Space Commercialization: The Need to Immediately Renegotiate Treaties Implicating International Environmental Law

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I. INTRODUCTION

"Man is an artifact designed for space travel. He is not designed to remain in his present biologic state any more than a tadpole is designed to remain a tadpole."[1] These words are finally ringing true as the commercialization of space becomes reality. However, with it brings many unforeseen environmental problems and challenges. Among these challenges is the need to adapt existing international environmental law —a body of law that predates even the thought of true space commercialization—to ensure that proper boundaries are established before space commercialization becomes locked down by the private-sector. What was once science fiction is now reality.

Space commercialization is a movement that encompasses many types of development. It may be something as whimsical as space tourism, where a private citizen pays a fare to take a trip into the heavens.[2] It may also be as utilitarian as strip mining an asteroid for its minerals, a process that has the potential to generate wealth vaster than any human's comprehension.[3] Finally, space commercialization could be the process of planet colonization, the creation of space stations and the development of other celestial terrae, which creates a need to transport supplies and other essentials—a form of commerce. In short, anything you can "do" in space can be considered space commercialization.[4]

Space commercialization is inherently a topic of international concern. While space missions, in their various forms, are originally the products of nation states and individuals therein, the missions quickly take on

1. ROBERT ANDREWS, THE COLUMBIA DICTIONARY OF QUOTATIONS 861 (Robert Andrews ed., 1993) (quoting William S. Burroughs).

2. *See generally Space Tourism*, SPACE FUTURE, http://www.spacefuture.com/tourism/tourism.shtml (last visited Oct. 7, 2011).

3. *See* JOHN S. LOUIS, MINING THE SKY: UNTOLD RICHES FROM THE ASTEROIDS, COMETS, AND PLANETS (1997).

4. *See generally U.S. Business Using the Unique Medium of Space to Benefit Our Economy*, SPACE COMMERCE, http://www.space.commerce.gov/ (last visited Oct. 2, 2011).

international significance the moment liftoff occurs. Rocketing upward, spacecraft carrying shuttles, satellites, and other space-bound items leave tremendous amounts of pollutants in the terrestrial atmosphere.[5] As spacecrafts leave Earth's atmosphere, rocket boosters are jettisoned into space where they spend decades in Earth's orbit amongst trillions of other man-made "satellites,"[6] until eventually falling to Earth or disintegrating upon entry. In the meanwhile, these pollutants travel through the atmosphere, crossing continents and oceans alike. The jettisoned debris circulating in Earth's geosynchronous orbit may remain there for near eternity.[7] In addition to physical debris, air pollution emissions from spacecraft are also another cause of international concern. Just like emissions from modern aircraft, air pollutants from spacecraft do not respect international boundaries and will travel the atmosphere as they see fit.

After takeoff, a spacecraft's mission must be addressed. Does it land on the moon? Does it dock with the space station to deliver parts and personnel? Does it continue into outer space to the Mars colonies? Whichever form the mission may take, it is has a direct effect on areas outside the state boundaries where the mission originated. A feat once viewed as a nationalistic conquest is now viewed as an international, capitalistic tool to take advantage of outer space and beyond.[8] Accordingly, international environmental law comes into play. This Comment will explore the current space commercialization landscape and the treaties bearing on the topic. It will then propose modifications to existing international treaties in order to prevent international environmental harm before it occurs. This Comment will explore and propose solutions to these issues by focusing on the externalities of air pollution and space trash resulting from space commercialization.

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5. Each space shuttle burns 2.3 million pounds of solid propellant in the launch boosters alone, with additionally 1.2 million pounds of propellant in the main engines. *See Shuttle Reference and Data: Space Shuttle Solid Rocket Boosters*, SHUTTLE PRESS KIT, http://www.shuttlepresskit.com/STS-106/REF137.htm (last updated Aug. 28, 2000).

6. *See* Daria Diaz, *Trashing the Final Frontier: An Examination of Space Debris from a Legal Perspective*, 6 TUL. ENVTL. L.J. 369, 373 (1993). The term "satellite" is used loosely in science to mean any object rotating in geosynchronous orbit.

7. *See Orbital Debris Frequently Asked Questions: 12). How Long Will Orbital Debris Remain in Earth Orbit?*, NASA ORBITAL DEBRIS PROGRAM OFF., http://orbitaldebris.jsc.nasa.gov/faqs.html (last updated July 2009).

8. *See generally* LOUIS, *supra* note 3.

A. The Current Space Commercialization Landscape

While space commercialization is now dominated by the private sector, this has not always been the case. From 1930 until 1984, the governments of various states exercised complete dominion over any efforts to explore and commercialize outer space.[9] While there are many social and political explanations for this, the main reason is that originally only states were willing and able to put forth the necessary capital to develop space-capable aircraft.[10] But, as technology began to advance and missions were successfully completed, private industry began to notice that space commercialization could be lucrative.[11]

In 1984, the George H. W. Bush administration signed the Commercial Space Launch Act ("Launch Act"), which enabled creation of the first American industry of private operators of expendable launch systems[12] (to date, the commercial launch industry operates under the Launch Act's authority). Prior to this, there was a *de facto* federal mandate that all expendable launch systems be manufactured for the National Aeronautics and Space Administration ("NASA") Space Shuttle program, a program created by the federal government to prevent the few private investors that desired to develop a private commercial launch industry from doing so.[13]

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9. In the United States, space launches could only be conducted by the government until the 1984 Commercial Space Launch Act was passed. *See* Ronald Reagan, *Statement on Signing the Commercial Space Launch Ac*t (Oct. 30, 1984), *available at* http://www.presidency.ucsb.edu/ws/index.php?pid= 39335#axzz1dcCLcGtl. In Russia and China, the only other contemporary space-faring nations, all space exploration was conducted by the government due to the nature of communism.

10. When NASA first began operations in 1958, its annual budget was approximately $100 million—far more than any private company could expend at the time. *See T. Keith Glennan*, NASA, http://www.hq.nasa.gov/office/pao/History/Biographies/glennan.html (last updated Aug. 4, 2006). Adjusted to today's dollars by the Consumer Price Index method, that annual budget equates to $754 million. *See Seven Ways to Compute the Relative Value of a Dollar Amount—1774 to Present*, MEASURING WORTH, http://www.measuringworth.com/uscompare/ (last visited Oct. 7, 2011). To compare this budget to that of its contemporary major for-profit corporations, General Motors was the United States' top grossing corporation with a profit of $843.6 million in 1958. *Fortune 500: A Database of 50 Years of Fortune's List of America's Largest Corporations, 1985 Full List*, CNNMONEY, http://money.cnn.com/magazines/fortune/fortune500_archive/full/1958/ (last visited Oct. 7, 2011). While GM's profits are slightly more than NASA's budget, it is quite obvious that GM would never "throw away" all that money into a fledgling space program that could not produce an immediate return on investment.

11. *See* P.Q. Collins & D.M. Ashford, *Potential Economic Implications of the Development of Space Tourism*, 17 ADA ASTRONAUTICA 421A31, 421A31 (1988), *available at* http://www.spacefuture.com/archive/potential_economic_implications_of_the_ development_of_space_tourism.shtml.

12. See Commercial Space Launch Act of 1984, Pub. L. No. 98-575, 98 Stat. 3055 (1984) (codified as amended at 49 § U.S.C. 70101).

