

# COMMERCIAL SPACE COMPANIES: LAWMAKERS OF 21<sup>ST</sup> CENTURY NEW SPACE

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## ABSTRACT

In July 2021, not one, but two of the world's richest people, Richard Branson and Jeff Bezos, successfully reached space via commercial spaceflight.<sup>1</sup> SpaceX, on the other hand, made history by launching an all-civilian crew of four into space and safely landing them back on Earth after a three-day mission orbiting the planet.<sup>2</sup> What was once the sole province of the world's political behemoths, spacefare has advanced to a point where full commercialization is no longer a question of how, but when.

Unfortunately, leaps and bounds in the technological world were not accompanied by similar advancements in the legal world. International treaty law that governs outer space activities chiefly comprises four treaties, the last of which was negotiated and became effective in 1976—almost half a century ago. It should generate scant surprise that the governance scheme outlined by these treaties is pitifully dated and unsuited for the reality of outer space

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<sup>1</sup> Kenneth Chang, *Highlights From Richard Branson's Virgin Galactic Flight*, N.Y. TIMES (Sept. 15, 2021), <https://www.nytimes.com/live/2021/07/11/science/virgin-galactic-launch-richard-branson>; Paul Rincon, *Jeff Bezos Launches to Space Aboard New Shepard Rocket Ship*, B.B.C. NEWS (July 20, 2021), <https://www.bbc.com/news/science-environment-57849364>.

<sup>2</sup> Denise Chow, *SpaceX Makes History with First All-Civilian Spaceflight*, NBC NEWS (Sept. 16, 2021), <https://www.nbcnews.com/science/space/spacex-makes-history-first-civilian-spaceflight-rna2027>; Kenneth Chang, *Inspiration4 Astronauts Beam After Return From 3-Day Journey to Orbit*, N.Y. TIMES (Sept. 18, 2021), <https://www.nytimes.com/2021/09/18/science/spacex-inspiration4.html>.

activities today. The problems that arise from this mismatch between technological reality and formal international law are legion.

Since it seems unlikely that the major spacefaring powers will be able to agree upon another treaty any time soon (given world politics today),<sup>3</sup> the burden of resolving contemporary governance problems in outer space falls upon customary international law (CIL). In fact, many articles in the space treaties were developed from CIL at the time or had since been accepted as CIL. However, while CIL's broad applicability to States is well-accepted, its applicability to non-State participants (most importantly commercial space companies) remains a contentious issue. This article argues for a direct application of CIL to commercial space companies and a recognition of the direct role commercial space companies will play in the creation of CIL in outer space.

Part I of the article gives a brief overview of treaty law that governs outer space activities, chief among them the four seminal treaties that came into force between 1967 and 1975. It also briefly examines efforts to update treaty law in the years following the negotiation of the original four. Part II explores the different sectors of the contemporary space industry, their market characteristics and associated legal problems. Part III analyzes the relationship between CIL and the governance of outer space activities, as well as recent developments in major spacefaring States that hint at potential changes in CIL. Part IV discusses the increasing prominence of large corporations' role in the formation of CIL and compares the commercial space industry (New Space) with the cybertechnology

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<sup>3</sup> As of this writing, the global geopolitical landscape is tense, to say the least. Just to name a few examples: US-China relations are at their lowest point in decades; US-Russia relations are at an all-time low; the war in Ukraine has led to a further deterioration of already-strained EU-Russia relations. (See generally Iain Marlow & Ana Monteiro, *China Ties at 'Lowest Moment' Since 1972, US Ambassador Says*, BLOOMBERG (Jun. 9, 2022), <https://www.bloomberg.com/news/articles/2022-06-09/china-ties-at-lowest-moment-since-1972-us-ambassador-says#xj4y7vzkg?leadSource=verify%20wall>; James T. Areddy & Charles Hutzler, *U.S., China Plunge Further Into a Spiral of Hostility*, THE WALL ST. J. (Mar. 7, 2023), <https://www.wsj.com/articles/u-s-china-plunge-further-into-a-spiral-of-hostilities-b9e539c0>; Caleb Davis & Kevin Liffey, *Russia says relations with U.S. at an all-time low*, REUTERS (Jan. 20, 2023), <https://www.reuters.com/world/europe/russia-says-relations-with-us-an-all-time-low-2023-01-20/>; Stefan Meister, *A Paradigm Shift: EU-Russia Relations After the War in Ukraine*, CARNEGIE EUROPE (Nov. 29, 2022), <https://carnegieeurope.eu/2022/11/29/paradigm-shift-eu-russia-relations-after-war-in-ukraine-pub-88476>.)

industry to portend a future where space companies not only influence, but directly create CIL.

### I. FOUR SEMINAL TREATIES, HALF A CENTURY OLD

In the dawn of humankind's space age, only States, and the most powerful States at that, had a realistic chance of reaching outer space successfully. The resultant international legal regime was therefore, perhaps unsurprisingly so, State-centric. While many treaties addressing the governance of space have been proposed and signed, four tower over the rest (because they have been ratified by the "Big Three" – the United States (US), the Soviet Union (now Russia) and the People's Republic of China (China))<sup>4</sup> and they are known colloquially as the Outer Space Treaty (OST),<sup>5</sup> the Rescue Agreement,<sup>6</sup> the Liability Convention,<sup>7</sup> and the Registration Convention.<sup>8</sup>

The OST is the foundational document of international space regulations.<sup>9</sup> It provides the main legal framework for space activities and centers around international cooperation, with an eye towards ensuring that space activities would benefit all countries and avoiding harmful interference of other States' legal space activities.<sup>10</sup> With 112 ratifiers and 23 signatories as of January 2022,<sup>11</sup> it is highly recognized by States and considered by many to constitute

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<sup>4</sup> Katherine Latimer Martinez, *Lost in Space: An Exploration of the Current Gaps in Space Law*, 11 SEATTLE J. TECH. ENV'T & INNOVATION L. 322, 328 (2021).

<sup>5</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 the Outer Space Treaty].

<sup>6</sup> Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119 [hereinafter Rescue Agreement].

<sup>7</sup> Convention on the International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention].

<sup>8</sup> Convention on Registration of Objects Launched into Outer Space, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15 [hereinafter Registration Convention].

<sup>9</sup> Martinez, *supra* note 4, at 326.

<sup>10</sup> Frans G. von der Dunk, *Billion-dollar Questions? Legal Aspects of Commercial Space Activities*, 23 UNIF. L. REV. 418, 420 (2018).

<sup>11</sup> Comm. on the Peaceful Uses of Outer Space, Rep. of the Legal Subcommittee on its Sixty-First Session, *Status of International Agreements Relating to Activities in Outer Space as at 1 January 2022*, 10 U.N. Doc. A/AC.105/C.2/2022/CRP.10 (2022) [hereinafter Status of International Space Agreements].

Customary International Law (CIL).<sup>12</sup> The OST declares that, *inter alia*, international law applies in outer space,<sup>13</sup> there is freedom in the exploration and use of space,<sup>14</sup> no nation may claim territory in outer space,<sup>15</sup> astronauts are to be given assistance in emergencies and returned to their State of registry,<sup>16</sup> State parties and launching States are liable for damage caused to another State through its own space activities or through the activities of those subject to its jurisdiction,<sup>17</sup> States must license and supervise the activities of their nationals,<sup>18</sup> and State parties retain jurisdiction and control over launched objects and personnel on the national registries created for that purpose.<sup>19</sup> Notably, the OST imposes upon State parties both an international responsibility for national outer space activity, including activity engaged in by a non-governmental entity, and a requirement to authorize and supervise those non-governmental space activities, making it impossible for a State to escape liability from outer space activity, even if it abandons the space object.<sup>20</sup>

The three treaties that followed functioned to clarify and further expand the OST, with the Rescue Agreement<sup>21</sup> coming into force one year after the OST was signed.<sup>22</sup>

The Rescue Agreement deals mainly with the rescue and return of astronauts, as well as space objects.<sup>23</sup> State parties have a duty to notify launching authorities and the Secretary-General of the United Nations about accidents, distress, or emergencies of spacecraft personnel if they have *knowledge* of such, regardless of

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<sup>12</sup> Mahulena Hofmann & P.J. Blount, *Emerging Commercial Uses of Space: Regulation Reducing Risks*, 19 J. OF WORLD INV. & TRADE 1001, 1007 (2018).

<sup>13</sup> See Outer Space Treaty, *supra* note 5, art III.

<sup>14</sup> *Id.* at art. I.

<sup>15</sup> *Id.* at art. II.

<sup>16</sup> *Id.* at art. V.

<sup>17</sup> *Id.* at art. VII.

<sup>18</sup> *Id.* at art. VI.

<sup>19</sup> *Id.* at art. VIII.

<sup>20</sup> *Id.* at art. VI; See FRANCIS LYALL & PAUL B. LARSEN, *SPACE LAW: A TREATISE* 78 (2nd ed. 2018) (“There is no suggestion that a state or other entity can divest itself of obligations in relation to space objects by their abandonment. In short, we believe that a state cannot cease to be ‘responsible for’ or avoid any correlative duties by abandoning a space object”).

