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## One-Way Ticket to Mars: The Privatization of the Space Industry and its Environmental Impact on Earth and Beyond

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# One-Way Ticket to Mars: The Privatization of the Space Industry and its Environmental Impact on Earth and Beyond

Yuree Nam\*

## ABSTRACT

*In the 21<sup>st</sup> century, the space industry has changed from a government-focused practice to a rapidly growing private sector. Billionaires like Elon Musk and Jeff Bezos operate private companies for the advance of space travel and exploration. Other companies like Lunar Outpost, ispace, and Masten Space Systems were selected by NASA to collect lunar resources back in 2020. The concern is that current international space law is insufficient to regulate private actors who play a significant role in exacerbating environmental problems. Whether it be rocket emissions and environmental justice concerns on Earth, or commercial resource extraction in outer space, private actors need to be regulated to protect the environment, create a sustainable long-term process for space exploration, and maintain international relations. The 1967 Outer Space Treaty and the 1979 Moon Agreement that were created for the purpose of banning weapons of mass destruction in outer space, do not address or regulate the environmental issues caused by private actors today. With the addition of new international agreements, like the U.S.-led Artemis Accords which encourage commercial activity by private actors, regulation is even more difficult and raises international relations concerns. This Note proposes regulating U.S. rocket emissions and facilities under the Clean Air Act and regulating commercial resource extraction through an international licensing system.*

**Keywords:** rocket emissions, natural resource exploitation, space law, environmental law

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### INTRODUCTION

The rise of space exploration and private sector innovation has sparked great interest and hope for our future in outer space. This development also raises concerns about the lack of regulation, scientific research, and policy surrounding the privatization of the space industry to create a sustainable long-term plan. For those who are optimistic about space exploration and developments in outer space, there is no doubt that humanity will eventually leave Earth and make changes to our fundamental organization as a society in order to adapt. However, with the current regulatory process, Earth and outer space are suffering under the regime. Are we working toward improving the environment on Earth and prioritizing conservation, or is leaving Earth behind our sole objective?

Privatizing the space industry impacts the environment both on Earth and in outer space. First, rockets release black carbon into the air, contributing to global warming and other environmental issues on Earth. Second, commercial resource extraction in outer space raises questions about how to best protect natural resources on the Moon and in outer space. Additionally, international relations problems can arise from commercial resource extraction as countries strenuously disagree and no real agreements created by an inter-governmental organization like the United Nations yet exist.

Besides the environmental issues, there are difficulties in regulating private actors' actions that affect Earth and outer space. Outdated international treaties like the Outer Space Treaty were created without considering private actor involvement. Therefore, there are no actual provisions in the Outer Space Treaty or other international law to adequately regulate private actors. Domestic regulation in the United States under the Federal Aviation Administration (FAA) is also insufficient for regulating environmental issues because

environmental review is only a small piece of their permitting process for private space companies.

A better way to regulate private actors in the space industry is through a combination of national and international laws. National laws can help with air pollution and the environmental issues that stem from rocket facilities and emissions. On the other hand, international bodies can create a system of licensing that ensures neutrality and transparency for protecting natural resources and maintaining positive international relations. Also, encouraging more government-funded research projects on “green” propulsion—propulsion that does not release black carbon into the air—can help with protecting the environment on Earth.

Part I of this Note discusses the recent rise of private actors that are changing space exploration in both space flight development and lunar resource extraction. Part II discusses rocket emissions, their environmental impact on Earth, and alternative propulsion systems. The issue of rocket emissions is further discussed in connection with ineffective regulation, as seen at a launch site located in Boca Chica, Texas. I propose a solution for regulating rocket emissions through the Clean Air Act (CAA). Part III discusses commercial resource extraction, an environmental concern in outer space and an international relations issue. I propose regulating commercial resource extraction through an international licensing system, like one that is used by the United Conventions on the Law of the Sea (UNCLOS) for deep seabed mining.

## I. THE RISE OF PRIVATE ACTORS IN THE SPACE INDUSTRY

When the Outer Space Treaty was first created in 1967, its main goal was to prevent weapons of mass destruction in outer space.<sup>1</sup> After the Soviet Union launched the first artificial satellite, Sputnik, in 1957, the United States engaged in a competition for political superiority and development.<sup>2</sup> In 1958, the United States launched its first satellite, the Explorer.<sup>3</sup> The Soviets followed with another launch, and the space race continued.<sup>4</sup> With the success of Sputnik, U.S. policymakers accelerated space and weapons programs.<sup>5</sup> In the late 1950s, Soviet Premier Nikita Khrushchev talked about Soviet technological superiority and growing stockpiles of intercontinental ballistic missiles (ICBMs).<sup>6</sup> The United States then also worked to develop its own ICBMs to counter what it assumed was a growing stockpile of Soviet missiles directed against the United States.<sup>7</sup>

In 2023, the space industry and governments have shifted focus away from preventing mass destruction in space. Instead, the space industry is now concerned with private actors commercializing spaceflight and private companies trying to develop commercial activity on Earth and in outer space.

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<sup>1</sup> *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, U.S. DEP’T OF STATE, <https://2009-2017.state.gov/t/isn/5181.htm> [<https://perma.cc/G94R-24AB>] (last visited Sept. 13, 2023).

<sup>2</sup> *Sputnik, 1957*, OFF. OF THE HISTORIAN, U.S. DEP’T OF STATE, <https://history.state.gov/milestones/1953-1960/sputnik> [<https://perma.cc/WM7J-5DBZ>] (last visited Sept. 14, 2023).

<sup>3</sup> *Id.*

<sup>4</sup> *Id.*

<sup>5</sup> *Id.*

<sup>6</sup> *Id.*

<sup>7</sup> *Id.*

A. *SpaceX and Blue Origin Revolutionizing Space Travel*

Two leading companies for space travel are SpaceX and Blue Origin. Both companies have previously worked with the National Aeronautics and Space Administration (NASA) and continue to do so. From building a moon lander to providing rocket launch services for private companies like these, NASA in the twenty-first century is committed to working with private companies to develop the next generation of space-transportation technologies.<sup>8</sup>

SpaceX was founded by Elon Musk in 2002 and is NASA's second-highest paid vendor for fiscal year 2022 behind the California Institute of Technology (Caltech), which manages the Jet Propulsion Laboratory (JPL) for NASA.<sup>9</sup> As of October 20, 2023, SpaceX has conducted a total of 273 launches, 236 landings, and 208 reflights from its inception.<sup>10</sup> On average, SpaceX launched a rocket every six days in 2022.<sup>11</sup> For 2023, SpaceX plans to launch up to 100 flights.<sup>12</sup> In 2020, SpaceX handled about two-thirds of NASA's launches, including many research payloads.<sup>13</sup> A payload is any object, such as a satellite or person, that is delivered into space.<sup>14</sup>

SpaceX's mission statement is to make humanity multiplanetary and carry humans to Mars and other destinations in the solar system.<sup>15</sup> Starship is SpaceX's massive prototype rocket and is central to the goal of travelling to Mars because of its 394-foot height and its carrying capacity of around 550,000 pounds.<sup>16</sup> In comparison to Starship, Saturn V, the rocket used in the Apollo mission in the late 1960s, was only able to hold around 310,000 pounds. To illustrate, Starship can carry the weight of three more fully grown humpback whales than Saturn V.<sup>17</sup>

<sup>8</sup> Claire A. O'Shea, *NASA Selects Blue Origin as Second Artemis Lunar Lander Provider*, NASA (May 19, 2023), <https://www.nasa.gov/press-release/nasa-selects-blue-origin-as-second-artemis-lunar-lander-provider> [<https://perma.cc/682U-VY36>]; Andrew Chambers & Dan Rasky, *NASA + SpaceX Work Together*, NASA (Oct. 17, 2010), [https://appel.nasa.gov/2010/10/17/40s\\_space-x-html](https://appel.nasa.gov/2010/10/17/40s_space-x-html) [<https://perma.cc/JX8Y-W8M5>].

<sup>9</sup> Michael Sheetz, *Investing in Space: NASA and SpaceX Need Each Other*, CNBC (Nov. 3, 2022, 12:11 PM), <https://www.cnbc.com/2022/11/03/investing-in-space-nasa-and-spacex-need-each-other.html> [<https://perma.cc/7WVM-SPLP>].

<sup>10</sup> *Launches*, SPACEX, <https://www.spacex.com/launches/> [<https://perma.cc/33WM-ZEY2>] (last visited Oct. 20, 2023).

<sup>11</sup> SpaceX (@SpaceX), TWITTER (Dec. 30, 2022, 12:11 PM), <https://twitter.com/SpaceX/status/1608888588711899137> [<https://perma.cc/SRA7-62Y9>].

<sup>12</sup> Elon Musk (@elonmusk), TWITTER (Aug. 31, 2022, 10:13 AM) <https://twitter.com/elonmusk/status/1564994769826172929> [<https://perma.cc/444L-GFB7>].

<sup>13</sup> Adam Mann, *SpaceX Now Dominates Rocket Flight, Bringing Big Benefits—and Risks—to NASA*, SCIENCE (May 20, 2020), <https://www.science.org/content/article/spacex-now-dominates-rocket-flight-bringing-big-benefits-and-risks-nasa> [<https://perma.cc/2DS5-9JQQ>].

<sup>14</sup> UNITED LAUNCH ALL., ROCKET SCIENCE: A BEGINNER'S GUIDE TO LAUNCH (2019), [https://www.ulalaunch.com/docs/default-source/rockets/a\\_beginners\\_guide\\_to\\_launch.pdf](https://www.ulalaunch.com/docs/default-source/rockets/a_beginners_guide_to_launch.pdf) [<https://perma.cc/NFT4-36R4>]; *Payload Systems*, NASA, <https://www.grc.nasa.gov/www/k-12/rocket/payload.html> [<https://perma.cc/C6S7-Z2JF>] (last visited Sept. 14, 2023).

<sup>15</sup> *Mission*, SPACEX, <https://www.spacex.com/mission/> [<https://perma.cc/L6QH-MKNQ>] (last visited Sept. 14, 2023).

<sup>16</sup> Paul Rincon, *What is Elon Musk's Starship Space Vehicle?*, BBC (Apr. 17, 2023), <https://www.bbc.com/news/science-environment-55564448> [<https://perma.cc/UK7C-GKE5>].

<sup>17</sup> *Humpback Whale*, OCEANA, <https://oceana.org/marine-life/humpback-whale/> [<https://perma.cc/V9R4-M6YE>] (last visited Sept. 14, 2023).

