Bracing for the Impending Rocket Revolution: How to Regulate International Environmental Harm Caused by Commercial Space Flight

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TABLE OF CONTENTS

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I. INTRODUCTION

The new commercial space market offers the world unprecedented access to space but may also herald unprecedented dangers to the upper atmosphere that could hasten climate change. The launching of satellites, scientific research payloads, and people into space is transitioning from a purely governmental enterprise to an increasingly private industry that receives government contracts.[1] The private sector is assuming the role that governments once held in space activities, particularly in the United States. For instance, private companies including Lockheed Martin[2] and SpaceX[3] have designed spacecraft capable of delivering astronauts to the moon and the International Space Station. Until there is a viable private alternative, U.S. astronauts must hitch a ride on the Russian Soyuz for a lift to the International Space Station, so private spacecraft capable of filling that void would fill a profitable and necessary role in the United States' space program. Many nations, including the United States, are rapidly creating new legislation and regulatory bodies to govern the new commercial space market.[4] However, there are certain global problems that are challenging to regulate with existing laws. For instance, one such problem is harm from commercial space craft to the atmosphere that could hasten climate change.

In the coming years, commercial space activity is expected to increase as the world grows more reliant on satellite-based technology for broadband internet, voice communications, satellite radio, television, and global positioning system devices.[5] The new realm of suborbital commercial space flight is evolving and may soon provide such services as space tourism, high-speed travel, and even package delivery.[6] All of

1. FED. AVIATION ADMIN., 2011 COMMERCIAL SPACE TRANSPORTATION FORECASTS 15 (2011), *available at* http://www.faa.gov/about/office_org/headquarters_offices/ast/media/2011%20Forecast%20Report.pdf [hereinafter FORECASTS].

2. Alan Boyle, *Lockheed Martin to Build Future Moonship*, MSNBC (Sept. 1, 2006), http://www.msnbc.msn.com/id/14594789/ns/technology_and_science-space/t/lockheed-martin-build-future-moonship/#.UEQ0Zo53aio.

3. NASA awarded SpaceX a $1.6 billion contract to deliver supplies to the International Space Station. *First Outing for SpaceX*, NY TIMES (Oct. 29, 2012), http://www.nytimes.com/2012/10/30/opinion/first-outing-for-spacex-pleases-nasa.html.

4. *See* Ronald L. Spencer Jr. et al., *International Space Law: A Basis for National Regulation*, *in* NATIONAL REGULATIONS OF SPACE ACTIVITIES (Ram S. Jakhu ed., 2010).

5. FORECASTS, *supra* note 1, at 47–72.

6. *See, e.g.*, FED. AVIATION ADMIN., U. S. DEP'T OF TRANSP., THE U.S. COMMERCIAL

these new capabilities will require careful regulation that preserves the environment while allowing the industry to flourish.

For instance, in the United States, five companies plan to conduct commercial suborbital flights between 2012 and 2014.[7] One of the five companies is Virgin Galactic ("Virgin"). A trip on Virgin's SpaceShipTwo ("SS2"), which carries eight passengers and flies to an altitude of one-hundred kilometers (sixty-two miles) and then returns to Earth, costs $200,000.[8] Despite the high cost, customers have made deposits on more than 440 flights.[9] In addition to the money it has received from the deposits, Virgin has also secured funding through the United States National Aeronautics and Space Administration ("NASA") and the Southwest Research Institute.[10] As commercial orbital and suborbital space flight becomes a reality, some scientists and organizations within the United States' Federal Aviation Administration ("FAA") are concerned that commercial space flight may have a negative impact on the ozone layer and hasten climate change.[11] What once sounded like fantasy—reasonably priced, frequent access to space—now appears poised to become a reality. These innovations likely will come with real-life consequences for the environment.

Although exactly how many commercial space flights will take place in the near future is unclear, Virgin intends to "launch hundreds of

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SUBORBITAL INDUSTRY: A SPACE RENAISSANCE IN THE MAKING, *available at* http://www.faa.gov/about/office_org/headquarters_offices/ast/media/111460.pdf [hereinafter RENAISSANCE]; Véronique Ziliotto, *Relevance of the Futron/Zogby Survey Conclusions to the Current Space Tourism Industry*, 66 ACTA ASTRONAUTICA 1547, 1547–48 (2010).

7. RENAISSANCE, *supra* note 6, at 4.

8. *Id*. at 14.

9. *Id*. at 15.

10. *Id*.

11. FORECASTS, *supra* note 1, at 1–5; RENAISSANCE, *supra* note 6, at 2; Martin Ross et al., *Potential Climate Impact of Black Carbon Emitted by Rockets*, 37 GEOPHYSICAL RES. LETTERS 1 (2010); *see generally* OFFICE OF THE ASSOC. ADM'R FOR COMMERCIAL SPACE TRANSP., FED. AVIATION ADMIN., U. S. DEP'T OF TRANSP., GUIDELINES FOR COMPLIANCE WITH THE NATIONAL ENVIRONMENTAL POLICY ACT AND RELATED ENVIRONMENTAL REVIEW STATUTES FOR THE LICENSING OF COMMERCIAL LAUNCHES AND LAUNCH SITES (2001), *available at* http://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/media/epa5dks.pdf [hereinafter GUIDELINES FOR COMPLIANCE].

fare-paying customers" beginning in 2013.[12] Already, private companies in many countries routinely launch satellites into orbit.[13] However, scientists are not sure exactly how many orbital and suborbital launches with the present amount of emissions it will take to negatively affect the stratosphere.[14] Studies of natural phenomena that have an effect on the atmosphere similar to that of rocket emissions, such as volcanic eruptions, indicate that introducing small particles into the stratosphere can cause widespread problems, such as drought.[15]

Scientists are uncertain how many companies can launch vehicles with the current amount and type of emissions before the environment is adversely affected, so over-regulating the commercial space industry is premature, especially when the world economy stands to benefit from new jobs and industry growth.[16] With reasonable standards and regulations, the new industry can flourish and the impact of potential harms can be minimized.[17] Three issues should be considered in order to plan regulation for commercial space flight. First, the needs of the commercial space industry should be taken into account so that the fledgling industry is given a chance to flourish. Second, would-be regulators must consider the unique danger that space flight poses to the atmosphere and the potential consequences of environmental harm from commercial orbital and suborbital space flight. Third, existing treaties and voluntary industry standards should be considered as ways to regulate damage to the upper atmosphere caused by commercial space flight.

12. FORECASTS, *supra* note 1, at 5; Barry Nelid, *Richard Branson: Galactic spaceship to blast off in 2013*, CNN (July 12, 2012), http://www.cnn.com/2012/07/11/tech/branson-farnborough-virgin-galactic/index.html.

13. *See generally* FORECASTS, *supra* note 1.

14. Ross et al., *supra* note 11, at 1.

15. Renyi Zhang et al., *Variability in Morphology, Hygroscopicity, and Optical Properties of Soot Aerosols During Atmospheric Processing*, 105 PROC. NAT'L ACAD. SCI. U.S. 10291, 10291–96 (2008).

16. Ross et al., *supra* note 11, at 1; Ziliotto, *supra* note 6, at 1551.

17. BENJAMIN J. RICHARDSON, ENVIRONMENTAL REGULATION THROUGH FINANCIAL ORGANISATIONS: COMPARATIVE PERSPECTIVES ON THE INDUSTRIALISED NATIONS 7 (Eric W. Orts & Kurt Deketelaere eds., 2002).

II. THE COMMERCIAL SPACE INDUSTRY

The existing commercial space industry's global nature makes it challenging to regulate. Governments must be careful to walk a fine line, by regulating innovative industries in a way that allows them to thrive while simultaneously minimizing potential international environmental problems.

