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## Out of this World: 3D Printing and Space Law Regulation

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# OUT OF THIS WORLD PRINTING: 3D PRINTING AND SPACE LAW REGULATION

*Caitlyn Fischer\**

Imagine waking up one day and stepping out of the front door of your new home on Mars. You have left Earth and everything you are familiar with behind and have started a new life in outer space. You walk out of your front door, zero-G coffee cup in hand, and look around your neighborhood at all the houses that have been built on Mars.

Frankly, that scenario could be a real possibility in the future, especially with the help of technology like 3D printing. Outer space colonization and human occupancy on planets other than Earth may even be necessary in the future, depending on the state of the planet due to war or global warming. As Stephen Hawking once said, “I don’t think the human race will survive the next 1,000 years, unless we spread into space. There are too many accidents that can befall on a single planet.”<sup>1</sup> To help the U.S. accomplish this task, well-known government agencies and companies in the realm of all things space, such as NASA and SpaceX, already use 3D printing for a variety of space related issues.<sup>2</sup>

SpaceX first started exploring and experimenting with 3D printing technology

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<sup>1</sup> *Stephen Hawking Dies: Scientist’s Most Memorable Quotes*, BBC (Mar. 14, 2018), <https://www.bbc.com/news/uk-43396627>.

<sup>2</sup> *NASA Looks to Advance 3D Printing Construction Systems for the Moon and Mars*, NASA (Oct. 1, 2020), <https://www.nasa.gov/centers/marshall/news/releases/2020/nasa-looks-to-advance-3d-printing-construction-systems-for-the-moon.html>; Vanesa Listek, *Ahead of Historic Demo-2 Astronaut Launch: All SpaceX Has 3D Printed*, 3DPRINT.COM (May 27, 2020), <https://3dprint.com/267919/ahead-of-historic-demo-2-astronaut-launch-all-spacex-has-3d-printed/>.

in 2014, when it printed a valve used in rocket engines.<sup>3</sup> That same year, SpaceX went even further with the SuperDraco thruster—the “first fully printed rocket engine to ever see flight.”<sup>4</sup> Similarly to SpaceX, NASA has also started using 3D printing technology. NASA has posed the idea of 3D printed homes on Mars and has invested in the technology in the hopes of building habitats on other planets.<sup>5</sup> 3D printing could make the potential colonization on Mars much easier by eliminating the need to transport materials back and forth from Earth, and instead using 3D printed objects made with Martian raw materials to help construct habitats.<sup>6</sup> NASA has already begun experimenting with this concept and has worked with Jacobs — a company that “provides a full spectrum of professional services including consulting, technical, scientific and project delivery for the government and private sector”— in using 3D printing.<sup>7</sup> Jacobs is “NASA’s largest professional and technical service provider.”<sup>8</sup> Together, NASA and Jacobs are studying the planet’s properties including, soil, chemistry, and minerals, to ensure that the habitats can withstand the conditions on Mars and in outer space, since those atmospheric conditions differ from Earth.<sup>9</sup> NASA has also started building 3D printed homes and other types of buildings on Earth, using the methods and technologies it believes will be successful in outer space.<sup>10</sup> Many agencies are coming together to explore this technology and implement it as soon as possible to realize the benefits both on Earth and in space.<sup>11</sup>

Expansion into Mars and habitat construction is one aspect of how 3D printing technology can be beneficial to the expansion and exploration of outer space. However, it is by no means the only way it can be helpful and utilized in the context of space. Currently, it takes astronauts aboard the International Space Station weeks or even months to receive supplies and tools, which prolongs missions.<sup>12</sup> This process of procuring supplies for space missions from Earth can

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<sup>3</sup> Listek, *supra* note 2.

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

<sup>5</sup> *NASA Looks to Advance 3D Printing Construction Systems for the Moon and Mars*, *supra* note 2.

<sup>6</sup> *How Imagining Life on Mars Is Made Possible Through 3D Printing*, JACOBS, <https://www.jacobs.com/projects/NASA-3D-printing> (last visited March. 28, 2022) [hereinafter JACOBS I].

<sup>7</sup> *Id.*; *Our Jacobs*, JACOBS, <https://www.jacobs.com/about/company-facts> (last visited Mar. 21, 2022).

<sup>8</sup> *About Us*, JACOBS, <https://jseg.space/> (last visited Mar. 21, 2022) (discussing Jacobs Space Exploration Group and their contribution to NASA).

<sup>9</sup> JACOBS I, *supra* note 6.

<sup>10</sup> *NASA Looks to Advance 3D Printing Construction Systems for the Moon and Mars*, *supra* note 2.

<sup>11</sup> *Id.*

<sup>12</sup> *Space Tools on Demand: 3D Printing in Zero G*, NASA,

also be extremely expensive and complex.<sup>13</sup> With the use of 3D printing, astronauts can print the tools needed and have them within minutes or hours, effectively limiting costs and time spent on these missions.<sup>14</sup> 3D printing technology in outer space is bound to raise legal issues or questions that have yet to be resolved because space is a new frontier that has not been fully explored by many countries in accord with the treaties and regulations in place to promote peaceful exploration. 3D printing technology will be an extremely important asset in the exploration of space, as well as the human expansion into space. This technology will allow items to be printed and built directly in space instead of bringing them from Earth which takes a long time and costs a lot of money.

This comment will explore the current international treaties and U.S. domestic laws that may affect and impose requirements on 3D printing manufacturers. This will be of great importance when the U.S. and U.S. companies start to use 3D technology in space to build habitats or use it in other ways to expand space exploration. Part III of this comment will introduce the various international treaties already in existence in the realm of international space law. Part III will start by discussing the Outer Space Treaty, specifically Articles VI and IX. Next, Part III will introduce the Liability Convention followed by the Registration Convention. Part IV will then introduce the domestic regulatory agencies that could potentially regulate 3D printing and the relevant authority given to them by Congress. The regulatory agencies this comment will be addressing are the FCC and the FAA. Part V will then provide an analysis as to how each of these treaties and agencies are relevant to 3D printing and how they could potentially regulate 3D printing in space. Having explored the possible treaties and laws that could affect 3D printing and manufacturing, this comment will suggest that because we can regulate does not necessarily mean we should regulate. Regulation could hinder progress and prudent policy and other goals that all involve human expansion into space.<sup>15</sup>

## I. BACKGROUND

3D printing, also known as additive manufacturing, is an appropriate name, as it vividly describes the technology used to print 3D objects.<sup>16</sup> Additive

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[https://www.nasa.gov/sites/default/files/files/3D\\_Printing-v3.pdf](https://www.nasa.gov/sites/default/files/files/3D_Printing-v3.pdf) (last visited Mar. 18, 2022).

<sup>13</sup> *Id.*

<sup>14</sup> *Id.*; see also Patrick Tucker, *Space Force Eyes Orbiting 3D Printers, Satellite Tow Trucks*, DEF. ONE (Oct. 7, 2020), <https://www.defenseone.com/technology/2020/10/space-force-eyes-orbiting-3d-printers-satellite-tow-trucks/169084/> (explaining how the Space Force is also planning on using 3D printing technology in an attempt to cut down on the costs that are involved in space).

<sup>15</sup> Intellectual Property implications are outside the scope of this paper.

<sup>16</sup> James M. Beck & Matthew D. Jacobson, *3D Printing: What Could Happen to*

manufacturing technology means that the technology only uses materials necessary to create the objects being printed.<sup>17</sup> When one looks at the additive manufacturing technology of 3D printers and compares it with the basic 2D printer everyone is commonly familiar with, the understanding of the name behind the technology becomes clearer.<sup>18</sup> 2D printers take information, and the technology prints the results on a single piece of paper. Differently, 3D printers additively build layer upon layer until the result takes form in a 3D object, hence the term additive manufacturing.<sup>19</sup>

There are two main types of printers used in 3D printing: deposition printers and binding printers.<sup>20</sup> Deposition printers deposit material layer by layer using ink that consists of deposited materials.<sup>21</sup> This differs from the binding printers, which create 3D objects, exactly as the name suggests, by binding layers of material together.<sup>22</sup> The exact type of printer used in the process of 3D printing does not matter because the end result and overall process remain the same—layer by layer material adds and fuses to each new layer to create an object.<sup>23</sup> However, before one can even begin printing a 3D object, one needs a Computer Aided Design (“CAD”) file.<sup>24</sup> CAD is a file or a digital blueprint that essentially creates the object that will become the 3D printed item, like an architect’s blueprint prior to the building of a home.<sup>25</sup> A CAD file is analogous to the text document that communicates to a 2D printer, so it knows what to print, and without both of those things, neither printer would create their end result.<sup>26</sup>

In order to figure out if there is, or should be, any regulation of 3D printing in space, one must understand space law. Space law is the area of law that governs space activity, and it consists of both international and national laws.<sup>27</sup> In terms of international space law, the Committee on the Peaceful Uses for Outer Space (“COPUOS”) was the source for the development of the major international

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*Products Liability When Users (and Everyone Else in Between) Become Manufacturers*, 18 MINN. J.L. SCI. & TECH. 143, 144, 150 (2017).

