

# Onwards and Upwards: Space Tourism's Climate Costs and Solutions

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Space tourism is an industry of today, not just tomorrow. This industry is set to take off in the coming years and decades as dozens of companies and thousands of people race to experience space for themselves. The world continues to step into space even as the rise of a commercial space industry threatens our own planet's climate. In a study released in October 2010, climate scientists concluded that as few as 1,000 rocket launches per year would cause worldwide climate change.<sup>1</sup> This revelation presents both a problem and an opportunity. The threat is significant, and Part I of this Field Report will explain the new research and its implications. Part II will survey the current legal terrain applicable to the environmental impacts of space tourism, including space law, the National Environmental Policy Act (NEPA) and the Clean Air Act (CAA). It concludes that while NEPA and the CAA partially address the licensing of commercial spaceflights by the Federal Aviation Administration (FAA), neither space law nor current environmental law respond sufficiently to the environmental threat posed by this industry. This leaves the United States with the opportunity to problem-solve at an industry's birth, before damage is done. Part III will attempt a modest start at that opportunity by proposing potential solutions.

## I. THE PROBLEM: BLACK CARBON AND OZONE DEPLETION

A large increase in the number of rocket launches per year would greatly alter temperatures at both the tropics and at the poles, causing significant sea ice loss. This is the conclusion drawn by a paper published in *Geophysical Research Letters*, the first study of the

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1. Adam Mann, *Space Tourism to Accelerate Climate Change*, NATURE NEWS (Oct. 22, 2010), <http://www.nature.com/news/2010/101022/full/news.2010.558.html>.

effects of mass rocket usage on global temperatures.<sup>2</sup> The atmosphere is sensitive to rocket emissions generally, and is particularly sensitive to black carbon emitted by the industry's hybrid rockets, as black carbon can remain trapped in the stratosphere for years.<sup>3</sup> The researchers predict that 1,000 rocket launches per year would reduce ozone by 1.7% in tropical areas while increasing it five to seven percent in the polar regions. This would lower tropical temperatures by 0.4 °C and raise polar temperatures by as much as 1 °C, reducing polar sea ice by five to fifteen percent in thirty years.<sup>4</sup> A suborbital rocket fleet launched 1,000 times per year would influence global climate about as much as the entire world's fleet of subsonic aircraft, leading the researchers to conclude that "rocket emissions on this scale clearly cross a threshold to be considered a human-influenced climate impact of global importance."<sup>5</sup>

The "thousand rockets problem" is not a fanciful estimate. Ross, et al., drew the number from their examination of detailed plans for space tourism and science flights using suborbital hybrid rockets.<sup>6</sup> Indeed, evidence from the industry supports the probability of a coming explosion in space tourism and commercial space activity generally. As early as 1998, Space Adventures, Ltd., was booking spaceflights for private citizens; today it is doing the same with potential private expeditions to the moon. The world's first space tourist, Dennis Tito, joined a Russian Soyuz craft in 2001; by 2004, SpaceShipOne—the world's first privately funded and operated space launch vehicle—flew successfully. Today, the European Aeronautic and Defense Company is designing an orbiting hotel, while Virgin Galactic has signed up over 300 people

2. MARTIN ROSS, MICHAEL MILLS, & DARIN TOOHEY, POTENTIAL CLIMATE IMPACT OF BLACK CARBON EMITTED BY ROCKETS 1 (2010) available at <http://sciences.blogs.liberation.fr/files/tourisme-spatial-et-climat.pdf>.

3. *Id.* at 1–2. A "hybrid rocket" is a jet propulsion system consisting of one solid propellant and one liquid propellant. Hybrid rockets are considered cheaper and safer than the alternatives. See, e.g., *Hybrid Rocket Propulsion Overview*, SPACE PROPULSION GROUP, INC., <http://www.spg-corp.com/space-propulsion-group-resources.html> (last visited Nov. 11, 2011). "Black carbon" is a climate change agent consisting of "soot, charcoal and/or possible light-absorbing refractory organic material." INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS 942 (S. Solomon et al. eds., 2007) available at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-annexes.pdf>.