The commercial space industry includes a variety of services and spans multiple cultures and continents; any single governing body would be challenged to regulate it.[18] Furthermore, existing space treaties assign liability for damage done to the Earth, Earth's atmosphere, or objects on the Earth, on a nation-by-nation basis, so there is no existing international law that directly regulates the role of private actors in space.[19]

Despite the lack of formal regulations and standards to keep the industry in check, the role of private companies in commercial space activity is increasing.[20] Arianespace bears the motto "any mass, to any orbit . . . anytime," signaling that frequent space flights are available.[21] Multi-national launch efforts make it difficult to assess liability for individual actors under the existing space treaties.[22] France's Arianespace launches its own vehicles, as well as the Russian Soyuz rocket, from a spaceport in French Guiana.[23] The company says it wins more than half of the "commercial launch contracts open to competition worldwide each year."[24] The increasingly multinational character of

18. *See generally* Spencer Jr. et al., *supra* note 4.

19. Convention on International Liability for Damage Caused by Space Objects, art. II, Mar. 29, 1972, 961 U.N.T.S. 188, (entered into force Oct. 9, 1973) [hereinafter Liability Convention], *available at* http://www.oosa.unvienna.org/pdf/publications/st_space_11rev2E.pdf.

20. FORECASTS, *supra* note 1, at 7, 44.

21. *Launcher Family*, ARIANESPACE, http://www.arianespace.com/launch-services/launch-services-overview.asp (last visited Nov. 16, 2012) [hereinafter *Arianespace Launchers*]. In Europe, Arianespace, a space service provider that primarily launches satellites, "bears the motto: 'any mass, to any orbit . . . anytime.' "

22. *See* Wayne W.N. White, *The Legal Regime for Private Activities in Outer Space*, CATO INST. (March 15, 2001), *available at* http://www.spacefuture.com/archive/the_legal_regime_for_private_activities_in_outer_space.shtml.

23. *Arianespace Launchers*, supra note 21.

24. *Id*; *Service & Solutions*, ARIANESPACE, http://www.arianespace.com/about-us/service-solutions.asp (last visited Nov. 16, 2012).

commercial space activities makes it hard to regulate under the Liability Convention.

The UN 1972 Convention on International Liability for Damage Caused by Space Objects ("Liability Convention") assesses fault on a nation-by-nation basis, which leaves individual states to regulate internally to avoid liability.[25] However, commercial launches are carried out in nations as ideologically diverse as France, India, China, and the United States.[26] China's commercial space efforts are marketed by China Great Wall Industries Corporation ("CGWIC").[27] CGWIC uses three launch sites dispersed across China to launch satellites into orbit.[28] The United States has eight commercial spaceports licensed by the FAA's Office of Commercial Space Transportation ("FAA/AST").[29] Currently, Europe controls about sixty percent of the commercial space market, the United States has about thirty percent, and other countries featuring low-cost launches divide the remaining ten percent.[30] With so many states involved and each state having multiple launch facilities in diverse geographic locations, it will be difficult to find a one-size-fits-all international solution to regulation.

Similarly, the growing suborbital commercial space market will put different stresses on the environment than orbital space flights.[31] The new suborbital industry is forecast to have increasingly frequent flights, which will have a unique impact on the upper stratosphere.[32] States will have to regulate the industry to avoid censure under the Liability Convention. To comply with the Liability Convention, the United States

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25. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, art. 7, *opened for signature* Jan. 27, 1967, 610 U.N.T.S. 205, *available at* http://www.oosa.unvienna.org/pdf/publications/st_space_11rev2E.pdf [hereinafter Outer Space Treaty].

26. *Space Launch Sites Around the World*, SPACETODAY.ORG, http://www.spacetoday.org/Rockets/Spaceports/LaunchSites.html#CommercialSpaceports (last visited Nov. 16, 2012).

27. MARCIA S. SMITH, CONG. RESEARCH SERV., RS21641, CHINA'S SPACE PROGRAM: AN OVERVIEW 4 (2005), *available at* http://www.fas.org/sgp/crs/space/RS21641.pdf.

28. *Id*. at 1.

29. RENAISSANCE, *supra* note 6, at 22.

30. *Space Launch Sites Around the World*, *supra* note 26.

31. Steven Fawkes, *Carbon Dioxide Emissions Resulting from Space Tourism*, 60 J. BRIT. INTERPLANETARY SOC'Y 409, 409 (2007); Carl Q. Christol, *Stratospheric Ozone, Space Objects, and International Environmental Law*, 4 J. SPACE L. 23, 27 (1976).

32. *See* Ross et al., *supra* note 11.

will have to enact legislation that will regulate licensed spaceports in areas as geographically diverse as Alaska, California, Florida, New Mexico, Oklahoma, and Virginia.[33] Some of those locations specialize in either orbital or suborbital launches while some are capable of launching both orbital and suborbital vehicles.[34]

Despite the increasing number of private actors spread across the continents, states must successfully regulate the new commercial space industry to avoid penalties under the Liability Convention.[35] Governing bodies must walk a fine line to regulate both orbital and suborbital space flight while also allowing these industries to grow and develop in order to reap the economic benefits promised by commercial space.[36] The needs of the orbital and suborbital space industries will dictate what type of regulations will be effective. Therefore, this Note will next discuss each in turn.

A. Orbital Commercial Space Flight

Launching objects such as satellites into orbit around the Earth is an important portion of the emerging privatized industry. In order for the new market to evolve, regulators must understand the need for this technology and not over-regulate it.[37]

There will be 130 launches internationally over the next decade.[38] Commercial telecommunications satellites will account for forty-three percent of the orbital launch market, science and engineering payloads will be about thirty percent, commercial cargo and crew transportations services will be twenty-two percent, and commercial remote sensing satellites will take up five percent.[39] Demand for global connectivity

33. RENAISSANCE, *supra* note 6, at 22.

34. *Id*; Outer Space Treaty, *supra* note 25, art. 6.

35. Outer Space Treaty, *supra* note 25, art. 6.

36. Rachel A. Yates, *Informal Regulation of Space Activities*, 87 NEB. L. REV. 530, 531 (2008).

37. *Id*. at 537.

38. FORECASTS, *supra* note 1, at 73.

39. *Id.* at 74. Annually, the FAA/AST and the Commercial Space Transportation Advisory Committee create a forecast of international demand for orbital space launch services. The forecast gauges demand for launching satellites, science and engineering payloads, and commercial cargo and crew into orbit around the Earth from 2011–2020. *Id.* at 4. Payloads with basic research missions include biological and physical research, space science, Earth science, and related fields. Payloads with applied research missions

through telecommunications satellites is expected to increase over the next decade as well.[40] Additionally, there may be a rising demand for crew and cargo transportation to the International Space Station from organizations such as NASA.[41] Changes in the economy, the political environment, and technology all may affect the demand for launches, but current forecasts point to a steady increase in the number of proposed orbital launches over the next decade.[42] As governments and businesses are increasingly reliant on the private industry's ability to reach orbital space for all of the above-mentioned activities, over-regulating the commercial space industry would be imprudent and may destroy the economic benefits that might come with it. The world must consider the needs of the orbital commercial space industry while simultaneously regulating it in a way that protects the environment and minimizes damage to the upper atmosphere.

B. Suborbital Commercial Space Flight

One of the newest areas of commercial space activity, suborbital space flight is emerging as a reasonably-priced alternative to orbital flight for some scientists and travelers. Governments should understand the unique benefits of suborbital space flight and the unique dangers suborbital space flight poses to the upper atmosphere before trying to regulate it. Suborbital space flight gives scientists a chance to perform experiments in low gravity situations at reasonable rates, allows the development of super-rapid package delivery, and provides the chance for wealthy individuals to become space tourists.[43]

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are designed to solve practical problems and are usually driven by government or industry needs. *Id*. at 63.

> Remote sensing refers to any orbital platform with optical or radar sensors trained on Earth to gather data for geographic analysis, military use, meteorology, or climatology. The remote sensing industry comprises three parts: aerial imagery, satellite imagery, and geographic information systems (GIS). GIS consists of the products developed using images obtained from aircraft or satellites. GIS constitutes the largest part of the industry both in terms of demand and revenue generation. *Id*. at 55.

40. *Id*. at 21.

