Federal Communications Commission, that coming up with an international agreement whereby countries would hand over both valuable

⁶² *Id.* at 138.

⁶³ *Id.* at 139-140.

⁶⁴ *Id.* at 150.

⁶⁵ *See, e.g., id.* at 328-392 (discussions of the development of various international organizations highlight the many countries during the 1950s which Haley visited).

information, and police powers to an international agency, was a formidable task.

The foregoing discussion in this chapter has been offered, in many instances, in contemplation of the existence of a police power in some international agency. If, in this time of extreme nationalistic tendencies and ideological struggles, it is difficult even to discuss the question of an international police power, actually creating one would be a far greater struggle. Eventually, however, some recognized police power must come into being in order to enforce the regulations of the many international and interplanetary activities which the space age surely will bring upon us. If no effort is made to cope with and resolve this problem today, the only justifiable expectation is that it will be much more onerous tomorrow. Some writers are extremely optimistic regarding the potential role of the U.N. in enforcing controls of space activity. Donald W. Cox, for example, has written that one of the prime shortcomings in all the literature on the establishment of an upper limit to national sovereignty is the absence of any clear realization that a U.N. police force is needed for purposes of enforcement. In any event, the problem of police power and enforcement – assuming a body of law for space can be promulgated – is one of the questions to which leading figures on both national and international levels must devote a major amount of time and effort.⁶⁶

And that's where Haley left us. He identified the problem of orbital debris in a way few if any of his contemporaries had, he pointed out the proper pathway forward to avoid contaminating orbits, but then brought the discussion "back down to Earth," by acknowledging how difficult it ultimately would be to reach international consensus on a registration and licensing regime with full police powers. He was confident, nonetheless, that this was possible, and if implemented, would establish bedrock principles of space law that would bind the spacefaring nations into a course of action for the next century.

⁶⁶ *Id.* at 150-51.

[T]he rule of law in outer space also includes a third principle, namely, the norm of orderliness. This norm has received more recognition than is generally known. It embraces the orderly use of the radio spectrum—which belongs to all mankind — including the development and use of devices which will turn off transmitters on space vehicles so that interfering signals may be eliminated; it also embraces the use of devices that will cause earth-orbiting vehicles to return to earth, so that they will not perpetually exist as a hazard to safety and property in outer space; and so on.⁶⁷

III. THE DEVELOPMENT OF INTERNATIONAL LAW AND POLICY SURROUNDING ORBITAL DEBRIS: 1963 TO PRESENT

A. *A Slow Recognition of the Problem*

In the early days of spaceflight there certainly was no consensus that satellites could ever pose a threat to each other (other than radio interference). Until *Space Law and Government*, there was little attention paid to the issue. For instance, in the 1959 Congressional *Survey of Space Law*,⁶⁸ while there were concerns raised about radio interference from no longer controllable satellites, it was stated plainly: “This does not mean that scientists worry about collision, for space is a very big area.”⁶⁹ The only real threat of derelict spacecraft, according to Dr. John P. Hagen, director of Project Vanguard, is to make detection of incoming ICBM’s from the Soviet Union more difficult. “Filling the air with a great many dead satellite bodies is simply going to make that task extremely difficult.”⁷⁰

The COPUOS 1959 report on the status of space law had this to say about what we now refer to as orbital debris:

The continued orbiting of satellites beyond the period of their useful operational life imposes the necessity of continuing

⁶⁷ *Id.* at 157. The author can’t help but wonder whether Haley at some point intended to return to this paragraph and embellishing it further. The sentence fragment “and so on” seems strangely out of place in a book that otherwise is tightly written.

⁶⁸ SURVEY OF SPACE LAW, *supra* note 9.

⁶⁹ *Id.*, p. 7.

⁷⁰ *Id.* at 6 (*quoting* Hearings before the House Select Committee on Astronautics and Space Exploration, April 21, 1958, at 323).

their observation and registration. The foreseeable increase in this space ‘traffic’ problem is formidable. Destruction or recovery of such spent satellites, if possible, might be desirable to limit the ‘traffic’ problem to those satellites actually performing useful functions. This is feasible in larger satellites, which are capable of carrying the necessary braking rockets required to cause the satellites to descend at the end of their useful lives. *The ‘traffic’ problem is, of course, not in space itself, but in the capacity of ground tracking networks.*⁷¹

In other words, as far as COPUOS was concerned in 1959, the orbital debris issue was tied back into the radio interference issue discussed above. Similarly, the 1960 Katzenbach Report only briefly dealt with the issue of orbital debris:

There is scientific opinion to the effect that a state with space capabilities could propel into orbit a large quantity of “junk” (for example, radioactive waste) the effect of which would be to preclude much further scientific experimentation and increase the hazards of space travel and the possibility of surprise missile attack. Such a program would overload tracking facilities and could distort communications. Presumably an effort would be made to justify it as a measure of self-defense.

It is important that all nations with space capabilities use them with discretion and reserve in the interest of future scientific and technological programs. As space capabilities increase, the possibility of an iron curtain holding back scientific progress for years to come increases as well. Steps to limit the number of satellites that can be put into orbit and to furnish some assurance that each serves a useful function would be constructive contributions to the law of space. It would be unconscionable to future generations for us unnecessarily to hamper their opportunities.⁷²

Here again we see that there is little or no concern about orbital debris from “normal” operations of nations.⁷³ The Katzenbach

⁷¹ 1959 COPUOS Study, *supra* note 49, at 17, ¶ 72 (emphasis added).

⁷² Katzenbach Report, *supra* note 50, at 29-30.