Besides going to Mars, SpaceX is invested in creating reusable rockets for space travel.<sup>18</sup> The motivation behind producing reusable rockets is to lower the cost of space access and space travel.<sup>19</sup> Unlike a one-use rocket that breaks apart and gets destroyed after launch, a reusable rocket will return to Earth vertically, in the same orientation in which it launched.<sup>20</sup> Falcon 9 is one example of a reusable rocket that was successfully launched by SpaceX.<sup>21</sup> Reusable rockets like Falcon 9 eliminate the cost of creating a new rocket for each space mission.<sup>22</sup> Though NASA has stopped using a space shuttle because of its high price, until 2011, NASA had used a shuttle that cost an average of \$1.6 billion per flight.<sup>23</sup> With SpaceX, the price per flight has decreased 23 times to around \$67 million per flight. This reusability would benefit NASA by saving money and lessening the burden that space travel and innovation place on the government.<sup>24</sup>

Blue Origin was founded in 2000 by Jeff Bezos and also focuses on the reusability of rockets. Additionally, Blue Origin is in the business of creating high-tech engines.<sup>25</sup> Blue Engine 3 (BE-3) is the first among a series of Blue Origin engines that uses liquid hydrogen and liquid oxygen for propellant.<sup>26</sup> Other private space companies like United Launch Alliance (ULA) have contracted with Blue Origin to use Blue Engine to supply rockets.<sup>27</sup> NASA recently awarded Blue Origin its first interplanetary contract to study the magnetic field around Mars; that project is planned for 2024.<sup>28</sup>

*B. NASA's Partnership with Private Actors for the Artemis Mission to the Moon and Lunar Resource Collection*

The Artemis Mission is NASA's ongoing three-part project to return to the Moon.<sup>29</sup> NASA plans to land the first woman and first person of color on the Moon and explore more of the lunar surface.<sup>30</sup> While NASA learns more about the Moon's surroundings, it

<sup>18</sup> Emre Kelly, *How Elon Musk Took SpaceX From an Idea to the Cusp of Making History*, USA TODAY (May 26, 2020, 11:01 AM), <https://www.usatoday.com/story/news/nation/2020/05/26/spacex-how-elon-musk-took-idea-cusp-history/5257977002/> [https://perma.cc/2S4V-8SYJ].

<sup>19</sup> Mann, *supra* note 13.

<sup>20</sup> Cathal O'Connell, *Reusable Rockets Explained*, COSMOS (Feb. 6, 2018), <https://cosmosmagazine.com/space/launch-land-repeat-reusable-rockets-explained/> [https://perma.cc/F8NN-D6FT].

<sup>21</sup> *Falcon 9*, SPACE X, <https://www.spacex.com/vehicles/falcon-9/> [https://perma.cc/AR3D-ZZTD] (last visited Sept. 14, 2023).

<sup>22</sup> *Id.*

<sup>23</sup> Denise Chow, *To Cheaply Go: How Falling Launch Costs Fueled a Thriving Economy in Orbit*, NBC (Apr. 8, 2022, 10:52 AM), <https://www.nbcnews.com/science/space/space-launch-costs-growing-business-industry-rcna23488/> [https://perma.cc/D59N-UA5C].

<sup>24</sup> *Id.*

<sup>25</sup> *Engines*, BLUE ORIGIN, <https://www.blueorigin.com/engines/> [https://perma.cc/9Y4G-BRZA] (last visited Sept. 14, 2023).

<sup>26</sup> *Id.*

<sup>27</sup> *Blue Origin Completes the Delivery of Flight Engines to ULA for Vulcan's Initial Launch*, BLUE ORIGIN (Oct. 31, 2022), <https://www.blueorigin.com/news/blue-origin-completes-the-delivery-of-flight-engines-to-ula-for-vulcan-initial-launch> [https://perma.cc/L7FD-9E5M].

<sup>28</sup> Claire A. O'Shea, *NASA Selects Blue Origin to Launch Mars' Magnetosphere Study Mission*, NASA (Feb. 9, 2023), <https://www.nasa.gov/press-release/nasa-selects-blue-origin-to-launch-mars-magnetosphere-study-mission> [https://perma.cc/GBD7-X6Q8].

<sup>29</sup> *Artemis*, NASA, <https://www.nasa.gov/specials/artemis/> [https://perma.cc/7U5D-RWLD] (last visited Sept. 14, 2023).

<sup>30</sup> *Id.*

ultimately plans to send the first astronauts to Mars.<sup>31</sup> NASA's motivations for going back to the Moon are scientific discovery, economic benefit, and inspiration for a new generation of explorers. NASA also wants to maintain U.S. leadership in space exploration and wants to build a global alliance to explore deep space for the benefit of all humankind through the Artemis Mission.<sup>32</sup>

The first part of the Artemis Mission has been completed, and the last two parts of the mission are planned for 2024 and 2025 respectively. Artemis I was completed in 2022 by launching the Orion spacecraft and the Space Launch System (SLS) rocket with no on-board crew. This mission aimed to demonstrate the Orion's systems in a spaceflight environment and ensure a safe re-entry, descent, splashdown, and recovery.<sup>33</sup> Artemis II is expected to fly four astronauts around the Moon to test the SLS rocket and Orion spacecraft with crew for the first time.<sup>34</sup> Artemis II is scheduled for a ten-day flight test to lead the way for the last mission, landing on the Moon.

Artemis III, the last part of the Artemis Mission, is expected to be the first human mission to the lunar south pole.<sup>35</sup> The lunar south pole offers unique insights into lunar ice and water.<sup>36</sup> First, in the lunar south pole, sunlight hits the Moon's surface at a very low angle.<sup>37</sup> Therefore, the floors of polar craters in the polar regions of the Moon reach extremely low temperatures, down to negative 414 degrees Fahrenheit, creating ice deposits.<sup>38</sup> The small tilt on the Moon's rotation axis also contributes to sunlight not reaching the south pole region.<sup>39</sup> Steven Clarke, deputy associate administrator of the Science Mission Directorate at NASA Headquarters in Washington D.C., said, "[w]e know the South Pole region contains ice and may be rich in other resources based on our observations from orbit, but, otherwise, it's a completely unexplored world."<sup>40</sup> However, in 2020, NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) confirmed that there was water on the sunlit surface of the Moon.<sup>41</sup>

Back in 2020, NASA selected companies to collect lunar resources for Artemis demonstrations.<sup>42</sup> The leading companies that NASA has contracted with for lunar resource extraction are Lunar Outpost, ispace, and Masten Space Systems.<sup>43</sup> The

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<sup>31</sup> *Id.*

<sup>32</sup> *Id.*

<sup>33</sup> *Artemis I*, NASA, <https://www.nasa.gov/mission/artemis-i/> [<https://perma.cc/K26Q-W8WK>] (last visited Oct. 12, 2023).

<sup>34</sup> *Artemis II*, NASA, <https://www.nasa.gov/mission/artemis-ii/> [<https://perma.cc/8NQ9-HTVR>] (last visited Oct. 12, 2023).

<sup>35</sup> Lee Mohon, *Artemis III: NASA's First Human Mission to the Lunar South Pole*, NASA (Jan. 13, 2023), <https://www.nasa.gov/feature/artemis-iii> [<https://perma.cc/28GV-M9TJ>].

<sup>36</sup> *Moon's South Pole in NASA's Landing Sites*, NASA (Apr. 16, 2019), <https://solarsystem.nasa.gov/news/907/moons-south-pole-in-nasas-landing-sites/> [<https://perma.cc/V789-32YM>].

<sup>37</sup> *Id.*

<sup>38</sup> *Id.*

<sup>39</sup> *Id.*

<sup>40</sup> *Id.*

<sup>41</sup> *NASA's SOFIA Discovers Water on Sunlit Surface of Moon*, NASA (Oct. 26, 2020), <https://www.nasa.gov/press-release/nasa-s-sofia-discovers-water-on-sunlit-surface-of-moon> [<https://perma.cc/LP23-ERQ8>].

<sup>42</sup> *NASA Selects Companies to Collect Lunar Resources for Artemis Demonstrations*, NASA (Dec. 3, 2020), <https://www.nasa.gov/press-release/nasa-selects-companies-to-collect-lunar-resources-for-artemis-demonstrations> [<https://perma.cc/R9AU-F54U>].

<sup>43</sup> *Id.*

companies have agreed to individually collect a small amount of lunar soil or rocks from any location on the surface of the Moon, then provide imagery to NASA of the collection location data, and finally transfer ownership of the collected material from the Moon to NASA for use under the Artemis Program.<sup>44</sup> NASA says that the collection and transfer of the lunar material will be a “proof of concept for conducting space commerce on the Moon.”<sup>45</sup> Mike Gold, NASA’s acting associate administrator for international and interagency relations, says, “[t]hese awards expand NASA’s innovative use of public-private partnerships to the Moon. We’re excited to join with our commercial and international partners to make Artemis the largest and most diverse global human space exploration coalition in history.”<sup>46</sup>

Lunar Outpost is a company with the mission of creating advanced technology that enables an extended presence on the lunar surface while having positive impact on Earth.<sup>47</sup> Lunar Outpost has missions planned in 2023 and 2024 to send a rover to the Lunar South Pole. Other than NASA, Lunar Outpost has previously worked for the U.S. Air Force, U.S. Environmental Protection Agency (EPA), and the Massachusetts Institute of Technology (MIT).<sup>48</sup> Masten Space Systems, acquired by Astrobotic, produces reusable landers that delivers satellites and instruments to the lunar surface or lunar orbit.<sup>49</sup> ispace, founded in Japan, develops micro-robotic technology to provide a lunar robotic exploration service.<sup>50</sup> ispace also aims to take advantage of lunar water resources and make the Earth and the Moon one new economy with space infrastructure to support human life.<sup>51</sup>

## II. ROCKET LAUNCHES ON EARTH

Rocket launches have environmental impacts on Earth that affect global warming, public health, and marginalized groups. These impacts can be attributed to inadequate regulation, research, and misguided priorities. Since the space industry and space travel are still in their early stages, it will be important to implement new legislation and research projects to prevent further environmental harm on Earth and create a sustainable long-term plan for space exploration. Regulating rocket launches and their facilities through the CAA is a promising potential solution.

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<sup>44</sup> *Id.*

<sup>45</sup> NASA, *NASA Asks Commercial Companies to Collect Moon Rocks*, YOUTUBE (Sept. 10, 2020), [https://www.youtube.com/watch?v=V7bhhKOON\\_o&ab\\_channel=NASA](https://www.youtube.com/watch?v=V7bhhKOON_o&ab_channel=NASA).

<sup>46</sup> NASA, *supra* note 42.

<sup>47</sup> *Our Philosophy*, LUNAR OUTPOST, <https://lunaroutpost.com/about/> [<https://perma.cc/G9M3-YZPK>] (last visited Sept. 14, 2023).

<sup>48</sup> *Id.*

<sup>49</sup> *Lunar Landers*, MASTEN, <https://masten.aero/lunar-landers/> [<https://perma.cc/Y6VK-4CTE>] (last visited Sept. 14, 2023).

<sup>50</sup> *About Us*, ISPACE, <https://ispace-inc.com/aboutus> [<https://perma.cc/2JG3-DLW2>] (last visited Sept. 14, 2023).