41. *Id*. at 45.

42. *Id.* at 77.

43. RENAISSANCE, *supra* note 6, at 36–37. The recent surge of interest in suborbital commercial space activity, and in particular space tourism, may be due in part to the $10 million Ansari X PRIZE that challenged competitors to build a privately funded

There is a growing demand for the services promised by the commercial suborbital space industry that underlies the optimistic forecasts showing an increase in suborbital launches over the next decade.[44] Even President Barack Obama showed his support of the fledgling industry by offering $6 billion to be awarded over five years to "spur the development of American commercial human spaceflight vehicles."[45]

Two companies that are meeting the growing need for suborbital commercial space flight, Virgin and Scaled Composites, joined together in 2005 to create the SS2.[46] Armadillo Aerospace and Space Adventures report that they already have a customer wait list of more than 200 people for rides on their suborbital vehicle.[47] Another company, UP Aerospace, will launch "basic and applied research payloads, test and demonstration payloads, and remote sensing cameras" to an altitude of 160 kilometers (approximately 99.4 miles).[48]

Several other companies are developing their own vehicles and will soon be able to take passengers and payloads to the edges of space for a relatively inexpensive fee.[49] The forecast and marketing plans for these up-and-coming businesses support the idea that the number of commercial suborbital flights will increase in the near future.[50] In the interest of developing this industry and preserving the environment, governments must apply regulations carefully. However, the next Part addresses why there is a pressing need for international environmental standards and enforcement for the commercial space industry.

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spacecraft that could fly to 100 kilometers (sixty-two miles) on two separate occasions within a two-week timeframe. *Id*. at 2, 14. Scaled Composites won the competition in 2004 with its vehicle, SpaceShipOne. *Id.* at 14. SpaceShipOne was carried by a conventional jet airplane, WhiteKnightOne, to an altitude of fourteen kilometers (8.7 miles) before it was released. *Id*.

44. *See generally* FORECASTS, *supra* note 1.

45. Katharine Sanderson, *Science Lines up for Seat to Space*, 463 NATURE 716, 716 (2010) (internal quotations omitted).

46. RENAISSANCE, *supra* note 6, at 15. Virgin plans to launch out of New Mexico's Spaceport America.

47. *Id.* at 7. Suborbital flights will start at $102,000.

48. *Id*. at 12–13. UP Aerospace plans to charge $350,000 per launch, but currently has no plans to create a manned vehicle.

49. *Id.* at 5, 21.

50. FORECASTS, *supra* note 1, at 23.

III. COMMERCIAL SPACE FLIGHT AND THE POTENTIAL FOR ENVIRONMENTAL HARM

An increase in commercial space activity could negatively impact the upper atmosphere and hasten climate change. Consequently, governments should seek to regulate this new industry in a way that maximizes the economic and societal benefits while minimizing lasting environmental damage. The current demand for and developments in commercial space flight are unprecedented.[51] Scientists hope that commercial carriers will have frequent enough orbital and suborbital flights so that scientists will have relatively cheap and reliable access to space.[52] Similarly, adventure tourists are thrilled by the idea of space travel.[53] However, commercial space flight poses a unique risk to the stratosphere and particularly the ozone layer.[54]

States and the international community must regulate the dangers that commercial space flight poses to the upper atmosphere and the potential for that damage to affect climate change before we have reached a tipping point and the damage cannot be undone. Several issues should be considered: (a) the impact of rockets on the stratosphere; (b) suborbital spacecraft and how their engines deposit black carbon into the stratosphere; (c) the principles of geoengineering and how they apply to the potential effects of black carbon in the stratosphere; and (d) the precautionary principle and how it is a call to action for regulation before the atmosphere is irretrievably damaged.

A. The Effect of Rockets on the Stratosphere

Government should regulate this activity sooner rather than later because orbital launches pose a threat to the ozone layer. The rockets emit ozone-destroying compounds throughout the stratosphere on their way to orbit.[55] Based on current rocket design, the negative impact from rockets on the ozone layer will only increase as launch rates increase,

51. Sanderson, *supra* note 45, at 716. "We have never had a capability like this in 50 years of human space exploration," planetary scientist Alan Stern said in reference to the new suborbital vehicles.

52. *Id.*

53. Ziliotto, *supra* note 6, at 1550–51.

54. Christol, *supra* note 31, at 27.

55. Martin Ross et al., *Limits on the Space Launch Market Related to Stratospheric Ozone Depletion*, 7 ASTROPOLITICS 50, 79 (2009) [hereinafter Ross, *Limits*].

unless new technologies are developed.[56] One climatologist defined the question at hand as: "What is the maximum number of large rockets of the kind that are being used now (or are actually under development) that can be launched per year without causing a widespread change in the upper atmosphere that is larger than the natural variations that are already present?"[57]

While a detailed chemical analysis of the effects of rocket emissions on the ozone layer is beyond the scope of this Note, the phenomenon of ozone holes created by rocket launches are indicative of the potentially large impact that increased launches could have on the ozone layer.[58] Scientists have noted that rocket plumes "cause a prompt, localized, ozone 'hole.' "[59] A single reactive molecule emitted into the stratosphere "can destroy up to [approximately 10,000] ozone molecules before being deactivated and transported out of the stratosphere."[60] In fact, rocket plume ozone holes have been observed minutes to hours after a launch, confirming that rocket engines emit significant quantities of these reactive particles.[61] Similarly, ozone was reduced by more than forty percent within the launch trail of a Titan II booster rocket, thirteen minutes after launch at an altitude of eighteen kilometers (eleven miles).[62]

Another climatologist studying the effect of rockets on the ozone layer noted that even though the rocket emissions he was considering were primarily comprised of water vapor and carbon dioxide, it was not so much the chemical makeup that was worrisome, but the fact that they were being injected into the upper atmosphere at levels above 100 kilometers (sixty-two miles)—a region with relatively little atmospheric mass, where the emissions would have a disproportionately large impact.[63] Even water vapor could have an impact by changing the

56. Lynne Anne Shapiro, *The Need for International Agreements Concerning the Ozone Depleting Effects of Chemical Rocket Propulsion*, 4 S. CAL. INTERDISC. L.J. 739, 749 (1994–1995).

57. W.W. Kellogg, *Pollution of the Upper Atmosphere by Rockets*, 3 SPACE SCI. REV. 275, 276, 303 (1964).

58. Ross, *Limits*, *supra* note 55, at 54.

59. *Id*.

60. *Id*.

61. *Id.* at 54, 81 n.16.

62. Shapiro, *supra* note 56, at 749.

63. Kellogg, *supra* note 57, at 276.

"energy balance and the temperature" of the upper atmosphere.[64] Another statement by the International Council of Scientific Union points out:

> The problem is magnified by the fact that the most common exhaust products of liquid-fuel rockets—hydrogen, water and carbon monoxide—are extremely rare in the upper atmosphere. . . . Other effects include changes in the composition, structure and temperature of the upper atmosphere; all of which could materially alter the earth's climate.[65]

The delicate nature of the upper atmosphere means it is particularly susceptible to harm. Perhaps more to the point, humans do not have any experience in repairing such damage.[66] In fact, upon consideration of the potential havoc that repeated human visits to space might wreak, one pundit and environmental activist quipped, "It is hard to think of a better designed project for maximum environmental destruction."[67]

Although there is not enough data to know how many rocket flights are too many, the unique danger posed by rockets to the ozone layer suggests that this area requires further study and careful monitoring. In the face of uncertain consequences for the environment, continuing commercial space activity with caution makes sense.[68]

B. The Effect of Suborbital Commercial Space Flight on the Stratosphere

Suborbital commercial space flight poses a danger to the upper atmosphere and has the propensity to hasten climate change. Not much data exist for scientists to analyze from suborbital space flight because many of the vehicles are still experimental, so launches are not a common occurrence.[69] However, a 2010 study found that if Virgin follows its business plan of launching 1,000 flights a year powered by

64. *Id*. at 301.

65. *Id*. at 312–13.