13. It was the national policy of the United States to use NASA as the primary research and operational engine to conduct space launches and research: "The Congress further declares that such activities shall be the responsibility of, and shall be directed by,

The Launch Act was, and continues to be, successful in privatizing the space industry.

Soon after the passing of the Launch Act, the private space industry came to a screeching halt in response to the 1986 Space Shuttle *Challenger* disaster. The United States declared that it was officially the nation's policy that NASA would be the sole provider of launch services for and from the United States.[14] While the private launch sector became effectively frozen by this policy shift, it once again thawed when the government's position officially changed in 1990 with the passage of the Launch Services Purchase Act ("Purchase Act").[15] The Purchase Act officially and reversed the government's position on the privatization of the space industry, requiring NASA to purchase launch services for its payloads *from* the private sector.[16] Later, Congress passed the Commercial Space Launch Amendments Act in 2004, which instructed the Federal Aviation Administration to begin formulating rules governing the transport of passengers into space.[17] Two key reasons for the passage of this act were to resolve the regulatory ambiguity surrounding private spaceflight and to further promote development of the emerging United States space industry.[18]

Following the Purchase Act, private companies began to feel comfortable entering the space industry. In 1995, the private company Sea Launch—a consortium of four companies from the United States, Russia, Ukraine, and Norway—was formed, and as of April 2009, twenty-seven of thirty launches were successful and were primarily focused around placing communications satellites into orbit.[19] Following Sea Launch's footsteps, numerous other private companies have emerged to claim their share of a

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a civilian agency exercising control over aeronautical and space activities sponsored by the United States . . . ." 42 U.S.C. § 2451(b) (repealed 2010).

14. In 1986, the Space Shuttle Challenger was destroyed after 73 seconds of flight, killing all seven crewmembers. Congress responded to the incident by overhauling its policy on the privatization of commercial space travel. *See* CONG. BUDGET OFFICE, SETTING SPACE TRANSPORTATION POLICY FOR THE 1990S 1–4 (1986), *available at* http://www.cbo.gov/ftpdocs/59xx/doc5935/doc24c-Entire.pdf.

15. *See* Launch Services Purchase Act of 1990, Pub. L. No. 101-611, 104 Stat. 3205 (1990) (codified at 42 U.S.C. § 2451) (repealed 2010).

16. *See id.*

17. *See* Commercial Space Launch Amendments Act of 2004, Pub. L. No. 108-492, 118 Stat. 3974 (2004).

18. Collins & Ashford, *supra* note 11, at 421A31.

19. *See Cruising to Orbit*, SEA LAUNCH, www.sea-launch.com/history.htm (last visited Apr. 20, 2011).

$100 billion per year industry.[20] Like the United States, other regions and countries such as Europe and Russia have begun to enter the private space industry with great success.[21] As time moved forward, it became apparent that space tourism would eventually become a legitimate industry as companies such as Virgin Galactic and Benson Space Company emerged to fulfill the demand.[22] In 2004, Virgin Galactic's *SpaceShipOne* successfully attained suborbital space flight and was crowned as the first private manned spacecraft to enter outer space.[23] This tremendous success encouraged Virgin to continue its developments towards true space tourism.[24] While many individuals have expressed a clear desire to enter space, the cost is prohibitive for the vast majority of the world's population.[25]

B. Space Launches Have and Will Continue to Cause Significant International Environmental Harm

When a spacecraft is launched into space, it is propelled by ozone-depleting rockets consisting of either solid or liquid propellant.[26] Solid propellants, consisting of ammonium perchlorate oxidizer ("NH_4ClO_4")[27] are bound together using powdered aluminum.[28] When burned, these solid

20. After Sea Launch's success, companies such as SpaceX and United Launch Alliance felt confident that profit was to be made in the commercial launch sector. SpaceX was formed in 2002, and was the first private company to successfully place a communications satellite into orbit. *See Launch Manifest*, SPACEX, http://www.spacex.com/launch_manifest.php (last visited Apr. 20, 2011). United Launch Alliance was formed in 2006 as a 50-50 joint venture between The Boeing Company and Lockheed Martin. *ULA Company Overview*, UNITED LAUNCH ALLIANCE, http://www.ulalaunch.com/site/pages/About_Overview.shtml (last visited Apr. 20, 2011).

21. The European Space Agency sponsored the first private commercial space corporation, Arianespace, Inc., in 1980. Arianespace has experienced great commercial success, placing over 100 satellites into orbit since inception—more than any other company in the world. *See Launch Program Activity*, ARIANESPACE, http://www.arianespace.com/news/mission-status.asp (last visited Apr. 20, 2011).

22. *See* VIRGIN GALACTIC, http://www.virgingalactic.com (last visited Apr. 20, 2011).

23. *See Overview*, VIRGIN GALACTIC, http://www.virgingalactic.com/overview/ (last visited Apr. 20, 2011).

24. *Id.*

25. To buy a ticket on Sir Richard Branson's ride, expect to pay approximately $200,000. *See Booking*, VIRGIN GALACTIC, http://www.virgingalactic.com/booking/ (last visited Apr. 20, 2011) [hereinafter Virgin Galactic Booking]. That figure pales in comparison to the price paid by Dennis Anthony Tito in 2001, who spent $20 million to take a trip with the Russians to the International Space Station, despite heavy criticism. *See Profile: Tito the Spaceman*, BBC NEWS (Apr. 28, 2011, 11:57PM), http://news.bbc.co.uk/2/hi/science/nature/1297924.stm.

26. *See* Lynne Anne Shapiro, *The Need for International Agreements Concerning the Ozone Depleting Effects of Chemical Rocket Propulsion*, 4 S. CAL. INTERDISC. L.J. 739, 743 (1995).

27. NH_4ClO_4 is the molecular formula for ammonium perchlorate oxidizer.

28. Shapiro, *supra* note 26, at 745–46.

propellants release massive quantities of hydrogen chloride ("HCl"), aluminum oxide ("Al_2O_3"), water ("H_2O"), hydrogen ("H_2"), carbon monoxide ("CO"), and carbon dioxide ("CO_2").[29] Additionally, the exhaust contains trace amounts of halogens like nitrogen ("N_2"), metal particles, and organics.[30] "Solid propellants present an acute environmental danger to the ozone since their effluents are disseminated below fifty kilometers, directly into the area of highest ozone concentration. These solid propellants are also very dangerous, as compared to liquid propellants, since HCl is a by-product of the combustion, and the chlorine atom—the 'Cl' in HCl—is known to deplete the ozone."[31]

Liquid propellants on the other hand, are of an especially large concern because of the availability of raw materials and the potential for component re-use.[32] "Liquid propellants usually consist of one of three combinations: (1) liquid oxygen and hydrocarbon; (2) nitrogen tetroxide used with a mixture of asymmetrical dimethylhydrazine and hydrazine; or (3) liquid oxygen and liquid hydrogen. [Finally,] [c]ountries just starting development of space launch vehicles often use a combination of kerosene and liquid oxygen."[33] When burned, liquid propellants emit carbon monoxide ("CO"), carbon dioxide ("CO_2"), hydrogen ("H"), molecular hydrogen ("H_2"), water ("H_2O"), hydroxyl ("OH"), nitrogen oxide ("NO_x"),[34] molecular nitrogen ("N_2"), and even soot, ice particles, and