⁷³ The term “collision” is used elsewhere in the Katzenbach Report, but only in the context of providing a list of issues addressed in other space law literature. *See id.* at 41 (“34. The legal problems created by space flight, as upon ascent and descent, property

Report's only concern was with a nation using debris as a weapon, and the effectiveness of this weapon would only be to interfere with space communications.⁷⁴

Within this context, then, we can analyze the development of international law as it applies to orbital activities to determine what it says about responsibility for orbital debris. Any such analysis must begin with a review of the "Big Four Plus One" international treaties that impact space law, to wit:

- 1) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the

damage, collision, interference with communications, landing on other planets and the moon, and the creation of space stations, cannot be solved by any one nation, but require regulation by an international authority under the auspices of the U.N. or the ICAO"); and *id.* at 42 ("49. An international coordinated program, which the existing international organizations could provide, should be established to lay down and supervise regulations relating to the launching of satellites, the traffic of objects in space, liability arising from any possible collision and related problems"). It can be argued, however, that the "collisions" the Katzenbach Report talks about are collisions between satellites and aircraft and satellites and objects on the surface of the Earth. *See id.* at 45 ("76. International agreement should be sought on the problem of ascending and descending spacecraft and the dangers of collision with aircraft and property damage, and on the problem of interference with telecommunications by spacecraft in orbit"). Further, the issue of a collision between two objects was not addressed in terms of the impact on the space environment (e.g., debris), but rather, from the perspective of liability of one of the parties under a tort theory. *See id.* at 78 (listing as a subject of an article "A fantasy set several decades in the future, and suggesting that (1) traditional conflict-of-laws rules should apply in a dispute with an extragalactic legal system; (2) rules covering collisions in outer space should be derived from general maritime law; and (3) to avoid possible legal complications the orbit of a U.S. satellite should be planned to miss space over the USSR and Nicaragua").

⁷⁴ The citations above help to provide a much needed context to the legal and policy approaches taken by the United States and the international community in the first decade of spaceflight. There was significant concern about space becoming the new "high ground" in the cold war, and much of the impetus for getting any international space treaty negotiated, signed, and ratified by the super powers was to eliminate the danger of "bombs in orbit." *See, e.g.,* Hearings Before the Committee on Foreign Relations, United States Senate, 90th CONG., 1st SESS., at 7 (Mar. 7, 13, and Apr. 12, 1967) ("another origin of this treaty, as the Secretary of State has pointed out, is the "no bombs in orbit" resolution, and it is pertinent to recall the origin of that particular declaration"). *See also,* Bureau of Arms Control, Verification and Compliance, *Narrative*, <http://www.state.gov/t/isn/5181.htm> (last visited Sept. 23, 2013) (U.S. State Department discussion of the 1967 Outer Space Treaty as the "second of the so-called 'non-armament' treaties.").

Moon and Other Celestial Bodies (“1967 Outer Space Treaty,” or simply “OST”);⁷⁵

- 2) Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (“1968 Rescue and Return Agreement”);⁷⁶
- 3) Convention on International Liability for Damage Caused by Space Objects (1972 “Liability Convention”);⁷⁷
- 4) Convention on Registration of Objects Launched into Outer Space (1975 “Registration Convention”);⁷⁸
- 5) Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (1979 “Moon Agreement”).⁷⁹

Although none of the international agreement directly addresses the issue of orbital debris, several contain provisions that could (and should) have had a bearing on the orbital debris issue and developing international law and policy in this area.

Turning first to the 1967 Outer Space Treaty, the OST contains a number of provisions that could have a legal bearing on orbital debris. First, Article VIII speaks to the ownership of objects launched into space:

A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body. Ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their component parts,

⁷⁵ Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, *opened for signature* Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty].

⁷⁶ Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, *opened for signature* Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119 [hereinafter Rescue and Return Agreement].

⁷⁷ Convention on International Liability for Damage Caused by Space Objects, *opened for signature* Mar. 29 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention].

⁷⁸ Registration Convention, *supra* note 21.

⁷⁹ Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, *opened for signature* Dec. 18, 1979, 1363 U.N.T.S. 21.

is not affected by their presence in outer space or on a celestial body or by their return to the Earth.⁸⁰

Second, Article VII of the OST specifies that states are liable for the damage caused by their vehicles during launch and once in orbit:

Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies.⁸¹

Article IX of the OST provides that States “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.” Article IX continues that exploration of outer space, the Moon, and other celestial bodies by States shall be conducted “so as to avoid their harmful contamination” and requires nations to “where necessary, ... adopt appropriate measures for this purpose.” Article IX requires that a State planning an activity or experiment that could potentially harm the activities of another State in the peaceful exploration and use of outer space consult with any such parties prior to launch.⁸²

It is easy in 2013, therefore, to look at these provisions and conclude that orbital debris is adequately addressed in the following manner: launching states must maintain control over their objects (Article VIII), are liable for any damage caused by such items (Article VII), and must not place or leave an object in an orbit if it could interfere with another states’ objects or contaminate orbits (Article IX). It is also a very small step to conclude that the OST prohibits the launch of any item without a

⁸⁰ Outer Space Treaty, *supra* note 75, at art. VIII.

⁸¹ *Id.* at art. VII.

⁸² *Id.* at art. IX.

plan to minimize any debris caused by its launch and operation, including a requirement that the object either be deorbited, or moved to an orbit where it could cause no collision threat at end-of-life.

If one studies both the history of the OST and the customary international law that has evolved surrounding these provisions, however, one finds that orbital debris was never considered in these contexts. In ratifying the OST, the United States Senate did not even discuss the issue of "debris," "trash," or "junk" during the March and April, 1967 hearings on ratifying the OST, which constitute 162 pages of analysis and hearing colloquy.⁸³ Article VIII was discussed only in terms of the rights of states to retrieve any vehicles that reentered and land in another country.⁸⁴ The "interference" provision of Article IX was interpreted by the U.S. Senate to relate mainly to radiofrequency interference, and the duties of states not to jam or otherwise interfere with the operations of satellites.⁸⁵ The remainder of Article IX was interpreted by the U.S. Senate to provide a prohibition against contaminating the atmosphere with nuclear testing.⁸⁶

Furthermore, while there are several references to vehicles and objects as being on the "registry" of a given state,⁸⁷ the OST does not explicitly require states to register their objects, nor does it set up any specific mechanism for registration, nor propose any penalties or sanctions for a state failing to properly register it launches.⁸⁸ The U.S. Senate noted the failure of the

⁸³ Hearings before the Committee on Foreign Relations, *supra* note 74.

⁸⁴ *Id.* at 42.

⁸⁵ *Id.* at 39, 54, & 71.

⁸⁶ *Id.* at 42 & 100.

⁸⁷ Outer Space Treaty, *supra* note 75, at art. V (astronauts making a landing in a foreign jurisdiction "shall be safely and promptly returned to the State of registry of their space vehicle"); and *id.* at art. VIII ("A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body").