66. *Id*. at 275; ETC GROUP, GEOPIRACY: THE CASE AGAINST GEOENGINEERING 3 (2010), *available at* http://www.etcgroup.org/sites/www.etcgroup.org/files/publication/pdf_file/ETC_geopiracy_4web.pdf [hereinafter GEOPIRACY].

67. George Monbiot, *Lost in Space*, GUARDIAN, Nov. 13, 1999, *available at* http://www.monbiot.com/1999/11/13/lost-in-space/.

68. Shapiro, *supra* note 56, at 768.

69. *See* RENAISSANCE, *supra* note 6, at 4–5.

"hybrid" hydrocarbon rocket engines, the suborbital flights will create a "persistent layer of black carbon particles in the northern stratosphere that could cause potentially significant changes in the global atmospheric circulation and distribution of ozone and temperature."[70] This means that black carbon particles introduced into the upper atmosphere by the type of rockets favored by the space tourism industry will soak up the heat of the sun, warm the upper atmosphere, and potentially be a catalyst for climate change.[71]

Atmospheric scientists do not know how much black carbon is necessary to create a deleterious effect.[72] Small amounts of black carbon may cause barely noticeable changes, moderate amounts may cause changes in weather patterns that could lead to drought and famine, and large amounts could heat the polar regions and deplete the ozone layer.[73] The study used an atmospheric model and illustrated the impact of small amounts of black carbon on the upper atmosphere and warned that the potential harm from suborbital space vehicle emissions should not be ignored.[74] Scientists say it is "surprising that this small amount of emissions would have a significant effect on the climate system but we think it should be studied with more models before it goes forward."[75]

If enough black carbon is introduced into the upper atmosphere that deleterious effects are observed and launches are discontinued, due to weather patterns and air currents, it will take about ten years after the last launch for all of the particles to "wash out from the stratosphere."[76] Scientists have studied a similar phenomenon and noted that after a volcanic eruption, volcanic particles, albeit in larger amounts, brought on widespread drought in a matter of months.[77]

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70. Ross et al., *supra* note 11, at 1. The hydrocarbon rocket engines oxidize a solid synthetic hydrocarbon fuel with nitrous oxide ("N_2O") and in that process emit small particles of black carbon.

71. *Id.*; Telephone Interview with Michael J. Mills, Project Scientist, WACCM Liaison, National Center for Atmospheric Research (Nov. 2, 2011).

72. Mills, *supra* note 71.

73. *Id.*

74. Ross et al., *supra* note 11, at 5.

75. Mills, *supra* note 71.

76. Ross et al., *supra* note 11, at 5; Kellogg, *supra* note 57, at 297.

77. Kevin E. Trenberth & Aiguo Dai, *Effects of Mount Pinatubo Volcanic Eruption on the Hydrological Cycle as an Analog of Geoengineering*, 34 GEOPHYSICAL RES. LETTERS 1, 1 (2007). Scientists believe that the particles from the 1991 Mount Pinatubo volcanic eruption, which were aloft for only a matter of months, were responsible for widespread drought in 1992.

The FAA/AST has introduced standards designed to mitigate possible damage to the upper atmosphere from commercial launches in its Guidelines for Compliance with the National Environmental Policy Act and Related Environmental Review Statutes for the Licensing of Commercial Launches and Launch Sites ("Launch Guidelines").[78] The Launch Guidelines warn that contaminants from launch emissions can come from the "propellant type, propellant additives and/or impurities, or operational factors of the propulsion system itself."[79] Carbon monoxide and hydrogen chloride are substances likely to be emitted that are routinely regulated because of their propensity to damage the ozone layer, but the FAA/AST also regulates normally non-toxic substances like aluminum oxide, water, and carbon dioxide "because they may affect the chemical/physical properties of the atmosphere and result in undesirable impacts such as global climatic changes."[80] The FAA/AST further cautions commercial space flight companies to research and mitigate their impact on the atmosphere from Earth's surface to eighty kilometers (forty-nine miles).[81] Although lack of hard data about the exact effects of emissions from suborbital space vehicles on the stratosphere muddies the waters, it is clear that the burgeoning industry should proceed with caution.[82] "The details of the changes caused by aircraft and rockets will certainly differ, but rockets emissions on this scale clearly cross a threshold to be considered a human-influenced climate impact of global importance."[83]

Although scientists are uncertain how many suborbital and orbital space flights can occur with the present amount of emissions before there is a deleterious effect, because both rockets and suborbital spacecraft have the potential to have a long-lasting negative impact on the stratosphere that is hard to reverse, governing organizations should begin regulating the industry as soon as possible.

78. GUIDELINES FOR COMPLIANCE, *supra* note 11, at 20–21.

79. *Id*. at 21.

80. *Id*.

81. *Id*.

82. Ross et al., *supra* note 11, at 5; Ross, *Limits*, *supra* note 55, at 50, 80; Zhang, *supra* note 15, at 10291–96; Tilmes et al., *Impact of Geoengineered Aerosols on the Troposphere and Stratosphere*, 114 J. GEOPHYSICAL RES. 1, 1 (2009); Fawkes, *supra* note 31, at 412.

83. Ross et al., *supra* note 11, at 5.

C. Geoengineering

Some individuals might question the harm of injecting black carbon particles into the upper atmosphere by suborbital commercial space vehicles because at one time scientists considered a similar application of sulfate particles as a possible antidote to the effects of global warming.[84] This activity is a type of geoengineering, which broadly speaking is "the intentional, large-scale technical manipulation of the Earth's systems, including systems related to climate."[85]

The geoengineering movement was originally embraced by politicians and businesses because it would be cheaper and more convenient to treat the symptoms of global warming rather than eradicate the root causes of the phenomenon by reducing the emissions of greenhouse gases.[86] Although the idea of geoengineering doubtlessly appeals to people seeking a quick fix, climatologists who first entertained the idea of using sulfate-based aerosols to reflect sunlight into the stratosphere in order to cool the earth are re-thinking the proposal.[87] One scientist who changed his mind regarding geoengineering recently published an essay stating that blasting sulfur dioxide into the stratosphere in a way that simulates a volcanic eruption is a desperate measure that should only be undertaken if everything else fails.[88] The essay notes that there would likely be human costs in premature deaths that would result from the intentional particulate pollution.[89]

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84. Alan Robock, *20 Reasons Why Geoengineering May Be a Bad Idea*, BULL. ATOMIC SCIENTISTS, May–June 2008, at 14.

85. *Id.* at 14; GEOPIRACY, *supra* note 66, at 4.

86. Graeme Wood, *Re-Engineering the Earth*, ATLANTIC, July–Aug. 2009, *available at* http://www.theatlantic.com/magazine/archive/2009/07/re-engineering-the-earth/7552/. Virgin's founder, Sir Richard Branson, signaled his agreement with this proposal by saying "If we could come up with a geoengineering answer to this problem, then Copenhagen wouldn't be necessary. We could carry on flying our planes and driving our cars." GEOPIRACY, *supra* note 66, at 13.

87. Wood, *supra* note 86; GEOPIRACY, *supra* note 66, at 11.

88. GEOPIRACY, *supra* note 66, at 11.The 2006 essay is by Paul Crutzen, a Nobel laureate whose Prize-winning work involved researching the ozone layer. Crutzen had reluctantly supported the movement in 2002.

89. *Id.* Unlike the black carbon particles emitted by suborbital spacecraft that scientists expect to be suspended for ten years, the essay was referring to larger quantities of particles that would remain suspended in the air for only two years.