29. *Id.*
30. *Id.*
31. *Id.* at 745.
32. Liquid propellant systems are so simple that the blueprints are readily available online for purchase. *See Liquid Fuel Rocket Engines and Propulsion Systems*, SYSTEME SOLAIRE, http://home.total.net/~launch (last visited Oct. 5, 2011). Additionally, it appears that liquid propellant raw materials will become increasingly available. It has been suggested that raw materials required to formulate liquid propellant can be harvested from space and sent back to earth. This technology would almost certainly accelerate the rate of space commercialization because it would constitute a new local, i.e. space-based, source of fuels. *See generally* CHRISTOPHER JONES ET AL., PHARO: PROPELLANT HARVESTING OF ATMOSPHERIC RESOURCES IN ORBIT 2 (2010), *available at* http://www.nianet.org/getattachment/RASCAL/2011-Winners/Previous-Winners/2010-Technical-Papers/GaTech-and-University-of-VA-graduate-%282%29.pdf.aspx.
33. Shapiro, *supra* note 26, at 746.
34. In atmospheric chemistry, air pollution and related fields, nitrogen oxide refers specifically to NO_x, a generic term for the compounds NO and NO_2. *See* Clean Air Act, 42 U.S.C. § 7602–7671q (2006). Nitrogen oxide, which is not a GHG, should *not* be confused with nitrous oxide, a GHG. *See Nitrogen Dioxide*, EPA, http://www.epa.gov/oaqps001/nitrogenoxides/ (last updated Nov. 1, 2011). *Cf. Nitrous Oxide*, EPA, http://www.epa.gov/nitrousoxide/ (last updated June 22, 2010).

organics.[35] Because private industry is increasingly entering the space commercialization market, it would be logical that start-ups would use the more basic liquid propellants, such as kerosene and liquid oxygen, if they were to be able to acquire these at a discounted rate. This is important because if these kerosene-based fuels are used by start-ups, then great pollution may occur even more quickly.

While "no studies have indicated a catastrophic ozone loss due to chemical rocket fuels and their emissions and by-products," this lack of results likely exists because "[t]he modeling techniques currently in use do not provide sufficient [a] basis to comfortably predict the future harm that may be caused by continued use of ozone depleting rocket fuels."[36] Despite inconclusive results, the international legal community should not wait around for a scientific organization to assemble such a study, only to find it too late to reverse the damage. If the international community does not act now, the potential threats from unregulated space commercialization will likely come to fruition.

C. International Environmental Law Will Be Invoked from Space Commercialization

In order to invoke international environmental law, it must be shown that there is serious harm.[37] For purposes of this paper, we will use the example of emissions and space trash (also known as "space debris," "orbital debris," and "space junk") to illustrate that a state is capable of causing injury to another state through its space commercialization endeavors.

Entering space is an enormous task, which requires a tremendous of amount of power. When this power is exerted, carbon dioxide, pollutants, and other particles enter and remain trapped within Earth's atmosphere.[38] It has been well documented that these substances are greenhouse gasses ("GHGs") and contribute to global warming.[39] As the privatized space industry continues to develop, the amount of emissions and space trash produced by spacecraft and related operations will naturally increase.

As the space industry continues to grow, and the amounts of pollutants continue to fill our atmosphere, it appears almost certain that negative environmental effects will result.[40] When the negative effects become

35. Shapiro, *supra* note 26, at 746.
36. *Id.* at 752.
37. Trial Smelter Arbitration (U.S. v. Can.), 3 R.I.A.A. 1905 (1941), *available at* http://untreaty.un.org/cod/riaa/cases/vol_III/1905-1982.pdf.
38. Shapiro, *supra* note 26, at 749–51.
39. *Id.* at 744.
40. *Id.* at 746–52.

prominent enough, states will likely complain of injury and international environmental lawsuits will arise. While the injury must be serious, and it must be established by clear and convincing evidence,[41] it should not be difficult for a harmed country to point to the particular space company at fault.

First, states will be able to prove that an injury created by space commercialization is serious because of the nature of the harm. As described above, large amounts of GHGs are released into the atmosphere when a rocket is launched into space.[42] In turn, as the GHGs build up, the emitted gasses will inevitably exacerbate the Greenhouse Effect or deplete the ozone layer, causing potential widespread crop destruction—a serious harm that would certainly warrant judicial intervention.[43] Another example of serious harm would be a spacecraft striking a piece of space trash intentionally or knowingly jettisoned into space, which could result in the injury of the craft or its occupants. Finally, it is not uncommon for debris to reenter the atmosphere and remain intact until colliding with Earth.[44] While many other examples of serious harm could be surmised, this paper will focus on air pollution and space trash.

Second, it will be more difficult, but nonetheless possible, to establish causation by clear and convincing evidence that a particular state was responsible for causing the injury. Currently, most states' governments have regulatory laws in effect that require companies to notify their respective agencies when planning a launch.[45] Also, because space missions are

41. *See Trial Smelter Arbitration*, *supra* note 37, at 1964–65.

42. *See* Shapiro, *supra* note 26, at 750–52.

43. In the landmark 1941 *Trail Smelter Arbitration*, an international tribunal held that crop destruction constituted serious harm. An ore smelter located in Canada emitted pollutants in the form of gas and contaminated water, which made its way downstream to the American side. The contaminants eventually caused crop destruction and land contamination, and the tribunal found that said harm was sufficient to have a claim for violations of international environmental law. *See Trial Smelter Arbitration*, *supra* note 37, at 1964–65.

44. Recently, NASA's once-defunct and now destroyed UARS satellite re-entered Earth's atmosphere and caused slight panic as to where the satellite would crash. The agency had no idea where it would land. *See* Denise Chow, *NASA Satellite Falls to Earth . . . But Where Did it Land?*, SPACE.COM (Sept. 24, 2011, 9:31 AM), http://www.space.com/13078-nasa-uars-satellite-falls-earth.html.

45. For reasons of safety, if a person or entity wishes to conduct a launch in the United States, an application must be submitted to the Federal Aviation Administration. This application must contain all engineering specifications relating to the safety of the launch vehicle. Because propellants pose one of the largest dangers due to their explosive nature, the exact amount of propellants used must be stated in the application.

one of the most expensive types of private aeronautic ventures,[46] much rocket propulsion emissions data has surely been recorded through the research and design process.[47] Therefore, calculating the particular emissions generated by a given state over a period of time would simply entail comparing the number and types of launches that occur. While the breaching state will then say that it is too difficult to ascertain whether a particular state's launches are causing injury, technology exists to monitor and project the route that a set of emissions takes through the Earth's atmosphere.[48] By combining this modeling data with the emissions data of the launching country, a state will be able to clearly and convincingly demonstrate harm caused by particular launches.

Obtaining evidence of a spacecraft colliding into another craft's debris would likely prove more difficult. One possible way to collect evidence would be to standardize the use of high frame-rate cameras around the perimeter of spacecrafts. When the tape is reviewed, particular objects can be identified and, if unique, its origin determined. If the origin can be proved, then liability can be assessed.[49]

See 14 C.F.R. § 414.11(c) (2011).

46. For example, the average cost to launch a United States Space Shuttle mission is $450 million. The cost to launch a communications satellite is significantly less because of the absence of human life aboard. *See Kennedy Space Center: Frequently Asked Questions*, NASA, http://www.nasa.gov/centers/kennedy/about/information/shuttle_ faq.html (last visited Apr. 21, 2011). Modern satellite-launching rockets, such as those made by Arianespace, cost approximately $120 million per launch. David Robertson, *Satellite Makers Flinch at $120m Price of Launch Cost*, THE TIMES (Apr. 28, 2008), http:// business.timesonline.co.uk/tol/business/industry_sectors/telecoms/article3828181.ece.