⁸⁸ The United Nations established a space registry in 1962, following the adoption of U.N. Resolution 1721B (XVI) (1961).

Believing that the United Nations should provide a focal point for international cooperation in the peaceful exploration and use of outer space,

then-current U.N. registration system while debating ratification of the OST.

Mr. GOLDBERG. Oh, yes, and we have communicated with them and have said that our devices detect satellites in space originating from the Soviet Union that have not been reported. Now, this is not only a matter of the question of cooperative efforts in space. This is a matter of national security. We believe that when there is registration of all launchings this gives us an opportunity to, and the world community to, check up on whether the launchings are, indeed, peaceful or whether they are for some other purposes. And we have made it a matter of protest and we have been fairly successful with our protests because, following the protests, the Soviet Union, which has not put some launchings into the registry of the U.N., they are doing better after a protest.⁸⁹

Of course, the Soviet Union charged the same thing – that the United States routinely failed to fully and timely register all objects it launched into space.⁹⁰

As noted above, Haley's first requirement to solve the long term problem of orbital debris was the establishment of a fully functioning registration system.⁹¹ A crucial step was taken when the Registration Convention was adopted by the U.N. in 1975.⁹² It provided, in pertinent part under Article IV:

Each State of registry shall furnish to the Secretary-General of the United Nations, as soon as practicable, the following information concerning each space object carried on its registry:

-
1. Calls upon States launching objects into orbit or beyond to furnish information promptly to the Committee on the Peaceful Uses of Outer Space, through the Secretary-General, for the registration of launchings;
 2. Requests the Secretary-General to maintain a public registry of the information furnished in accordance with paragraph 1 above.

See also United Nations Office for Outer Space Affairs, Registration of Objects Launched into Outer Space, <http://www.oosa.unvienna.org/oosa/SORegister/index.html> (last visited Sept. 23, 2013).

⁸⁹ Hearings Before the Committee on Foreign Relations, United States Senate, *supra* note 74, at 61.

⁹⁰ *See* I. DIEDERIKS-VERSCHOOR, AN INTRODUCTION TO SPACE LAW 42 (1993).

⁹¹ SPACE LAW AND GOVERNMENT, *supra* note 1, at 138.

⁹² *Registration Convention*, *supra* note 21.

- (a) name of launching State or States;
- (b) an appropriate designator of the space object or its registration number;
- (c) date and territory or location of launch;
- (d) basic orbital parameters, including:
 - (i) nodal period;
 - (ii) inclination;
 - (iii) apogee;
 - (iv) perigee;
- (e) general function of the space object.⁹³

Importantly, the Registration Convention defined “space object” to “include[] component parts of a space object as well as its launch vehicle and parts thereof.”⁹⁴ There is the implicit assumption in the Registration Convention that states will update the registry in the event that the orbital parameters of a space object were to change.⁹⁵ In theory, a state should update the registry in the event that one of its satellites explodes, exfoliates, or otherwise breaks into pieces, with each piece separately registered if its orbital parameters now differ from the original registration.

As Haley predicted, however, the Registration Convention lacked any sanctions or penalties for a state not registering, not providing complete information about its space objects, or not updating the registry. In fact, the spacefaring nations have done almost none of these. Some launching states do not provide space object data until months after a launch.⁹⁶ Many, if not most of the registrations fail to include orbital data on all payloads and spent stages.⁹⁷ And some claim that military satel-

⁹³ *Id.* at art. IV.

⁹⁴ *Id.* at art. I.

⁹⁵ *See, e.g., id.* at art. IV(2)(“Each State of registry may, from time to time, provide the Secretary-General of the United Nations with additional information concerning a space object carried on its registry”); *and* art. IV(3)(“ Each State of registry shall notify the Secretary-General of the United Nations, to the greatest extent feasible and as soon as practicable, of space objects concerning which it has previously transmitted information, and which have been but no longer are in earth orbit.”)

⁹⁶ FRANCIS LYALL & PAUL LARSEN, *SPACE LAW: A TREATISE* 93 (Ashgate Publishing, 2009).

⁹⁷ *Id.*

lites are often never registered at all.⁹⁸ The standard form used by the United Nations does not even adequately allow for the registration of a launch which contains multiple satellites and may leave multiple spent bodies in orbit.⁹⁹ The UN registry, therefore, looks almost nothing like the UCS database of space objects, which in turn looks little like the JSpOC database. At least until the early 1990's,¹⁰⁰ if not far later, the spacefaring nations simply were not concerned with the number of space objects orbiting Earth, or even keeping track of them. The "Big Sky" theory was in full force.

Finally, the Liability Convention sets for the obligations of states for their activities. The Liability Convention states that "states shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft flight."¹⁰¹ As to damage caused to other objects in space, Article III states that a launching state shall be liable "only if the damage is due to its fault or the fault of persons for whom it is responsible."¹⁰² In other words, a strict liability regime applies to damages on Earth, whereas a negligence regime applies to damages caused in space. These differing legal approaches, as discussed below, may have played a key role in why the orbital debris problem has been ignored by the international legal community for so long.

But the separate question must be asked, why did the international community ignore the warnings of Haley in *Space Law and Government* for nearly 30 years? It would be patently false to conclude that Haley was not ignored, his work was just never given proper attention at the time. The importance of *Space Law and Government* from the day it was written was obvious: The first forward to the book was written by none

⁹⁸ AN INTRODUCTION TO SPACE LAW, *supra* note 90.

⁹⁹ See UNOOSA, *United Nations Register of Objects Launched into Outer Space: Model Registration Form*, <http://www.oosa.unvienna.org/oosa/SORegister/resources.html> (last visited Sept. 23, 2013).

¹⁰⁰ See *infra*, discussion of the history of orbital debris mitigation policies.

¹⁰¹ Liability Convention, *supra* note 77, at art. II. "Space object" is defined in a rather circular manner, to include a "space object as well as its launch vehicle and parts thereof." *Id.* at art. I.