Beyond possible human fatalities, the aerosolized sulfate plan would not actually eliminate any greenhouse gases; it would just block the sun's rays that would heat the atmosphere and cause global warming.[90] The problem with this approach is that if the minute pumping of aerosolized sulfates into the atmosphere stopped, calamity would ensue.[91] "The aerosols would rain down and years' worth of accumulated carbon would make temperatures surge."[92] This type of geoengineering, without also reducing greenhouse gas emissions, would be "like fighting obesity with a corset, and a diet of lard and doughnuts. Should the corset ever come off, the flab would burst out as if the corset had never been there at all."[93]

Furthermore, an international think-tank reports that geoengineering is likely to temporarily benefit the wealthy countries that implement it and equally likely to disadvantage poorer countries by increasing instances of drought and famine.[94] Moreover, the group cautions that "[w]e do not know how to recall a planetary-scale technology once it has been released."[95] Meteorologists and policy makers now concede it is simply too risky to deliberately alter the stratosphere.[96] "With so much at stake, there is reason to worry about what we don't know."[97] For these reasons, it is important to be cautious about pursuing any activity that would mirror the effects of geoengineering. Because suborbital space flight would likely affect the upper atmosphere in a way similar to aerosolized sulfate particles, governments must monitor and regulate it carefully to prevent hastening climate change.

D. The Precautionary Principle and Commercial Suborbital Space Flight

This Subpart considers the precautionary principle and how it may be applied to regulating commercial space activity. The precautionary principle embodies the idea that if scientific evidence suggests there is a

90. Wood, *supra* note 86.

91. *Id.*

92. *Id.*

93. *Id.*

94. GEOPIRACY, *supra* note 66, at 3, 8.

95. *Id.* at 3.

96. *See* Robock, *supra* note 84; GEOPIRACY, *supra* note 66, at 3; Wood, *supra* note 86, at 11.

97. Robock, *supra* note 84, at 17.

potential for an activity to cause serious environmental harm to a particularly delicate ecosystem, then states have an obligation to regulate the possibly harmful activity before any damage is done.[98] Although the precautionary principle is not legally binding, it is now considered "a generally accepted rule of customary international law."[99] Policymakers have taken it into consideration since it was introduced in the 1972 Stockholm Declaration as Principle 21:[100]

> States have . . . the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.[101]

For the precautionary principle to be helpful in international environmental policymaking, decision makers must often act on preliminary information to create rules and regulations. "[S]ubstances or activities that *may* be harmful to the environment should be regulated even if conclusive scientific evidence of their harmfulness is not yet available."[102]

When considering North Sea solid-waste pollution, ministers of the states bordering the body of water wrote a final report that stated, "[a]ccepting that in order to protect the North Sea from possibly damaging effects of the most dangerous substances, a precautionary approach is necessary which may require action to control inputs of such substances even before a causal link has been established by absolutely clear scientific evidence."[103] Subsequent reports and declarations have encouraged states to act once they have discovered a likely source of

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98. Bernard A. Weintraub, *Science, International Environmental Regulation, and the Precautionary Principle: Setting Standards and Defining Terms*, 1 N.Y.U. ENVTL. L.J. 173, 181 (1992).

99. AARON SCHWABACH, INTERNATIONAL ENVIRONMENTAL DISPUTES: A REFERENCE HANDBOOK 19–20 (2006).

100. *Id*. at 19.

101. Weintraub, *supra* note 98, at 183 (quoting U.N. Conference on the Human Environment, June 5–16, 1972, Stockholm Declaration on the Human Environment, princ. 21, U.N. Doc. A/CONF. 48/14/Rev.1 (1973)).

102. *Id.* at 181 (emphasis added) (quoting JAMES CAMERON & JACOB D. WERKSMAN, THE PRECAUTIONARY PRINCIPLE: A POLICY FOR ACTION IN THE FACE OF UNCERTAINTY 1 (1991)) (internal quotations omitted).

103. *Id*. at 184 (quoting Second International Conference on the Protection of the North Sea, London, the United Kingdom, Nov. 24–25, 1987, 27 I.L.M. 835, 838).

danger but before the harm occurs because it is often far more difficult and costly to repair an international environmental harm than it is to prevent it.[104]

Because orbital and suborbital commercial space flights present unique dangers to the sensitive layers of the upper atmosphere, the precautionary principle dictates that the developing industry should be regulated sooner rather than later.[105] International governing bodies and individual states should heed the warnings from anti-geoengineering climatologists who are concerned about the unforeseen consequences of injecting particles into the upper atmosphere. Governments must effectively regulate the industry to prevent a cumulative negative impact from commercial space flight on the stratosphere while also considering the need for industry growth.

IV. HOW CAN ATMOSPHERIC HARM FROM COMMERCIAL SPACE FLIGHT BE REGULATED EFFICIENTLY?

The commercial space flight industry promises jobs and economic growth to nations willing to foster it. However, the precautionary principle dictates that a technology capable of harm to a uniquely vulnerable area, such as the stratosphere, should be regulated before there is a tragedy of the global commons that is nearly impossible to reverse.[106] Therefore, it is important to regulate commercial space flight efficiently while allowing for industry growth. The next Subparts will first discuss how governments could regulate the industry through existing international treaties using arbitration for enforcement, if necessary; then why the commercial space industry will likely adopt voluntary standards; and finally, how an international space flight trade association will apply those standards and help regulate the industry.

104. *See id*. at 187.

105. *See* Ross *Limits*, *supra* note 55, at 77; Fawkes, *supra* note 31, at 411–12; *see also* Weintraub, *supra* note 98, at 181.

106. GEOPIRACY, *supra* note 66, at 3; *see also* RICHARDSON, *supra* note 17, at 13.

A. Regulation Through International Treaties

While the United Nations' ("UN") treaties on outer space apply to commercial orbital space flight, businesses and governments struggle to decide which laws and treaties apply to environmental harms caused by suborbital commercial spacecraft. The suborbital vehicles fly above the region common to commercial aircraft and merely skirt the edges of space.[107] It is possible that the international environmental impact of commercial suborbital space flight could be regulated under existing international space treaties or the 1979 Convention on Long-Range Transboundary Air Pollution ("LRTAP"). However, these treaties rely on voluntary compliance by their signatories.[108]

1. Can the International Environmental Impact of Commercial Space Flight Be Regulated Under Existing Space Treaties?

Existing space treaties could be used to help regulate environmental harm caused by commercial space activities. There are five international treaties that were finalized through the UN Committee on the Peaceful Uses of Outer Space ("UNCOPUOS").[109] Provisions included in the treaties assess liability on signatory nations that launch objects into space that then cause harm to other nations.[110] The Outer Space Treaty sets out tenets to govern the activities of space-faring nations.[111] Many of the principles suggest that states should only use space for peaceful purposes and should ensure that their space activities do not damage other

107. *See* Steven Freeland, *Fly Me to the Moon: How Will International Law Cope with Commercial Space Tourism?*, 11 MELB. J. INT. L. 90, 98 (2010). Virgin's space launch system includes a plane that flies to an altitude of about fifteen kilometers (9.5 miles) before releasing a rocket that can rise above 100 kilometers (sixty-two miles), and so it may be regulated both under laws aimed at commercial aircraft and under international space treaties. *See id.* at 91–92.

108. *See* Convention on Long-Range Transboundary Air Pollution, Nov. 13, 1979, 34 U.S.T. 3043, 1302 U.N.T.S 217 [hereinafter LRTAP]; Shapiro, *supra* note 56, at 754.

109. Freeland, *supra* note 107, at 4, 5, 94–95, 93 n.15. The treaties were developed during the Cold War era and primarily focus on issues such as requiring nations to accept responsibility for objects they launch into space, who can own the moon, and how astronauts should be treated if they crash land in a foreign nation.

110. *Id*. at 95.