<sup>17</sup> *Id.* at 150.

<sup>18</sup> Lucas S. Osborn, *Regulating Three-Dimensional Printing: The Converging Worlds of Bits and Atoms*, 51 SAN DIEGO L. REV. 553, 558–59 (2014).

<sup>19</sup> *Id.*

<sup>20</sup> *Id.* at 559.

<sup>21</sup> *Id.*

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

<sup>23</sup> *Id.*

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

<sup>25</sup> Beck & Jacobson, *supra* note 16, at 150.

<sup>26</sup> Osborn, *supra* note 18, at 559.

<sup>27</sup> *Space Law*, U.N. OFF. FOR OUTER SPACE AFFS., <https://www.unoosa.org/oosa/en/ourwork/spacelaw/index.html> (last visited Mar. 18, 2022) [hereinafter U.N. OFF. FOR OUTER SPACE AFFS.].

space law treaties.<sup>28</sup> International space law includes five multilateral treaties including, the Outer Space Treaty, Registration Convention, Rescue Agreement, Moon Agreement, and the Liability Convention.<sup>29</sup> Much like any other area of law, space law addresses many different matters, including “the preservation of the space and Earth environment, liability for damages caused by space objects, the settlement of disputes, the rescue of astronauts, the sharing of information about potential dangers in outer space, the use of space-related technologies, and international cooperation.”<sup>30</sup> Currently, there are many countries and private companies entering the realm of space, which will cause the practice area of space law to grow at a rapid pace.<sup>31</sup> Companies in the U.S. that are participating in the space market need to be aware of international and U.S. regulations.<sup>32</sup> Several regulatory agencies in the U.S. regulate space activities under authority from Congress, including, the Federal Aviation Administration (“FAA”), the Commerce Department, and the Federal Communications Commission (“FCC”), among others.<sup>33</sup> Additionally, as of December 20, 2019, the U.S. established a new branch of the military known as the U.S. Space Force (“USSF”).<sup>34</sup> The USSF is within the Air Force and the Chief of Space Operations (“CSO”) is a four-star general that is the senior military officer in charge.<sup>35</sup> USSF’s mission includes “organiz[ing], train[ing], and equip[ing] space forces in order to protect U.S. and allied interests in space and to provide space capabilities to the joint force.”<sup>36</sup> Prior to the establishment of the USSF, the Air Force provided space capabilities through the Air Force Space Command (“AFSPC”).<sup>37</sup>

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<sup>28</sup> *Space Law Treaties and Principles*, U.N. OFF. FOR OUTER SPACE AFFS., <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html> (last visited Mar. 18, 2022).

<sup>29</sup> *Id.* I will not be discussing the Rescue Agreement or the Moon Agreement any further in this article because the Rescue Agreement does not apply, and the Moon Agreement was not signed by the U.S. *See generally* Justin Rostoff, “Asteroids for Sale”: *Private Property Rights in Outer Space, and the SPACE Act of 2015*, 51 *NEW ENG. L. REV.* 373 (2017).

<sup>30</sup> U.N. OFF. FOR OUTER SPACE AFFS., *supra* note 27.

<sup>31</sup> *Space Law Bibliography*, NASA, [https://www.nasa.gov/centers/hq/library/find/bibliographies/space\\_law](https://www.nasa.gov/centers/hq/library/find/bibliographies/space_law) (last visited Mar. 18, 2022).

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

<sup>33</sup> *Id.* This article will be focusing on FAA and FCC only.

<sup>34</sup> *What Is the U.S. Space Force (USSF)?*, USSF, <https://www.spaceforce.mil/About-Us/FAQs/Whats-the-Space-Force/> (last visited Mar. 18, 2022).

<sup>35</sup> *Office of the Chief of Space Operations*, USSF, <https://www.spaceforce.mil/About-Us/About-Space-Force/> (last visited Mar. 18, 2022).

<sup>36</sup> *What Is the U.S. Space Force (USSF)?*, *supra* note 34.

<sup>37</sup> *USSF People*, USSF, <https://www.spaceforce.mil/About-Us/About-Space-Force/USSF-People/> (last visited Mar. 21, 2022).

## II: CURRENT INTERNATIONAL LAW

In terms of the five international space law treaties, 3D printing could potentially implicate three of these treaties based on the objects that result from the printing process. Those three treaties are the Outer Space Treaty, the Liability Convention, and the Registration Convention.

## A. Outer Space Treaty

The Outer Space Treaty (“OST”) is an international space law treaty that ensures nations that are parties to it explore space peacefully, and holds those nations responsible for their actions in violation of its rules.<sup>38</sup> In 2017, the OST celebrated its 50<sup>th</sup> anniversary and within those fifty years, 104 nations had become parties to the treaty.<sup>39</sup> This treaty was enacted during the Cold War era and was effective at the time.<sup>40</sup> The treaty was created following President Dwight D. Eisenhower’s 1960 UN Speech.<sup>41</sup> At the time of his speech, the Antarctic Treaty of 1959 had already been enacted and it promoted the protection of the uninhabited continent by banning militarization.<sup>42</sup> Eisenhower believed that the concept of protecting an uninhabited continent could be equated to outer space.<sup>43</sup> As time and events have evolved, however, there has been a call for change and revisions—even a new treaty.<sup>44</sup>

The current OST ensures the peaceful exploration of space, and the agreement is short, which means it can be both flexible yet also limited.<sup>45</sup> In relation to 3D printing and its potential impact on space and the U.S. obligations under the OST, it is important to discuss Article VI of the OST. Article VI states that:

States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the

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<sup>38</sup> Loren Grush, *How an International Treaty Signed 50 Years Ago Became the Backbone for Space Law*, VERGE (Jan. 27, 2017), <https://www.theverge.com/2017/1/27/14398492/outer-space-treaty-50-anniversary-exploration-guidelines>.

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

<sup>40</sup> Brian Bozzo, *Not Because it Is Easy: Exploring National Incentives for Commercial Space Exploration Through Geopolitical Space Exploration Through Geopolitical Lens*, 11 DREXEL L. REV. 597, 605–06 (2019).

<sup>41</sup> *Space Law Bibliography*, *supra* note 31.

<sup>42</sup> *Id.*

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

<sup>44</sup> Bozzo, *supra* note 40, at 606.

<sup>45</sup> Grush, *supra* note 38.

provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried on in outer space, including the Moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.<sup>46</sup>

The second OST article that this comment will be analyzing is Article IX. Article IX states that:

In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, may request consultation concerning the activity or experiment.<sup>47</sup>

The important takeaway from Article IX is that it requires parties to the treaty to “conduct exploration of them [celestial bodies] so as to avoid their harmful

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<sup>46</sup> Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies art. VI, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 (entered into force Oct. 10, 1967) [hereinafter Outer Space Treaty].

<sup>47</sup> *Id.* at art. IX.

contamination.”<sup>48</sup>

#### B. The Liability Convention

The Liability Convention took ten years to come to fruition.<sup>49</sup> This treaty took a long time to finalize due to the differing views held by the countries that were to be parties of the treaty in terms of what should govern certain activities in space.<sup>50</sup> The U.S. delegation wanted the treaty to touch on liability without having to prove fault, as this would be difficult to show.<sup>51</sup> Delegates also wanted specific standards to measure losses and how much compensation should be paid, as well as to make sure that anyone claiming liability due to damages based on this treaty would have to exhaust judicial and administrative remedies before relying on the treaty.<sup>52</sup> Lastly, the U.S. wanted to limit negotiations between the state that claimed damages and the launching state.<sup>53</sup> Eastern European states mainly disagreed with the U.S. stance on the treaty.<sup>54</sup> However, there was not just tension between European countries and the U.S., but also between the European countries themselves as to what should be in the treaty.<sup>55</sup> While it took a while, the treaty was ultimately completed in 1972.<sup>56</sup> Specifically, Article II of the Liability Convention is of importance to those hoping to 3D print in space. Article II states: “A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight.”<sup>57</sup>

#### C. Registration Convention

Russia launched Sputnik and then the U.S. launched the first “Explorer” satellite in 1958, thus initiating what is still known today as the space race.<sup>58</sup> The space race ultimately led to the Registration Convention, as there became a

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

<sup>49</sup> Marc S. Firestone, *Problems in the Resolution of Disputes Concerning Damage Caused in Outer Space*, 59 TUL. L. REV. 747, 753 (1985).