<sup>21</sup> Rescue Agreement, *supra* note 6.

<sup>22</sup> Status of International Space Agreements, *supra* note 11, at 1-2.

<sup>23</sup> Rescue Agreement, *supra* note 4. See LYALL & LARSEN, *supra* note 20, at 91.

where the incident occurs.<sup>24</sup> State parties have similar notification duties if a space object has returned to Earth, whether or not such object is within its territory.<sup>25</sup> Other than notification duties, State parties also owe limited duties to rescue personnel of a spacecraft.<sup>26</sup>

The Liability Convention<sup>27</sup> mainly clarifies the nature of liability mentioned in the OST. Under this convention, a launching State whose space object causes damage *on the surface of the Earth* or to an aircraft in flight is “absolutely liable” to pay compensation.<sup>28</sup> However, if a space object causes damage to *another space object*, a launching State is only liable if the damage was due to its fault.<sup>29</sup> The differentiation of absolute and fault-based liability applies even in the situation when a third State is harmed by the collision of space objects of two other launching States (in this situation, the two launching States would be jointly and severally liable).<sup>30</sup> When two or more States jointly launch a space object, they are also jointly and severally liable for any damage caused.<sup>31</sup> Notably, a State from whose territory or facility a space object is launched is automatically regarded as a participant in a joint launching.<sup>32</sup> Another point to note is that the Liability Convention does not apply to damage caused by a launching State to *its own nationals* or foreign nationals taking part in the operation of the space object.<sup>33</sup>

The Liability Convention allows the State of nationality of an individual to present a claim, if such State does not do so, it then allows the State in whose territory damage was sustained to present a claim, if such State does not do so, it then allows the State of permanent residence of the individual to present a claim.<sup>34</sup> If no resolution is achieved, the Convention contemplates the formation of a dispute resolution mechanism – a Claims Commission.<sup>35</sup>

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<sup>24</sup> Rescue Agreement, *supra* note 6, art. 2.

<sup>25</sup> *Id.* at art. 5.

<sup>26</sup> *Id.* at art. 3.

<sup>27</sup> Liability Convention, *supra* note 7.

<sup>28</sup> *Id.* at art. II (emphasis added).

<sup>29</sup> *Id.* at art. III (emphasis added).

<sup>30</sup> *Id.* at art. IV.

<sup>31</sup> *Id.* at art. V.

<sup>32</sup> *Id.* at art. I.

<sup>33</sup> *Id.* at art. VII.

<sup>34</sup> *Id.* at art. VIII.

<sup>35</sup> *Id.* at art. XIV.

The Registration Convention provides for the registration of objects launched into space in relevant States' registries and a central world register with open public access (maintained by the United Nations Secretary-General).<sup>36</sup> This is particularly important regarding articles in the OST and the Rescue Agreement that link jurisdiction, control and the return of space objects and astronauts with States of registry.<sup>37</sup> The Registration Convention also reiterates a number of important definitions. "Launching State" is defined as 1) a State that *launches* or 2) *procures* the launching of a space object or 3) a State from whose *territory* or 4) from whose *facility* a space object is launched while "State of registry" is defined as a launching State on whose registry a space object is carried in accordance with the convention.<sup>38</sup> When two or more launching States are involved with a space object, they are to determine amongst themselves who will enter the object onto its register.<sup>39</sup>

Following the convention, the United Nations Register was established and maintained by the United Nations Office of Outer Space Affairs (UNOOSA), containing notifications under the convention and unofficial data on unnotified objects.<sup>40</sup> It bears significance to note, however, that the UNOOSA register is not the first of its kind. In a 1961 resolution, the United Nations General Assembly called on States to "furnish information" to COPUOS "for the registration of launchings" and requested the Secretary-General to "maintain a public register of the information furnished".<sup>41</sup> That procedure remains available even after the convention was adopted and UNOOSA now maintains the Online Index of Objects Launched into Outer Space containing information provided to the United Nations in accordance with the convention and the resolution.<sup>42</sup>

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<sup>36</sup> See Registration Convention, *supra* note 8, arts. II and III.

<sup>37</sup> LYALL & LARSEN, *supra* note 20, at 80.

<sup>38</sup> Registration Convention, *supra* note 8, art. I.

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

<sup>40</sup> LYALL & LARSEN, *supra* note 20, at 83.

<sup>41</sup> G.A. Res. 1721 (XVI) Part B (Dec. 20, 1961).

<sup>42</sup> LYALL & LARSEN, *supra* note 20, at 83; The Online Index of Objects Launched into Outer Space is available online at [https://www.unoosa.org/osa/osoindex/index.jsp?lf\\_id=](https://www.unoosa.org/osa/osoindex/index.jsp?lf_id=)

There have been attempts to update treaty law concerning outer space governance following the Registration Convention, but the same level of international consensus was never reached. First and foremost is another international treaty – colloquially known as the 1979 Moon Agreement<sup>43</sup> – which, while valid international law, is only binding on the 18 States that ratified it—none of which included the Big Three.<sup>44</sup> Nonetheless, I believe the Moon Agreement is valuable as an object lesson of an unappealing agreement. While most sections of the agreement are in line with the OST, some believe that its most controversial provision addresses the issue of non-appropriation.<sup>45</sup> The agreement explicitly prohibits “the surface [or] the subsurface of the moon, [or] any part thereof or natural resources in place” to become property of any State, organization, entity, or natural person.<sup>46</sup> It also designated the Moon and its natural resources as part of the “common heritage of [hu]mankind” and proposes the establishment of an international regime to govern the commercial exploitation of natural resources of the Moon.<sup>47</sup> Perhaps most importantly, the language of the agreement proposes the principle of “equitable sharing by all States Parties in the benefits derived from [lunar activities],”<sup>48</sup> which suggests that all benefits are to be shared *equally*, seemingly favoring less-developed nations over more-developed ones.<sup>49</sup>

In 2012, there was an attempt to address commercial space law issues via the Space Assets Protocol, proposing to apply the Cape Town Convention to international mobile assets in space, which would have facilitated the private financing of such assets by, among other features, enabling lenders to create an enforceable security interest in the assets.<sup>50</sup> Unfortunately, it has received little

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<sup>43</sup> The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, Dec. 18, 1979, 1363 U.N.T.S. 3 [hereinafter Moon Agreement].

<sup>44</sup> Martinez, *supra* note 4, at 328.

<sup>45</sup> Moon Agreement, *supra* note 43, art. 11. See Michael Listner, *The Moon Treaty: Failed International Law or Waiting in the Shadows?*, THE SPACE REVIEW (Oct. 24, 2011) <https://www.thespacereview.com/article/1954/1>.

<sup>46</sup> Moon Agreement, *supra* note 43, art. 11.

<sup>47</sup> *Id.* at art. 11.

<sup>48</sup> *Id.* at art. 11(7)(d).

<sup>49</sup> Fabio Tronchetti & Hao Liu, *Australia's Signing of the Artemis Accords: A Positive Development or a Controversial Choice?*, 75 AUSTL. J. INT'L AFF. 243, 244 (2021).

<sup>50</sup> Ignacio Tirado & Bernhard Schmidt-Tedd, *Status of and Way Forward for the UNIDROIT Space Protocol*, Comm. on the Peaceful Uses of Outer Space, Int'l Inst. of

support thus far and more work is required before it can viably enter into force in the future.<sup>51</sup>

It is also important to mention that the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) is a “focal point for international cooperation.”<sup>52</sup> While its impact is dependent solely on the willingness of States members, it plays a crucial role in helping bring about international consensus.<sup>53</sup> Most recently in 2021, during the sixtieth session of the Legal Subcommittee of COPUOS, working papers and oral statements seem to indicate widespread support for the establishment of a working group on space resources (albeit with a difference in view on execution).<sup>54</sup>

Thus, it can be said that after 1975, despite efforts by many, space treaty law remained relatively stagnant and largely preserved a State centric nature<sup>55</sup> (with some exceptions)<sup>56</sup>, presumably assuming (incorrectly) that only States can be major players in outer space.

## II. NEW SPACE – A COMPLEX ECOSYSTEM OF COMMERCIAL SPACE COMPANIES WITH MODERN PROBLEMS

Space treaties may have stood still for the past fifty years, but space technology boldly marched forward nonetheless. The ingenuity of the human mind and the grit of the human spirit combined to utterly change the nature of outer space activities in the past half century. Today, the commercialization of space activities is not a

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Space L. and Eur. Ctr. for Space L. Space Law Symp. 2021 “Space Law for the Global Space Economy” as part of the Legal Subcomm. on Its Sixtieth Session 2 (June 8, 2021), <https://www.unoosa.org/documents/pdf/copuos/lsc/2021/05.pdf>.

<sup>51</sup> *Id.* at 9-10.