4. Mann, *supra* note 1.

5. ROSS, MILLS, & TOOHEY, *supra* note 2, at 9.

6. *Id.* at 4.

for SpaceShipTwo to begin flights in 2013.<sup>7</sup> The industry estimates that 13,000 people will have been space tourists by 2021, generating nearly \$700 million in revenue.<sup>8</sup>

These years mark the birth of space tourism, and the industry will only continue to grow. It is possible that 1,000 rocket launches per year is a conservative estimate; XCOR Aerospace plans to offer four flights a day.<sup>9</sup> If it is successful, one company alone will launch 1,460 annual rocket flights. The climate warning of Ross, et al., may be conservative.

## II. THE FIELD: CURRENT LAW AND ITS INSUFFICIENCY

Neither space law nor current environmental law is sufficient to address the environmental problems presented by this growing industry. Current space law is a patchwork of international treaties,<sup>10</sup> federal law,<sup>11</sup> and state laws.<sup>12</sup> Very broadly, the international agreements demonstrate that even during the Cold War, the focus of space law has been on assigning responsibility and mitigating harm. The Outer Space Treaty, for example, makes

7. Thomas Brannen, *Private Commercial Space Transportation's Dependence on Space Tourism and NASA's Responsibility to Both*, 75 J. AIR L. & COM. 639, 653 (2010); Timothy M. Ravich, 2010: *Space Law in the Sunshine State*, FLA. B.J., Oct. 2010, at 24, 29–30; Andy Pasztor, *Virgin Galactic's Flights Seen Delayed Yet Again*, WALL ST. J. (Oct. 26, 2011), <http://online.wsj.com/article/SB10001424052970204777904576653690338241146.html>.

8. FUTRON CORP., SUBORBITAL SPACE TOURISM DEMAND REVISITED 4 (2006), available at [http://www.futron.com/upload/wysiwyg/Resources/Whitepapers/Suborbital\\_Space\\_Tourism\\_Revisited\\_0806.pdf](http://www.futron.com/upload/wysiwyg/Resources/Whitepapers/Suborbital_Space_Tourism_Revisited_0806.pdf).

9. Brannen, *supra* note 7, at 655.

10. Convention on Registration of Objects Launched into Outer Space, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15; Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187; Rescue Agreement, Apr. 26, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119 (providing for the mutual rescue of stranded astronauts); Outer Space Treaty, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205.

11. Commercial Space Launch Amendments, Pub. L. No. 108-492, 118 Stat. 3974 (2004) (expressly promoting the commercial human space flight industry); Commercial Space Launch Act, Pub. L. No. 98-575, 98 Stat. 3055 (1984) (allowing the development and launching of commercial launch vehicles and vesting permitting authority with the Secretary of Transportation); National Aeronautics and Space Act, Pub. L. No. 85-568, 72 Stat. 426 (1958) (creating NASA and dedicating the United States' space endeavors to peaceful purposes in "benefit of mankind").

12. See, e.g., Space Florida Act, FLA. STAT. §§ 331.301–331.370 (2010) (creating a spaceport, "Space Florida," and ordering it to work towards the growth of aerospace); Florida Informed Consent for Spaceflight Act, FLA. STAT. § 331.501 (2010) (shielding private space tourism entities from liability to their passengers). See also Joanne Irene Gabrynowicz, *One Half Century and Counting: The Evolution of U.S. National Space Law and Three Long-Term Emerging Issues*, 4 HARV. L. & POL'Y REV. 405, 421 (2010).

each state party internationally liable for damages caused by objects launched.<sup>13</sup> However, none of these regimes directly address environmental issues posed by space activity. “Traditional” space law is basically silent on climate change.

Federal environmental law, on the other hand, is not entirely silent on commercial spaceflight and space tourism. The Department of Transportation’s Office of Commercial Space Transportation (AST)<sup>14</sup> is responsible for regulating private sector launches and licensing private spacecraft.<sup>15</sup> It is responsible for complying with NEPA per FAA internal regulations, which consider AST’s exercise of authority a “major Federal action subject to NEPA requirements.”<sup>16</sup> According to AST, NEPA encourages it to “integrate environmental values into its decision-making process.” It “considers the environmental impacts of proposed actions and reasonable alternatives . . . [taking] actions that protect, restore, and enhance the environment.”<sup>17</sup> In practice, this means that AST prepares Environmental Assessments (EAs) and Environmental Impact Statements (EISs).<sup>18</sup>