<sup>50</sup> *Id.*

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

<sup>52</sup> *Id.*

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

<sup>54</sup> *Id.* at 754.

<sup>55</sup> *Id.*

<sup>56</sup> *Id.* at 753.

<sup>57</sup> Convention on International Liability for Damage Caused by Space Objects art. II, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 (entered into force Sept. 1, 1972) [hereinafter *Liability Convention*].

<sup>58</sup> Rostoff, *supra* note 29, at 378–79.

need to register, track, and attribute objects in outer space to State actors.<sup>59</sup> The Registration Convention was “the last U.N. space treaty signed and ratified by the United States.”<sup>60</sup> This article will analyze Article II of the Registration Convention, specifically sections 1 and 3. Section 1 states:

When a space object is launched into earth orbit or beyond, the launching State shall register the space object by means of an entry in an appropriate registry which it shall maintain. Each launching State shall inform the Secretary-General of the United Nations of the establishment of such a registry.<sup>61</sup>

Section 3 discusses how each State will keep its registry, stating, “[t]he contents of each registry and the conditions under which it is maintained shall be determined by the State of registry concerned.”<sup>62</sup>

### III. CURRENT NATIONAL LAW

Congress has already given authority to several agencies to regulate specific space activities. Current regulatory agencies are important to keep in mind for those wishing to 3D print in space. The FCC and the FAA are two agencies that could potentially have the ability to regulate 3D printing in space based on direction from Congress.

#### A. Federal Communications Commission

The FCC is an important agency to discuss when determining how to handle 3D printing technology in space from a legal perspective. The FCC currently regulates satellite transmission because it considers these satellites to be radio stations in space, thereby giving it the authority to regulate.<sup>63</sup> The FCC oversees the operation of private companies that operate satellite communications.<sup>64</sup> Since the U.S. is a member of the International Telecommunication Union (“ITU”), the FCC also has the authority to issue regulations to implement U.S.

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

<sup>60</sup> *Id.* at 380.

<sup>61</sup> Convention on the Registration of Objects Launched into Outer Space art. II, Nov. 12, 1974, 28 U.S.T. 695, 1023 U.N.T.S. 15 (entered into force Sept. 15, 1976) [hereinafter Registration Convention].

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

<sup>63</sup> DANIEL MORGAN, CONG. RSCH. SERV., R45416, COMMERCIAL SPACE: FEDERAL REGULATION, OVERSIGHT, AND UTILIZATION 11 (2018), <https://fas.org/sgp/crs/space/R45416.pdf>.

<sup>64</sup> Laura Montgomery, *US Regulators May Not Prevent Private Space Activity on the Basis of Article VI of the Outer Space Treaty*, MERCATUS CTR. 5, <https://www.mercatus.org/system/files/montgomery-outer-space-treaty-mercatus-working-paper-v1.pdf> (last visited Mar. 28, 2022) [hereinafter MERCATUS CTR.].

obligations from the ITU.<sup>65</sup> The ITU is an agency within the UN that “allocates global radio spectrum and satellite orbits.”<sup>66</sup> The FCC gets its authority to regulate radio frequency in the Communications Act of 1934.<sup>67</sup> The authority given to it is understood as:

[R]egulating interstate and foreign commerce in communication by wire and radio . . . for the purpose of national defense, for the purpose of promoting safety of life and property through the use of wire and radio communication, and for the purpose of securing more effective execution of policy by centralizing authority. . . .<sup>68</sup>

Since the FCC considers satellites radio stations in space, it is important to understand that the definition of a radio station is “a station equipped to engage in radio communication or radio transmission of energy,” in order to understand if the FCC has regulatory authority extends to 3D printers in space.<sup>69</sup>

#### B. Federal Aviation Administration

The FAA is another important regulatory agency to discuss in terms of potential space regulation of 3D printing, because of the payload review. The FAA has a space-related office known as the Office of Commercial Space Transportation.<sup>70</sup> The Office of Commercial Space Transportation was initially housed as part of the Office of Secretary of Transportation in 1984 but was then later transferred to the FAA in 1995.<sup>71</sup> The purpose of this office is to regulate commercial space transportation.<sup>72</sup> In other words, its job is to make sure that a U.S. launch or reentry is in compliance with international obligations.<sup>73</sup> The office recommends changes to “statutes, treaties, regulations, policies, plans, and procedures.”<sup>74</sup>

The FAA could try and regulate 3D printing through its payload review. The Commercial Space Launch Act established the FAA’s payload review authority:

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<sup>65</sup> Major Susan J. Trepczynski, *New Space Activities Expose a Potential Regulatory Vacuum*, 43 REPORTER 12, 15 (2016).

<sup>66</sup> *About International Telecommunication Union (ITU)*, ITU, <https://www.itu.int/en/about/Pages/default.aspx> (last visited Mar. 23, 2022).

<sup>67</sup> DANIEL MORGAN, *supra* note 63, at 11–12; Communications Act of 1934, as amended 47 U.S.C. §§ 151 et. seq. (2020).

<sup>68</sup> § 151 (2020).

<sup>69</sup> § 153 (2020) (defining all of the key terms in the Communications Act of 1934, as amended in 47 U.S.C. §§ 151 et. seq. (2020)).

<sup>70</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/) (last visited Mar. 16, 2022).

<sup>71</sup> *Id.*

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

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

<sup>74</sup> *Id.*

The Secretary of Transportation shall establish whether all required licenses, authorizations, and permits required for a payload have been obtained. If no license, authorization, or permit is required, the Secretary may prevent the launch or reentry if the Secretary decides the launch or reentry would jeopardize the public health and safety, safety of property, or national security or foreign policy interest of the United States.<sup>75</sup>

The payload review is “performed as part of launch authorization” and is done in accordance with chapter 14 section 415.51 of the Code of Federal Regulations.<sup>76</sup> The FAA reviews proposed payloads for launch unless the payload is exempt under section 415.53.<sup>77</sup> The purpose of the payload review is to make sure an applicant has all necessary documents and that the launch will not violate any laws or public safety:

The FAA reviews a payload proposed for launch to determine whether a license applicant or payload owner or operator has obtained all required licenses, authorization, and permits, unless the payload is exempt from review under § 415.53 of this subpart. If not otherwise exempt, the FAA reviews a payload proposed for launch to determine whether its launch would jeopardize public health and safety, safety of property, U.S. national security or foreign policy interests, or international obligations of the United States. A payload determination is part of the licensing record on which the FAA’s licensing determination is based. The safety requirements of subpart C and F of this part and of part 417 of this chapter apply to all payloads, whether or not the payload is otherwise exempt.<sup>78</sup>

The Commercial Space Launch Act defines the term Payload as “an object that a person undertakes to place in outer space by means of a launch vehicle or reentry vehicle, including components of the vehicle specifically designed or adapted for that object.”<sup>79</sup> The real question is whether 3D printed objects could be considered payloads for the purposes of FAA payload review. It is also important to consider whether the regulation is even applicable to activities happening beyond orbit and after the launch has already occurred.

#### IV. ANALYSIS

Firstly, this section will explore the OST, Liability Convention and the

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<sup>75</sup> 51 U.S.C. § 50904(c) (2015).

<sup>76</sup> 14 C.F.R. § 415.51 (2022); *see Payload Reviews*, FAA, [https://www.faa.gov/space/licenses/payload\\_reviews/](https://www.faa.gov/space/licenses/payload_reviews/) (last modified Jan. 28, 2020).

<sup>77</sup> § 415.53 (2022).

<sup>78</sup> § 415.51 (2022); *see Payload Reviews*, *supra* note 76.

<sup>79</sup> 51 U.S.C. § 50902(13) (2015).

Registration Convention, and whether these international treaties can regulate 3D printing in space. Then, this section will explore two domestic regulatory agencies: the FCC and the FAA and if these agencies can use their current regulatory authority to regulate 3D printing in space.