<sup>52</sup> Eilene Galloway, *United Nations Committee on the Peaceful Uses of Outer Space*, 5 PROC. ON L. OUTER SPACE [ix], 3 (1963).

<sup>53</sup> See generally S. Neil Hosenball, *The United Nations Committee on the Peaceful Uses of Outer Space: Past Accomplishments and Future Challenges*, 7 J. SPACE L. 95 (1979).

<sup>54</sup> Valerie Oosterveld & Anne Campbell, *Space Resource Discussions in the UN Committee on the Peaceful Uses of Outer Space*, OPINIOJURIS (July 11, 2021), <http://opiniojuris.org/2021/07/11/space-resource-discussions-in-the-un-committee-on-the-peaceful-uses-of-outer-space/>. (The proposal to establish the Working Group on Legal Aspects of Space Resource Activities was accepted in 2022.)

<sup>55</sup> von der Dunk, *supra* note 10, at 420.

<sup>56</sup> See Outer Space Treaty, *supra* note 5, art VI.

pipe dream; far from it. New Space promises a dazzlingly diverse array of business models coming into fruition as technology continues to develop.

### A. *Smaller and Smarter Satellites*

The first human-made object that reached space was Sputnik, an artificial satellite.<sup>57</sup> It thus stands to reason that the first sector of space that matured sufficiently to be truly commercialized was artificial satellites. Earth is orbited by a constellation of satellites that serve a variety of functions, including Global Positioning Systems, Earth imaging, weather observation, internet access and secure data storage.<sup>58</sup> Following the tradition of State-sponsored space programs, cost and profit was not the driving concern of satellites in the initial decades of humans in space. Weather, navigation, and telecommunication satellites could cost upwards of hundreds of millions of dollars to build and were designed to be deployed for decades, typically orbiting between Medium Earth Orbit (MEO) and Geosynchronous Orbit (GSO) (1200 to 22236 miles above Earth).<sup>59</sup> However, with the digital revolution and Moore's Law, the size of electronics has miniaturized substantially.<sup>60</sup> With that came a radically disruptive idea: build and deploy fleets of smaller and cheaper satellites (SmallSats) that as a collective, rival traditional satellites.<sup>61</sup> The crux of it centers around the ability to maintain shorter development timelines for cheaper satellites that are deployed for less time, enabling developers to constantly update

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<sup>57</sup> *Sputnik and the Dawn of the Space Age*, NASA HISTORY DIV., <https://history.nasa.gov/sputnik-timeline.html> (last visited Sept. 17, 2021).

<sup>58</sup> Fraser Cain, *Artificial Satellites*, UNIVERSE TODAY (Dec. 2, 2009), <https://www.universetoday.com/46659/artificial-satellites/>.

<sup>59</sup> Gary Brown & William Harris, *How Much Do Satellites Cost?*, HOWSTUFFWORKS <https://science.howstuffworks.com/satellite10.htm> (last visited Sept. 17, 2021); Dan Elliott, *Next-generation of GPS satellites are headed to space*, PHYSORG (Dec. 17, 2018), <https://phys.org/news/2018-12-next-generation-gps-satellites-space.html>; Elizabeth Howell, *Navstar: GPS Satellite Network*, SPACE.COM (Apr. 26, 2018), <https://www.space.com/19794-navstar.html>; *Types of orbits*, EUR. SPACE AGENCY (Mar. 30, 2020), [https://www.esa.int/Enabling\\_Support/Space\\_Transportation/Types\\_of\\_orbits](https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits).

<sup>60</sup> John Loeffler, *No More Transistors: The End of Moore's Law*, INTERESTING ENGINEERING (Nov. 29, 2018), <https://interestingengineering.com/no-more-transistors-the-end-of-moores-law>.

<sup>61</sup> *What is a Smallsat?*, BLACK SKY, <https://www.blacksky.com/what-is-a-smallsat/> (last visited Sept. 17, 2021).

satellites with better and newer technology.<sup>62</sup> In fact, Morgan Stanley predicts that satellite production costs could decrease from the current price of \$500 million per satellite down to \$500 thousand.<sup>63</sup>

Market analysts estimate that the SmallSat market will surpass \$62 billion by 2030.<sup>64</sup> With such massive potential for profit, unsurprisingly, the commercial SmallSat market is growing at an incredible pace. In 2019, 45% of all launches included SmallSats, 62% of which were for commercial purposes (compared to 6% in 2012).<sup>65</sup> Notably, of the 133 commercial SmallSat operators between 2012 and 2019, 70% were owned by three companies: Planet (owning 55% of remote sensing SmallSats), SpaceX (owning nearly half of communications SmallSats) and Spire Global.<sup>66</sup> Market reports have projected that thousands of SmallSats will be launched over the next five to ten years.<sup>67</sup>

Other than a smaller size, satellites are also becoming much smarter in this era of Big Data.<sup>68</sup> Built with the most sophisticated technology and uniquely positioned in the most advantageous vantage point (both physically and legally), satellites and the companies controlling them are changing the way data is collected, transmitted and stored.<sup>69</sup>

Cloud Constellation Corporation's SpaceBelt Data Security is revolutionizing cybersecurity by storing data in a space-based cloud infrastructure consisting of ten satellites in LEO.<sup>70</sup> By storing data beyond the literal clouds, this system operates independently of

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<sup>62</sup> *Smaller Satellites Present New Ways to Leverage Space Resources*, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION, (Mar. 03, 2021), <https://www.saic.com/features/space/smallsats-present-new-ways-to-leverage-space-resources>.

<sup>63</sup> *Space: Investing in the Final Frontier*, MORGAN STANLEY (July 24, 2020), <https://www.morganstanley.com/ideas/investing-in-space>.

<sup>64</sup> Vivek Suresh Prasad, *SmallSat Launch Market to Soar Past \$62 Billion by 2030*, VIA SATELLITE (June 08, 2018), <https://interactive.satellitetoday.com/via/july-2018/smallsat-launch-market-to-soar-past-62-billion-by-2030/>.

<sup>65</sup> *Smallsats by the Numbers 2020*, BRYCE SPACE AND TECH. 4, 10 (2020), [https://brycetech.com/reports/report-documents/Bryce\\_Smallsats\\_2020.pdf](https://brycetech.com/reports/report-documents/Bryce_Smallsats_2020.pdf).

<sup>66</sup> *Id.* at 9, 21, 23.

<sup>67</sup> ROBERT C. JACOBSON, *SPACE IS OPEN FOR BUSINESS* 97 (2020).

<sup>68</sup> *See generally Satellites: A Smarter Design for the Thermal Constraints*, NEURAL CONCEPT, <https://www.neuralconcept.com/post/satellites-a-smarter-design-regarding-the-thermal-constraints> (last visited Apr. 11, 2022).

<sup>69</sup> *Id.*

<sup>70</sup> *SpaceBelt Data Security as a Service*, SPACEBELT, <https://spacebelt.com/#about> (last visited Sept. 17, 2021).

terrestrial networks, reducing the risks of data breaches and avoiding the red tape involved in traversing an international network.<sup>71</sup>

Several companies are working on providing internet access to locations without a robust terrestrial infrastructure network via satellite constellations. O3b (which stands for “Other three billion” - the population of the world which would have no broadband access without outside help) Network’s satellite constellation has been providing internet access since 2013 from MEO.<sup>72</sup> Now owned by SES, Europe’s first private satellite operator, the company has plans to launch the next generation of satellites in 2021-2023.<sup>73</sup> As of September 2021, OneWeb has launched 322 satellites, nearly half of the envisioned 648 satellite-strong constellation which will beam broadband service down to Earth.<sup>74</sup> As of June 2021, SpaceX has more than 1,800 satellites in orbit for its Starlink constellation (with Federal Communications Commission approval to launch close to 12,000 total satellites and further approval pending for another additional 30,000 satellites).<sup>75</sup> Not one to fall behind, in April 2019, Blue Origin announced plans to launch a 3,000 satellite-strong constellation to provide internet to “unserved and underserved communities around the world.”<sup>76</sup> Apart from the giant astrophrenuers, smaller startups like Fleet Space Technologies, Sky & Space Global and Kepler also have plans to launch constellations of satellites targeting this market segment.<sup>77</sup>

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

<sup>72</sup> *O3b Satellite Overview*, SPACECRAFT & SATELLITES, <https://spaceflight101.com/spacecraft/o3b/> (last visited Sept. 17, 2021).

<sup>73</sup> Jason Rainbow, *O3b mPOWER Get First Cloud Customer, on Track for Launch Even as COVID-19 Issues Loom*, SPACENEWS (Aug. 17, 2021), <https://spacenews.com/o3b-mpower-get-first-cloud-customer-on-track-for-launch-even-as-covid-19-issues-loom/>.

<sup>74</sup> Mike Wall, *Arianespace Soyuz Rocket Launches 34 More OneWeb Internet Satellites to orbit*, SPACE.COM (Sept. 14, 2021), <https://www.space.com/arianespace-soyuz-launches-oneweb-10-internet-satellite-mission>.