The EISs prepared by AST do consider air pollution and climate change concerns, but those concerns appear to have had little effect on AST’s licensing decisions. For example, in 2005, AST prepared an EIS for the licensing of horizontal launch vehicles and reentry vehicles, as well as necessary support facilities.<sup>19</sup> In the EIS, AST was obligated, among other things, to consider the effect of these vehicles on air pollution and global warming. The EIS admitted that the Environmental Protection Agency’s (EPA) air

13. Outer Space Treaty, *supra* note 10, at art. VII.

14. AST is an abbreviation of Associate Administrator for Commercial Space Transportation.

15. *Office of Commercial Space Transportation*, FAA, [http://www.faa.gov/about/office\\_org/headquarters\\_offices/ast/](http://www.faa.gov/about/office_org/headquarters_offices/ast/) (last visited Oct. 7, 2011); Ravich, *supra* note 7, at 28.

16. Environmental Impacts: Policies and Procedures § 214f, FAA, Order No. 1050-1E, (Mar. 20, 2006), *available at* [http://www.faa.gov/documentLibrary/media/order/energy\\_orders/1050-1E.pdf](http://www.faa.gov/documentLibrary/media/order/energy_orders/1050-1E.pdf).

17. *Environmental Program*, FAA, OFFICE OF COMMERCIAL SPACE TRANSP., (May 24, 2011, 3:03 PM), [http://www.faa.gov/about/office\\_org/headquarters\\_offices/ast/environmental/](http://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/).

18. *See* 42 U.S.C. § 4332(C) (2006).

19. FAA, OFFICE OF COMMERCIAL SPACE TRANSP., FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR HORIZONTAL LAUNCH AND REENTRY OF REENTRY VEHICLES 2-1 (2005), *available at* [http://www.faa.gov/about/office\\_org/headquarters\\_offices/ast/licenses\\_permits/media/Final\\_FAA\\_PEIS\\_Dec\\_05.pdf](http://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/media/Final_FAA_PEIS_Dec_05.pdf).

quality standards for PM, CO, CO<sub>2</sub>, SO<sub>2</sub>, and Pb could theoretically require conformity analysis for vehicles launching or reentering over a nonattainment area. However, even assuming that all the proposed launches and reentries were in the same region, the EIS concluded that the emissions would still be “far below” the de minimis levels specified and therefore exempt.<sup>20</sup> The EIS also admitted that these vehicles emit greenhouse gases—including CO, CO<sub>2</sub>, NO<sub>x</sub>, and H<sub>2</sub>O—but concluded that this was of little concern because in comparison to emissions by all American sources, these emissions would have “a negligible impact on global warming.”<sup>21</sup> Finally, the report addressed ozone depletion from launch emissions, which it claimed was “a temporary and limited phenomenon.”<sup>22</sup>

Another AST EIS released in 2009 demonstrated the same pattern. AST filed an EIS for the issuance of experimental permits for the launch of reusable suborbital rockets.<sup>23</sup> In it, AST was again obligated to examine air quality, climate change, and ozone depletion. The EIS found that the activity would “likely have a cumulative impact on climate change.”<sup>24</sup> Although the EIS noted that these vehicles would emit “ozone-depleting substances and greenhouse gasses,” it stated that these emissions would be negligible compared to emissions worldwide.<sup>25</sup> AST concluded that these issues were, in the parlance of EISs, “Unavoidable Adverse Impact[s].”<sup>26</sup> The underlying project was approved as the environmentally preferred alternative.<sup>27</sup>

In both cases, NEPA functioned as designed—the agency examined the evidence and considered the environmental risks posed. However, NEPA did little to motivate AST to actively address the threat to the world’s climate posed by private space

20. *Id.* at 4-8-10.

21. *Id.* at 4-13-14.

22. *Id.*

23. FAA, FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR STREAMLINING THE PROCESSING OF EXPERIMENTAL PERMIT APPLICATIONS ES-1 (2009), *available at* [http://www.faa.gov/about/office\\_org/headquarters\\_offices/ast/media/20090803\\_eppeis.pdf](http://www.faa.gov/about/office_org/headquarters_offices/ast/media/20090803_eppeis.pdf).

24. *Id.* at ES-7.

25. *Id.* at ES-6.

26. *Id.* at 6-1.