¹⁰² *Id.* at art. III.

other than the Vice President of the United States, Lyndon B. Johnson, who only a few short months after he penned the forward, and by the time the book was available to the public, would ascend to the presidency upon the assination of John F. Kennedy. Here is what Johnson had to say about the importance of space law and Haley's book:

In this foreword I intend to indicate that the great new problems confronting civilization in the Age of Space require the close and devoted attention of the social scientists as well as of the natural scientists, and that principles of justice and order should be established in these early days of man's exploration of space. *Space Law and Government* is a penetrating examination and analysis of such principles and, as such, merits the careful attention of thoughtful people in all walks of life . . . The distinguished background of the author and the painstaking research which has gone into this book point up the value of *Space Law and Government*.¹⁰³

Additional forwards were written by Carl Albert, Majority Leader, U.S. House of Representatives, and George P. Miller, Chairman, House Committee on Science and Astronautics.¹⁰⁴ Albert had this to say about Haley and the importance of *Space Law and Government*:

I have known Mr. Haley for many years, having served with him in the military during the Second World War. He is an author, scientist, and lawyer. He is outstanding in the field of communications law and possesses the finest credentials to offer that is to my knowledge the first comprehensive study on space law and government. . . I am confident that *Space Law and Government* will be a major contribution to our emerging Space Age. Mr. Haley has devoted to the preparation of this work a matchless integrity and years of research and exhaustive study of the legal and sociological aspects of space flight. I commend this work to my colleagues with confidence.¹⁰⁵

¹⁰³ SPACE LAW AND GOVERNMENT, *supra* note 1, at vii, viii.

¹⁰⁴ *Id.* at viii, ix.

¹⁰⁵ *Id.*

Finally, Chairman Miller also recognized the importance of this work:

Mr. Haley embodies the benefit of his knowledge and experience in his penetrating book. It is a major contribution to the world's understanding of the nature of man's activities in space and in the legal consequences flowing from such activities. It deserves an honored place among the great and epoch-making legal studies in the libraries of the world.¹⁰⁶

Clearly, *Space Law and Government* did not "fly under the radar" as an academic treatise destined from the outset to be placed on the bookshelves of a few scholars to collect dust, and otherwise be ignored. Haley was a legal practitioner, after all, not an academic scholar. His work in opening up communications spectrum above 890 MHz after World War II to commercial operators had as much impact on 21st Century communications as any other human on the planet.¹⁰⁷

Haley's warnings of the dangers of an unmanaged satellite population were not ignored because *Space Law and Government* was unknown. Rather, it is more likely that the spacefaring nations ignored Haley's warnings for thirty years for one of two reasons, either in order to limit liability, or for national security reasons.

The desire to limit liability has some logical merit. Under both the OST and the Liability Convention, after all, nations are strictly liable for their space activities where such activities cause damage during launch, or upon reentry to any aircraft in air or property on the ground.¹⁰⁸ For damage caused in orbit, the international treaty regime adopts a negligence standard.¹⁰⁹ The Restatement (Second) of Torts defines negligence as "conduct that falls below the standard established by law for the protection of others against unreasonable risk of harm."¹¹⁰ In a

¹⁰⁶ *Id.* at ix.

¹⁰⁷ *See, id.* at 175-76 (discussion of the FCC's "Above 890 MHz" proceeding and opening up formerly government-only spectrum to new uses, including space communications).

¹⁰⁸ Outer Space Treaty, *supra* note 75, at art. VII.

¹⁰⁹ *Id.*

¹¹⁰ RESTATEMENT (SECOND) OF TORTS, §282.

successful negligence suit, the plaintiff must show that each of the following five elements is present:

- (1) a duty of care is owed by the defendant to the plaintiff;
- (2) a breach of that duty has occurred;
- (3) an actual causal connection between the defendant’s conduct and the resulting harm;
- (4) proximate cause, which relates to whether the harm was foreseeable; and
- (5) damages resulting from the defendant’s conduct.¹¹¹

So, by failing to establish sanctions in the Registration Convention for failure to register all items launched into outer space, by failing specifically adopt debris mitigation standards (including the deorbiting or placement of satellites in “safe” orbits at the end of their useful lives), and by failing to even track derelict satellites and spent upper stages in the early years of spaceflight, the spacefaring nations effectively established, through customary international law, that there was no duty of care when it comes to orbital debris, thus making it difficult, if not impossible, to prove that a satellite loss was caused by a collision, and the source of the colliding debris.

An equally plausible reason for the international community to ignore Haley’s warnings was the issue of national defense. Simply put, the United States and the Soviet Union simply did not want anyone (especially each other), knowing what surveillance satellites were overhead. In the past decade, with the passage of time, more information concerning the Eisenhower administration has been released. This information provides strong evidence that while Eisenhower knew there was no “missile gap,” the false supposition of which may well have led to the defeat of his Vice President Richard Nixon in the 1960 presidential election, Eisenhower was unwilling to prove the lack of the “missile gap,” because to do so would have revealed the full extent of the U.S. surveillance capacities in 1960, in-

¹¹¹ *Id.*

cluding space reconnaissance, which was then just coming online.¹¹² If Eisenhower was willing to see his party lose the White House in 1960 to protect the secrets of the space reconnaissance community, it is easily as plausible to posit that there existed in the early days of spaceflight an unwritten policy to keep discussion of orbital debris “off the table” of international organizations, because as policy makers well knew from *Space Law and Government*, the only antidote to space debris would be full registration, full tracking, and full liability for damages caused, in other words, transparency in space operations, something the United States was no more willing to do than was the Soviet Union.

Eisenhower’s farewell speech to the Nation, delivered on national television on January 17, 1961, may well provide a glimpse of the internal struggle Eisenhower felt over the rise of the “military-industrial complex” and the impact it was having on domestic and international relations.

This conjunction of an immense military establishment and a large arms industry is new in the American experience. The total influence -- economic, political, even spiritual -- is felt in every city, every State house, every office of the Federal government. We recognize the imperative need for this development. Yet we must not fail to comprehend its grave implications. Our toil, resources and livelihood are all involved; so is the very structure of our society.

In the councils of government, we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for the disastrous rise of misplaced power exists and will persist.