<sup>75</sup> Ry Crist, *Starlink Explained: Everything You Should Know About Elon Musk’s Satellite Internet Venture*, CNET (Mar. 24, 2022), <https://www.cnet.com/home/internet/starlink-satellite-internet-explained/>; Adam Mann, *Starlink: SpaceX’s Satellite Internet Project*, SPACE.COM (Jan. 07, 2022), <https://www.space.com/spacex-starlink-satellites.html>.

<sup>76</sup> Eli Blumenthal, *Amazon’s Project Kuiper Gets FCC Approval For Over 3,200 Internet Satellites*, CNET (July 31, 2020), <https://www.cnet.com/news/amazons-project-kuiper-gets-fcc-approval-for-over-3200-internet-satellites/>.

<sup>77</sup> *About Us*, FLEET SPACE, <https://fleetSPACE.com/about> (last visited Sept. 17, 2021); *Satellite Communication Services*, SKY AND SPACE CO,

With satellite technology taking leaps and bounds forward, naturally, satellite capabilities, especially data collection, follows. Planet is a private-sector data provider that uses high-resolution imagery from space to collect data for customers in agriculture, government and commercial mapping.<sup>78</sup> The ICARUS Initiative uses satellite data and tracking of animals to manage outbreaks of diseases and viruses (something with which humankind as a collective have unfortunately gotten far too familiar in the recent months).<sup>79</sup> Companies are utilizing satellite data sets for weather forecasting, with Spire Global and GeoOptics notably obtaining contracts from the National Oceanic and Atmospheric Administration to become commercial weather data providers.<sup>80</sup> Even humankind's first revolution – agriculture – is benefitting from these little pieces of equipment orbiting our planet.<sup>81</sup> Companies are using constellations of satellites with remote sensing capabilities to collect a range of data from environmental conditions (such as soil moisture and pasture maps) to forecasts of weather and disasters.<sup>82</sup> At the pinnacle of innovation are companies like Orbital Sidekick and Hypercubes, which utilize hyperspectral imaging (even more precise than multispectral) on nanosatellites to aid precision agriculture, land surveying and environmental monitoring.<sup>83</sup> In fact, Fábio Teixeira, co-founder of Hypercubes, notes that “with [hyperspectral imaging] we will be able to identify phenomenon in the day they happen; not one or two months afterwards, when we can already see with the

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<https://skyandspace.co/index.php/satellite-communication-services/> (last visited Sept. 17, 2021); *Our Mission*, KEPLER COMM., <https://kepler.space/about-us/> (last visited Sept. 17, 2021).

<sup>78</sup> *Customer Stories*, PLANET, <https://www.planet.com/company/customer-stories/> (last visited Sept. 17, 2021).

<sup>79</sup> *About Icarus*, ICARUS, <https://www.icarus.mpg.de/28056/about-icarus> (last visited Sept. 17, 2021).

<sup>80</sup> Rachel Jewett, *NOAA Awards Spire 6-Month Contract for Commercial Weather Data*, VIA SATELLITE (Aug. 31, 2021), <https://www.satellitetoday.com/imagery-and-sensing/2021/08/31/noaa-awards-spire-6-month-contract-for-commercial-weather-data/>; Debra Werner, *GeoOptics and Spire Global win NOAA weather data contracts*, SPACENEWS (Nov. 23, 2020), <https://spacenews.com/noaa-awards-first-ro-contracts/>.

<sup>81</sup> Alexander Joe, *Satellite Technology in Agriculture*, MKT. BUS. NEWS (Jan. 19, 2021), <https://marketbusinessnews.com/satellite-technology-in-agriculture/256356>.

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

<sup>83</sup> *Solutions*, ORBITAL SIDEKICK, <https://orbitalsidekick.com/solutions/> (last visited Sept. 17, 2021); Luís Felipe & Marcelo Carneiro, *Hypercubes: A Brazilian Idea That Reached Space*, 2 FUTURE HOLDING, <https://www.2futureholding.com/en/detalhe-blog.php?cod=3> (last visited Sept. 17, 2021).

naked eye and the damage is too big and risking losing great deals of cultivation.”<sup>84</sup>

However, while the amount and extent of data collected by satellites are vast, its full potential is realized when combined with the advanced data analytical tools of Big Data.<sup>85</sup> This yields a possibility for the commercial sector to monitor and examine the Earth to an extent hitherto unseen in human history. By adding insights, analytics and intelligence to weather and environmental data, incomprehensibly large volumes of ones and zeroes are translated into useable advice for policymakers, farmers and even Wall Street pencil pushers. For example, BlackRock uses computer analyses of satellite images to monitor the Chinese economic landscape to aid in their investment decisions.<sup>86</sup>

### *B. Reusable Rockets*

It should come as no surprise that one of the most important pieces of the puzzle is the rocket, the very vessel that propels humankind beyond this little blue marble we call home. The holy grail of space exploration surrounds “reusability.”<sup>87</sup> With reusable rockets (and/or other launch devices), launch cost would be drastically reduced in the way plane tickets would be drastically more expensive if every plane was ditched in the ocean after one flight.<sup>88</sup> This is a bottom-line cost reduction applicable to any space venture that involves sending an object into space (so, every space venture).<sup>89</sup> In 2018, Morgan Stanley estimated that with reflying, satellite launch costs have dropped from \$200 million each to \$60 million and

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

<sup>85</sup> Ryan Kh, *Big Data Plays Key Role in Helping Satellites Get Launched into Orbit*, SMART DATA COLLECTIVE, <https://www.smartdatacollective.com/big-data-plays-key-role-in-helping-satellites-get-launched-into-orbit>.

<sup>86</sup> Samuel Shen & John Ruwitch, *Satellites and Blogs: BlackRock to Raise Game in China Stock Picking*, REUTERS (July 24, 2018), <https://www.reuters.com/article/us-china-blackrock-fund/satellites-and-blogs-blackrock-to-raise-game-in-china-stock-picking-idUSKBN1KE16U>.

<sup>87</sup> *In Space, This Is the Age of Reusability*, THE CONVERSATION (July 13, 2017) <https://theconversation.com/in-space-this-is-the-age-of-reusability-77964>.

<sup>88</sup> Rich Smith, *How Much Cheaper Are SpaceX Reuseable Rockets? Now We Know*, THE MOTLEY FOOL (Oct. 05, 2020) <https://www.fool.com/investing/2020/10/05/how-much-cheaper-are-spacex-reusable-rockets-now-w>.

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

predicted that they could further drop to a mere \$5 million.<sup>90</sup> In fact, SpaceX's quote for a launch in 2019 was \$450 million, whereas in 2021, it was \$178 million, a 75% decrease.<sup>91</sup> By partnering with SpaceX, NASA was able to save more than \$500 million.<sup>92</sup>

Some of the biggest names in New Space today are focused on reusable space vehicles. SpaceX, the poster child of New Space, has been unapologetically loud about their ambitions to send humans to Mars, perhaps as early as 2024 with their Starship.<sup>93</sup> Jeff Bezos, owner of Blue Origin (and one of the richest humans alive), did not mince words when he expressed the company's goal of developing reusable rockets and, eventually, building out space infrastructure atop of which other space companies could be built.<sup>94</sup> As another Jeff (Garzik, a software engineer and bitcoin developer) agreed, with reusable rockets, the cost of launches will plummet exponentially, paving the way for "a generous number of small businesses" finding their place in this space niche.<sup>95</sup> In fact, in his Masterclass, retired astronaut and former commander of the International Space Station Chris Hadfield said that the reusable rocket "is the way of the future," and that we will look back on the past decades of single-use rockets with the same combination of awe and befuddlement that we give early sailing ships and locomotives.<sup>96</sup>

### C. Commercial Space Stations

The International Space Station (ISS) is a laboratory in space maintained by an international collaboration among the National

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<sup>90</sup> *Space: Investing in the Final Frontier*, MORGAN STANLEY (Jul. 24, 2020) <https://www.morganstanley.com/ideas/investing-in-space>.

<sup>91</sup> Tim Fernholz, *SpaceX Just Saved NASA \$500 million With One Rocket*, QUARTZ (July 29, 2021), <https://qz.com/2040243/elon-musks-spacex-saved-nasa-500-million/>.

<sup>92</sup> *Id.*

<sup>93</sup> Elijah Chiland, *These 4 Programs Fuel SpaceX's Ambitions*, L.A. BUS. J. (Mar. 14, 2021), <https://labusinessjournal.com/technology/these-4-programs-fuel-spacex-ambitions/>.

<sup>94</sup> Hannah Miao & Michael Sheetz, *Jeff Bezos Says First Spaceflight Was 'Tiny Little Step' in Blue Origin's Plan to Build a Road to Space*, CNBC (July 20, 2021), <https://www.cnbc.com/2021/07/20/jeff-bezos-says-this-is-a-tiny-little-step-toward-blue-origins-plan-to-build-a-road-to-space.html>.