47. With companies investing millions of dollars in designing rockets of various kinds, and with modern computer-based research and design, raw data must surely have been stored somewhere. It would be up to international environmental committees to harvest this data and adapt it to the committees' purposes.

48. The United States Environmental Protection Agency ("EPA") has dedicated significant resources for monitoring pollution. Each year EPA releases a report on air pollution change. By using this information and taking rocket launches into account, it could be possible to determine if certain states' launches are significantly contributing to air pollution. *See Air Pollution Monitoring*, EPA, http://www.epa.gov/airquality/montring .html (last updated Nov. 4, 2011).

49. If suit is brought in an international tribunal for damages caused by a corporation acting inside a state's territories, the state would be held responsible for damages, rather than the corporation. For example, in the *Trail Smelter Arbitration*, a state was held responsible for damages even though it was a corporation within its boundaries that caused the damage. However, there is nothing stopping the remitting state from seeking subrogation from the corporation. *See Trial Smelter Arbitration*, *supra* note 37.

D. We May Use the Doctrine of Clausula Rebus Sic Stantibus *to Amend the Treaties Now*

The circumstances which initially gave rise to many of the existing international environmental treaties have changed sufficiently enough that *clausula rebus sic stantibus* applies, and therefore the treaties may be amended. This legal doctrine, along with the adoption of Article 62 of the Vienna Convention on the Law of Treaties ("Article 62"),[50] allows for the modification of treaties when a fundamental change in circumstances has occurred and has been officially recognized by nation states. Article 62 provides that a treaty may not be modified unless: (1) "the existence of those [original, but now changed] circumstances constituted an essential basis of the consent of the parties to be bound by the treaty; and [(2)] the effect of the [changed circumstance] is radically to transform the extent of obligations still to be performed under the treaty."[51] Additionally, case law subsequent to Article 62 requires that if *clausula rebus sic stantibus* is to apply, then the changed circumstance must have never been contemplated by the parties as being a realistic situation.[52]

Both requirements of Article 62 and case law will be met due to the current landscape of space commercialization and therefore *clausula rebus sic stantibus* will enable modification. Addressing the issue of whether the changes were ever contemplated by the parties as required by the *Fisheries Jurisdiction Case*,[53] it would be safe to assume that true space commercialization was never truly envisioned at the time the original space treaties were entered into. The vast majority of treaties that involve international environmental issues, including the ones that this paper will propose to modify, were written before 1995. While many science fiction authors have postulated that man would one day colonize planets beyond our own,[54] it was envisioned as just that—science fiction.

50. Vienna Convention on the Law of Treaties art. 62, May 23, 1969, 8 I.L.M. 679, 1155 U.N.T.S. 331.
51. *Id.*
52. *See* Fisheries Jurisdiction (F.R.G. v. Ice.), 1973 I.C.J. 56, ¶ 43 (Feb. 2), *available at* http://www.icj-cij.org/docket/files/56/10713.pdf.
53. *Id.*
54. The Star Wars Trilogy has been the most prolific science franchise novel regarding activities in outer space. Authors such as H.G. Wells wrote about extraterrestrials ("Martians") making contact with Earth, suggesting that perhaps humans could once do the same to other planets. *See* H.G. WELLS, THE WAR OF THE WORLDS (1898). H.G. Wells' writing helped to usher in the Golden Age of science fiction, which focused heavily

However, with the fast progression of technology, as well as the creation of private space companies providing both industrial and tourism services, space commercialization is now a reality.

Furthermore, it is also clear that the change of circumstances warrants modification, meeting the two requirements set forth in Article 26. First, it can be demonstrated that the existence of the circumstances constituted an essential basis of the particular treaty. While this requirement necessitates that the circumstance was contemplated for that particular treaty technically requires us to examine this requirement for each particular treaty addressed in this Comment, it shall be assumed for purposes of disposing of this requirement that emissions formed a basis for the negotiation for each of the treaties because they either overtly mention the topic of omissions or because emissions played such a central role in post-1975 environmental thought.

Second, and more importantly, the extent of the change is so dramatic that it transforms the obligations under the treaty in a way that was never contemplated by the parties. When the existing environmental treaties were negotiated, the main concern was from activities that were solely connected to this planet. For example, when emissions were discussed at the 1944 Chicago Convention on International Civil Aviation, the delegates did not take into account the transport of humans to other planets and back. One can assume that what they contemplated was civil aviation as they knew it: that planes traveled within the Earth's atmosphere, and accordingly any restrictions on flight in the name of environmental policy would be created under that particular understanding of aviation. Now however, our concept of civil aviation is changing at an ever-quickening rate, with actual instances of people taking trips into space and back.[55]

Because the notion of true space commercialization was never contemplated at the time significant treaties were adopted and because Article 62 will be satisfied, *clausula rebus sic stantibus* will apply and therefore existing international environmental treaties may be modified.

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on space-based drama. *See* ADAM ROBERTS, THE HISTORY OF SCIENCE FICTION 195–218 (2006).

55. The Virginia-based Space Adventures, Inc. has been flying high-paying tourists into space since 2001. *See* SPACE ADVENTURES, http://www.spaceadventures.com/ (last visited Apr. 21, 2011).

II. THE PROBLEM AND SOLUTION: PROPOSALS FOR RENEGOTIATING INTERNATIONAL ENVIRONMENTAL TREATIES

While many international environmental treaties exist, few touch on aircraft emissions and none truly contemplate the commercialization of space. With space being the next frontier and forum for international private commercial activities, the international community should establish safeguards before the commercialization truly takes off. If the private sector of the world's economy is allowed to commercialize space before environmental regulations are in place, the crushing momentum of private industry will be incredibly difficult to stop once it has begun. It has been demonstrated numerous times that once money has begun to pour into a given industry, lobbyists can oftentimes keep environmental reform at bay for some time, if not permanently.[56] Instead of being reactive, the international community must be proactive. This paper will examine two treaties under the lens of air pollution and space trash; the Chicago Convention and the Outer Space Treaty, respectively.

A. To Combat Air Pollution and Its Effects: Annex 16

Annex 16 to the Chicago Convention on International Civil Aviation addressed the environment in two volumes: Volume I, which addressed environmental noise produced by aircraft, and Volume II, which addressed aircraft emissions.[57] For the remainder of this Comment, Annex 16 Volume II will be referred to as "Annex 16" unless otherwise stated. There are two important inquiries to address before proposing any amendments to Annex 16: first, whether the Chicago Convention applies to spaceships, and second, whether the modern and future commercialized spaceships are considered "aircraft" under the Chicago Convention.

56. *See* Amy Melissa McKay, The Effects of a Competitive Lobbying Environment on Policymakers, Demanders, and Outcomes (Apr. 12, 2006) (unpublished Ph.D. dissertation, Duke University), *available at* http://proquest.umi.com/pqdlink?did=1404335371&Fmt=7&clientI%20d=79356&RQT=309&VName=PQD.

57. Chicago Convention on International Civil Aviation, Annex 16, Dec. 17, 1944, 15 U.N.T.S. 295, *available at* http://www.mcgill.ca/files/iasl/chicago1944a.pdf [hereinafter Chicago Convention].