We must never let the weight of this combination endanger our liberties or democratic processes. We should take nothing for granted. Only an alert and knowledgeable citizenry can compel the proper meshing of the huge industrial and military ma-

¹¹² See, Y. MIECZKOWSKI, *EISENHOWER’S SPUTNIK MOMENT: THE RACE FOR SPACE AND WORLD PRESTIGE* (Cornell University, 2013); see also W. MCDUGALL, *THE HEAVENS AND THE EARTH: A POLITICAL HISTORY OF THE SPACE AGE* PP (Basic Books, 1985).

chinery of defense with our peaceful methods and goals, so that security and liberty may prosper together.¹¹³

For whatever reason, adherence to the misguided “Big Sky theory,” a desire to limit liability, or a belief that national security interests trumped the need to protect the orbital environment from contamination, the spacefaring nations largely ignored Haley’s warnings until at least the 1990’s, when the potential magnitude of this “tragedy of the commons”¹¹⁴ began to be discussed.

B. *Establishment of Orbital Debris Mitigation Guidelines*

The first steps to begin mitigation of future orbital debris were undertaken by NASA in 1982 with the adoption of NASA Management Instruction 1700.8, which specified that all unspent propellants and gases from Delta upper stages were to be vented so as to prevent explosions due to the mixing of fuel residues.¹¹⁵ DOD adopted similar internal guidelines in 1987.¹¹⁶ President Reagan’s 1988 National Space Policy directed that “all space sectors will seek to minimize the creation of space debris . . . consistent with mission requirements and cost effec-

¹¹³ Dwight D. Eisenhower, Eisenhower Farewell Address, Pub. Papers 1035-1040 (1960). See also, J. LEDBETTER, UNWARRANTED INFLUENCE: DWIGHT D. EISENHOWER AND THE MILITARY-INDUSTRIAL COMPLEX (Yale University Press, 2011). The reader is invited to actually watch closely recordings of the farewell address, copies of which are available from a number of online sources, including YouTube. The strain on Eisenhower’s face as he delivered this portion of the address is evident, and contrasts his demeanor during much of the rest of the farewell address.

¹¹⁴ The term “Tragedy of Commons” has its origins in British land use, and the ability of farmers and ranchers to use common ground to graze cattle and sheep. In 1833 William Forster Lloyd published a pamphlet pointing out that with no one taking care of the common grounds, while each rancher profited from the common ground usage in proportion to his/her use, all ranchers would ultimately suffer if the common ground was overgrazed and became unusable. The term itself has been attributed to the article “The Tragedy of the Commons,” published by Garrett Hardin in the journal *Science* in 1968 dealing more generally with the economics of the misuse of commonly held resources.

¹¹⁵ See, *Interagency Report on Orbital Debris*, *supra* note 10, at 27. That policy was updated in August 1995 by NASA Safety Standard 1740.14. See, 1(1) ORBITAL DEBRIS Q. NEWS (June 1996).

¹¹⁶ AFMC, Space and Missile Systems Center regulation SDR 55-1. See, *Interagency Report on Orbital Debris*, *supra* note 10, at 27.

tiveness.”¹¹⁷ The NASA guidelines were updated in August 1995 by NASA Safety Standard 1740.14.¹¹⁸ Both the FCC and the FAA currently have similar orbital debris mitigation policies as part of their licensing authority,¹¹⁹ and today both aggressively enforce their rules.¹²⁰

The international community began to come to grips with the orbital debris problem in the early 1990’s as well. Study Group 4 of the ITU endorsed a recommendation in 1993 that all geosynchronous orbit satellites be boosted not less than 300 km above the GEO orbit at the end of live and that all residual liquids be vented and all batteries “safed.”¹²¹ The Inter-Agency Space Debris Coordination Committee (IADC) was formed in 1993 by the major space agencies of the world: ESA,¹²² JAXA, NASA, and the Russian Space Agency (RSA). CNSA (China) joined in 1995, and BNSC (UK), CNES (France), and ISRO (India) joined in 1996, the German Aerospace Centre (DLR) in

¹¹⁷ See *Presidential Directive on National Space Policy* (Feb. 11, 1988), <http://www.hq.nasa.gov/office/pao/History/policy88.html>.

¹¹⁸ See 1(1) ORBITAL DEBRIS Q. NEWS (June 1996).

¹¹⁹ See, e.g., Second Report and Order in IB Docket No. 02-54, 69 FED. REG. 54581 (Sept. 9, 2004) (adopting rules related to orbital debris mitigation by the FCC codified at 47 C.F.R. § 25.114); see also 14 C.F.R. § 415.39 (FAA rules related to orbital debris mitigation requiring applicants for a launch license to demonstrate that: (1) there will be no unplanned contact between the vehicle, its components, and payload after payload separation; (2) no debris will be generated from the conversion of chemical, pressure, and kinetic energy sources into energy that fragments the vehicle or its components; and (3) stored energy must be removed by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in permanent discharge state, and removing any remaining source of stored energy).

¹²⁰ For example, the FCC returned an application to modify the authorization of the in-orbit Ku-band AMC-5 satellite, because SES Americom, Inc., had failed to submit an orbital debris mitigation plan pursuant to Section 25.114 of the FCC’s rules. See Letter of Robert G. Nelson to Daniel C. H. Mah, DA 10-1259 (July 2, 2010). AMC-5 was placed into orbit prior to the adoption of the FCC’s rules. Nevertheless, in requesting authority to move AMC-5 half a degree (from 78.95° W.L. to 79.05° W.L. in the GEO orbit), the FCC concluded that it had the jurisdiction to require SES to now file a debris mitigation plan, which would have to include agreeing to expand the fuel necessary to move AMC-5 out of the GEO orbit to a higher safe orbit at the end of its useful life.

¹²¹ International Telecommunications Recommendation, ITU-R S.1003 (Geneva, 1993). *Id.*

¹²² ESA has developed its own Code of Conduct entitled “Requirements on Space Debris Mitigation for Agency Projects,” which went into effect on April 1, 2008. See *ESA Mitigating Space Debris Generation*, http://www.esa.int/Our_Activities/Operations/Space_Debris/Mitigating_space_debris_generation (last visited Sept. 26, 2013).