#### A. Outer Space Treaty

##### 1. *Article VI Does not Prevent Unregulated 3D Manufacturing in Outer Space under U.S. Law*

Although Article VI of the OST states that private activities “shall require authorization and continuing supervision,” it provides no basis for a regulatory agency such as the FAA or FCC to stop 3D manufacturing, according to scholars and Supreme Court jurisprudence, as evidenced in *Medellin v. Texas*.<sup>80</sup> The U.S. Constitution provides that treaties are the law of the land; however, the Supreme Court has held that when a treaty is not self-executing, Congress must pass a law in order for the treaty to have an effect on commercial U.S. operators.<sup>81</sup> Article VI of the OST compels authorization and continuing supervision of nationals in outer space;<sup>82</sup> however, Congress has yet to pass legislation enabling an agency to authorize and supervise 3D printing manufacturing in space.<sup>83</sup> The FAA’s 2016 Moon Express Press Release is an excellent example of how the FAA has already tried to use Article VI of the OST against private actors in the past.<sup>84</sup> This may raise the question in the minds of manufacturers and companies looking to use 3D printers in space: does Article VI prohibit unregulated 3D printing in space under current U.S. law? The answer is no, Article VI does not stop or prohibit manufacturers from 3D printing in space.

First, it is important to know if this treaty applies to 3D printing in space based on the language of that treaty itself. The first part of Article VI states:

States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other

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<sup>80</sup> Outer Space Treaty, *supra* note 46, at art. VI; MERCATUS CTR., *supra* note 64, at 3; *see* *Medellin v. Texas*, 552 U.S. 491, 505, 1356–57 (2008) (holding that there are distinctions on which international law obligations constitute automatically binding federal law).

<sup>81</sup> MERCATUS CTR., *supra* note 64, at 11–13; U.S. CONST. VI.

<sup>82</sup> Outer Space Treaty, *supra* note 46, at art. VI.

<sup>83</sup> *See generally* Matthew Schaefer, The Contours of Permissionless Innovation in the Outer Space Domain, 39 U. PA. J. INT’L L. 103 (2017) (noting the deficit of regulatory authority for authorizing and supervising commercial space activities).

<sup>84</sup> MERCATUS CTR., *supra* note 64, at 8 (citing Press Release, Federal Aviation Administration, Fact Sheet—Moon Express Payload Review Determination (Aug. 3, 2016)).

celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty.<sup>85</sup>

The treaty language is clear that it would cover all 3D printing activities in space, whether done by a U.S. government agency or by a private U.S. entity: “activities . . . carried on by government agencies or non-governmental entities.”<sup>86</sup> The next section of Article VI states: “The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty.”<sup>87</sup> This only applies to private entities like manufacturers and not to government 3D printing activities, and establishes an ongoing requirement of supervision of the specific space activity.<sup>88</sup> However, while the language appearing in this article of the treaty may apply to 3D printing, since it is arguably an activity of non-governmental entity in outer space, it does not do so automatically. Article VI does not prohibit U.S. private actors from operating in space, and they can do so without authorization and continuing supervision.<sup>89</sup>

Since the treaty applies to the subject matter at hand, it is now important to understand whether the treaty is self-executing. Article VI of the OST is not self-executing,<sup>90</sup> meaning that this article requires Congress to pass a law to have a legal effect on commercial operators in the U.S.<sup>91</sup> In *Medellin v. Texas*, the court explained that the text of the treaty must be analyzed.<sup>92</sup> The Court relied on language that has a future effect to indicate whether a treaty is self-executing.<sup>93</sup> There is future effect language in Article VI in the following sentence: “The activities of non-governmental entities in outer space . . . shall require authorization and continuing supervision by the appropriate State Party to the Treaty.”<sup>94</sup> This sentence indicates that, in the future, the U.S. government, as a party to the treaty must, “require authorization and continuing supervision of

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<sup>85</sup> Outer Space Treaty, *supra* note 46, at art. VI.

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

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

<sup>88</sup> *Id.*

<sup>89</sup> MERCATUS CTR., *supra* note 64, at 3.

<sup>90</sup> *Id.* at 3; *Reopening the American Frontier: Exploring How the Outer Space Treaty Will Impact American Commerce and Settlement in Space: Hearing Before the Subcomm. on Space, Sci., and Competitiveness, Comm. of Commerce, Sci., and Transp.*, 115th Cong. (2017) [hereinafter *Hearings*] (statement of James E. Dunstan, Senior Adjunct Fellow, TechFreedom, & Berin Szoka, President, TechFreedom).

<sup>91</sup> MERCATUS CTR., *supra* note 64, at 18; Bozzo, *supra* note 40, at 614–15.

<sup>92</sup> *Medellin v. Texas*, 552 U.S. 491, 506 (2008).

<sup>93</sup> MERCATUS CTR., *supra* note 64, at 15–16.

<sup>94</sup> Outer Space Treaty, *supra* note 46, at art. VI; MERCATUS CTR., *supra* note 64, at 21.

private activities in outer space.”<sup>95</sup>

In addition to the future looking language, when looking at the text in this article, there is specific language that points to the article not being self-executing: “States Parties to the Treaty shall bear international responsibility . . . for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty.”<sup>96</sup> The language of the treaty, especially the last line, leaves it in the hands of the individual countries to make any law that implements the treaty’s provisions.<sup>97</sup> This means, in the U.S., the legislative branch would be responsible for keeping the U.S. in compliance with the treaty.<sup>98</sup> In order for this article to have any force in the U.S., Congress must explicitly act and apply it to whatever activity is to be regulated by passing a law to give an executive agency regulatory authority.<sup>99</sup> Not all activities in space require oversight under the treaty—the treaty leaves that decision to the specific countries that are parties of the treaty.<sup>100</sup> In the U.S., it is up to Congress to decide what activity requires oversight.<sup>101</sup> For 3D printing manufacturers, this means that it is within Congress’ discretion to decide if 3D printing in space requires oversight. It is possible for Congress not to act or not to regulate a specific space activity.<sup>102</sup> Congress stays silent on a certain activity if it has not found that the specific activity requires regulation, notwithstanding exposing the U.S. to a risk of liability.<sup>103</sup> If Congress is silent on 3D printing, it would indicate that there are no barriers to the private sector for that activity, and regulatory agencies should not stand in the way of private entities looking to partake in 3D printing manufacturing.<sup>104</sup> This topic, in relation to regulatory agencies, will be dealt with below under subsections C and D of this analysis section.

## 2. *Article IX: Human Occupancy in Space vs. Harmful Contamination*

Article IX requires parties to the treaty to “conduct exploration of [celestial bodies] so as to avoid their harmful contamination.”<sup>105</sup> Article IX could be an obstacle to 3D printing in space because humans are full of bacteria and viruses; therefore, if humans are needed in the 3D printing manufacturing process, then

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

<sup>96</sup> Outer Space Treaty, *supra* note 46, at art. VI.

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

<sup>98</sup> MERCATUS CTR., *supra* note 64, at 22.

<sup>99</sup> *Id.* at 3–4. This concept will be explored further under National Law Heading.

<sup>100</sup> *Id.* at 23.

<sup>101</sup> *Id.* at 26.

<sup>102</sup> *Id.* at 22.

<sup>103</sup> *Id.* at 24.

<sup>104</sup> *Id.* at 23.

<sup>105</sup> Outer Space Treaty, *supra* note 46, at art. IX.

the harmful contamination requirement language of Article IX could be implicated.<sup>106</sup> However, Article IX applies only to the government, not to private companies.<sup>107</sup> This means that Article IX cannot prohibit private companies from engaging in 3D printing manufacturing in space.<sup>108</sup> This could also occur when humans start living in products these 3D printers create. It is also important to understand that Article IX is not self-executing.<sup>109</sup> Since it is not, then it is important to understand the role of domestic regulatory agencies.

First, it is important to understand if this treaty article applies to the 3D printing manufacturing process in space based on the language of the treaty itself. The part of Article IX of interest to 3D printing in space and its manufacturer is the following:

States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose.<sup>110</sup>

This language could potentially apply to 3D printing manufacturers given the human interaction needed in 3D printing and the worry of harmful contamination. There are two ways people could be involved in 3D printing and its resulting objects. The first way is that humans might be needed in order to operate the machines. The second way is that humans could end up living on Mars or other planets in homes that have been created by these printers. Humans are full of bacteria, enzymes, viruses, that cause concern for the harmful contamination element of Article IX. Even, if robots are used to operate the printers, Article IX would still remain an issue because NASA implements Article IX's requirement to avoid harmful contamination by sterilizing all spacecrafts headed to Mars.<sup>111</sup> This NASA policy is called planetary protection.<sup>112</sup>

Some regulatory agencies, like the FAA, argue that Article VI's requirement that States Parties to the treaty maintain "that national activities are carried out

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<sup>106</sup> *Id.*

<sup>107</sup> *Id.* (referring only to "state parties"); MERCATUS CTR., *supra* note 64, at 11 n.31.

<sup>108</sup> *See* Outer Space Treaty, *supra* note 46, at art. IX.