1. The Chicago Convention Should Apply to Spacecraft

The first inquiry when investigating Annex 16's role on space commercialization is whether Annex 16 governs spacecrafts at all. As of the time of publication, no scholarly articles have addressed this topic. Because the scope of this Comment is more of a general survey rather than a deep exploration of Annex 16 applicability, this issue will be handled rather briefly.

The purpose of the 1944 Chicago Convention was to agree on "certain principles and arrangements in order that civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the basis of equality of opportunity and operated soundly and economically."[58] However, no mention is ever made of spaceships or outer space. Rather, the term "air transport services" is used summarily.[59] The obvious reason for this is because the first human spaceflight was not accomplished until 1961 (with Annex 16 being ratified in 1944).[60] While no mention of spacecraft is made, this should not defeat the Chicago Convention's applicability to spacecraft for two reasons.

First, the spirit of the convention is directly in line with the situation surrounding space commercialization. As stated above, the purpose of the convention is to promote air travel.[61] While the early spacecrafts launched from a vertical position, using rockets in a unique manner different from the horizontal takeoff of 1944 airplanes, modern spacecrafts are being launched in a traditional runway fashion.[62] This similarity brings the Chicago Convention more in line with current modes of space travel than it would have back in the early 1980s. Presumably, the purpose of modern space travel is to transport humans and goods to space, for both commercial and leisure purposes. The goods that will travel into space will be much the same as those carried by a traditional air freighter: clothes, food, supplies, and industrial materials. Also, of course, modern space travel will also transport humans just like traditional air travel. Because of the similarities in modality and purpose, the Chicago Convention should apply to modern spacecraft.

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58. *Id.* pmbl.
59. *Id.*
60. Yuri Gagarin, a Soviet national, became the first human in space in 1961. *See Yuri Gagarin: First Man in Space*, NASA, http://www.nasa.gov/mission_pages/shuttle/sts1/gagarin_anniversary.html (last updated Apr. 13, 2011).
61. *See* Chicago Convention, *supra* note 57, pmbl.
62. Companies such as Virgin Galactic will conduct horizontal launches via a carrier airplane (more explanation to follow). *See Overview*, VIRGIN GALACTIC, http://www.virgingalactic.com/overview/experience/ (last visited Apr. 21, 2011) [hereinafter Virgin Galactic Overview].

Second, the Chicago Convention should apply to spacecraft because the concerns surrounding flight have already been considered. The Chicago Convention successfully bound 191 countries together, after a long series of international discussion.[63] Getting a group of people, let alone 191 countries, to agree on a set of rules and regulations governing such an important topic as air travel is a commendable achievement. To require a treaty to be rewritten simply because the air being traveled extends through an invisible layer surrounding our planet certainly constitutes waste for the world's delegates and legislatures, especially when much of the work has already been done. Because much time and energy has already been expended establishing findings and reconciling various countries' concerns on air travel, the Chicago Convention should apply to spacecraft under a theory of efficiency and prior determination.

2. Annex 16 Should be Renegotiated Under Clausula Rebus Sic Stantibus

Annex 16 requires manufacturers of airplanes and airplane engines to meet prescribed standards before the product can enter into commercial service.[64] Because aircrafts are an international commodity, all major airlines and manufacturers conform their products to Annex 16 standards.[65] So far, Annex 16 has been incredibly successful in holding the industry accountable to the imposed standards, and only eleven of the 191 signatories have been unable to adhere.[66]

When Annex 16 was added to the Chicago Convention, the Committee on Aviation Environmental Protection ("CAEP") was created and tasked with the responsibility of making ongoing recommendations regarding aviation emissions standards.[67] While tasking the CAEP to make proposals works well in theory, these proposals, in practice, are often taken with a grain of salt by the International Civil Aviation Organization ("ICAO") Council. At least once, their recommendations to increase standards have

63. *ICAO in Brief*, ICAO, *available at* http://www.icao.int/Pages/icao-in-brief. aspx (last visited Jan. 15, 2011).
64. Heather L. Miller, *Civil Aircraft Emissions and International Treaty Law*, 63 J. AIR L. & COM. 697, 714 (1998).
65. *Id.*
66. *Id.*
67. *Id.* at 714–15.

been rejected.[68] For example, the CAEP in 1995 recommended a 16 percent increase in emissions stringency for medium and large engines. The Council declined to adopt such standards despite incredible gains in technology and efficiency.[69] Keeping this in mind, it seems highly unlikely to think that the CAEP could successfully propose amendments specifically addressing emissions generated by spacecraft launches. Therefore, in light of the Council's resistance to change, even when promulgated by its recommendation organ, the international community must invoke *clausula rebus sic stantibus* and renegotiate Annex 16 if changes of magnitude required by space commercialization are to be made.

3. Aircraft or Space Object Under the Chicago Convention? A Blurring Line

With all the mention of aircraft, it begs the question: is a spacecraft an "aircraft" under Annex 16? Unfortunately, the current answer to this is ambiguous, and history indicates that it could be either. For example, in 1981, the United States chose to register its space shuttles under the United States Space Shuttle program as "space objects" pursuant to the Registration Convention[70] rather than as an aircraft under the Chicago Convention.[71] This was likely because the Chicago Convention is "only applicable to civil aircraft and [is] not applied to state aircraft."[72] A more likely reason is that by designating the shuttle as a space object rather than an aircraft, all of the emissions requirements imposed under Annex 16 of the Chicago Convention are bypassed.

While it may have made sense to classify the shuttle as a space object in 1981, there has been a substantial increase in technology and a corresponding decrease in expense that makes this classification questionable. For example, in 1981, the cost of spaceflight was so prohibitive and experimental, that it took two decades before the first leisure space tour took place. The first space tourist, Dennis Anthony Tito, reportedly paid $20 million for this soirée.[73] Now, bookings are offered through Virgin Galactic for $200,000—one-hundred times less expensive than Mr. Tito's adventure.[74]

Another example of this mischaracterization of spacecraft as "space

68. *Id.*
69. *Id.*
70. *See generally* Convention on Registration of Objects Launched into Outer Space arts. II-IV, Nov. 12, 1974, 28 U.S.T. 695, 1023 U.N.T.S. 15.
71. *Cf.* Chicago Convention, *supra* note 57, art. 17.
72. *Id.* art. 3(a).
73. *See* BBC NEWS, *supra* note 25.
74. Virgin Galactic Booking, *supra* note 25.

objects" is the difference in launch mode for modern-day space shuttles, such as the Virgin Galactic shuttle, in comparison to the 1981-esque shuttles. While the U.S. space shuttles launch from a vertical terrestrial position that begins by an earth-shaking rocket blast (a sight anyone who has watched a television can envision), some modern shuttles such as the ones from Virgin Galactic launch from the air. Modern spaceflight is gentle and graceful, more reminiscent of traditional civil aviation. The latest model of spacecraft by Virgin Galactic is *SpaceShipTwo*. To be launched into orbit, a mother ship named Virgin Mothership *Eve* attaches *SpaceShipTwo* to its wings, and makes a traditional runway takeoff.[75] Reaching 50,000 feet, *SpaceShipTwo* detaches, fires its rocket and completes its entry into space.[76] The difference between these two launch methods is staggering, and should make one re-think whether a spacecraft is classified as a space object, or an aircraft under Annex 16.