1997, and the Italian Space Agency (ASI) in 1998.¹²³ The IADC adopted space debris mitigation guidelines in 2002, and revised them again in 2007.¹²⁴ The guidelines have three major principles:

- (1) Preventing on-orbit break-ups;¹²⁵
- (2) Removing spacecraft and orbital stages that have reached the end of their mission operations from the useful densely populated orbit regions;¹²⁶ and
- (3) Limiting the objects released during normal operations.¹²⁷

COPOUS itself took up the issue of orbital debris as a separate agenda item in February, 1994.¹²⁸ It embarked on a multi-year study of the issue, which included a program to measure orbital debris in 1996, model the space debris environment in 1997, and began development of space debris mitigation measures in 1998.¹²⁹ At the 47th IAF Congress held in Beijing China in October of 1996, there were three sessions dedicated to or-

¹²³ See Inter-Agency Space Debris Coordination Committee, <http://www.iadc-online.org/index.cgi?item=home> (last visited Sept. 26, 2013).

¹²⁴ IADC Space Debris Mitigation Guidelines, IADC-02-01 (*revised* Sept., 2007) (hereinafter IADC Guidelines).

¹²⁵ “On-orbit break-ups caused by the following factors should be prevented using the measures described in 5.2.1 – 5.2.3:

- (1) The potential for break-ups during mission should be minimized;
- (2) All space systems should be designed and operated so as to prevent accidental explosions and ruptures at end-of-mission;
- (3) Intentional destructions, which will generate long-lived orbital debris, should not be planned or conducted.”

Id. at 8. Section 5.2.1 deals with stored energy and the requirement to vent or safe them; Section 5.2.3 deals with spacecraft designs and building in failure mode analysis in the design to minimize break-up event in the event of a spacecraft failure. *Id.*

¹²⁶ Under the IADC Guidelines, spacecraft in GEO are to be moved to orbits of at least 235 kilometers above their current GEO position. Objects in LEO should be deorbited or placed in an orbit whereby the anticipated reentry is within 25 years. *Id.* at 9.

¹²⁷ “In all operational orbit regimes, spacecraft and orbital stages should be designed not to release debris during normal operations. Where this is not feasible any release of debris should be minimized in number, area and orbital lifetime. Any program, project or experiment that will release objects in orbit should not be planned unless an adequate assessment can verify that the effect on the orbital environment, and the hazard to other operating spacecraft and orbital stages, is acceptably low in the long-term.” *Id.* at 8.

¹²⁸ See *Technical Report on Space Debris*, A/AC.105/720 (1999).

¹²⁹ *Id.* at 1.

bital debris issues.¹³⁰ In 1999 COPUOS issued a Technical Report on Space Debris.¹³¹ In February, 2007, the Scientific and Technical Subcommittee (STSC) of COPUOS adopted orbital debris mitigation guidelines consistent with the U.S. and IADC guidelines. The U.N. General Assembly endorsed the guidelines in 2007.

From the discussion above, the reader might be asking, “why are we still talking about orbital debris if the problem was solved back in 2007?” The answer is that the orbital debris problem was in no way solved by the belated measures undertaken within the last decade and a half. The reason is two-fold. First, unlike the U.S. approach of promulgating enforceable rules with real sanctioning power (as Haley warned was necessary in *Space Law and Government*), the U.N. Guidelines are mere suggestions, and member states are free to adhere to or disregard them. A recent example evidences just how weak many of the international guidelines are. In 2002, ESA launched Envisat, an 8,000 kilogram Earth observation satellite into the highly crowded 790 km polar orbit.¹³² At 26 meters x 10 meters, by 5 meters, it is one of the largest satellites orbiting Earth. It had an expected operational life of five years, but continued to operate for an additional five years.¹³³ In April of 2012, ground controllers lost contact with the satellite. Although being operated well beyond its expected operational life, no efforts were made to deorbit the satellite, move it to a safer orbit, or safe the fuels and batteries onboard.¹³⁴ It is estimated that the satellite will remain in orbit, and a danger to space navigation, for between 100¹³⁵ and 150¹³⁶ years. ESA’s response to why nothing was done to prepare Envisat for its inevitable end of life? According to one report, “ESA officials insist that

¹³⁰ See 1(1) ORBITAL DEBRIS Q. NEWS, 2 (June 1996).

¹³¹ See *Technical Report on Space Debris*, *supra* note 128.

¹³² See ESA, *Observing the Earth*, http://www.esa.int/Our_Activities/Observing_the_Earth/Envisat_overview, (last visited Sept. 26, 2013).

¹³³ See Rendleman, *supra* note 39, at 3-4.

¹³⁴ See Peter B. de Selding, *Satellite Failure Puts European Space Agency in Tough Position*, SPACE.COM (Oct. 8, 2012), <http://www.space.com/17950-failed-satellite-esa-envisat-liability.html>.

¹³⁵ *Id.*

¹³⁶ Rendleman, *supra* note 39, at 4.

the international guidelines on disposal of debris were not in force when Envisat was designed.”¹³⁷ So apparently, the international community will have to wait decades or more to even begin to slow the increase of orbital debris if spacefaring nations take the position that the orbital debris mitigation guidelines only apply to satellites *designed* after 2007. Given the average lead time to design and build a satellite (a minimum of three to five years), under this approach, the world is just now, in 2013, beginning to heed the warnings of Haley in *Space Law and Government* 50 years ago.¹³⁸

Similarly, although China is a member of IADC through CNSA, its destruction of its Fengyun-1C weather satellite in 2007 clearly violated IADC guidelines, which state: “Any program, project or experiment that will release objects in orbit should not be planned unless an adequate assessment can verify that the effect on the orbital environment, and the hazard to other operating spacecraft and orbital stages, is acceptably low in the long-term.”¹³⁹ China did none of these things prior to blowing up one of its own satellites, producing thousands of new pieces of space debris.

The “sudden loss” of the ability to control a satellite provides the second reason why we can’t hope to begin to turn the tide on orbital debris anytime soon. Envisat provides a perfect example of how a multi-billion dollar space asset¹⁴⁰ was pushed well its design life because the environmental data being collected by Envisat was so important, and ESA could not afford a follow-on satellite to continue the function of Envisat, were it

¹³⁷ Peter B. de Selding, *Envisat to Pose Big Orbital Debris Threat for 150 Years, Experts Say*, SPACE NEWS (July 26, 2010), at 1, <http://www.spacenews.com/article/envisat-pose-big-orbital-debris-threat-150-years-experts-say>.