<sup>51</sup> *Id.*



### A. *The Environmental Impact of Rocket Emissions*

Rocket engines release pollution into the atmosphere like any form of combustion-driven propulsion.<sup>52</sup> Rocket soot and other emissions did not have any significant environmental impacts decades ago when there were only around seventy commercial rocket launches per year.<sup>53</sup> However, rocket launches have tripled in recent decades and are expected to increase significantly more over the next two decades.<sup>54</sup> This increase is due to demand for satellite internet services that rely on rockets to launch them into space and the increase of commercial space flights.<sup>55</sup> Research into green alternatives for propulsion, like electric propulsion, can help mitigate environmental damage from the current booming space industry and its continued growth.

#### 1. Greenhouse Gases and Global Warming

The Industrial Revolution brought development and innovation during the second half of the 1700s to the early 1800s, but at a great cost to the environment.<sup>56</sup> From mechanized looms for weaving cloth and the steam-powered locomotive to improvements in iron smelting, the economic growth and the invention of new technologies changed life in Europe and the United States.<sup>57</sup> However, there was a tradeoff between conserving the environment and widespread development, and development took precedence.<sup>58</sup>

The Industrial Revolution kick-started climate change and the warming of Earth.<sup>59</sup> The growth of industrial cities and the increased burning of coal, a fossil fuel, caused an unprecedented release of pollution and carbon dioxide into the atmosphere.<sup>60</sup> When carbon dioxide and other air pollutants collect in the atmosphere and absorb solar radiation, global warming occurs and causes Earth to get hotter.<sup>61</sup> “Carbon dioxide, methane, nitrous oxide, water vapor, and synthetic fluorinated gases are known as greenhouse gases and their impact is called the greenhouse effect.”<sup>62</sup> The greenhouse effect is essential to life on Earth, but human-made emissions in the atmosphere are trapping and slowing heat loss to space at a rate that is detrimental to Earth’s ecosystem.<sup>63</sup>

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<sup>52</sup> Mark Piesing, *The Pollution Caused by Rocket Launches*, BBC (July 15, 2022), <https://www.bbc.com/future/article/20220713-how-to-make-rocket-launches-less-polluting> [<https://perma.cc/QY9C-N4FR>].

<sup>53</sup> *Id.*

<sup>54</sup> *Projected Increase in Space Travel May Damage Ozone Layer*, NOAA RSCH. (June 21, 2022), <https://research.noaa.gov/2022/06/21/projected-increase-in-space-travel-may-damage-ozone-layer/> [<https://perma.cc/V7CR-X6YY>].

<sup>55</sup> Piesing, *supra* note 52.

<sup>56</sup> Patrick J. Kiger, *7 Negative Effects of the Industrial Revolution*, HISTORY (Aug. 9, 2023), <https://www.history.com/news/industrial-revolution-negative-effects> [<https://perma.cc/JF9D-XWU9>].

<sup>57</sup> *Id.*

<sup>58</sup> *Id.*

<sup>59</sup> *Id.*

<sup>60</sup> *Id.*

<sup>61</sup> Jeff Turrentine & Amanda MacMillan, *Global Warming 101*, NRDC (Apr. 7, 2021), <https://www.nrdc.org/stories/global-warming-101> [<https://perma.cc/5WZ8-BUJH>].

<sup>62</sup> *Id.*

<sup>63</sup> *The Causes of Climate Change*, NASA, <https://climate.nasa.gov/causes/> [<https://perma.cc/2TNT-YPKD>] (last visited Oct. 12, 2023).

The four major gases that contribute to the greenhouse effect are carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (CFCs).<sup>64</sup> Carbon dioxide is released through human activities like burning fossil fuels and deforestation.<sup>65</sup> Due to the increase of human activities, the amount of carbon dioxide in the atmosphere has grown up to 50% since the Industrial Revolution began.<sup>66</sup> Water vapor, though less discussed, also contributes to the greenhouse effect by trapping heat.<sup>67</sup>

## 2. Black Carbon, Water Vapor, and Electric Propulsion

Rockets require a multitude of propellants to make it out of the Earth's atmosphere, and many types of rocket fuel contain a toxic component called hydrazine.<sup>68</sup> Hydrazine is corrosive, toxic, and potentially carcinogenic.<sup>69</sup> Exposure to high levels of hydrazine can cause multiple health problems, including damage to the liver, kidneys, and central nervous system.<sup>70</sup> The vapor of hydrazine requires the use of Self Contained Atmospheric Protective Ensemble (SCAPE).<sup>71</sup> This overhead cost must be considered when planning ground processing workflow for rockets and may impose undesirable constraints with the launch provider and the rocket itself.<sup>72</sup> Hydrazine propulsion systems typically incorporate redundant serial valves to prevent spills or leaking vapor, which might harm ground personnel or hardware.<sup>73</sup> In 2011, the European Chemicals Agency added hydrazine to its list of "substances of very high concern," suggesting the future restriction of using hydrazine.<sup>74</sup> Phasing out the use of hydrazine for a "green" alternative would be beneficial for the environment and also reduce the lengthy process of working with hydrazine.

The type of propellants used in rockets differs between each space company, but propellant fuels that release carbon dioxide and black carbon are common in the industry. For example, SpaceX uses kerosene and liquid oxygen for fuel, which release carbon dioxide and black carbon into the atmosphere.<sup>75</sup> A SpaceX rocket, Falcon9, uses 112 tons

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<sup>64</sup> *Id.*

<sup>65</sup> *Id.*

<sup>66</sup> *Id.*

<sup>67</sup> *Id.*

<sup>68</sup> Katharine Gammon, *How the Billionaire Space Race Could be One Giant Leap for Pollution*, THE GUARDIAN (July 19, 2021), <https://www.theguardian.com/science/2021/jul/19/billionaires-space-tourism-environment-emissions> [<https://perma.cc/N2C2-384N>]; AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY, DEP'T OF HEALTH & HUM. SERVS., PUBLIC HEALTH STATEMENT FOR HYDRAZINES (Sept. 1997), <https://www.atsdr.cdc.gov/ToxProfiles/tp100-c1-b.pdf> [<https://perma.cc/72PR-EAM2>].

<sup>69</sup> Kelly Oakes, *Making Satellites Safer: The Search for New Propellants*, HORIZON (Mar. 30, 2020), <https://ec.europa.eu/research-and-innovation/en/horizon-magazine/making-satellites-safer-search-new-propellants> [<https://perma.cc/AA95-DUNN>]; AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY, *supra* note 68.

<sup>70</sup> Oakes, *supra* note 69; AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY, *supra* note 68.

<sup>71</sup> NASA, STATE-OF-THE-ART: SMALL SPACECRAFT TECHNOLOGY 65 (2023), <https://www.nasa.gov/wp-content/uploads/2023/05/2022-soa-full.pdf> [<https://perma.cc/F5P2-KF8Z>].

<sup>72</sup> *Id.*

<sup>73</sup> *Id.*

<sup>74</sup> Oakes, *supra* note 69.

<sup>75</sup> SPACEX, *supra* note 21.

of refined kerosene for its launch, emitting about 336 tons of carbon dioxide.<sup>76</sup> This is equivalent to driving an average car almost seventy times around the world.<sup>77</sup>

One pollutant released by propellants, black carbon, comprises a significant portion of particulate matter that is 2.5 micrometers and smaller (PM 2.5).<sup>78</sup> PM 2.5 has been shown to be one of the deadliest conventional pollutants because its particles can penetrate deep into the lungs.<sup>79</sup> Exposures to PM 2.5 can also have harmful effects on the cardiovascular system, including heart attacks and strokes,<sup>80</sup> which can result in emergency department visits, hospitalizations, and, in some cases, premature deaths.<sup>81</sup> On Earth, PM 2.5 causes haze in parts of the United States, including many national parks and wilderness areas.<sup>82</sup> PM 2.5 can also be carried over long distances by wind and settle on soils or surface waters.<sup>83</sup> This settling can make lakes and streams acidic, change the nutrient balance in coastal waters and large river basins, deplete the nutrients in soil, damage sensitive forests and agricultural crops, and affect the diversity of an ecosystem.<sup>84</sup>

Though rockets currently emit less black carbon than other sources that burn fossil fuel, this is only because the space industry has not fully expanded to its potential.<sup>85</sup> In 2022, Professor Eloise Marais and a team of researchers from the University College of London, the University of Cambridge, and the Massachusetts Institute of Technology found that black carbon emissions will more than double after just an additional three years of space tourism launches.<sup>86</sup> Furthermore, the team found that the particles emitted by rockets are almost 500 times more efficient at holding heat in the atmosphere than all other sources of soot combined, resulting in an enhanced warming climate effect.<sup>87</sup> Darin Toohey, a professor of atmospheric science at the University of Colorado Boulder, said, “If you look at kilogram per kilogram, black carbon is between 100,000 and a million times more effective at heating the upper atmosphere.”<sup>88</sup> Though rocket emissions in 2023 are insufficient to significantly affect global warming now, there should be more research and regulation created while the space industry is in its infancy for easier control and long term management.

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<sup>76</sup> Alexandra Franklin-Cheung, *Can Space Exploration be Environmentally Friendly?*, BBC SCIENCE FOCUS (Aug. 13, 2021), <https://www.sciencefocus.com/science/environmentally-friendly-space-travel/> [<https://perma.cc/8XDA-N7ZD>].

<sup>77</sup> *Id.*

<sup>78</sup> *Black Carbon*, CLIMATE & CLEAN AIR COAL. <https://www.ccacoalition.org/short-lived-climate-pollutants/black-carbon> [<https://perma.cc/UB93-MD4V>] (last visited Sept. 14, 2023). *See generally* ROBERT V. PERCIVAL, CHRISTOPHER H. SCHROEDER, ALAN S. MILLER, & JAMES P. LEAPE, ENVIRONMENTAL REGULATION, LAW, SCIENCE, AND POLICY 448–53 (2022).

<sup>79</sup> CLIMATE & CLEAN AIR COAL., *supra* note 78.

<sup>80</sup> *Id.*

<sup>81</sup> *Id.*

<sup>82</sup> *Id.*

<sup>83</sup> *Id.*

<sup>84</sup> *Id.*

<sup>85</sup> *See generally* Piesing, *supra* note 52.

<sup>86</sup> *Id.*

<sup>87</sup> *Id.*

<sup>88</sup> Stephanie Ebbs, *Experts Say Climate Impact Is a Question Mark if Space Tourism Takes Off*, ABC (Dec. 9, 2021, 5:07 AM), <https://abcnews.go.com/Technology/experts-climate-impacts-question-mark-space-tourism-takes/story?id=81609878> [<https://perma.cc/Y4BR-2QBT>].

Another problem stemming from rocket launches is the direct injection of pollutants into multiple layers of the atmosphere.<sup>89</sup> Unlike a commercial airplane that flies six to eight miles above Earth somewhere between the troposphere and stratosphere, space rockets go sixty-two miles above Earth into the mesosphere.<sup>90</sup> Professor Eloise Marais is concerned with the potential impacts of the direct injection of pollutants and believes that it is “too potentially hazardous” to gamble with having an unregulated industry.<sup>91</sup>

Besides global warming issues, rocket launches also have an impact on the ozone layer that raises concern.<sup>92</sup> According to 2022 research conducted by the National Oceanic and Atmospheric Administration (NOAA), a ten-fold increase in hydrocarbon-fueled launches, which is plausible to happen within the next two decades, will damage the ozone layer and change atmospheric circulation patterns.<sup>93</sup> Even though the current loss of the ozone caused by rocket launches is small, the rise of private actors and frequent rocket launches may undercut the improvement of the ozone layer and the success of ozone protection.