<sup>109</sup> *See generally* MERCATUS CTR., *supra* note 64 (arguing that Article VI is not self-executing and showing the importance of determining if a treaty is self-executing or not).

<sup>110</sup> Outer Space Treaty, *supra* note 46, at art. IX.

<sup>111</sup> *See Planetary Protection*, OSMA, <https://sma.nasa.gov/sma-disciplines/planetary-protection> (last visited Mar. 10, 2022); *see also* Laura Montgomery, *Congress and the Human Settlement of Space*, GROUND BASED SPACE MATTERS (Feb. 12, 2018), <https://groundbasedspacematters.com/index.php/2018/02/12/congress-human-settlement-space/>.

<sup>112</sup> *Id.*

in conformity with the provisions set forth in the present Treaty” means that commercial actors and not just governmental actors must abide by the provisions in the treaty.<sup>113</sup> However, Article IX’s harmful contamination provision makes no mention of private entities, and applying the provisions to commercial actors would ignore the plain language of the treaty itself.<sup>114</sup> Article IX consistently makes reference to “States Parties”<sup>115</sup> unlike Article VI, where reference specifically to “nongovernmental entities” is made.<sup>116</sup> If drafters wanted private entities to be subject to Article IX, they could have easily said so, as evidenced by Article VI and other parts of Article IX.<sup>117</sup>

Either way, if manufacturers are using humans to conduct 3D printing and Article IX applies, then it is important to understand that just like Article VI, Article IX is not self-executing.<sup>118</sup> As mentioned above in the Article VI analysis section, in *Medellin v. Texas*, the Court explained that in order to determine whether the treaty is self-executing one must analyze the text of that treaty.<sup>119</sup> The Court relied on language that has a future effect to indicate whether a treaty is self-executing.<sup>120</sup> In looking at Article IX, there is future language that indicates this provision is also not self-executing: “States Parties to the Treaty . . . where necessary, shall adopt appropriate measures for this purpose.”<sup>121</sup> The language here indicates that at some point in the future, a state’s legislative body may take measures in order to implement this part of Article IX.<sup>122</sup> This shows that this article of the treaty, much like Article VI, would also need congressional legislation to apply to private actors in the U.S.<sup>123</sup>

However, unlike Article VI, Article IX does not create an obligation on the U.S. to impose on the private sector.<sup>124</sup> Congress would essentially have to

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<sup>113</sup> Laura Montgomery, *New National Space Strategy and a Little Hope for Treaty Interpretation*, GROUND BASED SPACE MATTERS (Mar. 26, 2018), <https://groundbasedspacematters.com/index.php/2018/03/26/new-national-space-strategy-and-a-little-hope-for-treaty-interpretation/>.

<sup>114</sup> Outer Space Treaty, *supra* note 46, at art. IX; *New National Space Strategy and a Little Hope for Treaty Interpretation*, *supra* note 113.

<sup>115</sup> Outer Space Treaty, *supra* note 46, at art. IX.

<sup>116</sup> *Id.* at art. VI.

<sup>117</sup> *See New National Space Strategy and a Little Hope for Treaty Interpretation*, *supra* note 113.

<sup>118</sup> *See Hearings*, *supra* note 90, at 39 (statement of Laura Montgomery, Attorney and Proprietor of Ground Based Space Matters, LLC).

<sup>119</sup> *Medellin v. Texas*, 552 U.S. 491, 505 (2008).

<sup>120</sup> MERCATUS CTR., *supra* note 64, at 21.

<sup>121</sup> Outer Space Treaty, *supra* note 46, at art. IX.

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

<sup>123</sup> *Hearings*, *supra* note 90, at 39 (statement of Laura Montgomery, Attorney and Proprietor of Ground Based Space Matters, LLC).

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

weigh certain contamination views with human activity in space in deciding what and when to regulate.<sup>125</sup> Thus, Congress would need to make sure that whatever activity is taking place is conducive to human settlement.<sup>126</sup>

No matter what definition of harmful contamination is used, Article IX will not impact any private manufacturers looking to use 3D printing in space because it only applies to the government's activity.<sup>127</sup> Currently, NASA's definition of contamination is not conducive to human settlement in space.<sup>128</sup> NASA's current definition of contamination expands beyond just "toxins," "Agent Orange," and "peanuts on the aircraft," to include microbial contamination.<sup>129</sup> NASA considers two types of contamination harmful. The first is forward contamination "by terrestrial organisms and organic materials carried by spacecraft in order to guarantee the integrity of the search and study of extraterrestrial life."<sup>130</sup> The second is backward contamination "by extraterrestrial life or bioactive molecules in returned samples from habitable worlds in order to prevent potentially harmful consequences for humans and Earth's biosphere."<sup>131</sup> NASA goes to the extreme in trying to limit any possible bacteria that could present itself in space because it is concerned with protecting science, life on Earth, and potential life beyond Earth.<sup>132</sup> NASA believes that harmful contamination should be "prevented in order to preserve the integrity of exploring the solar system."<sup>133</sup> NASA does this by limiting "bacterial spores on any out-bound surface to no more than 30,000."<sup>134</sup> In order to make sure the limit stays in that range, every single spacecraft must be sterilized before going to Mars, to ensure no contamination takes place.<sup>135</sup>

In order to make sure 3D printing manufacturing is being used safely to create habitats and human settlements outside of Earth, the U.S. may believe that it needs to regulate because Article IX calls for avoiding harmful contamination.<sup>136</sup> The U.S. may believe it can do this given that NASA believes that its strict

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<sup>125</sup> 42 U.S.C. § 18312(a)(1) (2017); *see also Hearings, supra* note 90, at 39–40 (statement of Laura Montgomery, Attorney and Proprietor of Ground Based Space Matters, LLC).

<sup>126</sup> *Hearings, supra* note 90, at 39–40 (statement of Laura Montgomery, Attorney and Proprietor of Ground Based Space Matters, LLC).

<sup>127</sup> *Id.*

<sup>128</sup> *Id.*

<sup>129</sup> *Congress and the Human Settlement of Space, supra* note 111.

<sup>130</sup> *Planetary Protection, supra* note 111.

<sup>131</sup> *Id.*

<sup>132</sup> *Id.*; *Congress and the Human Settlement of Space, supra* note 111.

<sup>133</sup> *Completed, Ongoing & Future Missions*, NASA, <https://planetaryprotection.jpl.nasa.gov/missions> (last visited Mar. 28, 2022).

<sup>134</sup> *Congress and the Human Settlement of Space, supra* note 111.

<sup>135</sup> *Id.*

<sup>136</sup> *Outer Space Treaty, supra* note 46, at art. IX; *See generally Congress and the Human Settlement of Space, supra* note 111.

definition complies with Article IX.<sup>137</sup> However, people can and should go to Mars and live in printed habitats because Congress told NASA to focus on the expansion of human life beyond just Earth.<sup>138</sup> This is evident in the goals and objectives of NASA, which Congress articulates as “to expand permanent human presence beyond low-Earth orbit and to do so, where practical, in a manner involving international, academic, and industry partners.”<sup>139</sup> It also goes on to further explain the U.S.’s key objectives to determine if humans can live for long periods of time in space, with the idea in mind that eventually, they would need to rely less on Earth.<sup>140</sup> However, if the goal is human presence on Mars using these 3D printed habitats, then NASA may not be able to fulfill Congress’s goals and policy ideals for the agency because humans are full of bacteria and 3D printed objects created by humans will also naturally be covered in bacteria, thwarting NASA’s planetary protection plan.<sup>141</sup> Since Congress has told NASA to focus on enabling a human presence in space, including Mars,<sup>142</sup> NASA needs to recognize that its definition of contamination hinders that ability.<sup>143</sup> Congress’s mandates to NASA ultimately trump NASA’s need to sterilize every single thing if it hinders the goal; which is livable human habitats in space and beyond that the sustaining of human life in space.<sup>144</sup>

However, 3D printing manufacturers should make note that Article IX does not apply to private actors and even if it did, it is not self-executing meaning it does not apply to them without legislation from Congress.<sup>145</sup> Lastly, 3D printing manufacturers do not need to worry about NASA’s planetary protection policy and sanitation efforts because NASA is not a regulatory agency and should not impact the 3D printing manufacturers’ objectives or plans in space.<sup>146</sup>

## B. Are 3D Printed Objects Considered Space Objects Under the Liability

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<sup>137</sup> See generally *Congress and the Human Settlement of Space*, *supra* note 111.

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

<sup>139</sup> 42 U.S.C. § 18312(a)(1) (2017).

<sup>140</sup> § 18312(b)(1)-(5) (2017).