<sup>95</sup> JACOBSON, *supra* note 67, at 116.

<sup>96</sup> Chris Hadfield, *Rockets: How Rockets Work*, MASTERCLASS, <https://www.masterclass.com/classes/chris-hadfield-teaches-space-exploration/chapters/spaceships-shuttles-and-beyond> (last visited Sept. 17, 2021).

Aeronautics and Space Administration (NASA), Roscosmos, the European Space Agency, the Japanese Space Agency, the Canadian Space Agency and the Italian Space Agency.<sup>97</sup> Experiments conducted in space have widespread application in improving human life, but one of the most exciting areas is medicine.<sup>98</sup> The unique environment of microgravity enjoyed in orbit enables scientists to better study protein crystals and develop more effective medicines.<sup>99</sup> In a development that should surprise no one, many commercial actors are interested in using this platform.<sup>100</sup>

Although the ISS is sustained by government funding, such funding will run out in 2024, and the ISS's future remains uncertain.<sup>101</sup> Commercialization may be a path moving forward. Space Tango is a company that provides research and manufacturing "CubeLabs" on the ISS for commercial experiments.<sup>102</sup> Each CubeLab is a standardized, scalable platform that can "manage multiple fluids, media exchange, sampling, and fixation" and "maintain temperatures as low as 4°C."<sup>103</sup> As of September 2021, Space Tango has facilitated 181 experiments on the ISS.<sup>104</sup> In 2016, Bigelow Aerospace attached the Bigelow Expandable Activity Module (BEAM), an inflatable space habitat to the ISS, which surpassed expectations to such an extent that their two year contract was

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<sup>97</sup> *International Space Station*, NASA, [https://www.nasa.gov/mission\\_pages/station/cooperation/index.html](https://www.nasa.gov/mission_pages/station/cooperation/index.html) (last visited Sept. 17, 2021).

<sup>98</sup> Matteo Emanuelli, *Space Medicine*, SPACE SAFETY MAG., <https://www.spacesafetymagazine.com/spaceflight/space-medicine> (last visited Apr. 12, 2022).

<sup>99</sup> Amelia Williamson Smith, *Probing Proteins: Leveraging Microgravity for Medically Important Molecular Crystallization*, ISS360: THE ISS NAT'L LAB. BLOG (Aug. 7, 2019), <https://www.issnationallab.org/iss360/probing-proteins-leveraging-microgravity-for-medically-important-molecular-crystallization/>.

<sup>100</sup> See e.g. *Protein Crystallization*, AXIOM SPACE, <https://www.axiomspace.com/research/protein-crystallization> (last visited Sept. 17, 2021).

<sup>101</sup> Christian Davenport, *The International Space Station Can't Stay Up There Forever. Will Privately Run, Commercial Replacements Be Ready in Time?*, WASH. POST (Dec. 23, 2020), <https://www.washingtonpost.com/technology/2020/12/23/space-station-replace-biden/>.

<sup>102</sup> *About*, SPACE TANGO, <https://spacetango.com/about/> (last visited Sept. 17, 2021).

<sup>103</sup> *CubeLab*, SPACE TANGO, <https://spacetango.com/cubelab/> (last visited Sept. 17, 2021).

<sup>104</sup> SPACE TANGO, <https://spacetango.com/> (last visited Sept. 17, 2021).

extended by five years.<sup>105</sup> In 2020, NASA selected Axiom Space to attach a commercial habitable module it developed to the ISS.<sup>106</sup>

Even NASA supports the gradual privatization of the ISS. In 2010, NASA's Commercial Crew Development program began to contract the private sector to bring crew and cargo from Earth to the ISS.<sup>107</sup> In 2019, NASA announced that it would allow a minimum of two private astronauts per year to spend up to thirty days on the ISS to conduct "approved commercial and marketing activities."<sup>108</sup> Furthermore, NASA expressed its intention to award various task orders to private sector companies that can provide valid, long-term capabilities that serve NASA's needs on the ISS while shifting its operations to the commercial sector.<sup>109</sup>

Fully commercial space stations are the logical next step. In fact, it had been done before, when a private space company, MirCorp, used the Russian Mir as a commercial platform in 1999.<sup>110</sup> In 2016, Bigelow Aerospace partnered with United Launch Alliance to develop fully functioning space stations for research, exploratory missions and tourism.<sup>111</sup> Like their similarly situated competitor, Axiom intends to create a commercial space station to replace the ISS.<sup>112</sup> Curiously, this will be done by detaching Axiom components

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<sup>105</sup> Stephen Clark, *Bigelow's Expandable Module Goes Into Overtime on Space Station*, SPACEFLIGHT NOW (Dec. 6, 2017), <https://spaceflightnow.com/2017/12/06/bigelows-expandable-module-goes-into-overtime-on-space-station/>.

<sup>106</sup> Darrell Etherington, *NASA Taps Startup Axiom Space for the First Habitable Commercial Module for the Space Station*, TECHCRUNCH (Jan. 27, 2020), <https://techcrunch.com/2020/01/27/nasa-taps-startup-axiom-space-for-the-first-habitable-commercial-module-for-the-space-station/>.

<sup>107</sup> *Commercial Crew Program - Essentials*, NASA, <https://www.nasa.gov/content/commercial-crew-program-the-essentials> (last visited Sept. 17, 2021).

<sup>108</sup> Press Release, NASA, *NASA Opens International Space Station to New Commercial Opportunities, Private Astronauts* (June 7, 2019), <https://www.nasa.gov/press-release/nasa-opens-international-space-station-to-new-commercial-opportunities-private>

<sup>109</sup> *Id.*

<sup>110</sup> Louis de Gouyon Matignon, *MirCorp, The First New Space Company*, SPACE LEGAL ISSUES (Sept. 20, 2020), <https://www.spacelegalissues.com/mircorp-the-first-new-space-company/>.

<sup>111</sup> Emily Calandrelli, *Bigelow Aerospace Partners With ULA to Launch Private Space Habitats*, TECHCRUNCH (Apr. 13, 2018), <https://techcrunch.com/2016/04/13/bigelow-aerospace-partners-with-ula-to-launch-private-space-habitats/>.

<sup>112</sup> Michael Sheetz, *Private Spaceflight Specialist Axiom Space Raises \$130 million to Become the Latest Space Unicorn*, CNBC (Feb. 16, 2021), <https://www.cnbc.com/2021/02/16/axiom-space-raises-130-million-and-becomes-the-latest-space-unicorn.html>.

from the ISS (following its retirement) to form a separate commercial space station.<sup>113</sup> Far from being an outlier, Axiom finds peers in Blue Origin and Lockheed Martin, both of which have also unveiled plans to build their own space stations.<sup>114</sup>

#### *D. Asteroid Mining*

Technologies in the electronics, defense and clean energy sectors all depend on rare Earth elements.<sup>115</sup> As our technical capabilities advance, demand for such rare Earth elements will continue to increase. Alas, as the moniker may have implied, such elements are relatively difficult to come by on our planet.<sup>116</sup> The dwindling supplies that do exist on Earth are difficult and expensive to find and extract and the process of recycling of such elements is nowhere close to where the world needs it.<sup>117</sup> However, what is difficult to find below our feet exists in abundance above the clouds.<sup>118</sup>

There are more than 20,000 known near-Earth asteroids (increasing at a rate of 2,000 being discovered each year) in our planet's neighborhood; many of these asteroids contain precious metals like platinum, nickel, cobalt and other rare Earth elements.<sup>119</sup> The ability to tap into this pool of resources presents itself as a possible solution to humankind's problems with massive potential for profits; therefore, it should not come as a surprise that there are commercial efforts to mine celestial bodies.<sup>120</sup>

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

<sup>114</sup> Joey Roulette, *Jeff Bezos' Rocket Company Wants to Build a Space Station*, N.Y. TIMES (Oct. 25, 2021), <https://www.nytimes.com/2021/10/25/science/space-station-blue-origin-sierra.html>.

<sup>115</sup> Ariel Schwartz, *Visualizing the Importance Of Rare Earth Elements To Our Digital Lifestyle*, FAST COMPANY (Nov. 13, 2014), <https://www.fastcompany.com/1680658/visualizing-the-importance-of-rare-earth-elements-to-our-digital-lifestyle>.

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

<sup>117</sup> Aylin Woodward, *China Could Restrict its Export of Rare-Earth Metals as a Trade-War Tactic. Here's What They Are and Why They're So Crucial.*, BUS. INSIDER (June 4, 2019), <https://www.businessinsider.com/rare-earth-metals-elements-what-they-are-2019-6>.

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

<sup>119</sup> MARTIN ELVIS, ASTEROIDS: HOW LOVE, FEAR, AND GREED WILL DETERMINE OUR FUTURE IN SPACE 25 (2021); Bob Goldstein, *Mining A \$10,000 Quadrillion Asteroid*, AP NEWS (Feb. 1, 2021), <https://apnews.com/press-release/accesswire/technology-business-science-utilities-electric-utilities-7bb32ecaac33bebef6e4b97ade588c57>.