¹³⁸ Compare this somewhat cavalier approach to the U.N. Guidelines by ESA with the position of the FCC, Second Report and Order in IB Docket No. 02-54, *supra* note 119, where the FCC required SES to file an orbital debris mitigation plan, including moving the satellite to a GEO graveyard for AMC-5, a satellite that was built and launched before the FCC adopted its orbital debris mitigation rules in 2004.

¹³⁹ IADC Guidelines, *supra* note 124, at 8.

¹⁴⁰ See ESA, *Envisat FAQs*, http://www.esa.int/Our_Activities/Observing_the_Earth/Envisat_FAQs (last visited Sept. 26, 2013) (Envisat cost 2.3 billion Euros).

retired at its designed end of life.¹⁴¹ If it is the policy of satellite operators to squeeze every second of use out of a satellite, then even the best end of life disposal plans will be thwarted, because operators will continue to use satellites until they can no longer control them, meaning they also can't deorbit, reorbit, or safe them. Since there are no international sanctions, penalties, or repercussions for failing to comply with the end of life guidelines, there is little or no incentive for an operator to retire and safe a satellite while it is still functioning and either continuing to generate valuable scientific data, or in the case of a commercial satellite, revenue.¹⁴² If the only penalties, as Haley put it, are "irate expressions of disdain" from the international community,¹⁴³ there is little to stop nations and operators from ignoring the guidelines, or simply failing to carry out the paper plans to dispose of a satellite before it poses a potential threat to space navigation. But as is discussed *infra*, in the next section, this attitude may have to change if liability can be assessed to an operator who fails to safe a satellite at end of life, and that satellite later causes damage to other orbiting satellites.

The final reason why even the best debris mitigation strategies going forward are not going to solve the orbital debris problem, is the fact that, as noted above, the vast majority of new debris is caused not by recent launches or recently orbited satel-

¹⁴¹ Stories of engineers coaxing years, if not decades, of additional on-orbit life from satellites are very common. See, e.g., the story of the International Ultraviolet Explorer (IUE), launched in 1978 with a three year expected life, but with enough stationkeeping fuel for five years. When it was shut down on September 30, 1996, it had been in continuous operation for 18 years and 9 months. National Aeronautics and Space Administration, *IUE*, <http://science1.nasa.gov/missions/iue/> (last visited Sept. 26, 2013). As the six gyros onboard gave out, one after another, NASA engineers figured how to continue to control and point the observatory by using the remaining gyros. But what has been hailed as a scientific and engineering victory now exists only as another piece of space junk, slowly drifting from its original position at the 70° W GEO position, to the 110° W GEO slot which tends to accumulate uncontrollable geostationary satellites. See International Ultraviolet Explorer, http://en.wikipedia.org/wiki/International_Ultraviolet_Explorer#cite_note-38 (last visited Sept. 26, 2013).

¹⁴² This is probably more the case with one-off Earth observation satellites than it is for commercial communications satellites, where the "pipeline" for replacement satellites is more established, and operators often want to replace older satellites with new ones that have higher capabilities (and thus can generate higher revenues to justify building and launching replacements).

¹⁴³ SPACE LAW AND GOVERNMENT, *supra* note 1, at 150.

lites, but rather by the breakup of dormant satellites and upper stages, or the collision between such bodies, all of which long before became beyond the control of their human operators.¹⁴⁴ Even if the world were to stop any new launches, the orbital debris population would continue to rise because of “exfoliation” (as Haley called it) and future anticipated collisions. An IADC study, completed in January, 2013, concluded that the total amount of debris in LEO is likely to increase 30 percent over the next 200 years, even with 90% compliance with strict debris mitigation (end of life safeing) measures, and that catastrophic collisions can be expected every five to nine years.¹⁴⁵ The study assumed no new launches after 2006.¹⁴⁶ The study goes on to conclude that we may have already entered the Kessler Syndrome. The study concludes, rather ominously, that active remediation measures (removal of orbital debris) must be considered,¹⁴⁷ and that is what we will do in the next section of this article.

IV. ORBITAL DEBRIS REMOVAL: PROMISE AND CHALLENGES

Most of the preceding discussion tracking the slow development of international norms for debris mitigation has focused on the relationship of launching states to their own satellites while such states still have control over the objects. As has been demonstrated above regarding several satellites, including Envisat, however, debris mitigation policies are only as good as the intentions and actions of launching states to carry through with satellite safeing and removal from congested orbits at end-of-life. Further, the focus of debris mitigation policies has been on the satellite itself. The fact is, the most dangerous pieces of orbital debris (in terms of the probability they could collide with

¹⁴⁴ See *Orbital Debris Frequently Asked Questions #3*, *supra* note 31, and accompanying text. Of course, the debris caused by the Chinese in destroying their own satellite certainly was not beyond their control, and hopefully the damage caused by this single episode will serve as a warning to the spacefaring nations that the intentional destruction of an orbiting object cannot be countenanced.

¹⁴⁵ *Stability of the Future LEO Environment*, IADC-12-08, Rev. 1 (Jan. 2013).

¹⁴⁶ Obviously, the world did not stop launching new satellites after 2006, so the results of the IADC study, disturbing as they are, significantly underestimate the increase in orbital debris that actually will occur over the next two centuries.

¹⁴⁷ *Id.*

other objects), are actually derelict upper stages, used to carry satellites to their final orbits, and then discarded in adjacent orbits that may be just as crowded as the orbit into which they deliver their payloads.¹⁴⁸ These upper stages tend to be very large, with large surface area cross sections, increasing the likelihood that they can collide with other objects.¹⁴⁹

In recent years the topic of debris remediation (the active removal of space debris that is no longer controllable) has gained significant attention. The United States Defense Advanced Research Projects Agency (DARPA) requested comment on technical, economic, and legal issues involved in removing space debris in 2009,¹⁵⁰ which DARPA followed up with a three day workshop on December 8-10, 2009, at which this author and others presented ideas for debris remediation.¹⁵¹ Suggested technical solutions covered in the DARPA symposium and suggested elsewhere, include the use of electromagnetic tethers,¹⁵² lasers,¹⁵³ solar sails,¹⁵⁴ tractor beams,¹⁵⁵ and a variety of “snatch and deorbit”

¹⁴⁸ See, James Dunstan and Bob Werb, *Legal and Economic Implications of Orbital Debris Removal: Comments of the Space Frontier Foundation*, at Chart One (Space Frontier Foundation, Oct. 30, 2009), available at <http://www.scribd.com/doc/23379988/Legal-and-Economics-Implications-of-Orbital-Debris-Removal> (hereinafter *Legal and Economic Implications*).