<sup>141</sup> *Congress and the Human Settlement of Space*, *supra* note 111.

<sup>142</sup> 51 U.S.C. § 70504(b) (2017) (“[T]he Administrator shall take all necessary steps . . . to ensure that activities in the Administration’s human space exploration program balance[s] how . . . activities might also help meet the requirements of future exploration and utilization leading to human habitation on the surface of Mars.”).

<sup>143</sup> *Congress and the Human Settlement of Space*, *supra* note 111.

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

<sup>145</sup> Outer Space Treaty, *supra* note 46, at art. IX; *Hearings*, *supra* note 90, at 39–40 (statement of Laura Montgomery, Attorney and Proprietor of Ground Based Space Matters, LLC).

<sup>146</sup> Richard Blaustein, *Private-Sector Space Activities Require Government Regulation*, *Says US Report*, PHYSICSWORLD (July 4, 2018), <https://physicsworld.com/a/private-sector-space-activities-require-government-regulation-says-us-report/>.

Convention and Registration Convention?

It makes the most sense to analyze the Liability Convention and the Registration Convention together because the arguments for whether these treaties apply to 3D printing revolves around whether 3D objects printed in space are considered space objects. The answer is complicated, as seen *infra*, and it changes depending on if you are talking about the printer or the objects printed, under both treaties.<sup>147</sup> 3D printing manufacturers will need to register their printers, and or objects printed from those objects, and they will also need to keep these objects in mind when it comes to potential liability for any damage they cause in space.

The reason why the U.S. would be interested in regulating 3D printing is because, under Article II of the Liability Convention, a launching state is liable for damage caused by its space object launched into space.<sup>148</sup> A state is a launching state under Article I when “a State launches or procures the launching of a space object [or when] a State from whose territory or facility a space object is launched.”<sup>149</sup> It is also important to note that when the Liability Convention was written, the idea of 3D printing did not exist and the ability for people to legitimately build objects directly in space was not necessarily what was being thought about at the time.<sup>150</sup> This is exactly why it is important to try and understand if this new technology is something that would apply under both the Liability Convention and the Registration Convention.

In order to figure out whether either of these treaties apply, it must first be decided if 3D printed objects are considered space objects. Both the Liability Convention and the Registration Convention have identified parts of a “space object,” but with that term comes difficulty in truly understanding the meaning behind it since it remains broad and effectively undefined.<sup>151</sup> The Liability Convention gives a full definition of a space object by clarifying that a space object “includes component parts of a space object as well as its launch vehicle and parts thereof.”<sup>152</sup> Here the treaty essentially does the one thing that children are taught never to do in school: define something by using the word itself in its definition. The treaty defines the term space object by using the word space object; therefore, the definition is not very helpful and leaves analyzers stuck at and back at the beginning, wondering what the term truly means and what is

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<sup>147</sup> See *infra* notes 154–82 and accompanying text.

<sup>148</sup> Liability Convention, *supra* note 57, at art. II.

<sup>149</sup> *Id.* at art. I.

<sup>150</sup> Laura Rut Skopowska, *Is an Object Built in the Outer Space a ‘Space Object’ Under the Liability Convention?*, (2017) (L.L.M thesis, University of Luxembourg) (on file with author).

<sup>151</sup> *Id.*

<sup>152</sup> Liability Convention, *supra* note 57, at art. I(d); Skopowska, *supra* note 150.

included in its definition.

Another key word that is undefined in the treaty is “launch.” The definition of launch matters in the Liability Convention because a State Party that is also a “launching State” faces liability.<sup>153</sup> In other words, states who launch may face liability for damage caused by their space objects, thus making the definition of space object somewhat dependent on the definition of launch.<sup>154</sup> The term “launch vehicle” is similarly important because the definition of a space object is also dependent on the definition of a launch vehicle since a space object “includes component parts of . . . its launch vehicle . . .”<sup>155</sup> Using this definition one must first identify what a launch vehicle is in order to identify a space object.<sup>156</sup> The definition also matters to the Registration Convention because when a space object is “launched” either the State that launched the object must register that object or the State the object was launched from must register the object.<sup>157</sup> This lack of clarity allows for arguments and interpretations, especially when it comes to 3D printed objects created in space given that those objects have not been “launched.”<sup>158</sup> When looking at the words of a treaty and trying to understand the meaning, the Vienna Convention on the Laws of Treaties (“VCLT”) says that: “A treaty shall be interpreted in good faith in accordance with the ordinary meaning, to be given to the terms of the treaty in their context and in the light of its object and purpose.”<sup>159</sup> Treaty interpretations are codified in VCLT Articles 31 and 32 and despite the U.S. not being a party to the treaty it still holds itself to the provisions.<sup>160</sup>

The ordinary meaning of launch will be important in determining whether 3D printers and their resulting objects will be considered space objects under both treaties. The ordinary dictionary meaning of launch, is “to send forth, catapult, or release, as a self-propelled vehicle or weapon.”<sup>161</sup> In terms of the 3D printer itself, this ordinary meaning implies that since it is being “sent forth” into space on an object that is “self-propelled” into space,<sup>162</sup> it will be considered a space

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<sup>153</sup> *Id.* at art. II.

<sup>154</sup> *See generally id.*

<sup>155</sup> *Id.* at art. I(d).

<sup>156</sup> *Id.*

<sup>157</sup> *Id.* at art. 1, II.

<sup>158</sup> Skopowska, *supra* note 150.

<sup>159</sup> Vienna Convention on the Laws of Treaties art. XXXI, 1155 U.N.T.S. 331 (entered into force Jan. 27, 1980).

<sup>160</sup> *Hearings, supra* note 90, at 46–47 (statement of Matthew P. Schaefer, Professor of International Trade Law, Veronica A. Haggart, Co-Director of the Space, Cyber and Telecommunications Law Program, University of Nebraska College of Law, and Charles R. Work, Co-Chair, American Branch of International Law Assoc. Space Law Committee).

<sup>161</sup> *Launch*, DICTIONARY.COM, <https://www.dictionary.com/browse/launch> (last visited Mar. 28, 2022).

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

object since a space object “includes component parts of . . . its launch vehicle.”<sup>163</sup> In this case, the launch vehicle would be a rocket being self-propelled into space that carries on board the 3D printer, effectively making the 3D printer a space object.<sup>164</sup>

However, just because the 3D printer is a space object, does not necessarily mean that the objects the printer creates while in space will also be considered space objects. A printer launched from Earth is likely a space object, as detailed above. Some Scholars argue that anything made from material launched from Earth is also a space object since the printer originally launches from a state and the material used as ink, if brought from Earth, would be considered a space object.<sup>165</sup> It is argued that when the ink is either material from space or a mix of Earth and space material then it should still be analyzed the same way.<sup>166</sup> Explaining further, that ink that is solely space material is not a space object, but when an object is created out of it using 3D printing technology, then it becomes a space object because it has been launched or placed in this sense.<sup>167</sup>

This argument about printed objects also being space objects is incorrect, as the argument fails to acknowledge that manufacturing and launching are entirely different terms and that the words “launching,” “placing,” and “making” all have different meanings as well. Launching was defined above, but “placing” is defined as “to put or set in a particular place, position, situation, or relation”<sup>168</sup> and “making” is defined as “to bring into existence by shaping or changing material, combining parts.”<sup>169</sup> These definitions are all different and the argument fails to recognize that distinction.

When a manufacturer uses a 3D printer in space, it has created or made something that is already in space. Yes, the 3D printer was launched in space in accordance with the ordinary meaning of the word, therefore making it a space object, but once that happens it is already in space and nothing is being launched.<sup>170</sup> The objects that are being created from the printer, once already in space, are not being launched; they are being created because they are “being brought into existence . . . and combining parts” of materials to make a new

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<sup>163</sup> Liability Convention, *supra* note 57, at art. I(d).

<sup>164</sup> *Launch*, *supra* note 161.

<sup>165</sup> Louis de Gouyon Matignon, *The Legal Status of Objects Printed in Outer Space*, SPACE LEGAL ISSUES (Apr. 9, 2020), <https://www.spacelegalissues.com/space-law-the-legal-status-of-objects-printed-in-outer-space/>.

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

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

<sup>168</sup> *Place*, DICTIONARY.COM, <https://www.dictionary.com/browse/place?s=t> (last visited Mar. 28, 2022).

<sup>169</sup> *Make*, DICTIONARY.COM, <https://www.dictionary.com/browse/make?s=t> (last visited Mar. 28, 2022).

<sup>170</sup> *See generally Launch*, *supra* note 161.

object.<sup>171</sup> Since they are created and not launched, the 3D printed objects should not be considered space objects.