<sup>120</sup> *See generally* ELVIS, *supra* note 119.

Luxembourg, the second-largest investment fund center in the world, invests in and promotes policies to support the commercial exploration of space resources.<sup>121</sup> In 2016, Luxembourg launched its Space Resources initiative (\$223 million allocated to finance companies focused on space mining), the aim of which, as stated by the Deputy Prime Minister of Luxembourg, is to “open access to a wealth of previously unexplored mineral resources, on lifeless rocks hurtling through space.”<sup>122</sup> In the same year, Luxembourg invested heavily in commercial mining companies like Planetary Resources and Deep Space Industries.<sup>123</sup> While these investments ultimately ended as a loss for Luxembourg, there is no indication that it will deter the country and others to continue expanding celestial mining capabilities.<sup>124</sup> Most recently in April 2021, Chinese-based start-up Origin Space launched a robot prototype that will be used to test technologies and sequences crucial to asteroid mining.<sup>125</sup>

Even the world of academia refuses to take a backseat. In 2018, the Colorado School of Mines Center for Space Resources launched a multi-disciplinary Space Resources graduate program, focused on “learning the core knowledge in this field and developing design practices in the identification, extraction, processing, and responsible use of available resources in the solar system.”<sup>126</sup>

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<sup>121</sup> JACOBSON, *supra* note 67, at 169.

<sup>122</sup> *Luxembourg Sets Aside 200 Million Euros to Fund Space Mining Ventures*, REUTERS (June 3, 2016), <https://www.reuters.com/article/us-luxembourg-space-mining/luxembourg-sets-aside-200-million-euros-to-fund-space-mining-ventures-idUSKCN0YP22H>; Jason Daley, *Will Luxembourg Lead the Race for Space Mining?*, SMITHSONIAN MAG. (May 9, 2016), <https://www.smithsonianmag.com/smart-news/will-luxembourg-lead-race-space-mining-180959031/>.

<sup>123</sup> Louis Brennan, *How Luxembourg is Positioning Itself to be The Centre of Space Business*, THE CONVERSATION (July 16, 2019), <https://theconversation.com/how-luxembourg-is-positioning-itself-to-be-the-centre-of-space-business-120436>.

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

<sup>125</sup> Liangping Gao & Ryan Woo, *China Launches Robot Prototype Capable of Catching Space Debris With Net*, REUTERS (Apr. 27, 2021), <https://www.reuters.com/lifestyle/science/china-launches-robot-prototype-capable-catching-space-debris-with-net-2021-04-27/>; Anthony Cuthbertson, *China to Launch Asteroid-Mining Robot*, INDEPENDENT (Sept. 24, 2020), <https://www.independent.co.uk/life-style/gadgets-and-tech/asteroid-mining-robot-china-origin-space-b572318.html>.

<sup>126</sup> *Graduate Programs*, COLORADO SCHOOL OF MINES, <https://space.mines.edu/graduate-programs/> (last visited Sept. 18, 2021).

### *E. Industry in Space*

If one buys into Jeff Bezos's vision of the future, then one day all heavy industries are going to be moved off our planet into space orbit, where solar energy is abundant, and Earth will be left safe from pollution.<sup>127</sup> Remarkably, even for these seemingly far-fetched futures, there are companies developing enabling technology.

Tethers Unlimited, Inc. (TUI) is developing hardware for in-space manufacturing and has already received NASA grants for various projects.<sup>128</sup> TUI's SpiderFab can manufacture structures after achieving orbit, eliminating the need to comply with the size, shape and weight limitations of rocket launches.<sup>129</sup> TUI is also designing a robotic arm called the KRAKEN X that will support small satellite servicing and assembly.<sup>130</sup> TUI's DARPA-funded OrbWeaver project aims to create a satellite that can then convert (and thus reuse) elements of the launching rocket into a satellite antenna.<sup>131</sup> In addition, with funding from a NASA Small Business Innovation Research grant, TUI also developed and installed a Refabricator device on the ISS in 2019, a "highly automated recycling-and-manufacturing system" which can recycle plastic parts into 3-D printer filament, then use the filaments to 3-D print new parts.<sup>132</sup>

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<sup>127</sup> Natalie Musumeci, *Jeff Bezos Wants to Move 'All Polluting Industry' Into Space to Keep Earth Clean*, BUS. INSIDER (Jul 20, 2021), <https://www.businessinsider.com/jeff-bezos-move-all-polluting-industry-into-space-blue-origin-2021-7>.

<sup>128</sup> *In-Space Services*, TETHERS UNLIMITED, <https://www.tethers.com/in-space-services/> (last visited Sept. 18, 2021); Alan Boyle, *Tethers Unlimited and Rocket Propulsion Systems Win NASA Grants for Space Tech*, GEEKWIRE (May 5, 2020), <https://www.geekwire.com/2020/tethers-unlimited-rocket-propulsion-systems-win-nasa-grants-space-tech/>.

<sup>129</sup> Robert Hoyt, *SpiderFab: Process for On-Orbit Construction of Kilometer-Scale Apertures*, NASA (Nov 30, 2016), [https://www.nasa.gov/directorates/spacetech/niac/2012\\_phase\\_I\\_fellows\\_hoyt\\_spiderfab.html](https://www.nasa.gov/directorates/spacetech/niac/2012_phase_I_fellows_hoyt_spiderfab.html).

<sup>130</sup> Caleb Henry, *Tethers Unlimited Developing Satellite Servicer for LEO Missions*, SPACE.COM (June 04, 2019), <https://www.space.com/tethers-unlimited-developing-satellite-servicer.html>.

<sup>131</sup> *DARPA Awards Tethers Unlimited Contract to Pursue In-Space Manufacture of Comm Satellite*, NEW SPACE GLOBAL (June 12, 2017), <https://newspaceglobal.com/darpa-awards-tethers-unlimited-contract-pursue-space-manufacture-comm-satellite/>; Debra Werner, *Tethers Unlimited Expands to Fulfill Additive Manufacturing Orders*, SPACE NEWS (Dec. 8, 2017), <https://spacenews.com/tethers-unlimited-expands-to-fulfill-additive-manufacturing-orders/>.

<sup>132</sup> Alan Boyle, *Tethers Unlimited Delivers 3-D Printer and Recycler Combo to NASA for Space Station*, GEEKWIRE (May 30, 2018), <https://www.geekwire.com/2018/tethers-unlimited-delivers-3-d-printer-recycler-combo-nasa-space-station/>; Joris Peels, *Tethers*

Made in Space is developing an Archinaut spacecraft that has the capability to 3D print, manufacture and assemble unlaunchable structures in orbit.<sup>133</sup> SpaceFab is aiming to “build a family of robotic mining and manufacturing satellites that can make, form, weld, and assemble metal parts into larger structures” in space.<sup>134</sup>

If factories are to be in space in the future, then human life must be sustainable on such structures. One of the most important issues concerns food. In 2016, an aerospace engineering graduate student won the “Eat It!” Lemelson-MIT undergraduate prize with two robots she developed.<sup>135</sup> The first, SPOT, grows several fruits and vegetables in a soil-less environment with automatic watering cycles.<sup>136</sup> The second, AgQ, measures and tracks the health of plants and astronauts.<sup>137</sup>

On the other side of the globe, Japan is taking another approach to space exploration – sending virtual avatars instead of humans. In 2018, JAXA partnered with All Nippon Airways to begin work on the AVATAR X project, aiming to send humanoid robots (“inhabited” by humans on Earth) into space to experience space travel and eventually assist with space construction and farming.<sup>138</sup> In 2019, the Japanese Space Agency, RealTech Fund (a venture capital fund) and SigmaXYZ (a management consultancy) founded “Space Food X,” an initiative consisting of thirty technology and food companies, universities, investment firms and researchers

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*Unlimited Recycler and 3D Printer Refabricator Operational on Board the ISS*, 3DPRINT.COM (Feb. 11, 2019), <https://3dprint.com/235975/tethers-unlimited-recycler-and-3d-printer-refabricator-operational-on-board-the-iss/>.

<sup>133</sup> *On-Orbit Servicing, Assembly, and Manufacturing 2 (OSAM-2)*, NASA SPACE TECH. MISSION DIRECTORATE: TECH. DEMONSTRATION MISSIONS, [https://www.nasa.gov/mission\\_pages/tm/osam-2.html](https://www.nasa.gov/mission_pages/tm/osam-2.html) (last visited Sept. 18, 2021).

<sup>134</sup> *Our Mission*, SPACEFAB, <https://www.spacefab.us/> (last visited Sept. 18, 2021).

<sup>135</sup> Leanna Garfield, *An PhD Student Invented a Robot That Can Grow Fruits and Vegetables on Mars*, BUS. INSIDER (Apr. 19, 2016), <https://www.businessinsider.com/mit-student-invented-robot-for-food-in-space-2016-4>.