¹⁴⁹ The Atlas Centaur, upper stage, for example, which in various configurations has been launched over 200 times, is almost 13 meters (42 feet) long and with a diameter of over three meters (10 feet), with an inert (empty) weight of 2,247 kg (4,954 pounds). See *Atlas V-551*, SPACEFLIGHT 101, <http://www.spaceflight101.com/atlas-v-551.html> (last visited Sept. 26, 2013).

¹⁵⁰ See DARPA Solicitation DARPA-SN-09-68, FEDBIZOPPS.GOV (Sept. 17, 2009), available at <https://www.fbo.gov/index?s=opportunity&mode=form&id=a55fd6e5721284ee7df2068d2b300b5f&tab=core&cview=0> (last visited Sept. 26, 2013).

¹⁵¹ See Stephen Clark, *Military agency studying space garbage service*, SPACEFLIGHT NOW (Dec. 12, 2009), <http://www.spaceflightnow.com/news/n0912/12debris/>. The DARPA “Catcher’s Mitt” study described in the link above, however, never went beyond this three day symposium. While no official DARPA announcement was ever made as to why the study was not pursued, it was clear from many of the presentations that some of the tools suggested for removing orbital debris (e.g., ground-based or space-based laser), could just as easily be used as anti-satellite weapons.

¹⁵² See J. Pearson, E. Levin, and J. Carroll, *Affordable Debris Removal and Collection in LEO*, in 63RD INT’L ASTRONAUTICAL CONG., Paper IAC-12-A6.6.7 (Oct. 1-5, 2012), available at <http://www.star-tech-inc.com/id27.html>.

¹⁵³ See e.g., C. R. Phipps, et al., *Removing orbital debris with lasers*, ADVANCES IN SPACE RES., 49, 1283-1300 (2012).

¹⁵⁴ See Ray Sanders, *NASA to Test New Solar Sail Technology* (Oct. 13, 2011), <http://www.universetoday.com/89869/nasa-to-test-new-solar-sail-technology/> (Report on

technologies.¹⁵⁶ Each advocate of a particular technological approach to active debris removal (“ADR”), passionately argues that there are no technical “show stoppers” to ADR. This is not to say that the technical solutions are easy (or cheap); most would take years if not decades of technology development, and ultimately it might cost as much to take down a piece of space trash as it did to launch it into orbit in the first place.¹⁵⁷ As with any “tragedy of the commons,” figuring out who will pay for orbital debris removal is a difficult issue, and the economic solutions to the problem are not readily apparent to most.¹⁵⁸

In addition to the technical and economic issues, however, there are significant legal issues related to removing orbital debris which are every bit as vexing as the technical and economic issues. The major difficulty the international legal community has had in coming to grips with the orbital debris problem stems from four provisions of international law:

- 1) Under the Outer Space Treaty, a state launching an object retains jurisdiction over that object, presumably forever;¹⁵⁹
- 2) There is no explicit requirement under international treaty law to remove an object from space once its useful life is over (notwithstanding the various debris mitigation guidelines adopted by various countries);

NASA’s solar sail program and the possibility of using solar sails for orbital debris removal).

¹⁵⁵ See, e.g., Laura Boness, *Tractor beams may become a reality*, SCIENCE ILLUSTRATED (Nov. 2, 2011), <http://scienceillustrated.com.au/blog/science/tractor-beams-may-become-a-reality/>.

¹⁵⁶ See, e.g., Leonard David, *“Sling-Sat” Could Remove Space Junk on the Cheap*, SPACE.COM (Mar. 1, 2013), <http://www.space.com/20024-space-junk-removal-sling-sat.html>.

¹⁵⁷ Many of the more exotic proposals, such as tethers and the “Sling-Sat” hope to be able to retrieve multiple space objects with a single spacecraft, thus reducing the cost, per debris removed, substantially. Each of these missions could easily run hundreds of millions of dollars, even if they could remove multiple pieces of debris.

¹⁵⁸ At the 2009 DARPA symposium, this author proposed the establishment of a bounty system for orbital debris removal whereby all satellite operators would pay into a fund an amount based on the size, orbit, and history of successful debris mitigation, an authority would be established to place a value on each piece of orbital debris (with the highest value assigned to those pieces which pose the greatest threat of collision), and then private entities would be awarded money from the fund for successful removal. See, *Legal and Economic Implications*, *supra* note 148.

¹⁵⁹ Outer Space Treaty, *supra* note 75, at art. VIII.

- 3) The Registration Convention lacks any enforcement mechanisms or sanctioning provisions which would require a launching state to register each part of a launch, and any subsequent debris coming from a launch; and
- 4) Under the Liability Convention, fault must be established before liability can be assigned to any activity occurring in orbit.¹⁶⁰

As discussed above, there has been every reason for the spacefaring nations to ignore the orbital debris problem for the simple reason that to acknowledge it, and to establish norms of conduct, would go a long way toward establishing a “duty” and a “standard of care” that would feed into a negligence liability analysis.

The 1995 Inter-Agency Report on Orbital Debris¹⁶¹ explained the conundrum this way:

Although the Liability Convention provides a legal mechanism for establishing liability and damages, there would likely be problems of proof associated with a claim based on damage caused by orbital debris. In the likely event that damage to or destruction of a space objects was caused by a small, unobservable fragment, it would be difficult to establish the identity of the launching state and therefore to invoke the Liability Conventions.

* * *

Liability would then depend on whether a state's actions in controlling its space objects were ‘reasonable.’ The present state of space technology does not permit activities in space that are completely debris free; hence, a negligence regime might imply an obligation of states to take reasonable steps to prevent foreseeable damage. Many factors would come into play in decide what steps are reasonable and what damage is foreseeable, including the proximity of other space objects, the reason for the creation of the debris, the cost of preventing the

¹⁶⁰ Liability Convention, *supra* note 77, at art. III.

¹⁶¹ *Interagency Report on Orbital Debris 1995*, *supra* note 10.