111. Outer Space Treaty, *supra* note 25, arts. I–XII.

nations.[112] Although these principles have been considered "soft law," they may now represent customary international law.[113]

To know if these principles would apply to suborbital space flight, it must be determined if commercial suborbital spacecraft actually enter space.[114] Nowhere in the UNCOPUOS treaties or principles is the altitude at which space begins defined.[115] "Rather surprisingly to some, from a strictly legal perspective, there is as yet no clear definition of outer space."[116] NASA awards astronaut status to individuals who fly higher than eighty kilometers (fifty miles), but the 2008 Draft Treaty on the Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects defines outer space in Article I(a) as "space beyond the elevation of approximately 100 (kilometres) above [the] ocean level of the Earth."[117] Virgin and the handful of other companies intending to offer commercial suborbital flights all intend to take passengers and cargo to at least 100 kilometers (sixty-two miles), so it is likely that the UNCOPUOS principles will apply to those flights.[118]

Parts of two of the treaties describe a duty of space-faring nations to preserve the environment and to be responsible for any damage their space activities cause.[119] Article IX of the Outer Space Treaty notes, "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."[120] Article IX goes on to say that if any state is going to do anything that might negatively impact another state, the state that might cause the damage should first consult with the state that might

112. *Id*. arts. I–V, IX–XII.

113. Freeland, *supra* note 107, at 96.

114. *See* Outer Space Treaty, *supra* note 25.

115. *See id*.

116. Freeland, *supra* note 107, at 99.

117. Leonard David, *Private Spaceship Completes Third Supersonic Test*, MSNBC (May 13, 2004, 5:28 PM), http://www.msnbc.msn.com/id/4970837/ns/technology_and_science-space/t/private-spaceship-completes-third-supersonic-test/#.T1kSrpgSKRk; Freeland, *supra* note 107, at 2.

118. RENAISSANCE, *supra* note 6.

119. Liability Convention, *supra* note 19, art. VII; Outer Space Treaty, *supra* note 25, art. IX.

120. Outer Space Treaty, *supra* note 25, art. IX.

be damaged.[121] Similarly, if a state feels threatened by the activities of another state, it "may request consultation concerning the activity or experiment."[122] These and other similar statements create a feeling that the drafters of the Outer Space Treaty intended space-faring nations to take reasonable care in their activities and to act whenever possible to preserve the environment of the celestial bodies they visit and of the Earth.

Additionally, in 1972, the Liability Convention was signed and ratified by most space-faring nations.[123] Although the Liability Convention does not specifically address it, a reasonable interpretation based upon the language in the Outer Space Treaty is that the drafters of the Liability Convention would have intended to preclude the type of environmental harm contemplated in this Note.[124]

The Liability Convention assigns liability to the "launching State" whose space objects damage another nations' property in space or on Earth.[125] A "launching State" is "[a] State which launches or procures the launching of a space object," and "[a] State from whose territory or facility a space object is launched."[126] " 'Damage' means loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations."[127] "Space object" "includes component parts of a space object as well as its launch vehicle and parts thereof."[128]

Under the Liability Convention, strict liability attaches to a launching state if its space object harms the Earth in some way.[129] "A launching state shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the Earth or to

121. *Id*.

122. *Id*.

123. *See Treaty Signatures*, UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, http://www.oosa.unvienna.org/oosatdb/showTreatySignatures.do (search "Signatory" under "Status") (last visited Nov. 16, 2012).

124. *See* William N. Eskridge Jr., *Dynamic Statutory Interpretation*, 135 U. PA. L. REV. 1479, 1479, 1516 (1986–87).

125. Liability Convention, *supra* note 19, arts. II–III.

126. *Id.* art. I(c).

127. *Id*. art. I(a).

128. *Id.* art. I(d).

129. Shapiro, *supra* note 56, at 754.

aircraft in flight."[130] As space objects may be comprised of component parts, it is possible that the black carbon particles and other emissions from suborbital rocket engines could be aggregated and be considered "Space objects" under the definition in Article 1(d).[131] This would make launching states liable to other Liability Convention signatory nations if the launching state's suborbital vehicle pollutes the upper atmosphere and other nations were damaged as a result.

The Liability Convention does define a cause of action for member nations damaged by the space objects of other member nations, but the Liability Convention relies on voluntary compliance.[132] However, these principles may now represent customary international law.[133] For these reasons, it is possible that the Liability Convention and Outer Space Treaty could be used to regulate potential environmental harm from commercial space activities. The next treaty deals even more directly with international pollution to the atmosphere.

2. How Does the 1979 Convention on Long-Range Transboundary Air Pollution Apply to Commercial Space Flight?

The 1979 Convention on Long-Range Transboundary Air Pollution ("LRTAP") could be used to regulate environmental harm from commercial space activity. LRTAP is a global treaty that also may apply to the type of harm to the upper atmosphere that could result from commercial space flight.[134] LRTAP defines air pollution as "the introduction by man, directly or indirectly, of substance or energy into the air resulting in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems and material property and impair or interfere with amenities and other legitimate uses of the environment . . . ."[135] "Long-range transboundary air pollution" is defined as:

> [A]ir pollution whose physical origin is situated wholly or in part within the area under the national jurisdiction of one State and which

130. Liability Convention, *supra* note 19, art. II.

131. Telephone Interview with Milton Smith, Attorney specializing in space law, Sherman & Howard (Oct. 8, 2011).

132. Liability Convention, *supra* note 19, art. VIII.

133. Freeland, *supra* note 107, at 5.

134. SCHWABACH, *supra* note 99, at 70.

135. LRTAP, *supra* note 108, art. I(a).

> has adverse effects in the area under the jurisdiction of another State at such a distance that it is not generally possible to distinguish the contribution of individual emission sources or groups of sources.[136]

These definitions are broad enough that they encompass the type of harm to the upper atmosphere likely to result from both orbital and suborbital commercial space flight.[137] Articles 2–4 incorporate the precautionary principle by requiring Contracting Parties to perform research on potentially polluting activities and enact policies that would regulate such activities before other Contracting Parties are adversely affected.[138] Additionally, Article 7 encourages research and development and requires that Contracting Parties "shall initiate and co-operate in the conduct of research into and/or development of: … [i]nstrumentation and other techniques for monitoring and measuring emission rates and ambient concentrations of air pollutants."[139] As LRTAP applies specifically to the type of harm likely to be caused by commercial space flight, it seems suited to regulate the new industry.[140]

Unfortunately, like the Outer Space Treaty and the Liability Convention, an efficient enforcement mechanism is lacking and LRTAP contains no rule on "State liability as to damage."[141] Potential enforcement mechanisms will be discussed later in this Part, but the biggest impact such treaties have is through the threat of legal action.[142]

3. International Treaties Can Be Enforced Through Arbitration

Arbitration, a form of private dispute resolution that allows industry experts to act as judges and is binding on nations regardless of their sovereignty, can be used to enforce international treaties.[143] The arbitral process can be used if parties to a valid contract or treaty specify that disputes arising from the contract will be decided by a neutral third-party

136. *Id*. art. I(b).

137. *See id*. arts. I(a), (b).

138. *Id*. art. I(a).

139. *Id*. art. VII(b).

140. *See id*.

141. *See* SCHWABACH, *supra* note 99, at 71; LRTAP, *supra* note 108, art. VIII, n.1.

142. Marc L. Busch & Eric Reinhardt, *Bargaining in the Shadow of the Law: Early Settlement in GATT/WTO Disputes*, 24 FORDHAM INT'L L.J. 158, 158–59 (2000).

143. CHRISTOPHER R. DRAHOZAL, COMMERCIAL ARBITRATION: CASES AND PROBLEMS 32–33 (2d ed. 2006).

and that the neutral's decision will be final and binding.[144] Although neither the Liability Convention nor LRTAP have explicit enforcement clauses, as is discussed below, members to either convention could hold states that violate the treaties responsible through arbitration.[145]

a. Arbitration is the Preferred Method of Resolving International Disputes for High-tech Industries

Arbitration is the favored method for resolving international disputes for high-tech industries because it can be used to settle disputes arising from international treaties.[146] Further, arbitration is the preferred form of dispute resolution in an international setting because it provides a way to bind parties regardless of sovereignty or nationality.[147] Most space-faring nations have joined the New York Convention, which requires local courts to enforce international arbitral awards, and it is estimated that at least ninety percent of international commercial contracts contain an arbitration clause.[148] Local courts tend to enforce arbitral awards so that other countries will feel confident that any contract with that nation will be enforced according to its terms, which in turn facilitates the country's participation in international trade.[149]

Arbitration is often preferred by specialized, high-tech industries because the parties can contract for arbitrators with industry experience.[150] The UN Commission on International Trade Law ("UNCITRAL") has developed protocols for a variety of specific circumstances that can be applied in arbitrations administered by the UN International Court of Justice ("ICJ") or the Permanent Court of

144. DRAHOZAL, *supra* note 143, at 14. Arbitration has no formal legal definition, but is generally recognized to be a form of private dispute resolution, common amongst merchants in the same industry, that is agreed to by the parties in front of a neutral third-party who will issue a binding decision that is enforceable by public courts.