Unlike SpaceX, Blue Origin uses liquid oxygen and hydrogen, which only release water vapor when burned.<sup>94</sup> Water vapor is significantly better for the environment than black carbon, but it still produces environmental effects that contribute to global warming.<sup>95</sup> Alan Buis from NASA says, “water vapor does not condense and precipitate out of the atmosphere as easily at high temperatures.”<sup>96</sup> Therefore, water vapor absorbs heat radiated from Earth and prevents it from escaping out to space, causing the atmosphere to get warmer, resulting in even more water vapor in the atmosphere.<sup>97</sup> This is called a positive feedback loop, and scientists estimate that this effect more than doubles the warming that would happen due to increasing carbon dioxide alone.<sup>98</sup> Professor Eloise Marais says, “[w]ater vapor can also actually contribute to the formation of clouds in the upper atmosphere where clouds are quite rare and clouds, also, unfortunately, have climate impacts. They change how much sun is reflected or reaches the surface of the Earth.”<sup>99</sup>

Unlike chemical propulsion, like those discussed above that use fuel and an oxidizer that converts energy stored in the chemical bonds of the propellants, an electric propulsion system uses energy collected by either a solar electric propulsion or a nuclear electric propulsion for launching a rocket into space.<sup>100</sup> Electric propulsion uses electrical power to accelerate a propellant to create the thrust to launch a rocket to space whereas chemical propulsion uses energy from the discharge of propellant to create the thrust to send a rocket

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<sup>89</sup> *Id.*

<sup>90</sup> *Id.*

<sup>91</sup> *Id.*

<sup>92</sup> NOAA RESEARCH, *supra* note 54.

<sup>93</sup> *Id.*

<sup>94</sup> *Id.*

<sup>95</sup> *Id.*

<sup>96</sup> Alan Buis, *Steamy Relationships: How Atmospheric Water Vapor Amplifies Earth’s Greenhouse Effect*, ASK NASA CLIMATE (Feb. 8, 2022, 7:55 AM), <https://climate.nasa.gov/explore/ask-nasa-climate/3143/steamy-relationships-how-atmospheric-water-vapor-amplifies-earths-greenhouse-effect/> [<https://perma.cc/2GTK-LU7S>].

<sup>97</sup> *Id.*

<sup>98</sup> *Id.*

<sup>99</sup> Ebbs, *supra* note 88.

<sup>100</sup> *Electric Spacecraft Propulsion*, ESA SCIENCE & TECHNOLOGY (Sept. 1, 2019), <https://sci.esa.int/web/smart-1/-/34201-electric-spacecraft-propulsion> [<https://perma.cc/3JRV-WSBF>].

to space.<sup>101</sup> Rockets powered by an electric-base system require less propellant mass than a rocket using chemical propulsion for launch.<sup>102</sup> Therefore, electric propulsion can reduce the amount of fuel and propellant needed by up to 90% compared to chemical propulsion systems.<sup>103</sup> In turn, the cost of missions to outer space is diminished and the environment on Earth benefits from the lessened amount of propellants needed for each space launch.<sup>104</sup> This, however, is not to say that electric propulsion has absolutely no environmental impact. Rather, the use of electric propulsion is a better choice from an environmental standpoint than the conventional propellant, which is hydrazine.<sup>105</sup>

With private companies like SpaceX that have the capacity to successfully launch rockets and a consumer group that is willing to pay for space flights, it is likely that rockets will soon be a major player in depleting the Earth's atmospheric ozone layer and contributing to global warming. Instead of using the current industry standard of propellants for space travel, more research into electric propulsion could benefit the environment on Earth, as well as reducing costs of space exploration for more efficiency overall.<sup>106</sup>

### B. *Regulating Rocket Launches*

The Outer Space Treaty was adopted in 1967.<sup>107</sup> The treaty was written to be a guiding document for international space law and is focused on promoting the peaceful exploration of space.<sup>108</sup> As of 2023, there are 112 States Parties and eighty-nine Signatory States to the treaty.<sup>109</sup> The treaty contains seventeen articles and is composed of broad principles on what a country can and cannot do in space.<sup>110</sup> However, since the treaty was created during the early stages of space exploration, it does not address issues like private actors in space or environmental concerns on Earth.<sup>111</sup>

Besides the Outer Space Treaty, the National Environmental Policy Act (NEPA) requires environmental impact statements for launch sites.<sup>112</sup> In conjunction, the Federal Aviation Administration (FAA) is responsible for providing licenses to space companies

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<sup>101</sup> *Id.*

<sup>102</sup> NASA, ELECTRIC PROPULSION (2002), [https://www.nasa.gov/centers/marshall/pdf/100403main\\_electric\\_propulsion.pdf](https://www.nasa.gov/centers/marshall/pdf/100403main_electric_propulsion.pdf) [<https://perma.cc/C2SL-398H>].

<sup>103</sup> *Id.*

<sup>104</sup> *Id.*

<sup>105</sup> MARK W. CROFTON & TOBY D. HAIN, ENVIRONMENTAL CONSIDERATIONS FOR XENON ELECTRIC PROPULSION *passim* (2007), <http://electricrocket.org/IEPC/IEPC-2007-257.pdf> [<https://perma.cc/53XF-SEHR>].

<sup>106</sup> Nikki Welch & Kaveon Smith, *The Propulsion We're Supplying, It's Electrifying*, NASA (Oct. 22, 2020), <https://www.nasa.gov/feature/glenn/2020/the-propulsion-we-re-supplying-it-s-electrifying> [<https://perma.cc/AJ99-TN4N>].

<sup>107</sup> Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty].

<sup>108</sup> *Id.*

<sup>109</sup> *Status of the Treaty*, UNODA, [https://treaties.unoda.org/t/outer\\_space](https://treaties.unoda.org/t/outer_space) [<https://perma.cc/Q495-D5F8>] (last visited Sept. 13, 2023).

<sup>110</sup> *Id.*

<sup>111</sup> *Id.*

<sup>112</sup> *SpaceX Texas Launch Site Environmental Impact Statement*, FAA (May 13, 2021), [https://www.faa.gov/space/environmental/nepa\\_docs/spacex\\_texas\\_eis](https://www.faa.gov/space/environmental/nepa_docs/spacex_texas_eis) [<https://perma.cc/K8UM-5Y8W>].

to launch a rocket in the United States.<sup>113</sup> Nevertheless, the current federal regulatory scheme is insufficient to address the full environmental issues posed by rocket launches, as seen in Boca Chica, Texas. Using the CAA to regulate rocket launches and their facilities could be a viable solution.

### 1. Article VI and Article IX of the Outer Space Treaty

Among the seventeen articles of the Outer Space Treaty, there are two articles that are relevant to regulating private actors in space and addressing environmental concerns on Earth: Article VI and Article IX.<sup>114</sup> Under the treaty, there is no separate article or clause addressing private companies.<sup>115</sup> However, Article VI states that the activities of “non-governmental entities” in outer space, including on the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty.<sup>116</sup> Yet, depending on the interpretation of “non-governmental entities,” private actors may or may not be included and therefore escape any influence that the treaty has. For example, one interpretation of “non-governmental entities” is that it only includes inter-governmental organizations.<sup>117</sup> When the treaty was written in the late 1960s, the space industry comprised solely of individual countries and inter-governmental organizations.<sup>118</sup> A less likely interpretation is that when the treaty was written, drafters considered private actors and wanted to include those actors in Article VI.<sup>119</sup>

The Outer Space Treaty was created for the peaceful exploration of space and international cooperation, but there are no provisions discussing the possible environmental issues that may arise on Earth. Article IX, however, comes close to regulating potential environmental issues on Earth. Article IX states that State Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, conduct exploration of them so as to avoid harmful contamination and other adverse changes to the “environment of the Earth” resulting from the introduction of extraterrestrial matter and, where necessary, adopt appropriate measures for this purpose.<sup>120</sup> Article IX is referring to environmental harm on Earth caused by bringing some matter from outer space that could be dangerous, instead of addressing environmental harm on Earth that is caused by space activities like rocket emissions.<sup>121</sup>

In the treaty, the word “environment” appears only once in Article IX, and its focus is on the harmfulness of objects from space when introduced on Earth. The treaty includes no provision or other language that discusses environmental regulation of the space industry for the protection of the environment on Earth.<sup>122</sup> However, if there is to be an amendment that addresses environmental concerns on Earth, it would make the most sense to append it to Article IX, since none of the other articles concern the environment on

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<sup>113</sup> *Id.*

<sup>114</sup> Outer Space Treaty, *supra* note 107.

<sup>115</sup> *Id.*

<sup>116</sup> *Id.*

<sup>117</sup> See generally Christina Isnardi, *Problems with Enforcing International Space Law on Private Actors*, 58 COLUM. J. TRANSNAT'L L. 489 (2020).

<sup>118</sup> *Id.*

<sup>119</sup> *Id.*

<sup>120</sup> *Id.*

<sup>121</sup> Outer Space Treaty, *supra* note 107.

<sup>122</sup> *Id.*

Earth. Under Part IV, Article 39 of the Vienna Convention on the Law of Treaties, a treaty may be amended by agreement between the parties.<sup>123</sup> Article 40 further goes into the rule that every party to the multilateral treaty must be notified for the amendment to be possible.<sup>124</sup> There is nothing directly in the Vienna Convention on the Law of Treaties preventing an amendment for the addition of a whole new article, but it will likely take longer time and cause more delay than adding a few more words in an already existing Article IX that addresses the “environmental harm on Earth.”

Even if the Outer Space Treaty is interpreted to regulate private actors, international corporate liability for environmental harm is largely nonexistent.<sup>125</sup> The United Nations Office for Outer Space Affairs (UNOOSA) should write a new treaty addressing both space exploration and environmental protection on Earth. The new treaty can be a guiding document for countries to follow and create their own domestic laws with environmental protection as a base. Therefore, a solution for the United States could be focusing on domestic law such as the CAA, which is proposed at the end of Part II.

Considering the ambiguity in the Outer Space Treaty and how high the stakes are for the protection of the environment on Earth, it is important to consider a rewrite or supplement of the Treaty to regulate private actors in the space industry. The space industry is highly dependent on private actors for space exploration. Governments frequently partner up with private actors to further their goals of science and national missions.<sup>126</sup> Yet private actors also engage in their own commercial activities, separate from the government. Therefore, regulating private actors as a separate entity from the government must be considered and implemented by UNOOSA.