Aside from the ordinary meaning discussed above, and despite the treaty leaving “launch” undefined, the U.S. does define launch.<sup>172</sup> According to the U.S.,

Launch means to place or try to place a launch vehicle or reentry vehicle and any payload or human being from Earth – (A) in a suborbital trajectory; (B) in Earth orbit in outer space; or otherwise in outer space, including activities involved in the preparation of a launch vehicle or payload for launch, when those activities take place at a launch site in the United States.<sup>173</sup>

Even with the U.S. definition of launch, the objects printed would not be considered space objects because, they are not being launched.<sup>174</sup> These objects are being created in space, not created on Earth and then being launched into space after the fact.

While 3D printers themselves would be considered space objects, the items they create from earthly materials or Martian raw materials would not be considered space objects. Any 3D printing manufacturer looking to print in space needs to register only their 3D printer under the Registration Convention.<sup>175</sup> They also need to keep in mind the Liability Convention when it comes to the printers.<sup>176</sup>

#### C. FCC’s Tendency to Expand its Regulatory Authority Should Not be Used to Regulate 3D Printing.

Since the international treaties in play are not self-executing, domestic law may be of importance because regulatory agencies may regulate or attempt to regulate 3D printing manufacturers in space. As seen above, regulatory agencies like the FCC cannot do this automatically.<sup>177</sup> Congress would need to give a regulatory agency authority to regulate certain activities in space.<sup>178</sup> In this case the question is, does the FCC have authority to regulate and impact the 3D printing manufacturers in space? The FCC tends to go beyond its given authority and regulate things outside of its scope. Here, 3D printing in space should be

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<sup>171</sup> *Make, supra* note 169.

<sup>172</sup> 51 U.S.C. § 50902(7) (2015).

<sup>173</sup> *Id.*

<sup>174</sup> *Id.*

<sup>175</sup> Registration Convention, *supra* note 61.

<sup>176</sup> Liability Convention, *supra* note 57, at art. II.

<sup>177</sup> MERCATUS CTR., *supra* note 64, at 3–4. *See supra* Section IV.C.

<sup>178</sup> MERCATUS CTR., *supra* note 64, at 16.

considered outside of the FCC's scope of regulatory authority.

The FCC tends to go beyond direct regulation of radio frequency, which is easy to do when the mandate to issue licenses is so broad.<sup>179</sup> The mandate allows the FCC to issue a license “if public convenience, interest, or necessity will be served thereby.”<sup>180</sup> Laura Montgomery, in her Ground Based Space Matters Blog, discusses Mitigation of Orbital Debris in the New Space Age as an example of how the FCC tends to go beyond the regulatory authority given to it by Congress.<sup>181</sup> In this instance, the FCC is trying to require the “satellite industry to indemnify the U.S. Government.”<sup>182</sup> It specifically “propose[s] to modify our rule such that applicants must include in the orbital debris statement a demonstration concerning limiting risk from accidental explosions and associated orbital debris during mission operations.”<sup>183</sup> This is not the only instance where the FCC has attempted to go beyond its broad authority—it has also done so with trying to regulate internet access by adopting Open Internet rules, which is a more hands-on approach to the internet.<sup>184</sup>

Since the authority given to the FCC in the Communications Act was so broad, courts tended to give deference to the FCC and what it believes the Act says, as seen in cases like *Nat'l Cable & Telecomms. Ass'n v. Brand X Internet Servs.* (“*Brand X*”).<sup>185</sup> In *Brand X*, the Court looked into whether the FCC concluding that “cable companies that sell broadband internet service do not provide ‘telecommunications service’ as the Communication Act defines that term” is an accurate interpretation of the Communications Act.<sup>186</sup> In reaching a conclusion, the Supreme Court discussed the *Chevron* framework, which essentially involves the idea that agencies are better equipped than courts at

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<sup>179</sup> DANIEL MORGAN, *supra* note 63.

<sup>180</sup> *Id.*

<sup>181</sup> Laura Montgomery, *FCC Continuing to Push for Satellite Industry to Indemnify U.S. Government Despite Lack of Authority*, GROUND BASED SPACE MATTERS (Sept. 11, 2020), <https://groundbasedspacematters.com/index.php/2020/09/11/fcc-continuing-to-push-for-satellite-industry-to-indemnify-u-s-government-despite-lack-of-authority/>.

<sup>182</sup> Mitigation of Orbital Debris in the New Space Age, 85 Fed. Reg. 52455, 52443–52444 (Aug. 25, 2020) (to be codified at 47 C.F.R. pt. 5, 25, 97); *FCC Continuing to Push for Satellite Industry to Indemnify U.S. Government Despite Lack of Authority*, *supra* note 181.

<sup>183</sup> Mitigation of Orbital Debris in the New Space Age, 85 Fed. Reg. at 52456.

<sup>184</sup> Gus Hurwitz, *With ‘Net Neutrality’, FCC Moves Beyond Its Legal Authority*, REALCLEARMKTS. (Feb. 25, 2015), [https://www.realclearmarkets.com/articles/2015/02/25/with\\_net\\_neutrality\\_fcc\\_moves\\_beyond\\_its\\_legal\\_authority\\_101547.html](https://www.realclearmarkets.com/articles/2015/02/25/with_net_neutrality_fcc_moves_beyond_its_legal_authority_101547.html).

<sup>185</sup> *Id.*; *see generally* *Nat'l Cable & Telecomms. Ass'n v. Brand X Internet Servs.*, 545 U.S. 967 (2005) (holding that cable companies that sell broadband Internet service do not provide “telecommunications servic[e]” as the Communications Act defines that term, and hence are exempt from mandatory common-carrier regulation).

<sup>186</sup> *Nat'l Cable & Telecomms. Ass'n*, 545 U.S. at 973.

navigating difficult policy choices involved in interpreting gaps within statutes discussing agency jurisdiction.<sup>187</sup> The Court ultimately concluded that the FCC's conclusion was an accurate interpretation of the Communications Act.<sup>188</sup> However, Justice Scalia dissented from the majority opinion and expressed concern over the FCC going beyond its authority given to it by Congress.<sup>189</sup> Justice Scalia also expressed concern over the majority effectively giving agencies a lot of power over the courts by allowing agencies to ignore what the Court holds the statute means and instead utilize *Chevron* to apply their own expansive interpretations.<sup>190</sup>

The FCC was given authority by Congress to regulate telecommunications service, which allowed the FCC to claim that internet access falls under that authority and therefore should be regulated by it.<sup>191</sup> Courts expect that when Congress wants an agency to have a certain authority, then Congress will say so explicitly.<sup>192</sup> Those against the FCC regulating internet access focused on the fact that the statutory interpretation allows for the FCC to expand the scope of its authority.<sup>193</sup> For decades, the internet had been met with a hands-off approach and in expanding its authority the FCC would be effectively ending that long-standing policy.<sup>194</sup>

It is possible that given the FCC's history in trying to go beyond its regulatory authority, the FCC could see 3D printing as something that falls under its broad authority, and it could try and expand its reach to regulate 3D printers. However, as has been demonstrated, if Congress wants rules regulating net neutrality, or in this case rules regulating 3D printing, it should explicitly say so, and the regulations should originate with Congress.<sup>195</sup> The FCC should not just expand its idea of its broad authority to encompass 3D printing by classifying it as something the FCC has authority over, like radio frequency or by noting that manufacturing controls are transmitted over regulated frequencies.

#### D. FAA's Payload Review: Are 3D Printed Objects Subject to Review?

The FAA may falsely believe that it can deny access to space to those that are

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<sup>187</sup> *Id.* at 980; *see generally* *Chevron, U.S.A., Inc. v. Natural Defense Council, Inc.* 467 U.S. 837 (1984) (explaining that considerable weight should be accorded to executive department's construction of statutory scheme it is entrusted to administer).

<sup>188</sup> *Nat'l Cable & Telecomms. Ass'n*, 545 U.S. at 1003.

<sup>189</sup> *Id.* at 1005 (Scalia, J., dissenting).

<sup>190</sup> *Id.* at 1016–17.

<sup>191</sup> Hurwitz, *supra* note 184.