145. Liability Convention, *supra* note 19, art. VIII; *see also* SCHWABACH, *supra* note 99, at 71; White, *supra* note 22; LRTAP, *supra* note 108, arts. VIII(f) n.1, XIII.

146. DRAHOZAL, *supra* note 143, at 27–33.

147. *Id.* at 32–33 (internal citation omitted). Another advantage among international parties is that arbitration guarantees the "neutrality of the forum, i.e., the possibility to avoid being subjected to the jurisdiction of the home court of one of the parties, and the superiority of its legal framework, with treaties like the New York Convention guaranteeing the international enforcement of awards."

148. *Id.* at 287–301.

149. *Id*. at 287.

150. *See id*. at 33.

Arbitration ("PCA") at The Hague.[151] Additionally, the ICJ permits the appointment of specialists to advise its arbitrators on technical knowledge specific to a given dispute.[152] The ability to choose jurists from a pool of individuals with industry-specific knowledge, and the fact that arbitral decisions are uniquely binding in an international setting, makes arbitration the preferred method for settling international disputes in a high-tech industry.[153] Arbitration is a viable, binding way to enforce international disputes and to take into account the special needs of a high-tech industry. This is why high-tech industries favor it as a method of dispute resolution. Arbitration has an even longer history as a way to resolve international environmental disputes.

b. The Use of Arbitration to Resolve International Environmental Disputes

Arbitration has been used to settle international environmental disputes dating back to the 1941 Trail Smelter Arbitration.[154] This precedent-setting dispute is credited with establishing the modern approach to state responsibility for transboundary environmental harm.[155] The United States and Canada signed and ratified the Convention for Settlement of Difficulties Arising from Operation of Smelter at Trail, British Columbia in 1935 ("Trail Smelter Convention").[156] The Trail Smelter Convention explicitly states that any disputes arising from questions included in Article III of the Trail Smelter Convention should be decided by a panel of three arbiters chosen by the parties and that the decision of the jurists will be final and binding.[157] Pursuant to Article III of the Trail Smelter Convention, the United States submitted the dispute

151. Joost Pauwelyn, *Judicial Mechanisms: Is There a Need for a World Environment Court?, in* REFORMING INTERNATIONAL ENVIRONMENTAL GOVERNANCE: FROM INSTITUTIONAL LIMITS TO INNOVATIVE REFORMS 150, 155 (W. Bradnee Chambers & Jessica F. Green eds., 2005). Both the ICJ and the PCA allow for Contracting Parties to specify that the arbitrators for their case will come from a list of individuals with industry-specific knowledge.

152. *Id.* at 154–155. Of particular interest to disputes about international environmental harm stemming from commercial space activities are UNCITRAL's Environmental Protocol and the Permanent Court of Arbitration's newly released Optional Rules for Arbitration of Disputes Relating to Outer Space Activities.

153. Pauwelyn, *supra* note 151, at 154–56; DRAHOZAL, *supra* note 143, at 32–33.

154. SCHWABACH, *supra* note 99, at 14.

155. *Id*.

156. *Trail Smelter Case*, 3 R.I.A.A. at 1907.

157. *Id*. at 1907–08.

to arbitration because the smelting plant in Trail, British Columbia, was polluting the atmosphere and damaging crops, cattle forage, and forests near the Columbia River Valley in Washington.[158] The arbiters resolved the dispute and established a principle in dicta that some consider the "cornerstone of international environmental law:"[159]

> No State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties or person therein, when the case is of serious consequence and the injury is established by clear and convincing evidence.[160]

This means that a polluting state must be held responsible to an injured state for any environmental harm it caused.[161]

While a treaty like the Trail Smelter Convention specifically calls for disputes arising from it to be settled by arbitration, many other international environmental treaties are difficult to enforce.[162] However, both the Liability Convention and LRTAP include provisions for Member States to hold other Member States accountable through arbitration in international fora, as discussed in the following Subpart.

c. Arbitration's Role in Resolving Disputes Arising from the Outer Space Treaty, Liability Convention, and LRTAP

Both the Liability Convention and LRTAP can be enforced through arbitration according to their provisions. However, Article IX of the Liability Convention provides that as long as both of the disputing parties are members of the UN, the claim may be submitted through the Secretary-General of the UN.[163] This means that only one Member of the Liability Convention must consent to begin the dispute resolution process. This is not the case with LRTAP.

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158. *Id*. at 1908; SCHWABACH, *supra* note 99, at 14–15.

159. SCHWABACH, *supra* note 99, at 15.

160. *Id.*

161. *Id*.

162. *Trail Smelter Case*, 3 R.I.A.A. at 1907–08; SCHWABACH, *supra* note 99, at 29.

163. Liability Convention, *supra* note 19, art. IX; *The Court*, INT'L CT. JUST., http://www.icj-cij.org/court/index.php?p1=1 (last visited Nov. 16, 2012) (disputes submitted to the UN are resolved by the ICJ, the "principal judicial organ of the United Nations.")

Although LRTAP is directly applicable to the types of environmental harm likely to result from commercial space activity, the Treaty is difficult to enforce unless both parties agree to submit the dispute to the ICJ or some other forum for arbitration.[164] In relevant part, LRTAP Article XIII states that "[i]f a dispute arises between two or more Contracting Parties to the present Convention as to the interpretation or application of the Convention, they shall seek a solution by negotiation or by any other method of dispute settlement acceptable to the parties to the dispute."[165] While there is nothing in LRTAP to stop parties from seeking dispute resolution through the ICJ or PCA, no provisions compel it.[166] While LRTAP may be more directly applicable to the sorts of environmental harm likely to result from commercial space flight, enforcing the Outer Space Treaty and Liability Convention would be easier.

However, enforcement mechanisms and world police are generally not necessary to encourage state compliance with international treaties.[167] "[T]he threat of a 'punch that will not hit anyone' can still make a country flinch."[168] This means that the real power of so-called "weak law" is that its mere existence, plus the fact that it could be enforced in some manner, encourages disputants to settle or voluntarily comply with a treaty's provisions.[169] By casting a long shadow, arbitration can encourage countries and businesses to comply with otherwise hard-to-enforce international treaties.

B. Voluntary Standards in the Shadow of Government Regulations

High-tech industries often adopt voluntary standards rather than be vulnerable to legal action or constrained by governmental regulations they did not help develop. The possibility of legal action in an international court and over-regulation by governments often encourages industries to adopt voluntary standards and to self-regulate.[170] Like the

164. *See* LRTAP, *supra* note 108, arts. VII (b), VIII.

165. *Id*. art. XIII.

166. *See id*.

167. *See* Busch, *supra* note 142, at 165–66.

168. *Id*.

169. *Id*. at 165–69.