## 2. Boca Chica

NEPA is one of the few environmental statutes that regulates rocket launches in the United States by requiring the Office of Commercial Space to integrate environmental values into its decision-making process.<sup>127</sup> The Office of Commercial Space is a part of the Office of the Secretary of Transportation within the Department of Transportation.<sup>128</sup> The line of work that the Office of Commercial Space is responsible for are regulating the U.S. commercial space industry and managing licensing and regulatory work related to the private sector.<sup>129</sup> The Office of Commercial Space also considers the environmental impacts of proposed actions and reasonable alternatives to those actions to make decisions based on environmental consequences.<sup>130</sup> In conjunction, the FAA is responsible for giving

<sup>123</sup> Vienna Convention on the Law of Treaties, art. 39, May 23, 1969, 1155 U.N.T.S. 331.

<sup>124</sup> *Id.* art. 40.

<sup>125</sup> Outer Space Treaty, *supra* note 107.

<sup>126</sup> Laura L. Means, *NASA Awards SpaceX Second Contract Option for Artemis Moon Landing*, NASA (Nov. 15, 2022), <https://www.nasa.gov/press-release/nasa-awards-spacex-second-contract-option-for-artemis-moon-landing-0> [<https://perma.cc/N2KD-6LB7>].

<sup>127</sup> *Environmental*, FAA (June 2, 2023), <https://www.faa.gov/space/environmental> [<https://perma.cc/B7LE-SNXZ>].

<sup>128</sup> *About the Office of Commercial Space Transportation*, FAA, [https://www.faa.gov/about/office\\_org/headquarters\\_offices/ast](https://www.faa.gov/about/office_org/headquarters_offices/ast) [<https://perma.cc/X2RX-HHFZ>] (last visited Sept. 13, 2023).

<sup>129</sup> *Id.*

<sup>130</sup> *Office of Commercial Space Transportation Environmental Policy*, FAA (Sept. 23, 2011), [https://www.faa.gov/sites/faa.gov/files/space/environmental/AST\\_ENVIRONMENTAL\\_POLICY.pdf](https://www.faa.gov/sites/faa.gov/files/space/environmental/AST_ENVIRONMENTAL_POLICY.pdf) [<https://perma.cc/6QQW-5B6A>].

licenses and permits to commercial launches and individual launch operators.<sup>131</sup> The FAA can give a company a vehicle operator license which authorizes a licensee to conduct one or more launches or reentries using the same vehicle or family of vehicles.<sup>132</sup> The FAA can also give an experimental permit to authorize the launch of a reusable suborbital rocket for research, a showing of compliance with requirements for obtaining a license, or a crew training before obtaining a license.<sup>133</sup> During the evaluation of a license application, the FAA includes a review of potential environmental impact among other safety issues like national security, public safety, foreign policy concerns, and insurance requirements.<sup>134</sup>

However, NEPA and the FAA are largely ineffective at regulating the full environmental effect of rocket launches and environmental justice concerns. This is because of the fairly low barrier that private companies need to meet for the environmental assessment.<sup>135</sup> For example, the SpaceX Starship located in Starbase, one among four launch sites operated by SpaceX, received its environmental assessment from the FAA for a launch in the region along the Gulf Coast in Texas, despite local environmental concerns and criticism.<sup>136</sup>

Environmentalists were concerned that the repeated Starship launches would cause blasts of loud noise and rocket exhaust would disrupt the ecosystem.<sup>137</sup> This is because State Highway 4 runs next to the SpaceX site and passes through Boca Chica Beach, Texas State Parks, and the Lower Rio Grande National Wildlife Refuge.<sup>138</sup> The FAA concluded that SpaceX's plan for orbital launches will have "no significant impact on the environment."<sup>139</sup> SpaceX was required to undertake seventy-five actions to minimize the impact on the surrounding area but was not required to delay the launching date or engage in any comprehensive research on the potential environmental impact.<sup>140</sup>

Jim Chapman, a board member of the Save RGV, a nonprofit environmental advocacy group trying to protect the Rio Grande Valley, commented for the *New York Times* that "[f]or them to say there is no significant impact is ludicrous. The impacts are simply too large. We still feel that way. The FAA should have recognized that."<sup>141</sup> In October 2021, Save RGV sued the Texas General Land Office, Texas Land Commissioner George P. Bush, and Cameron County for closing Boca Chica for SpaceX operations because the Texas constitution does not allow restricting access to a public beach.<sup>142</sup> In

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<sup>131</sup> *Licensing and Permitting Process*, FAA (Nov. 12, 2020), [https://www.faa.gov/space/stakeholder\\_engagement/spacex\\_starship/license\\_review\\_process](https://www.faa.gov/space/stakeholder_engagement/spacex_starship/license_review_process) [<https://perma.cc/8KW2-XZG3>].

<sup>132</sup> *Id.*

<sup>133</sup> *Id.*

<sup>134</sup> *Id.*

<sup>135</sup> Kenneth Chang, *SpaceX Wins Environmental Approval for Launch of Mars Rocket*, N.Y. TIMES (June 13, 2022), <https://www.nytimes.com/2022/06/13/science/spacex-starship-faa-review.html> [<https://perma.cc/U9WT-XGH3>].

<sup>136</sup> *Starbase Overview*, SPACEX, <https://www.spacex.com/vehicles/starship/assets/media/Starbase%20Overview.pdf> [<https://perma.cc/EX4B-8RXD>]; Chang, *supra* note 135.

<sup>137</sup> Chang, *supra* note 135.

<sup>138</sup> *Id.*

<sup>139</sup> *Id.*

<sup>140</sup> *Id.*

<sup>141</sup> *Id.*

<sup>142</sup> *Sierra Club Joins Lawsuit Against Texas GLO and Cameron County for Closing Boca Chica Beach for SpaceX*, SIERRA CLUB (May 5, 2022), <https://www.sierraclub.org/press-releases/2022/05/sierra-club-joins-lawsuit-against-texas-glo-and-cameron-county-for-closing> [<https://perma.cc/AP5H-NCR2>].



2013, the Legislature amended the Texas Open Beaches Act to allow beaches in Texas to close for space flight operations.<sup>143</sup> Five years later, SpaceX built its rocket-launching facility 1,500 feet from water's edge on Boca Chia beach. The 2013 amendment conflicts with Texas state constitution, which guarantees the right to free and open access to public beaches.<sup>144</sup> In May 2022, the Sierra Club and Carrizo Comecrudo Tribe of Texas joined Save RGV in the lawsuit.<sup>145</sup> The plaintiffs argued that the defendants were closing Boca Chica Beach so frequently that Rio Grande Valley residents have seen their access to the public beach disappear.<sup>146</sup> Additionally, the Carrizo Comecrudo Tribe of Texas was concerned with a lack of access to their ancestral heritage land of Boca Chica Beach.<sup>147</sup> Neither FAA nor SpaceX have ever consulted with the Carrizo Comecrudo Tribe of Texas on the rocket launch operations.<sup>148</sup> In the first three months of 2022, the public beach was closed for 196 hours.<sup>149</sup> Back in 2021, the public beach was closed for over 600 hours.<sup>150</sup> In June 2022, the lawsuit was dismissed in Cameron County's 445<sup>th</sup> district court.<sup>151</sup> Judge Gloria Rincones ruled the plaintiffs do not have jurisdiction, saying there is "no private right of enforcement."<sup>152</sup> Save RGV previously said they would appeal the decision, but there has been no other legal action taken.<sup>153</sup>

The Spanish-speaking community in the Rio Grande Valley was also impacted by the FAA approving a license for SpaceX.<sup>154</sup> In October 2021, the Lone Star Chapter of the Sierra Club, Trucha RGV, Voces Unidas, Las Imaginistas, La Unión del Pueblo Entero, the Carrizo Comecrudo Tribe of Texas, and Another Gulf Is Possible Collaborative submitted a complaint to the FAA to demand that they restart the regulatory process for SpaceX because it was conducted poorly and did not include outreach to the Spanish-speaking community.<sup>155</sup> The FAA failed to provide materials that would have allowed Spanish speakers to participate in the process, such as translated documents and 30-day

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<sup>143</sup> *Id.*

<sup>144</sup> *Id.*

<sup>145</sup> Petition in Intervention, *SAVERGV v. Tex. Gen. Land Off.*, No. 2021-DCL-05887 (445th D. Ct., Cameron Cnty., Tex. May 5, 2022), <https://www.sierraclub.org/sites/default/files/blog/2022.05.05%20SC%20CCN%20Petition%20in%20Intervention.pdf> [<https://perma.cc/GLC7-V2YZ>].

<sup>146</sup> SIERRA CLUB, *supra* note 142.

<sup>147</sup> *Id.*

<sup>148</sup> Emma Guevara, *Hey, FAA! The RGV's Spanish-Speaking Community Deserves Equal Access to SpaceX Approval Process*, SIERRA CLUB (June 3, 2022), <https://www.sierraclub.org/articles/2022/06/hey-faa-rgvs-spanish-speaking-community-deserves-equal-access-spacex-approval> [<https://perma.cc/L5FK-CQD3>].

<sup>149</sup> *Id.*

<sup>150</sup> *Id.*

<sup>151</sup> Notice of Appeal, Exhibits A, B, and C, *SAVERGV v. Tex. Gen. Land Off.*, No. 2021-DCL-05887 (445th D. Ct., Cameron Cnty., Tex. June 30, 2022), <https://www.sierraclub.org/sites/default/files/blog/2022.07.28%20Notice%20of%20Appeal%20Exs.%20A%20B%20and%20C%20%281%29.pdf> [<https://perma.cc/Z8BL-KK3Q>]; Christian von Preysing, *Lawsuit Filed Against Cameron County Over Closure of Public Beach for SpaceX Test Denied*, KRGV (July 7, 2022, 9:13 AM), <https://www.krgv.com/news/lawsuit-filed-against-cameron-county-over-closure-of-public-beach-for-spacex-tests-denied/> [<https://perma.cc/F4HX-TFXS>].

<sup>152</sup> Von Preysing, *supra* note 151.

<sup>153</sup> *Id.*

<sup>154</sup> *Id.*

<sup>155</sup> Guevara, *supra* note 148.