27. *See* FAA, RECORD OF DECISION FOR STREAMLINING THE PROCESSING OF EXPERIMENTAL PERMIT APPLICATIONS 5 (2009), *available at* [http://www.faa.gov/about/office\\_org/headquarters\\_offices/ast/media/20091015%20eppei%20signed.pdf](http://www.faa.gov/about/office_org/headquarters_offices/ast/media/20091015%20eppei%20signed.pdf).

tourism. AST has asserted, correctly, that the launches it is considering licensing are a minute fraction of the nation's and world's climate problems. This approach squanders the opportunity to comprehensively address a likely problem, at least until that problem is comparable in scope to other climate problems. At this stage, AST has classified many climate change issues as "Unavoidable Adverse Impact[s]," and its suggestions for mitigating the potential damage are lackluster.<sup>28</sup> As an information-forcing regime NEPA requirements have their uses, but as a potential solution to the environmental threat posed by space tourism, they have not encouraged sufficient proactivity.

The CAA's method for accounting for dangerous gases similarly makes the law unsuitable to tackle the threat of worldwide climate change caused by space tourism. According to AST's interpretation, EPA's air quality guidelines only apply to space tourism launches and reentries in nonattainment regions, and there is no reason to assume the activity in those areas would meet the de minimis levels EPA specifies before it regulates.<sup>29</sup> As with NEPA, proactivity is a concern. However, the air quality guidelines are also insufficient to curb threatened worldwide climate change from space tourism because climate change is not a regional issue but a global one. The areas that need protection, according to Ross, et al., are the stratosphere, the tropics, and the polar regions.<sup>30</sup> The CAA's goal of reducing emissions in domestic nonattainment areas is simply too narrow.

Neither are the mobile source protections in the CAA currently sufficient to tackle the threat presented. Title II, Part B of the Act provides for the regulation of aircraft emissions standards.<sup>31</sup> Congress defined "aircraft" as "any contrivance invented, used, or designed to navigate, or fly in, the air," and the EPA Administrator is empowered to regulate emissions of aircraft, which it does.<sup>32</sup> However, this section of the CAA has not been interpreted to permit the regulation of rocket emissions, and the Administrator

28. FAA, *supra* note 23, at 5-1 (proposing no site-specific mitigation measures beyond continuing to monitor the situation).

29. See FAA, *supra* note 19, at 4-8-10.

30. See Mann *supra* note 1.

31. 42 U.S.C. §§ 7571-7574 (2006).

32. 49 U.S.C. § 40102(a)(6) (2006); 42 U.S.C. § 7571(a) (2006); *Nonroad Engines, Equipment, and Vehicles: Aircraft*, EPA (Feb. 7, 2011), <http://epa.gov/otaq/aviation.htm>.

does not do so.<sup>33</sup>

Current space and environmental law only tangentially relate to the problem of climate change caused by space tourism. What environmental laws are applicable, including NEPA and EPA's air quality guidelines, are neither proactive enough to get out in front of this new threat, nor broad enough in scope to handle the threat if and when it arrives. New solutions are needed to handle space tourism and commercial space flight.

### III. THE FUTURE: POTENTIAL SOLUTIONS

One solution would be to draft a new international treaty on space exploitation in the post-Cold War world that includes provisions for addressing climate change from private space-bound craft. International space law remains "anchored down by Cold War philosophies."<sup>34</sup> It makes states responsible for all space-bound activity within their borders and provides for relief of injuries caused by others in space exploration,<sup>35</sup> but it lacks a comprehensive plan to commercially exploit space or to address the externalities involved in exploitation. Given the growing potential—if not national necessity<sup>36</sup>—of private spaceflight, a new international space treaty could be in order. Such a treaty could promote the development of cleaner, more environmentally-friendly private spacecraft, could set up an international cap-and-trade permitting program for private space launches, or could even establish a body to recommend emissions standards for private launch vehicles. However, this would not be an easy path as the international community often has difficulty reaching consensus on environmental regulation.