4. Why This Matters—Corporate Reliance and Lobbyists

It is clear that corporations would prefer to classify their spacecraft as space objects rather than aircraft under the Chicago Convention in order to avoid emissions requirements under Annex 16. As of the publication of this Comment, it is unclear whether corporations are registering these Virgin Galactic-type spacecraft as space objects or aircraft.[77] Regardless of how spacecrafts will be classified, we must act now to prevent future claims of estoppel.

As explained above, the push towards true space commercialization is occurring at an ever-quickening rate. The corporations making that push are relying on the existing treaties that define their rights and responsibilities, and are acting in accordance with those bounds. If nothing is done, corporations will have space commercialized before the issue of environmental harm can be addressed. If this happens, it will be incredibly difficult to enact changes to Annex 16 that may render much of a corporation's space fleet noncompliant. Because of this, the private sector will likely flex its muscles through lobbying efforts and prevent

75. *See infra.* app. A (image of Virgin Galactic spaceship/mother ship configuration).
76. Virgin Galactic Overview, *supra* note 62.
77. The author sent an email to Virgin Galactic asking whether the spaceships will be registered as "space objects" under the U.N. or aircraft as defined under Article 17 of the Chicago Convention. Representatives from Virgin Galactic declined comment and referred the author to their website, which yielded no relevant information.

environmental changes to be made.

Additionally, if Annex 16 is in fact amended after companies develop their space fleet, it may be argued by either side that the regulations are either too generous for crafts that have such high emissions, or too restrictive to the point that Annex 16 is arguably inapplicable on grounds of development-strangling and detrimental reliance.

Multinational conglomerates hold much power over legislatures and delegates in times of treaty negotiation—power that often stems from the ability to influence through cash. For example, Virgin's 2009 net revenue exceeded $18 billion.[78] While it seems unfortunate that corporate lobbyists can sway the world's delegates, this is reality and the situation must be met head-on by amending Annex 16 immediately.

5. Proposed Changes

First and foremost, the Chicago Convention should be amended to directly apply to aircraft and spacecraft. If the Chicago Convention is amended to include both types of crafts, then any need for answering the question of whether a spacecraft is an aircraft, for purposes of the Chicago Convention, is rendered moot. Article 3(a) of the Chicago Convention currently states that the "Convention shall be applicable only to civil aircraft, and shall not be applicable to state aircraft."[79] The wording of this may simply be changed to: ". . . shall be applicable only to civil aircraft and spacecraft . . . ." By adding the word 'spacecraft,' this will eliminate any ambiguity in the applicability of the Chicago Convention to modern, privatized spacecraft.

Annex 16 separates emissions standards between vehicles that reach supersonic speeds, and those that do not.[80] In order to leave Earth's atmosphere and achieve orbit, a spacecraft must reach the "Escape Velocity," which is 11.2 kilometers per second (25,805 miles per hour).[81] This speed is considered "supersonic" because it is faster than the speed of sound (768 miles per hour).[82]

This begs the question of whether modern spacecraft fall under the "supersonic" category or the "subsonic" category. For example, the newest Virgin Galactic spacecraft will travel at subsonic speed up until 50,000

78. *About Virgin*, VIRGIN, http://www.virgin.com/about-us/ (last visited Apr. 22, 2011).

79. Chicago Convention, *supra* note 57, art. 3(a).

80. *See id*. annex 16, vol. II, chs. 2–3.

81. *See* JOHN D. ANDERSON, JR., INTRODUCTION TO FLIGHT (2d ed. 1985).

82. The speed of sound (i.e., the "sound barrier") is 768 miles per hour. *See The Speed of Sound and Mach Numbers*, U.S. CENTENNIAL OF FLIGHT COMM'N, http://www.centennialofflight.gov/essay/Dictionary/sound_barrier/DI94.htm (last visited Apr. 22, 2011).

feet and then detach its shuttle portion, which would attain supersonic speed via rocket propulsion.[83] The logical answer seems to be that one standard should apply before rocket firing, and one during. Because a spacecraft achieves supersonic speed as it leaves orbit, it could be governed by the chapter on supersonic speeds. However, there is one glaring problem: the chapter on supersonic speeds only applies "to all turbojet and turbofan engines intended for supersonic speed."[84] Rocket engines are not mentioned.

There are two solutions to this problem. One solution would be to amend section 3.1.1, the Applicability provision, to read: ". . . to all turbojet, turbofan, and rocket engines intended for supersonic speed." Many people will argue that this solution is inherently problematic because rocket engines are significantly different than turbojet and turbofan engines. For example, rocket engines are considerably less fuel-efficient than turbojet or turbofan engines, and to hold them to the same standard would essentially render space commercialization impossible. While some environmentalists would likely champion this approach, it is unlikely that any developed state would agree to such a modification as it would strangle the already developed, and currently developing, private space industry.

A more reasonable solution would be to add an additional Applicability chapter addressing rockets specifically. By adding a chapter to the Chicago Convention, rather than creating a whole new treaty addressing this issue, commercialized spacecraft would fall within the spirit of the Chicago Convention, which is to address civil aviation. This makes sense because as space travel becomes increasingly commercialized, it will eventually achieve the same utilitarian purpose as modern commercial airliners do.

Currently, no emissions standards exist that govern privatized spacecraft. Historically, it made sense that there were no emissions standards because the rockets were initially used for research purposes. As it was for "research," this likely proved a justification for using as much fuel as necessary to achieve the mission, notwithstanding the severe environmental impacts. Now, modern private space companies are able to conduct launches not for research, but for private satellite launches, and do not

83. *See* Virgin Galactic Overview, *supra* note 62.
84. *See* Chicago Convention, *supra* note 57, at annex 16, vol. II, ch. 3, § 3.1.1.

have to worry about profit-reducing emissions requirements. Soon, companies will be not only use rockets to launch satellites into orbit, but also to launch tourists into orbit—all with no regard for emissions.[85] This fact is an unfortunate reminder that it is absolutely essential to develop standards before tourism and space commercialization explodes. In light of this, emissions standards should be developed to be consistent with the spirit of the Chicago Convention—to promote and regulate international civil aviation—and these standards could be developed by the CAEP.

Having the CAEP add a section for rocket emissions under the Chicago Convention would fit well within the existing framework. Currently, the treaty controls three types of gaseous emissions: unburned hydrocarbons, carbon monoxide, and oxides of nitrogen.[86] The amount of emissions allowed are based on whether the engine is a supersonic or a subsonic engine, with supersonic engines being allowed a greater amount. Adding an additional chapter governing rockets would simply add one more category to accommodate the progress of technology and would not disturb existing standards governing traditional aircraft.

While the Council has had trouble passing emissions amendments in the past,[87] this could be remedied by creating a task force within the Council whose sole purpose is to develop and propose these standards. The task force would consist of environmental scientists, rocket scientists, and lobbyists representing both liberal and conservative interests. The CAEP would work jointly with the task force in developing the standards. Once standards have been developed and proposed to the Council by the CAEP and Council task force members, the Council would have veto power only if the standards would modify the underlying spirit of the Chicago Convention.

The Chicago Convention is an astounding treaty with much implication and future use in the arena of space commercialization. By implementing these proposed suggestions, the Chicago Convention would come within the scope of modern technology while maintaining the excellent environmental restrictions it provides.