<sup>156</sup> E-mail to FAA, Complaint Under Title VI of the Civil Rights Act of 1964, US DOT Order 5610.2(a), and FAA Order 1050.1F (Oct. 14, 2021), <https://drive.google.com/file/d/1oJzIsFa9FmftWSkrYhsTjQIY2JdHkHZ2/view> [<https://perma.cc/QQJ3-HBAQ>].

public notices in Spanish.<sup>156</sup> The FAA also provided inadequate interpretation during the public hearing on Zoom.<sup>157</sup> Sierra Club argues that this is unacceptable in a region where about 80% of the people speak primarily Spanish at home.<sup>158</sup>

In January 2022, the groups mentioned above submitted a complaint to the FAA and met with the FAA Office of Civil Rights to present their demands.<sup>159</sup> One demand was that the FAA should restart the entire license review process to include Spanish language access for the community.<sup>160</sup> This would include requiring the FAA to publish notice of public hearings and relevant permitting documents, such as the environmental assessment in Spanish.<sup>161</sup> Another demand was that the FAA should consult with the Carrizo Comecrudo Tribe of Texas because they are the Native people of the region whose ancestral and unceded lands include Boca Chica Beach and the surrounding areas.<sup>162</sup> After a couple months of the meeting with the FAA Office of Civil Rights, the groups did not receive any concrete response nor updates on the demands.<sup>163</sup>

Additionally, documents obtained by the Consumer News and Business Channel (CNBC) by the U.S. Fish and Wildlife Services (FWS), in response to a Freedom of Information Act request, showed a decline in endangered piping plovers around Starbase and cited potential harm to other shorebirds and critically endangered sea turtles, should Starbase expand.<sup>164</sup> Part of the FAA's process of granting license and permits includes a consultation with the FWS to ensure that the FAA will not violate the Endangered Species Act if it allows SpaceX to continue its proposed activity.<sup>165</sup> The FWS required SpaceX to monitor affected animal populations carefully, limit construction and launch activity to specific seasons or times of day and night, and use shuttles to reduce vehicle traffic of workers on location.<sup>166</sup> Jared Margolis, senior attorney with the Center for Biological Diversity says that the FWS requires very little in the way of spending, conservation, and commitments by SpaceX<sup>167</sup>: "It seems the [FWS] is bending over backwards to figure out a way to permit...a very detrimental use of the Boca Chica site as far as impacts to wildlife go."<sup>168</sup>

The current regulatory scheme for rocket sites and its emissions are insufficient as seen in Boca Chica. Instead of only having the FAA responsible for conducting environmental impact statements and review, EPA should oversee the approval process simultaneously through the CAA as proposed at subpart II.B.3.

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<sup>156</sup> Guevara, *supra* note 148.

<sup>157</sup> *Id.*

<sup>158</sup> *Id.*

<sup>159</sup> *Id.*

<sup>160</sup> *Id.*

<sup>161</sup> *Id.*

<sup>162</sup> *Id.*

<sup>163</sup> *Id.*

<sup>164</sup> Lora Kolodny, *SpaceX Starbase Expansion Plans Will Harm Endangered Species, According to Fish and Wildlife Service*, CNBC (May 3, 2022 11:43 AM), <https://www.cnbc.com/2022/05/03/spacex-starbase-expansion-plans-will-harm-endangered-species-fws.html> [<https://perma.cc/Y2Z9-6MFW>].

<sup>165</sup> *Id.*

<sup>166</sup> *Id.*

<sup>167</sup> *Id.*

<sup>168</sup> *Id.*

### 3. Proposal for Regulation: The Clean Air Act

The CAA offers a promising solution to regulate U.S. rocket launches by addressing the environmental issues that arise from both the rocket launching facility itself as a “stationary source,” and rocket emissions as a “mobile source.” The 1970 Clean Air Act is the comprehensive federal law that regulates air emissions from stationary and mobile sources.<sup>169</sup> Stationary sources of air pollution include factories, refineries, boilers, and power plants that emit air pollutants.<sup>170</sup> Mobile sources of air pollution include on-road vehicles and engines, such as cars, trucks, buses, motorcycles and nonroad vehicles and engines such as aircraft, diesel boats, forklifts, large ships, and snowmobiles.<sup>171</sup> Fuels and fuel additives such as ethanol and gasoline (E15), diesel, gasoline, and renewables are also regulated as a mobile source under the CAA.<sup>172</sup>

A “major source” is defined in the CAA as any stationary source or any group of stationary sources that are located on or more continuous or adjacent properties and are under common control of the same person.<sup>173</sup> Section 112 of the CAA requires that EPA establish emission standards that require the maximum degree of reduction in emissions of hazardous air pollutants for major sources.<sup>174</sup> A major source must emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants.<sup>175</sup> If a stationary source is considered a major source, the facility needs to obtain a Title V permit to operate.<sup>176</sup> On the other hand, an “area source” is any stationary source that is not a major source.<sup>177</sup> However, “non-major sources” are still subject to National Emission Standards for Hazardous Air Pollutants (NESHAP).<sup>178</sup> Black carbon is an air pollutant subject to NESHAP.<sup>179</sup>

Launch systems must be deemed as a major source because there may be multiple launch facilities in a single launching complex.<sup>180</sup> If launch systems are a major source, a single launching complex would be responsible for all the activities from the multiple launch systems and the buildings in which the operational work and research is situated.<sup>181</sup> Launch systems could also be considered major sources because their emissions consist of

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<sup>169</sup> 42 U.S.C. § 7401.

<sup>170</sup> *Stationary Sources of Air Pollution*, EPA, <https://www.epa.gov/stationary-sources-air-pollution#:~:text=Stationary%20sources%20of%20air%20pollution%2C%20including%20factories%2C%20refineries%2C%20boilers,and%20implementing%20standards%20and%20guidelines> [<https://perma.cc/M7SC-GFTN>] (last visited Sept. 16, 2023).

<sup>171</sup> *Regulatory and Guidance Information by Topic: Air*, EPA (June 6, 2023), <https://www.epa.gov/regulatory-information-topic/regulatory-and-guidance-information-topic-air> [<https://perma.cc/M9TQ-YZ3V>].

<sup>172</sup> *Id.*

<sup>173</sup> 40 C.F.R. § 70.2 (2016).

<sup>174</sup> 42 U.S.C. § 7401.

<sup>175</sup> *Id.*

<sup>176</sup> *Id.*

<sup>177</sup> *Id.*

<sup>178</sup> *Who Has to Obtain a Title V Permit?*, EPA (May 4, 2023), <https://www.epa.gov/title-v-operating-permits/who-has-obtain-title-v-permit> [<https://perma.cc/LPV5-W467>].

<sup>179</sup> *Id.*

<sup>180</sup> See generally Ashima Talwar, *One Small Step for the EPA, One Giant Leap for the Environment: A Hybrid Proposal for Regulating Rocket Emissions Due to the Rising Commercial Space Industry*, 9 GEO. WASH. J. ENERGY & ENV'T L. 87 (2018).

<sup>181</sup> *Id.*

the lift-off, assembly, and maintenance of rockets.<sup>182</sup> For example, the SpaceX facility in Boca Chica, Texas, consists of a rocket production facility, test site, and spaceport.<sup>183</sup> By combining the emissions from all three subparts of the facility, the total aggregate of pollutants could be classified as a major source, necessitating a Title V permit to operate.

The CAA also has an environmental justice permitting plan that outlines the first steps EPA should take to consider and engage overburdened communities in the permitting process.<sup>184</sup> First, the EPA Actions document identifies activities and approaches to promote public involvement by overburdened communities in the permitting process, particularly for major permitted activities that may significantly impact these communities.<sup>185</sup> Second, EPA encourages permit applicants operating or proposing to operate facilities in overburdened communities to strategically plan and conduct enhanced outreach during the permitting process.<sup>186</sup>

In December 2022, EPA's Office of Air and Radiation released eight principles<sup>187</sup> for addressing environmental justice in air permitting.<sup>188</sup> The principles themselves are not legally binding but provide a framework to assist each EPA region to promote environmental justice and equity through air permitting programs.<sup>189</sup> Environmental justice considerations in permit decisions under the CAA can help with the inequality that communities face with the FAA permit process. Though the FAA has its own environmental review process, it would be beneficial to have private companies like SpaceX obtain a permit through EPA as a second check to ensure that each facility is safe and regulated with the lens of environmental concern in mind.

The closest type of mobile source to a rocket that is currently regulated under the CAA are aircrafts.<sup>190</sup> Aircrafts are under the category of "nonroad vehicles and engines" and the EPA sets greenhouse gas emission standards for airplanes used in commercial aviation and for large business jets.<sup>191</sup> Though aircrafts are regulated as mobile sources under the CAA, space rockets are not.<sup>192</sup> A mobile source pollutant includes smog-forming volatile organic compounds and nitrogen oxides and various toxic air pollutant

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<sup>182</sup> *Id.*

<sup>183</sup> *Space X Brownsville*, VISIT BROWNSVILLE, <https://visitbtx.com/spacex/> [<https://perma.cc/W66N-JWQX>] (last visited Sept. 15, 2023).

<sup>184</sup> *Environmental Justice for Permitting in Region 6*, EPA (May 17, 2023), <https://www.epa.gov/caa-permitting/environmental-justice-permitting-region-6> [<https://perma.cc/9GWR-KSH9>].

<sup>185</sup> *Id.*

<sup>186</sup> *Id.*

<sup>187</sup> The eight principles are: (1) identify communities with potential environmental justice concerns; (2) engage early in the permitting process to promote meaningful participation and fair treatment; (3) enhance public involvement throughout the permitting process; (4) conduct a "fit for purpose" environmental justice analysis; (5) minimize and mitigate disproportionately high and adverse effects associated with the permit action to promote fair treatment; (6) provide federal support throughout the air permitting process; (7) enhance transparency through the air permitting process; and (8) build capacity to enhance the consideration of environmental justice in the air permitting process. EPA, PRINCIPLES FOR ADDRESSING ENVIRONMENTAL JUSTICE CONCERNS IN AIR PERMITTING (2022), <https://www.epa.gov/system/files/documents/2022-12/Attachment%20-%20EJ%20in%20Air%20Permitting%20Principles%20.pdf> [<https://perma.cc/46GA-YXRW>].

<sup>188</sup> *Id.*

<sup>189</sup> *Id.*

<sup>190</sup> *Id.*

<sup>191</sup> *Id.*

<sup>192</sup> *Id.*

such as cancer-causing benzene, carbon monoxide, and black carbon.<sup>193</sup> Rockets emit the same kind of pollutants that are already being regulated in mobile source.<sup>194</sup> Why then is a rocket not considered a mobile source under the CAA when even a dirt bike and garden equipment are?<sup>195</sup>

Besides regulating air emissions from stationary and mobile sources, the CAA divides responsibility to control air pollutants between the federal government and the state governments.<sup>196</sup> The EPA under the CAA establishes National Ambient Air Quality Standards (NAAQS) to regulate six common air pollutants, also known as criteria air pollutants based on what air quality criteria says about their effects on public health and welfare.<sup>197</sup> State governments are then required to decide how the numerous existing sources in their jurisdiction whose emissions contribute to the ambient levels of these pollutants should be controlled in order to meet the NAAQS for their jurisdiction. A state's set of regulations to meet the NAAQS is called a state implementation plan (SIP) and the SIP is submitted to EPA for approval.<sup>198</sup> If a state does not prepare its own SIP or prepares a SIP that does not meet the requirements of the CAA, EPA will instead prepare a federal implementation plan (FIP) that the state will use.<sup>199</sup>

For rocket emissions, NAAQS and SIPs are insufficient as a regulatory system because space travel is still at its early stage and accounts for minimal emissions. Space flights are infrequent: space flight emissions combined are less than cars, boats, and airplanes. Therefore, the small number of total emissions does not bring enough attention to public health and safety for regulators. However, space flights are increasing each year and effects on the environment are adding up. Therefore, regulating rockets and space launch bases under the CAA as mobile sources and stationary sources now can prevent the consequences of a rapidly growing industry for the future.