170. See U.S. DEP'T OF TRANSP., OFFICE OF COMMERCIAL SPACE TRANSP., VOLUNTARY INDUSTRY STANDARDS AND THEIR RELATIONSHIP TO GOVERNMENT

locomotive, automotive, and aviation industries, the commercial space industry is highly technical, has the potential to adversely affect the environment, and benefits from being perceived as safe by the public.[171] Over the years, such high-tech transportation industries have tended to self-regulate to avoid "command and control" measures from state governments and, conversely, to encourage those governments to adopt the guidelines suggested by the industry.[172]

Although the word "standards" often refers to technical specifications, it can also refer to an allowable emissions threshold, like in the aviation and automotive industries. Technical standards can be tied to environmental standards; standardized catalytic converters all remove the same amount of toxins from car exhausts. By adopting standards and producing consistent results, high-tech transportation industries can build public trust in certain companies and trade associations. "[W]here reliance on a particular standard or seal is significant, noncompliance becomes so competitively disadvantageous from the point of view of producers that voluntary standards become mandatory."[173] Under the threat of legal liability or government over-regulation, high-tech industries often self-regulate.[174]

C. Historic Self-regulation by Transportation Industries

Historically, the transportation industry has self-regulated. The aviation and aerospace industries have already begun to self-regulate under the auspices of the International Air Transport Association ("IATA") and the Aerospace Industries Association ("AIA"). One example of a high-tech industry that imposed its own environmental standards on its members, rather than wait to be regulated by various governments, is the IATA, which represents "230 Member airlines in

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PROGRAMS 14–17 (1993), *available at* www.strategicstandards.com/files/GovernmentStandards.pdf [hereinafter VOLUNTARY INDUSTRY STANDARDS], for an example of industries adopting voluntary standards and self-regulating in the United States.

171. *See id*. at 1, 3.

172. *Id*. at 3.

173. *Id*. at 17 (quoting BUREAU OF CONSUMER PROT., FED. TRADE COMM'N, STANDARDS AND CERTIFICATION: FINAL STAFF REPORT 34 (1983)).

174. *See id*. at 3–4.

over 110 countries."[175] The IATA actively lobbies governments and other international bodies on several issues including safety, taxation, and environmental responsibility.[176] The trade association is apparently successful as its members "carry 93% of the world's scheduled international air traffic."[177]

Although the IATA lists safety as its primary focus, it also lists environmental responsibility as a priority and says it is "driving the aviation industry towards carbon-neutral growth and ultimately a carbon-free future."[178] In addition, the IATA has flexible recommendations for member companies about how to comply with its environmental requirements.[179] Such voluntary industry standards can ultimately influence governmental regulations.[180]

Similarly, the AIA has been a powerful voice in creating aerospace industry standards since it was founded in 1919.[181] The AIA uses input from high-level representatives from its member companies to write its policies that it then shares with governments interested in crafting their own regulations.[182] Amongst its top goals, the AIA lists enhancing safety and security, protecting the environment, and operating with the highest ethical standards.[183] Specifically, the AIA plans to set the standard for environmental protection in coordination with European and United States government agencies.[184]

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175. IATA MEMBERSHIP, INT'L AIR TRANSPORT ASS'N 1, *available at* http://www.iata.org/membership/Documents/iata-membership-benefits-2012.pdf.

176. *Id*. at 5.

177. *Id*. at 1.

178. *Id*. at 5.

179. *See* A GLOBAL APPROACH TO REDUCING AVIATION EMISSIONS, INT'L AIR TRANSPORT ASS'N 4 (2009), *available at* http://www.iata.org/SiteCollectionDocuments/Documents/Global_Approach_Reducing_Emissions_251109web.pdf.

180. VOLUNTARY INDUSTRY STANDARDS, *supra* note 170, at 3.

181. *Id*. app. at 10; *About AIA*, AEROSPACE INDUS. ASS'N, http://www.aia-aerospace.org/about_aia/aia_at_a_glance/ (last visited Oct. 28, 2012) [hereinafter *About AIA*] (The AIA is a trade association that represents 300 aerospace or defense member companies, some of which are involved in commercial space activities).

182. VOLUNTARY INDUSTRY STANDARDS, *supra* note 170, app. at 10; *About AIA*, *supra* note 181.

183. *Stewardship*, AEROSPACE INDUS. ASS'N, http://www.aia-aerospace.org/about_aia/strategic_plan/stewardship/ (last visited Oct. 28, 2012).

184. *Id*.

One of the ways the AIA plans to continue to remain in compliance with the National Environmental Protection Act and the Clean Air Act is by controlling emissions of aerospace vehicles.[185] One of the AIA's goals for 2012 is to "[e]ffectively advocate public environmental policies on manufacturing issues that ensure sustainability and competitiveness in an international market."[186] The AIA's longevity points to the effectiveness of this system.

Since the 1970s, the United States has embraced the efforts of trade associations to help regulate their respective agencies.[187] Therefore, the FAA/AST will expect the commercial space industry to assist in its own regulation.[188] To this end, the agency has determined that a compilation of "voluntary industry standards" is the best way to:

> protect public safety and the environment . . . while simultaneously nurturing a healthy and internationally competitive commercial space industry. . . . [FAA/AST] has emphasized flexibility and the use of innovative approaches, rather than simply relying on the traditional 'command-and-control' regulatory strategy.[189]

Because they have the technical expertise, it makes sense that history is full of trade associations and organizations, like the IATA and AIA, that have successfully worked with national governments to promulgate standards and policies to govern their industries in the shadow of international law.[190] The transportation industry has historically self-regulated to avoid legal liability or over-regulation by the government. Accordingly, the commercial space industry will likely follow suit.

V. CONCLUSION

Forecasts and market predictions indicate that the number of orbital and suborbital launches will increase steadily over the next decade.[191] As

185. *Id*.

186. *Id*.

187. VOLUNTARY INDUSTRY STANDARDS, *supra* note 170, at 6–13.

188. *See id.* at 4.

189. *Id.* at 1.

190. *See id*. at 4.

191. *Satellites to be Built and Launched by 2020: World Market Survey: Table of Contents*, EUROCONSULT, http://www.euroconsult-ec.com/research-reports/space-

governments privatize their space activities and the private sector increasingly demands the services satellites provide, the commercial space industry will grow.[192] Already, commercial space companies and launch sites have sprung up around the globe[193] to create a geographically and culturally diverse industry that may prove difficult to regulate.

Regulating international environmental harm caused by space flight is likely to be difficult as well. Since humans have been launching objects into space, climatologists have noted negative effects from rockets on the ozone layer.[194] Up until now, the small number of launches has kept the impacts from those effects to a minimum. However, scientists believe that as the ozone layer is eroded by man-made pollutants and rocket launches increase, it could become a significant problem.[195] Under the precautionary principle, international environmental law recognizes the need to regulate industries capable of causing damage that would be difficult or impossible to remedy.[196] This principle should apply to damage by orbital and suborbital launches on the upper atmosphere because the type of harm those launches are likely to produce is hard to predict and probably harder to remedy.[197]

The concern of scientists for the effects of volcanic eruptions and geoengineering highlight the similar dangers posed by injecting particles into the upper atmosphere with suborbital launches.[198] Although the dangers of suborbital launches are potentially severe and unpredictable, as long as the number of launches is limited, the small amount of pollutants emitted in each individual launch is unlikely to have a devastating impact on the atmosphere.[199] With proper regulation, space-faring nations should be able to reap the economic benefits of the growing commercial space industry while also preserving the environment.

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industry-reports/satellites-to-be-built-launched-by-2020-38-50.html (last visited Oct. 28, 2012); Ziliotto, *supra* note 6.

192. *Satellites to be Built and Launched by 2020: World Market Survey: Table of Contents*, *supra* note 191; Ziliotto, *supra* note 6.

193. *See generally* FORECASTS, *supra* note 1.

194. Shapiro, *supra* note 56, at 749.

195. *Id*.

196. Weintraub, *supra* note 98, at 181.

197. Mills, *supra* note 71.

198. Ross et al., *supra* note 11, at 2.

199. *Id*.

Provisions of international treaties, such as the Outer Space Treaty, the Liability Convention, and LRTAP, may be useful in creating regulations for the emerging industry.[200] Companies that have specialized technical knowledge often voluntarily comply with these standards to avoid seemingly arbitrary regulations enacted by a government agency acting unilaterally.[201] The commercial space industry is poised to follow suit and assist governments to come up with meaningful and realistic regulations that will allow the industry to flourish while also preserving the environment.

200. Discussed s*upra* Part IV.

201. VOLUNTARY INDUSTRY STANDARDS, *supra* note 170, at 1, 3.