B. To Combat "Space Trash"

Regardless of a spacecraft's purpose—leisure, industry, or transport—each time a space object or craft enters space, an amount of debris, commonly referred to as "space trash," is usually left behind.[88] It could

85. *See* ARIANESPACE, *supra* note 21.
86. *See* Chicago Convention, *supra* note 57, at annex 16, vol. II, chs. 2–3.
87. Miller, *supra* note 64, at 714–15.
88. For the purposes of this paper, only human-made debris will be considered. Many organic particles such as meteor pieces continuously orbit Earth and are not the

be as small as a piece of solid rocket fuel or paint chip, or as large as jettisoned rocket boosters. It is estimated that there are over 500,000 pieces of space debris over one centimeter in diameter orbiting Earth, with 19,000 of those being actively tracked.[89] Estimates of space trash down to the near-microscopic level total in the trillions.[90]

While small pieces may be seemingly innocuous, even a nearly invisible particle can cause catastrophic damage to a functioning space object. For example, "in 1984 the Solar Max satellite was permanently disabled after it collided thousands of times with what may have been nearly invisible pieces of rocket fuel or satellite fragments. Scientists who examined the aforementioned debris also discovered microscopic shards of frozen human urine."[91] There have also been incidents where human life was implicated. In 1990, pieces of space trash destroyed a display unit on the space shuttle *Columbia* during the Astro mission, causing display units to burn up and preventing numerous planned outer space observations.[92] The impact could have been catastrophic if the debris impacted another place on the craft. Finally, the most dramatic and highly publicized instance of space trash affecting a mission was the impact of a paint chip measuring 0.2 millimeters in diameter impacting the windshield of the space shuttle *Challenger*'s window;[93] the replacement window cost $50,000.[94] A spacecraft entering or leaving Earth's orbit must be prepared to battle a 200 mile-wide belt of space trash.[95]

Currently the scientific community has a rough-estimate of what sources contribute certain percentages to space trash. Inactive, used-up space objects such as nonfunctioning satellites and probes account for approximately 20 percent of space trash.[96] Operational debris, such as rocket bodies, lens covers, payload shrouds, window insulation, raw

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result of human space activities.

89. *See Orbital Debris Frequently Asked Questions: 3). How Much Orbital Debris is Currently in Earth Orbit?*, NASA ORBITAL DEBRIS PROGRAM OFF., http://orbitaldebris.jsc.nasa.gov/faqs.html (last updated July 2009).

90. Donald J. Kessler, *Space Debris: More Than Meets the Eye*, SKY & TELESCOPE, June 3, 1987, at 587.

91. Diaz, *supra* note 6, at 371–72.

92. *Id.* at 371.

93. *Id.* at 372. *See infra* app. B (image of Virgin Galactic spaceship/mother ship configuration).

94. Diaz, *supra* note 6, at 372.

95. *Id.* at 371.

96. *Id.* at 372.

propellant, and raw sewage, account for approximately 26 percent of space trash (some remain in space, while some disintegrate as they re-enter Earth's atmosphere).[97] Fragmentation debris, such as the sheared parts of a satellite originating from a collision, account for approximately 46 percent of space trash.[98] The remaining 5 percent of space trash originates from organic sources, such as broken up asteroids.[99] Therefore, it is clear that human space activities are the cause of 95 percent of objects in Earth's geosynchronous orbit. Pursuant to an estimate made in 1985, of this 95 percent, the United States, Russia and the former Soviet Union are responsible for 97 percent of all space trash.[100] However, with China and India's ever-quickening entrance into space commerce, the likely suspects that the international community will turn to in the event of an incident may also include those in Asia.[101]

Most trash that enters space will never leave and will remain that way until technology is developed to remove space trash from orbit.[102] This is unlikely to occur any time soon as the private sector is more interested in revenue generated by commercial and industrial missions rather than spending money on research to alleviate an existing problem. In response to this problem, researchers are taking a reactive rather than proactive approach. The current thrust of space trash research is to defend against space trash impact. To do so, aluminum shields are placed around spacecraft and the International Space Station, whereupon impact, the aluminum absorbs the trash's impact by tearing off. While the spacecraft has been saved, there is additional debris floating around—the initial trash that impacted the spacecraft plus any shorn aluminum shield debris.[103]

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97. *Id.*
98. *Id.* at 373.
99. *See id.* at 372–73.
100. Eliot Marshall, *Space Junk Grows with Weapons Tests*, SCI., Oct. 25, 1985, at 424, 425.
101. In April 2011, a piece of debris from a Chinese anti-satellite test missile caused the International Space Station crew to take shelter in fear of a possible collision. Tariq Malik, *Space Junk Threat Forces Space Station Crew to Take Shelter*, SPACE.COM (Apr. 5, 2011, 12:58 PM), http://www.space.com/11300-space-junk-station-astronauts-shelter.html. Recognizing that India is going to contribute significantly to the space trash problem as it advances its technology, India has contributed as a participant in the Informal Working Group on Long Term Sustainability of Space Activities. *See* INDIAN SPACE RESEARCH ORGANISATION, SPACE DEBRIS ACTIVITIES IN INDIA (2010), *available at* http://www.oosa.unvienna.org/pdf/pres/stsc2010/tech-33.pdf.
102. *See* Mark Holman Turner, *Garbage Truck of the Future?*, POPULAR SCI., July 1990, at 83, 83.
103. Mark D. Uehling, *Tackling the Menace of Space Junk*, POPULAR SCI., July 1990, at 82, 83–84.

1. Key Existing Law Implicating Space Trash

a. The Outer Space Treaty

The Outer Space Treaty ("OST"), formally known as the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, is the landmark treaty governing the philosophy of the use of space and has been signed by every space-faring nation.[104] By executing this treaty, a signatory country has "relinquished sovereignty over the outer space domain and [has] concurred that the use and exploration of outer space shall be carried out for the benefit, and in the interest, of all countries."[105] It logically follows that a country may not freely pollute outer space without consequence because this would be against the interest of all nations.

Article VI of the OST provides that signatories "shall bear international responsibility for national activities in outer space."[106] This can be read as allowing for international liability on any state that damages another state stemming from its use of outer space. While there is no provision addressing the initial introduction of space trash into space, the treaty does allow for international liability if said space trash damages the other state. Clarification and elaboration of Article VI could create a powerful international environmental law pertaining to the littering of space.

Article IX of the OST provides that no state shall create harmful contamination in space.[107] When it is suspected that a particular activity "would cause potentially harmful interference with activities in the peaceful exploration and use of outer space . . . [a state party] may request consultation concerning the activity or experiment."[108] Some commentators have dismissed this Article as "virtually meaningless,"[109] but this author remains hopeful; a slight renegotiation of this article would make it the most powerful international environmental treaty bearing on outer space littering. As of the current date, no nation has invoked the OST to

104. *See* INST. OF AIR SPACE & SPACE LAW AT COLOGNE UNIV., SPACE LAW: BASIC LEGAL DOCUMENTS A.I.2, at 1–3 (Karl-Heinz Böckstiegel et al. eds., 2005) (1991).
105. Diaz, *supra* note 6, at 376.
106. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies art. VI, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty].
107. *Id.* art. IX.
108. *Id.*
109. Diaz, *supra* note 6, at 377–78.

address the space trash issue. By renegotiating now, it will be possible to make this once aspirational treaty into a venerable vehicle of enforcement against space-trashers.

b. A Strong Case for Clausula Rebus Sic Stantibus*—An Extreme Change of Circumstances*

As described earlier in this Comment, almost all treaties bearing on international space issues can be renegotiated due to new technologies in space exploration and travel that have emerged in the last decade. But the OST has an even greater reason for renegotiation: the fact that it was signed at a time when space exploration and travel was in its infancy.