<sup>136</sup> *Id.*

<sup>137</sup> *Id.*

<sup>138</sup> Rowan Hooper, *2018 in Science in Japan: Climate Change, Space Exploration and Water Bears*, THE JAPAN TIMES (Dec. 24, 2018) <https://www.japan-times.co.jp/news/2018/12/24/national/science-health/2018-climate-change-space-exploration-water-bears/>.

focused on developing technologies to create in-space food-production solutions.<sup>139</sup>

In the short run, some argue that the ISS could be a site in which to test and perfect large-scale space manufacturing, which would then be followed by widespread implementation in the commercial carriers that are emerging.<sup>140</sup> It is hard to tell how the space industry will continue to evolve, but Rich Glover, an expert with more than twenty years of experience in advanced space technologies, believes that commercialization will require moving into the realm of in-space manufacturing and import-export between Earth and space.<sup>141</sup> He believes that profits from the delivery of raw space materials will sustain the space transportation industry.<sup>142</sup> Perhaps in-space manufacturing will come sooner or later, but that timing will depend on funding and policy.

#### *F. Communities on the Moon and Beyond*

The idea of settling humans on worlds beyond the blue marble we call Earth is one abundantly covered by science fiction. Finally, humankind is on the precipice of realizing that dream. Or at least, of taking the first steps towards realizing that dream. The most obvious candidate is Earth's neighbor, the Moon, which has enthralled civilizations across the world throughout history. A mere three days away, by the most direct route, it is almost surprising that humankind has not yet built a base on the Moon. After all, Neil Armstrong first set foot on it more than half a century ago. Consider this, the iPhone 6 (practically an antique in 2021) is 120 million times faster than the Apollo 11 computer that landed humankind on the moon.<sup>143</sup> Yet, due to reasons beyond the scope of this paper,

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<sup>139</sup> Michael Wolf, *Meet Space Food X, Japan's New Initiative to Feed People in Space*, THE SPOON (Mar. 28, 2019), <https://thespoon.tech/meet-space-food-x-japans-new-initiative-to-feed-people-in-space/>.

<sup>140</sup> JACOBSON, *supra* note 67, at 177.

<sup>141</sup> *Id.* at 177-178.

<sup>142</sup> *Id.* at 178.

<sup>143</sup> David Pierini, *Your iPhone Could Handle 120 Million Moon Missions at Once*, CULT OF MAC (July 16, 2019), <https://www.cultofmac.com/639048/apollo-computer-iphone/>.

global superpowers collectively relegated Moon exploration to the backburner.<sup>144</sup>

Nevertheless, the time has finally come again for humankind to reach for the Moon, and this time, it is the private sector's turn. While superpowers such as the US and China have national plans to return to the Moon, private companies now have a much larger role to play.<sup>145</sup> In February 2019, Israeli SpaceIL launched its Beresheet lunar lander to the Moon (via a SpaceX Falcon 9 rocket), marking the first private lunar mission.<sup>146</sup> Granted, the lunar lander didn't so much land as it did crash.<sup>147</sup> Yet, at about \$100 million, the cost of this attempt was the least by far, exhibiting the cost-saving potential of private space industry yet again.<sup>148</sup> Seeing the important role private industry is and will continue to play, in 2021, NASA awarded a combined \$146 million to five private companies (Blue Origin, Dynetics, Lockheed Martin, Northrop Grumman and SpaceX).<sup>149</sup> According to a NASA press release, these companies will "develop lander design concepts, evaluating their performance, design, construction standards, mission assurance requirements, interfaces, safety, crew health accommodations, and medical capabilities" and "mitigate lunar lander risks by conducting critical component tests and advancing the maturity of key technologies."<sup>150</sup> These companies are among many suitors of the Moon.

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<sup>144</sup> See generally Dave Mosher & Hilary Brueck, *Astronauts Explain Why Nobody Has Visited the Moon in More Than 45 Years — and the Reasons Are Depressing*, BUS. INSIDER (July 19, 2019), <https://www.businessinsider.com/moon-missions-why-astronauts-have-not-returned-2018-7>.

<sup>145</sup> *Apollo's Legacy Is NASA's Future*, NASA, <https://www.nasa.gov/specials/apollo50th/back.html> (last visited Sept. 18, 2021); Steven Lee Myers, *The Moon, Mars and Beyond: China's Ambitious Plans in Space*, N.Y. TIMES (Oct. 15, 2021), <https://www.nytimes.com/article/china-mars-space.html>.

<sup>146</sup> Charlie Wood, *SpaceIL's Beresheet Lunar Lander: Israel's 1st Trip to the Moon*, SPACE.COM (Apr. 15, 2019), <https://www.space.com/spaceil-beresheet.html>.

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

<sup>148</sup> Kenneth Chang, *Moon Landing by Israel's Beresheet Spacecraft Ends in Crash*, N.Y. TIMES (Apr. 11, 2019), <https://www.nytimes.com/2019/04/11/science/israel-moon-landing-beresheet.html>.

<sup>149</sup> Aria Alamalhodaei, *SpaceX, Blue Origin Awarded NASA Contracts to Develop Moon Lander Concepts for Future Artemis missions*, TECH CRUNCH (Sept. 14, 2021), <https://techcrunch.com/2021/09/14/spacex-blue-origin-awarded-nasa-contracts-to-develop-moon-lander-concepts-for-future-artemis-missions/>.

<sup>150</sup> Press Release, NASA, *NASA Selects Five U.S. Companies to Mature Artemis Lander Concepts* (Sept. 14, 2021), <https://www.nasa.gov/press-release/nasa-selects-five-us-companies-to-mature-artemis-lander-concepts>.

There are now many startups seeking commercial opportunities on the Moon, such as ispace, Astrobotic and Moon Express.<sup>151</sup> Far from an exclusive niche for entrepreneurs, commercial space ventures have been seeing increased support from the traditional business world. For example, the century-old trading company Sumitomo Corporation announced that it will serve as a corporate partner for ispace's HAKUTO-R (with the lofty goal of extracting resources to eventually developing the infrastructure necessary for humans to live and work on the Moon).<sup>152</sup>

Beyond technology companies, the private investment sector is also exploring lunar development projects. In 2014, a weekend retreat (known as "Moon Base Alpha") consisting of experts from NASA, commercial space companies, technology executives, academics, space societies and Apollo astronauts concluded that an economically self-sustaining lunar base could be established for less than \$5 billion.<sup>153</sup> In 2019, a nonprofit organization, Open Lunar Foundation appeared on the scene.<sup>154</sup> Boasting a team including former astronaut and ISS commander Chris Hadfield, planetary scientist Lindy Elkins-Tanton, and Planet cofounder Will Marshall, the non-profit has the ultimate goal of creating a settlement on the Moon costing less than \$5 billion.<sup>155</sup>

Of course, I believe the golden apple is not the Moon, but Mars. Alas, the mere fact that Mars is much farther away from Earth than the Moon means building a human community on the Red Planet will be a challenge of an entirely different magnitude.<sup>156</sup> However, that does not mean this lofty goal is out of the minds of

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<sup>151</sup> ISPACE, <https://ispace-inc.com/> (last visited Sept. 18, 2021); ASTROBOTIC, <https://www.astrobotic.com/> (last visited Sept. 18, 2021); MOON EXPRESS, <https://moon-express.com/> (last visited Sept. 18, 2021).

<sup>152</sup> Press Release, Sumitomo Corp., Sumitomo Corporation Becomes Corporate Partner of ispace's HAKUTO-R Program (Aug. 22, 2019), <https://www.sumitomocorp.com/en/jp/news/release/2019/group/12280>.

<sup>153</sup> Steve Jurvetson, *Moon Base Alpha — Strategies for Low Cost Lunar Settlement Workshop*, FLICKR (Aug. 23, 2014), <https://www.flickr.com/photos/jurvetson/30929394984/>.

<sup>154</sup> Alan Boyle, *Open Lunar Foundation Comes Out in the Open With its Plan to Build a Moon Village*, GEEKWIRE (Sept. 5, 2019), <https://www.geekwire.com/2019/open-lunar-foundation-comes-open-plan-build-moon-village/>.

<sup>155</sup> *Id.*

<sup>156</sup> Aaron Ridley, *Is it Better to Live on the Moon or on Mars? A Scientific Investigation*, QUARTZ (Oct. 18, 2017), <https://qz.com/1105031/should-humans-colonize-mars-or-the-moon-a-scientific-investigation/>.

astropreneurs. In fact, Elon Musk has been quite vocal about his ambition to one day build a human community on Mars.<sup>157</sup>

### G. Legal issues of New Space

Therein, as they say, lies the rub. On the one hand, treaty law governing space activities is seemingly stuck in the past, its words a snapshot of a bygone era of State-centered spacefare. On the other hand, scientists and businesspeople have come together to promise a future that seems more apt in a science fiction novel than a law journal article. This disconnect has and will continue to give rise to a host of problems in the actual governance of commercial outer space activities.