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

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

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

<sup>195</sup> Hurwitz, *supra* note 184.

not authorized based on Article VI of the OST.<sup>196</sup> The FAA cannot rely on Article VI of the OST to prohibit private 3D manufacturers from carrying out activities in space.<sup>197</sup> As explained above, Congress would have to give the FAA authority over 3D printing and the private manufacturers.<sup>198</sup> Congress has given the FAA authority over what is known as a ‘payload review.’<sup>199</sup> The question then becomes are 3D printed objects payloads, and thus subject to payload review? The answer would be yes, a 3D printed object would be considered a payload under the payload review because it is an object.<sup>200</sup>

As mentioned above, the FAA has what is called payload review authority.<sup>201</sup> A payload is “an object that a person undertakes to place in outer space by means of a launch vehicle or reentry vehicle, including components of the vehicle specifically designed or adapted for that object.”<sup>202</sup> Here, a 3D printed object would be considered a payload if a manufacturer places a 3D printer on a launch vehicle with the intention of placing the 3D printer and the objects the printer produces in space.<sup>203</sup> When an authorization, license or permit is not required, then the FAA can act and essentially stop launches if it feels that the object is implicating public safety because that is the authority Congress has given it.<sup>204</sup> This most likely would not even apply to 3D printing manufacturers because “most payloads possess, at the very least, an authorization from the FCC for any necessary transmissions to the United States, thus making unnecessary any FAA consideration of foreign policy interests.”<sup>205</sup> A manufacturer would likely at least have an FCC authorization because the manufacturing controls are transmitted over regulated frequencies. Accordingly, it could be argued that the FAA should not perform a payload review.

Even if there was no authorization by the FCC, Congress has been very clear that while the FAA can regulate launches it cannot interfere or regulate activities of reentry vehicles once in orbit and beyond.<sup>206</sup> This would come into play with 3D printing considering once launched, the 3D printing activity could take place in space, and the FAA’s oversight does not go past launch and reentry, meaning

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<sup>196</sup> MERCATUS CTR., *supra* note 64, at 4.

<sup>197</sup> *Id.* at 11.

<sup>198</sup> *Id.* at 9. *See supra* Section V.A.1.

<sup>199</sup> 51 U.S.C. § 50904(c) (2015).

<sup>200</sup> § 50902(13) (2015).

<sup>201</sup> § 50904 (c) (2015). *See supra* notes 78–81 and accompanying text.

<sup>202</sup> § 50902(13) (2015).

<sup>203</sup> *Id.*

<sup>204</sup> § 50904 (c) (2015); *see also* Laura Montgomery, *No Tardigrades Here*, GROUND BASED SPACE MATTERS (Aug. 29, 2019), <https://groundbasedspacematters.com/index.php/2019/08/22/no-tardigrades-here/>.

<sup>205</sup> MERCATUS CTR., *supra* note 64, at 29.

<sup>206</sup> *No Tardigrades Here*, *supra* note 204; *see also* H.R. REP. NO. 105-347, pt. 2, at 22–23 (1997).

it cannot regulate in orbit activity.<sup>207</sup> The FAA would try and stop launches and reentries, because it worries that private manufacturers that are unsupervised and unauthorized would put the US at risk of not being in compliance with Article VI of the OST.<sup>208</sup>

The FAA has used Article VI against private actors in the past.<sup>209</sup> This can be seen in its 2016 Moon Express press release.<sup>210</sup> In this press release, the FAA discusses its payload review of Moon Express, and it suggests “that Article VI requires authorization and supervision of the activities of nongovernmental entities in outer space.”<sup>211</sup> While this payload review was favorable, the FAA said not all nontraditional activities will be as favorable and may require that Congress grant it additional authority.<sup>212</sup>

Since 3D printed objects would be considered payloads, the FAA does have authority to review them before launch or before reentry.<sup>213</sup> However, the FAA cannot prohibit private 3D manufacturers from entering space based on Article VI of the OST.<sup>214</sup> It can only stop launch or reentry by the manufacturers if it feels the 3D printed objects would implicate public safety.<sup>215</sup>

#### E. Other Industry Examples of Regulation’s Impact on Advancement

In discussing why the government should not impose regulations on a technological

advancement such as 3D printing in space, it is helpful to analogize to another advancement that either benefited by lack of, or lessening of governmental regulation, or was stifled by strict or too much governmental regulation. A good and timely example to consider is the COVID-19 vaccine. Similar to the goal of the U.S. to place humans in outer space,<sup>216</sup> the goal of the U.S. in terms of the vaccine is to end the threat of COVID-19 and to promote public health and safety.<sup>217</sup> Much like how 3D printing could be regulated by various international

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<sup>207</sup> MERCATUS CTR., *supra* note 64, at 9.

<sup>208</sup> *Id.* at 7.

<sup>209</sup> *Id.* at 4 (citing Press Release, Federal Aviation Administration, Fact Sheet-Moon Express Payload Review Determination, press release (Aug. 3, 2016)).

<sup>210</sup> *Id.* at 8 (citing Press Release, Federal Aviation Administration, Fact Sheet-Moon Express Payload Review Determination, press release (Aug. 3, 2016)).

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

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

<sup>213</sup> 51 U.S.C. § 50904(c) (2015).

<sup>214</sup> MERCATUS CTR., *supra* note 64, at 5.

<sup>215</sup> § 50904(c) (2015); *see also No Tardigrades Here*, *supra* note 204.

<sup>216</sup> 42 U.S.C. § 18312(a)(1) (2017).

<sup>217</sup> Karen Kaplan, *The FDA Didn’t ‘Approve’ Pfizer’s COVID-19 Vaccine. Here’s Why*, L.A. TIMES (Dec. 12, 2020), <https://www.latimes.com/science/story/2020-12-12/why-fda-didnt-approve-pfizer-covid-19-vaccine-eua>.

or national law, the FDA typically regulates and has a stringent process in place when issuing out new vaccines.<sup>218</sup> However, during a pandemic, when there is an urgent global health risk, and time is of the essence, the FDA had to utilize the emergency use authorization (“EUA”).<sup>219</sup> Naturally, the FDA still must make sure the vaccine will do more good than harm, it just does so in a quickened manner, rather than the usual approval process.<sup>220</sup> The normal vaccine development process in the U.S. lasts 10-15 years.<sup>221</sup> The COVID-19 vaccine still went through various phases of testing and once enough data has been procured, the EUA was given.<sup>222</sup> This example goes to show that sometimes the government should not always regulate something just because they can. Sometimes, relaxing those regulations can help accomplish goals and promote advancement, especially in emergent health and safety circumstances.

## V. CONCLUSION

The world’s increased fascination with space, mixed with society’s ever advancing technology has led to the very real possibility of 3D printing in space—specifically 3D printed human habitats in space. 3D printing allows for efficiency and cost saving technology that can really complement and further space exploration and eventual habitation. What was once a much harder reality has now become a likely reality with an ever-evolving timeline. Up until recently, this is something that people could only dream up in storylines of books and movies. However, this aspiration is no longer fiction or fantasy.

Since space law has both international and national components and certain aspects of each can be very broad at times, it is sometimes difficult to know when to regulate certain activities. When it comes to the U.S. and the international treaties aforementioned, Congress must effectuate how the U.S. is going to be in compliance with them for the treaties to actually apply. This can be seen with the authority Congress has given regulatory agencies to regulate certain aspects of space activity. However, the FAA and FCC do not have the authority to prevent 3D printing manufacturers from performing the action of 3D printing in space. The FAA only has authority to review 3D printed objects before launch or reentry during their payload review.

The environmental aspects of Article IX should not be overlooked. However, regulating 3D printing based on Article IX would greatly hinder the goals

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

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

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

<sup>221</sup> *Vaccine Development, Testing, and Regulation*, HIST. OF VACCINES, <https://www.historyofvaccines.org/content/articles/vaccine-development-testing-and-regulation> (last visited Mar. 28, 2022).

<sup>222</sup> Kaplan, *supra* note 217.

Congress has expressly stated and assigned to NASA of encouraging human settlement. Still, the private sector need not worry about regulation based on Article IX, as it only applies to government action and not to private action. Furthermore, if these potential habitats cause harmful contamination of any kind that NASA feels goes against its planetary protection policy, NASA is not a regulatory agency and should not impact the 3D printing manufacturers objectives or plans in space. The environmental issues could also be handled without regulating 3D printing anyway, simply by creating building or manufacturing standards, and certain codes that these habitats must meet to ensure that they would not cause environmental issues or harmful contamination.

Since objects assembled in space should not be considered space objects by the U.S., then the U.S. will not need to register the objects the printer creates and need only register the printer itself in compliance with the Registration Convention. This also means that the U.S. will only need to consider the printers when the U.S. is considering liability concerns under the Liability Convention. No matter what, just because the government can regulate something does not necessarily mean that it should. There are so many potential benefits to the use of 3D printing in space. The U.S. should be careful not to be too strict in regulating this technology in space so as not to hinder the ultimate goal which is to have a human presence in space.