The OST was signed in 1967, less than six years after Yuri Gagarin became the first human to enter space. In 1967, space commercialization was in its infancy compared to where it is now. Space travel was seen as mainly an exploratory, research-focused endeavor with little chance of any developing nations utilizing its celestial bodies. While primitive communications satellites had entered orbit since the late 1950s, it was only in 2004 that a nongovernmental human entered space via Virgin's *SpaceShipOne* flight.[110]

This temporal gap highlights the fact that it took over 40 years for the space community to begin the transition from research-only spacecraft to private, manned spacecraft. Now that private citizens have in-fact entered space, there has been an extreme change in circumstance: whereas when the OST was signed, space travel was restricted solely to government entities conducting research, now and in the immediate future, private citizens will be entering space at an ever increasing rate. By modifying the OST slightly, it will be possible to make this now philosophical, aspirational treaty into something that has modern applicability while retaining its original foundation and purpose.

c. Proposed Changes to the Outer Space Treaty

By modifying the OST rather than negotiating a new treaty, it will be possible to retain the original policy and objectives that this landmark treaty provides, while making it current with modern technology. Two simple modifications would have tremendous effect in reducing space trash and ultimately creating a safer environment for all those who wish to travel outside our planet.

First, a modification that clarifies Article VI would be beneficial. It is useful to look at the actual text of Article VI:

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110. *Id.* at 373.

> States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried on in outer space, including the Moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.[111]

Article VI's provision that states "shall bear international responsibility for national activities in outer space,"[112] has been read by commentators to infer that any damages caused by national activities will create liability.[113] Because this logically follows, the first sentence of Article VI should be amended to read: "States parties to the Treaty shall bear international responsibility for national activities, *and any damages stemming therefrom*, . . ." (emphasis indicating proposed text). While it may seem obvious that if a state is responsible for a national activity that it is also responsible for damages stemming from said activity, adding this text would solidify the treaty and allow for a solid cause of action for damages.

Additionally, a list of "national activities" should be added to reduce the ambiguity of Article VI's charge. In hindsight, it makes sense for the drafters of the 1967 treaty to use a vague term such as "national activities" without providing further clarity, simply because the pioneers were unaware of what was possible in space. Therefore, the following phrase should be added at the end of the Article: "*National activities include but are not limited to: dispatching satellites with limited lifespans into orbit, with no ability to retrieve once decommissioned; intentionally jettisoning objects into space, such as tools or parts, and; knowingly jettisoning waste into space. This is not an exhaustive list but is indicative of the activities which may give rise to international liability.*" By making the foregoing modifications to Article VI, much confusion will be alleviated in the types of proscribed national activities.

111. Outer Space Treaty, *supra* note 106.
112. *Id.*
113. Diaz, *supra* note 6, at 392.

Second, Article IX provides preemptive measures to prevent harm from occurring in the first place. While lengthy, it is worthwhile to examine the full text of Article IX, while especially considering the emphasized text:

> In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, *and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth* resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. *If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, may request consultation concerning the activity or experiment.*[114]

At first blush, this Article seems unwieldy because it is actually creating three provisions: 1) preventing Earth from becoming contaminated with extraterrestrial matter; 2) creating an affirmative duty of states conducting space activities to consult with the international community before conducting potentially dangerous activities; and 3) giving states the right to request that the activity-conducting state consult with the international community before conducting a potentially harmful activity. Because there are distinct notions within this article, they should be delineated to improve clarity while highlighting their importance.

Additionally, the word "consultation" is unnecessarily vague and antiquated. With today's world becoming more globalized, and with almost all nations, particularly the United States, abandoning the political policy of isolationism,[115] it would benefit all to create a more forceful and concrete remedy than a "consultation." For example, an arbitral tribunal or other uninterested third-party should determine whether the proposed activity falls within one of the proscribed activities under the OST. By recommending mere consultation, Article IX suggests that the activity-conducting state can still conduct potentially harmful activities notwithstanding the consulted state strongly disagreeing with such

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114. Outer Space Treaty, *supra* note 106.

115. *See* RONALD E. POWASKI, TOWARD AN ENTANGLING ALLIANCE: AMERICAN ISOLATIONISM, INTERNATIONALISM, AND EUROPE, 1901–1950 ch. 1 (1991).

action. If this is the final disposition of the dispute, it suggests that any consultation efforts or requests would be futile, which is likely the reason that no country has ever attempted to use or enforce this provision.

2. A Policy Based Alternative to Manage Space Trash: Government Funding

Currently little-to-no money is spent on preventing space trash, but rather to guard against its harmful effects.[116] The current policy on preventing space trash-related injuries is to create impact-resistant spacecrafts that can withstand contact to space debris. This unfortunate policy is reactive rather than proactive in nature and likely occurs because investing in defensive materials often results in concrete, tangible benefits, whereas research to prevent space trash from occurring is a long-term, scientifically intensive process. While the research may be long going and arduous, its long-term benefit is prophylactic and not a bandage.

To date, the scientific community has not seriously pursued researching the issue of reclaiming space debris. This is likely because the majority of research is paid for by private industry, which is usually interested in immediate results. In the United States, 63.7 percent of research is funded by the private sector, with the remaining 36.3 percent funded by government entities.[117] Focusing on the United States for purposes of analysis, it becomes obvious as to why research is trying to bandage the problem rather than prevent it. Namely, it is because private industry is not interested in "basic" research[118] but instead in turning an immediate profit and satisfying shareholders.

The most obvious solution, in light of the above discussion, is to channel federal research grants directly to the purpose of reclaiming space trash. By doing so, scientists will be able to conduct the basic research necessary to lay the groundwork which will enable private

116. *See* Diaz, *supra* note 6, at 392.

117. Brandon Shackelford, *U.S. R&D Increased 6.0% in 2006 According to NSF Projections*, NAT'L SCI. FOUND., Apr. 2007, at NSF 07-317, *available at* http://www.nsf.gov/statistics/infbrief/nsf07317/nsf07317.pdf.

118. The term "basic" research is used to distinguish from "applied" research in the scientific community. Basic research can often be thought of as "science for the sake of science," whereas applied research is concerned with immediate benefit. While basic research is almost always a stepping-stone for applied research, the private sector can be hesitant to engage in basic research because of the lack of a concrete, useable result.

companies to create the garbage man of the future—one who cleans up outer space. Regardless of what form the grants take, it seems clear that research funding will need to come from the government simply because private industry is primarily concerned about the bottom line.

III. CONCLUSION

Space commercialization is simultaneously exciting and problematic. With each solution it uncovers, it creates new problems: we discover how to travel through space, but we leave debris behind with every mission. Also, while private industry is able to utilize outer space for commerce, rocket fuels lead to extreme pollution. To reconcile these competing interests, many things must be done. One step in the right direction is to renegotiate pertinent, existing international treaties that have environmental consequences. As most would agree, it is clear that the state of exploration and technology is now in a state that was considered to be science fiction fifty years ago. In light of these changes in circumstances, the state of international law must be modernized if humanity wishes to keep the heavens a suitable medium for commercialization.

IV. APPENDICES

APPENDIX A
VIRGIN GALACTIC SPACESHIP/ MOTHER SHIP CONFIGURATION

APPENDIX B
CRACKED SPACE SHUTTLE WINDSHIELD,
CAUSED BY A PAINT CHIP