One potential area of dispute is whether a rocket launching facility can be considered a stationary source, which ultimately has to obtain a Title V permit. However, if a rocket launching facility is not considered a stationary source, it is still likely that the facility would have to obtain a Title V permit because emitting black carbon is equivalent in risk to the greater number of pollutants in tons that a stationary source emits.<sup>200</sup>

The CAA presents a promising avenue for effectively regulating rocket launches in the United States because of its ability to address both issues of the launch facility itself and rocket emissions. By using the CAA, a launch facility like one in Boca Chica can be regulated as a stationary source. Furthermore, the rocket emissions could be treated as a mobile source. In this new growing space industry, the CAA is able to provide a comprehensive framework to carefully manage environmental impacts.

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<sup>193</sup> *Id.*

<sup>194</sup> *Id.*

<sup>195</sup> *Id.*

<sup>196</sup> See generally PERCIVAL, SCHROEDER, MILLER, & LEAPE, *supra* note 78, at 480–81.

<sup>197</sup> 42 U.S.C. § 7409.

<sup>198</sup> 42 U.S.C. § 7410.

<sup>199</sup> *Id.*

<sup>200</sup> See generally Talwar, *supra* note 180.

### III. COMMERCIAL RESOURCE EXTRACTION IN OUTER SPACE

There are loopholes in the Moon Agreement and Outer Space Treaty regarding outer space resource exploitation. The Outer Space Treaty has a non-appropriation clause in Article II that is ambiguous as to whether a country can sell resources it finds on the Moon and in outer space, thereby excluding other countries. The Moon Agreement also bars individuals and businesses from claiming possession of celestial bodies.<sup>201</sup> Nevertheless, the Agreement does not discuss taking resources from outer space and selling them for profit back on Earth.<sup>202</sup> Therefore, countries have been creating their own laws that seem to work around the purpose of the Moon Agreement and the Outer Space Treaty banning appropriation.<sup>203</sup>

The Moon Agreement was created in 1979 and became binding in 1984.<sup>204</sup> The Agreement can be considered a supplement to the Outer Space Treaty and develops in further detail the provisions of the Outer Space Treaty as applied to the Moon and other celestial bodies. The Agreement provides that those bodies should be used exclusively for peaceful purposes, that their environments should not be disrupted, and that the United Nations should be informed of the location and purpose of any station established on those bodies.<sup>205</sup> Additionally, the Agreement provides that the Moon and its natural resources are the common heritage of mankind and that an international regime should be established to govern the exploitation of such resources when such exploitation is about to become feasible.<sup>206</sup> However, the United States has not ratified the Agreement, nor has any other major country involved in space exploration like Russia, China, or Japan.<sup>207</sup> Therefore, the Moon Agreement has little effect internationally.

A solution proposed in Part III is an international licensing system to regulate commercial activity on the Moon and maintain beneficial international relations. The international licensing system proposed is based on the one that UNCLOS uses for private deep seabed mining companies.

#### A. *International and U.S. Efforts for Commercial Resource Extraction*

The U.S. Commercial Space Launch Competitiveness Act was passed in 2015 and “promote[s] the right of United States citizens to engage in commercial exploration for and commercial recovery of resources free from harmful interference.”<sup>208</sup> The Act intended to facilitate a pro-growth environment for the developing commercial space industry by encouraging private sector investment and creating more stable and predictable regulatory

<sup>201</sup> *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, art. IV, Dec. 18, 1979, 1363 U.N.T.S. 22, 18 I.L.M. 1434 [hereinafter Moon Agreement].

<sup>202</sup> *Id.*

<sup>203</sup> See generally, JAPAN AEROSPACE EXPL. AGENCY (July 2022), <https://global.jaxa.jp/activity/pr/brochure/general.html> [<https://perma.cc/A5WF-RGDQ>].

<sup>204</sup> See *supra* text accompanying note 201.

<sup>205</sup> Moon Agreement, *supra* note 201, arts. III, V, VII.

<sup>206</sup> *Id.* art. XI.

<sup>207</sup> UNOOSA, STATUS OF INTERNATIONAL AGREEMENTS RELATING TO ACTIVITIES IN OUTER SPACE AS AT 1 JANUARY 2022 5–10 (2022), [https://www.unoosa.org/res/oosadoc/data/documents/2022/aac\\_105c\\_22022crp/aac\\_105c\\_22022crp\\_10\\_0.html/AAC105\\_C2\\_2022\\_CRP10E.pdf](https://www.unoosa.org/res/oosadoc/data/documents/2022/aac_105c_22022crp/aac_105c_22022crp_10_0.html/AAC105_C2_2022_CRP10E.pdf) [<https://perma.cc/6GRC-6EMD>].

<sup>208</sup> Michael Dodge, *The U.S. Commercial Space Launch Competitiveness Act of 2015: Moving U.S. Space Activities Forward*, 29 No. 3 AIR & SPACE LAW., no. 3, 2016 4, 1 (2016).

conditions.<sup>209</sup> The United States is not the only country taking steps to regulate mining for resources in space by creating domestic laws. The United Arab Emirates (UAE), the European Space Agency, China's Chang'e 5 lunar exploration, and Lunar Polar Exploration (LUPEX) are all initiatives to mine resources in outer space.<sup>210</sup> Luxembourg and the UAE also adopted similar national legislation like the U.S.'s Commercial Space Launch Competitiveness Act to encourage commercial activity.<sup>211</sup>

In 2020, NASA and the U.S. Department of State drafted the Artemis Accords to create a safe and transparent environment which facilitates exploration, science, and commercial activities.<sup>212</sup> The Accords are another initiative by the United States to support commercial activity in outer space and natural resource extraction. The Artemis Accords have thirteen provisions and are grounded in the Outer Space Treaty.<sup>213</sup> The Accords have been signed by twenty-one countries,<sup>214</sup> but China and Russia have both refused to sign the Accords. Section 10 of the Accords states that the Signatories emphasize that the extraction and utilization of space resources, including any recovery from the surface or subsurface of the Moon, Mars, comets, or asteroids, should be executed in a manner that complies with the Outer Space Treaty and in support of safe and sustainable space activities.<sup>215</sup> The section also states that the extraction of space resources does not inherently constitute natural appropriation under Article II of the Outer Space Treaty.<sup>216</sup> Therefore, the Accords create enough leeway to allow countries to recover natural resources and sell them back on Earth. With the creation of the Accords and U.S. domestic law allowing natural resource extraction, the private sector can exploit what they find in outer space and on the Moon.

One legal issue from the Accords is "safety zones" discussed in Section 11—regions on the surface of Moon that allow the exclusion of other countries.<sup>217</sup> The Accords define a safety zone as "an area wherein this notification and coordination will be implemented to avoid harmful interference. A safety zone should be the area in which nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference."<sup>218</sup> A safety zone is expected to change over time reflecting the status of the relevant operation.<sup>219</sup> If the nature of an operation changes, the operating Signatory should

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<sup>209</sup> *Id.* at 2.

<sup>210</sup> Frans von der Dunk, *The Artemis Accords and the Law: Is the Moon 'Back in Business'?*, U. OF AUCKLAND (June 2, 2020), <https://www.thebigq.org/2020/06/02/the-artemis-accords-and-the-law-is-the-moon-back-in-business/> [https://perma.cc/6RKS-VAY9].

<sup>211</sup> *Id.*

<sup>212</sup> *Id.*

<sup>213</sup> The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes, § 10, Oct. 13, 2020 [hereinafter Artemis Accords].

<sup>214</sup> The countries are Australia, Bahrain, Brazil, Canada, Colombia, France, Israel, Italy, Japan, the Republic of Korea, Luxembourg, Mexico, New Zealand, Poland, Romania, Saudi Arabia, Singapore, Ukraine, the UAE, the United Kingdom, and the United States. *First Meeting of Artemis Accords Signatories*, U.S. DEP'T OF STATE (Sept. 19, 2022), <https://www.state.gov/first-meeting-of-artemis-accords-signatories/> [https://perma.cc/G65R-VZ72].

<sup>215</sup> Artemis Accords, *supra* note 213.

<sup>216</sup> *Id.*

<sup>217</sup> *Id.* § 11.

<sup>218</sup> *Id.*

<sup>219</sup> *Id.*

alter the size and scope of the corresponding safety zone as appropriate.<sup>220</sup> Safety zones will ultimately be temporary, ending when the relevant operation ends.<sup>221</sup>

Article II of the Outer Space Treaty however states that “outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.”<sup>222</sup> China argued against the safety zones, claiming that they violate international law by allowing acquisition of land on the surface of the Moon.<sup>223</sup> Instead of a U.S.-based effort like the Accords, China wants rulemaking to be settled by the United Nations.<sup>224</sup> The official *China Daily* in January 2022 said that “It’s time the U.S. woke up and smelled the coffee. The world is no longer interested in its divisive, hegemonic schemes.”<sup>225</sup> *China Daily* criticized how NASA invented the concept of “safety zones” to allow governments or companies to reserve areas of the Moon.<sup>226</sup> Malcolm Davis, a former official with Australia’s defense department who now researches space policy, says “The biggest risk is you have two opposite set of rules. You could have a Chinese company on the Moon in the 2030s claiming territory with a resource on it, in the same way the Chinese have claimed the entire South China Sea.”<sup>227</sup>

Russia and China are together planning a joint Moon mission that would involve both an orbiter and a Moon-base, like what NASA is trying to build.<sup>228</sup> The growth of plans to commercialize the Moon have created fears that any international disputes between major global economies could also be reflected in outer space.<sup>229</sup> In 2022, China’s space program established an Earth-orbiting space station and has mounted lunar orbiting and sample retrieving missions.<sup>230</sup> A third phase of the program to establish an autonomous lunar research station near the Moon’s south pole is scheduled for 2025.<sup>231</sup>

Is the United States violating international law, as China alleges? Kim Ellis-Hayes, an international space lawyer and commercial astronaut in training, says that there is a degree of murkiness to the non-appropriation clause in Article II of the Outer Space Treaty, because extracting resources by definition excludes others from accessing those same resources.<sup>232</sup> She says,

[o]n Earth, with real estate, when you buy a property what you’re actually buying is a bundle of rights. One of those rights is that you can exclude

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<sup>220</sup> *Id.*

<sup>221</sup> *Id.*

<sup>222</sup> Outer Space Treaty, *supra* note 107.

<sup>223</sup> Bruce Einhorn, *China, US Are Racing to Make Billions From Mining the Moon’s Minerals*, BLOOMBERG (May 17, 2022, 4:00 AM), <https://www.bloomberg.com/news/features/2022-05-17/china-us-are-in-a-space-race-to-make-billions-from-mining-the-moon-s-minerals> [<https://perma.cc/F8DG-PM33>].