Many of these solutions could also be enacted through federal law by creating a comprehensive regulatory scheme for commercial space launch emissions regulation. In fact, Article VI of the Outer Space Treaty may potentially obligate the federal government to

33. See EPA, *supra* note 32.

34. Ravich, *supra* note 7, at 26.

35. Outer Space Treaty, *supra* note 10, at Art. VI, Art. VII.

36. NASA, SUMMARY REPORT OF THE REVIEW OF U.S. HUMAN SPACE FLIGHT PLANS COMMITTEE 7 (2009), *available at* [http://www.nasa.gov/pdf/384767main\\_SUMMARY%20REPORT%20-%20FINAL.pdf](http://www.nasa.gov/pdf/384767main_SUMMARY%20REPORT%20-%20FINAL.pdf) (recommending NASA learn to "rely" on private launch vehicles, especially during the 7-year gap between the cancellation of the Shuttle program and the Constellation program's completion).

step in.<sup>37</sup> Considering that significant elements of United States space law are already the de facto standard for other nations,<sup>38</sup> these actions could still have the desired worldwide effect. A desirable national solution should also include close consultation with the private spaceflight entities themselves. However, unlike an international solution, a national regime presents the danger of impeding or snuffing out the nascent industry by making it unable to compete with private spaceflight companies from other nations. Although potentially easier to enact than a new international regime, a national solution that has the potential to damage American competitiveness in this new field is a weakness.

A third solution would be to unify air and space law into one, overarching, aerospace law, and place space tourism under the jurisdiction of EPA and the International Civil Aviation Organization (ICAO). ICAO has long been an international forum capable of providing technical management, and has the potential to create traffic safety, security, and environmental rules for launch vehicles.<sup>39</sup> Similarly, EPA already monitors and regulates aircraft emissions.<sup>40</sup> Air law and space law share common values: the recognized desire to develop these arenas for the benefit of all humanity, as well as a belief in state equality and sovereignty.<sup>41</sup> Adding space tourism to ICAO's aegis would most likely help. ICAO is already engaged in studying and promoting ways to reduce aircraft emissions.<sup>42</sup> In fighting climate change, ICAO has agreed to a global two percent annual improvement in fuel efficiency until 2050, and to work towards carbon-neutral growth.<sup>43</sup> This technical focus and long-term vision could help address and mitigate climate change caused by space tourism in a proactive, effective way.

Finally, there are long-term potential technological solutions to rocket emissions, which should not be dismissed out-of-hand.

37. See Gabrynowicz, *supra* note 12, at 421 (noting that Art VI makes the federal government responsible for continually supervising all nongovernmental U.S. space actors).

38. *Id.* at 420.

39. Ruwantissa Abeyratne, *ICAO's Involvement in Outer Space Affairs—A Need for Closer Scrutiny?*, 30 J. SPACE L. 185, 186 (2004).

40. See EPA, *supra* note 32.

41. Abeyratne, *supra* note 39, at 188–90.

42. *Environment Branch: Aircraft Engine Emissions*, INT'L CIVIL AVIATION ORG., <http://www.icao.int/icao/en/Env2010/Aee.htm> (last visited Nov. 11, 2011)

43. *Environment Branch: Climate Change*, INT'L CIVIL AVIATION ORG., <http://www.icao.int/icao/en/Env2010/ClimateChange.htm> (last visited Nov. 11, 2011).

Although still science-fiction today, space elevators<sup>44</sup> and mass drivers<sup>45</sup> have the potential to minimize or even eliminate rocket emissions while maintaining the ability to deliver things into orbit. Any proper solution to the threat of climate change from space launches should promote the development of technology that can ease the need for rocket launches generally.

#### IV. CONCLUSION

Space tourism is coming in force, and bringing with it the specter of hastening climate change. The most recent research suggests that even a conservative estimate of the number of rocket launches possible in the coming years and decades will drastically affect the earth's climate. Current space law is silent on climate change, and current United States environmental law centered on the FAA AST's licensing of private launch vehicles is insufficient to address the problem in a serious, proactive way. However, there are solutions, including new federal law, a new space treaty, or folding space tourism into the jurisdiction of ICAO. Although the United States should promote the nascent industry, an awareness of the ecological danger the industry poses presents the United States with the opportunity to find the right balance between our planet and our space-bound future. The United States should seize that opportunity.

44. See, e.g., David Shiga, *'Space Elevator' wins \$900,000 NASA prize*, NEWSIDENTIST SPACE (Nov. 6, 2009, 11:37 PM), <http://www.newscientist.com/article/dn18122-space-elevator-wins-900000-nasa-prize.html>.

45. See, e.g., David Shiga, *Huge 'launch ring' to fling satellites into orbit*, NEWSIDENTIST SPACE (Oct. 3, 2006, 4:00 PM), <http://www.newscientist.com/article/dn10180>.