<sup>224</sup> *Id.*

<sup>225</sup> *Id.*

<sup>226</sup> *Id.*

<sup>227</sup> *Id.*

<sup>228</sup> Amalyah Hart, *Mining The Moon: Do We Have the Right?*, COSMOS (Feb. 3, 2023), <https://cosmosmagazine.com/space/mining-the-moon/> [<https://perma.cc/M59N-Y3VD>].

<sup>229</sup> *Id.*

<sup>230</sup> Edward Helmore, *‘We’re in a Space Race’: Nasa Sounds Alarm at Chinese Designs on Moon*, THE GUARDIAN (Jan. 2, 2023, 9:13 AM), <https://www.theguardian.com/science/2023/jan/02/china-moon-nasa-space-race> [<https://perma.cc/KBB5-RZ7K>].

<sup>231</sup> *Id.*

<sup>232</sup> Hart, *supra* note 228.



others from that property. In space, property doesn't exist in that way, because non-appropriation means that no nation can sell a piece of property to its citizens.<sup>233</sup>

Ellis-Hayes' point about the ambiguity is valid, as Article II explicitly declares that “[o]uter space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.”<sup>234</sup> If a country itself cannot appropriate outer space, how then does a country have the authority to allow private companies to appropriate resources on the Moon?

On the other hand, Professor of Space Law at the University of Nebraska-Lincoln Frans von der Dunk says that the United States interpreted the Outer Space Treaty to allow unilateral approval of commercial extraction.<sup>235</sup> The U.S. interpretation is that Article I and II of the Outer Space Treaty designate outer space as an international area, where the freedom for countries to act is the default legal principal and limitation to such freedoms can only be established by international law.<sup>236</sup> Countries are held liable for their actions in outer space under Article VI of the Outer Space Treaty and liable for private space activities under Article VII.<sup>237</sup> Therefore, Article VI can provide for an obligation to authorize and continuously supervise relevant non-governmental activities, an obligation usually implemented through national space legislation, like the 2015 U.S. Commercial Space Launch Competitiveness Act, which is a foundation for the Accords to ensure commercial extraction.<sup>238</sup>

Professor Frans von der Dunk's and the U.S. interpretation of the Outer Space Treaty is to allow unilateral approval for commercial extraction. However, for regulating resources on the Moon and commercial extraction in outer space, an international licensing system should also be implemented as proposed at Part III.B.2. Unlike rocket emissions, which a country can largely control through national legislation like the CAA as discussed in Part II, outer space is an area where multiple international organizations, countries, private actors, and politics exist. To maintain international relations and advance space exploration in agreement with countries around the world, an international licensing system is necessary.

### B. Comparing Outer Space to Open Oceans

Outer space is similar to open oceans because they are both “open access” resource regimes where resource exploitation occurs outside the confines of country regulations. In both maritime and space law, no country can claim sovereignty over the open access resource regime.<sup>239</sup> However, unlike maritime law, space law does not have an exclusive economic zone (EEZ) that countries have jurisdiction over natural resources, nor is there an international licensing system that regulates commercial activity by private companies

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<sup>233</sup> *Id.*

<sup>234</sup> Outer Space Treaty, *supra* note 107.

<sup>235</sup> Von der Dunk, *supra* note 210.

<sup>236</sup> *Id.*

<sup>237</sup> *Id.*

<sup>238</sup> *Id.*

<sup>239</sup> Outer Space Treaty, *supra* note 107; U.N. Convention on the Law of the Sea, art. LXXXIX, *opened for signature* Dec. 10, 1982, 1833 U.N.T.S. 397.

in outer space. To protect the environment in outer space and maintain international relations, I propose mirroring the UNCLOS international licensing system.

### 1. Exclusive Economic Zone

An EEZ is defined in UNCLOS as an area where countries have jurisdiction over natural resources.<sup>240</sup> Some rights a country has in its EEZ include sovereign rights for the purpose of exploring, exploiting, conserving, and managing natural resources, whether living and non-living, exploration of the waters superjacent to the seabed and of the seabed and its subsoil, and other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds.<sup>241</sup>

However, an EEZ does not necessarily protect the environment. For example, the EEZs incentivized countries to fish more, depleting fish populations. There are also still ongoing conflicts between the boundaries and territory of some EEZs. Therefore, whether having an EEZ would be a solution for protecting natural resources in outer space is questionable. Nevertheless, it is worthwhile to consider whether something like an EEZ in space would help regulate exploitation in space, because it is relatively successful in regulating the oceans.

The Accords do not discuss anything like an EEZ explicitly, but the concept of safety zones in Section 11 comes close. Like an EEZ, a safety zone exists to keep countries out of a specific area in an open access regime. EEZs and safety zones both focus on preventing harmful interference and supporting peaceful exploration. One notable difference is that an EEZ was created by the 1982 United Nations Convention on the Law of the Sea<sup>242</sup> but “safety zones” were created by the U.S.-led Accords. To avoid issues of international relations and politics, UNOOSA should create an updated treaty or convention concerning commercial resource extraction. Unlike UNCLOS, where there exists a distinction between “within national jurisdiction in the high seas” and “beyond national jurisdiction,” outer space does not have an EEZ where countries can exploit natural resources. With the current legal framework for space law and no concept of an EEZ that is applicable to resources in outer space, the impending natural resource exploitation in outer space would be unregulated and lead to a proverbial gold rush. The involvement of an intergovernmental organization like the United Nations whose mission is to support international peace will help reduce tension between different countries.

### 2. Proposal for Regulation: International Licensing System

Instead of only having the U.S.-led Accords, an international organization like the UN needs to be one making rules and guidelines that are restricting or limiting access to specific parts of space. Though the U.S.-led Accords are valid and much needed in the growing space industry, politics make it difficult for certain countries to sign on to agreements.<sup>243</sup> Having a neutral body like the UN will aid in getting the majority of countries active in space to sign onto one new all-encompassing convention or treaty, making the laws of space clear and help in avoiding future conflict. The U.S.-led Accords

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<sup>240</sup> U.N. Convention on the Law of the Sea, *supra* note 239, art. LV.

<sup>241</sup> *Id.* art. LVI.

<sup>242</sup> *Id.* at art. LV.

<sup>243</sup> *See generally* Einhorn, *supra* note 223; Helmore, *supra* note 230.

are a great initiative towards making exploration in space safe and having rules that are unified, but they are only acting as a band-aid obscuring the real problem. Without having Russia and China included as a part of the U.S.-led Accords, safety in space exploration and international relations are subject to great risk.<sup>244</sup> Therefore, the creation of a new United Nations Convention on Space Law is necessary between the many countries involved in space exploration, and there must be active participation from all three leading countries in space activity—the United States, China, and Russia.<sup>245</sup> One particular section that must be implemented in a new convention or treaty is one about an international licensing system, similar to UNCLOS.

UNCLOS has an international licensing system for deep seabed mining that can be successfully replicated for commercial resource extraction in outer space. Deep seabed mining is the process of extracting and excavating mineral deposits from the deep seabed.<sup>246</sup> The deep seabed covers around two-thirds of the total seafloor.<sup>247</sup> The commercial interest is in three marine mineral deposits: polymetallic nodules, polymetallic sulfides, and cobalt crusts.<sup>248</sup> All three mineral deposits are rich in a variety of metals like copper, iron, zinc, and cobalt. Interest in deep seabed mining exists because of the increased consumption of mineral deposits on land and the decline of easily mined, high-grade ore deposits.<sup>249</sup> Research suggest deep seabed mining could be harmful to marine biodiversity and ecosystems, but there is an insufficient understanding of the potential effects to implement more strict regulation.<sup>250</sup> Nevertheless, there is an international licensing system in place for private companies wanting to engage in commercial activity.

UNCLOS, the Commission on the Limits of the Continental Shelf, and the International Tribunal for the Law of the Sea are the three major international frameworks that regulate maritime law.<sup>251</sup> One of the primary functions of these frameworks is to regulate exploration and exploitation of deep seabed minerals in the “Area.”<sup>252</sup> The “Area” was defined by UNCLOS as the seabed and subsoil beyond the limits of national jurisdiction.<sup>253</sup> The Area consists of over 50% of the entire seabed on Earth.<sup>254</sup> To explore and exploit seabed minerals in the Area, a private or public entity needs a contract with the International Seabed Authority and is subject to the rules, regulations, and procedures of the Authority.<sup>255</sup> Private companies need to further be sponsored by a country that is a party to UNCLOS and meet certain standards of technological and financial capacity.<sup>256</sup> The economic rewards of deep seabed mining are paid in the form of royalties to the Authority,

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<sup>244</sup> *Id.*

<sup>245</sup> *Id.*

<sup>246</sup> *Deep-Sea Mining*, IUCN (May 2022), <https://www.iucn.org/resources/issues-brief/deep-sea-mining> [<https://perma.cc/Z74Z-WPB2>].

<sup>247</sup> *Id.*

<sup>248</sup> Michael Lodge, *The International Seabed Authority and Deep Seabed Mining*, UN CHRONICLE (May 2017), <https://www.un.org/en/chronicle/article/international-seabed-authority-and-deep-seabed-mining> [<https://perma.cc/BL2S-BVH8>].

<sup>249</sup> *Id.*

<sup>250</sup> *Id.*

<sup>251</sup> *Id.*

<sup>252</sup> *Id.*

<sup>253</sup> *Id.*

<sup>254</sup> *Id.*

<sup>255</sup> *Id.*

<sup>256</sup> *Id.*

to be shared for the “benefit of mankind as whole.”<sup>257</sup> This way, countries that do not have the sufficient technology and capacity to conduct projects on seabed mining also receive funds to start or continue projects.<sup>258</sup>

Private companies that want to engage in commercial resource extraction in outer space should have to obtain an international license similar to those held by deep seabed mining companies. Not only will the private companies be subject to rules, regulations, and procedures of a specialized international licensing system for outer space, but a similar form of royalties can be paid to the licensing system. Those royalties could be shared with other countries to make sure that nations who do not have as much economic prosperity can still benefit from space resources. This approach advances the core mission of the Outer Space Treaty: “the exploration and use of outer space shall be carried out for the benefit and in the interest of all countries and shall be the province of all mankind.”<sup>259</sup>

### CONCLUSION

At what point does exploration become exploitation? At the end of our endeavor to learn about outer space, do we as humanity want to return back to a livable Earth? To regulate a rapidly increasing private sector in the space industry, individual countries should create domestic laws for rocket emissions and international bodies should implement an international licensing system for commercial resource extraction. The United States should regulate rocket launches through the CAA because it can address the environmental issues that arise from both the rocket launching facility itself as a “stationary source” and rocket emissions as a “mobile source.” Establishing such regulation at the national and international level can help ensure that space is governed neutrally and effectively.

As alluring as space exploration is, there are real costs to the environment on Earth and in outer space that should not be overlooked. Regulation that is specialized to each issue can help with developing sustainable long-term exploration, while maintaining international relations. Outer space is the last frontier and requires much more carefully written regulation than currently exists. Though Earth may not be our last home, it is our first that needs protection now.

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<sup>257</sup> *Id.*

<sup>258</sup> *Id.*

<sup>259</sup> Outer Space Treaty, *supra* note 107.