First, while States are in theory liable for damage caused to another State by the actions of non-governmental entities under its jurisdiction, licensing and supervision, such claims can be initiated only by States against other States, private entities have no formal standing under any of the space treaties.<sup>158</sup> Without *jus standi*, private entities may be left with little recourse for enforcement without help from related States.<sup>159</sup> However, since States have neither sovereignty nor jurisdiction over space and celestial bodies, they may have little incentive to police the treaties.<sup>160</sup> Granted, private enterprises have the option of resolving disputes through institutional or *ad hoc* arbitration rules and procedures such as those of the International Chamber of Commerce (ICC) or the Permanent Court of Arbitration (PCA).<sup>161</sup> In fact, the PCA adopted the Rules on Outer Space Disputes in late 2011, which were based on the 2010 UNCITRAL Arbitration Rules and changed to reflect “the

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<sup>157</sup> Alejandra O’Connell-Domenech, *Elon Musk Predicts He Will Rocket People to Mars in Less Than 10 Years*, THE HILL (Dec. 29, 2021) <https://thehill.com/changing-america/sustainability/infrastructure/587648-elon-musk-predicts-he-will-rocket-people-to/>.

<sup>158</sup> Liability Convention, *supra* note 7, art. VIII; LYALL & LARSEN, *supra* note 20, at 101-102; von der Dunk, *supra* note 10, at 423. It is worth noting, however, that art. XI of the Liability Convention contemplates the possibility of and does not prevent non-State parties from pursuing a claim in the relevant adjudicative body in the launching State.

<sup>159</sup> Jelena Aparac, *Business, Human Rights and Transitional Justice: Overcoming the Regulatory Dysfunction of International Law* 10 GLOB. BUS. L. REV. 52 (2022).

<sup>160</sup> Martinez, *supra* note 4, at 349.

<sup>161</sup> Charles B. Rosenberg & Vivasvat Dadwal, *The 10 Year Anniversary of the PCA Outer Space Rules: A Failed Mission or The Next Generation?*, KLUWER ARBITRATION BLOG (Feb. 16, 2021), <http://arbitrationblog.kluwerarbitration.com/2021/02/16/the-10-year-anniversary-of-the-pca-outer-space-rules-a-failed-mission-or-the-next-generation/>.

particular characteristics of disputes having an outer space component” and “the public international law element” involving the use of outer space by States, international organizations and private entities.<sup>162</sup> Yet, while decisions are binding, the Rules are completely voluntary and require contractual parties to agree beforehand to the arbitration clause(s).<sup>163</sup> With the exception of public-private joint ventures, commercial entities may still struggle to protect their rights (if any) under space treaties. In any event, it seems that space-specific arbitration rules have not picked up steam yet among the private sector.<sup>164</sup>

Setting aside the enforcement issue, many important terms and concepts in the treaties were also left vague. For example, “celestial bodies” is used generally in the space treaties and can be interpreted to encompass any non-human-made object—a definition that is far too general to suffice for the numerous types of space objects with vastly different purposes.<sup>165</sup> With the rise of private commercial spaceflight, there is an open question of whether private space “tourists” should be afforded the same legal privileges as astronauts under the Rescue Agreement<sup>166</sup> Most critically, however, is that the OST’s non-appropriation and “province of [hu]mankind” principles are undefined and open to interpretation.<sup>167</sup> The opacity in the meanings behind these terms implicates the legality of private property rights over space resources, the rights

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<sup>162</sup> Permanent Ct. of Arb., *Optional Rules for Arbitration of Disputes Relating to Outer Space Activities* 4, <https://docs.pca-cpa.org/2016/01/Permanent-Court-of-Arbitration-Optional-Rules-for-Arbitration-of-Disputes-Relating-to-Outer-Space-Activities.pdf>; Fausto Pocar, *An Introduction to the PCA’s Optional Rules for Arbitration of Disputes Relating to Outer Space Activities*, 38 J. OF SPACE L. 171, 190 (2012).

<sup>163</sup> Rosenberg & Dadwal, *supra* note 161.

<sup>164</sup> *Id.* (While there have been space disputes resolved with arbitration rules and procedures of the International Chamber of Commerce (ICC), the London Court of International Arbitration and the International Center for Dispute Resolution, there has yet to been one publicly recorded arbitration using the PCA Rules as of February 2021.)

<sup>165</sup> See generally *Outer Space Treaty*, *supra* note 5; Martinez, *supra* note 4, at 344.

<sup>166</sup> Steven Wood, *The scope of international obligations to extend rescue assistance to ‘astronauts’ and ‘personnel’ under the Outer Space Treaty and the Return and Rescue Agreement*, in *COMMERCIAL USES OF SPACE AND SPACE TOURISM: LEGAL AND POLICY ASPECTS* (Jan Wouters et al. eds., 2017) 44, 49-51; Pranay Lekhi & Tanishtha Vaid, *A Case for the Protection of Space Tourists - Reimagining the Vacuum in Space*, 68 ZLW 229 (2019).

<sup>167</sup> P.J. Blount & Christian J. Robison, *One Small Step: The Impact of the U.S. Commercial Space Launch Competitiveness Act of 2015 on the Exploitation of Resources in Outer Space*, 18 N. C. J. L. & TECH. 160, 168 (2016).

associated with building bases and communities on off-Earth locales and more, an existential issue for the existence of New Space. The interpretation of these terms remains a major point of contention in the international community today.

On the one hand, there are countries who interpret the OST to mean that nothing, including resources, can be appropriated from space since all should be the “province of [hu]mankind.”<sup>168</sup> This interpretation is supported by the Moon Agreement, which declared that “natural resources in place” shall not become the property of any entity or person.<sup>169</sup>

On the other hand, countries like the US and Luxembourg are staunch supporters of the development of a commercial space industry. States in this camp interpret non-appropriation to be a ban on States claiming sovereignty over territory rather than property rights, thus making resource extraction permissible under the OST.<sup>170</sup> They would point out that “province of [hu]mankind” is too vague to create legal obligations on States parties and that the legal regime of the high seas supports the severability of resource extraction from notions of sovereign territory, since States parties to the UN Convention on the Law of the Sea are allowed to freely extract fish from the high seas while prohibited to claim territorial sovereignty.<sup>171</sup>

As commercial space companies boldly went where none had gone before, it left behind a slew of legal grey areas (at best). However, while entrepreneurs, a class of market participants that is inherently risk-tolerant was not deterred by such opacities, more risk-averse market participants, such as financiers and insurers, have a far lower wherewithal for this type of regulatory unknown. And yet, for New Space to be kicked into full gear and develop into a mature market, participation of these conservative actors is absolutely necessary. Thus, there is an urgent need to find answers to the legal questions that plague New Space.

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<sup>168</sup> 9 PHILIP DE MAN, EXCLUSIVE USE IN AN INCLUSIVE ENVIRONMENT 206-211 (Ram S. Jakhu ed., 2016).

<sup>169</sup> Moon Agreement, *supra* note 43, art. 11.

<sup>170</sup> See generally Blount & Robison, *supra* note 167, at 164-170.

<sup>171</sup> United Nations Convention on the Law of the Sea arts. 87 & 89, Dec. 10, 1982, 1833 U.N.T.S. 397, 57.

### III. CUSTOMARY INTERNATIONAL LAW – THE ANSWER TO SPACE COMPANIES’ PROBLEMS?

Hope, like Pandora’s box, is not yet lost. Since treaty law is no longer up to the task, the burden falls upon CIL. CIL is an accepted source of international law<sup>172</sup> and widely recognized to apply to outer space activities.<sup>173</sup> Unlike treaty law, CIL rules are understood to create rights and obligations binding upon *all* States, regardless of acceptance.<sup>174</sup> In the *North Sea Continental Shelf* cases, the International Court of Justice (ICJ) held that a treaty can relate to CIL in three ways: 1) as a declaration or codification of existing custom; 2) as a crystallization of custom to which States agreed during negotiations; and 3) as a starting point from which States accept provisions as custom following its adoption.<sup>175</sup>

In the *North Sea Continental Shelf* cases, the ICJ outlined the two key elements of CIL: State practice and *opinio juris*.<sup>176</sup> Put another way, CIL is “a clear and continuous habit of doing certain actions which has grown up under the aegis of the conviction that these actions are, according to international law, obligatory or right.”<sup>177</sup> While there is a continued dispute surrounding the relative weight that should be attributed to the objective element (State practice) and the subjective element (*opinio juris*),<sup>178</sup> an objective State practice is nonetheless necessary for the formation of CIL. It is thus in the nature of CIL that it evolves through changing practices.<sup>179</sup> This characteristic of CIL is of especial import in the rapidly changing domain of outer space.

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<sup>172</sup> Statute of the International Court of Justice art. 38(1)(b).

<sup>173</sup> See generally Vladlen S. Vereshchetin & Gennady M. Danilenko, *Custom as a Source of International Law of Outer Space*, 13 J. SPACE L. 22 (1985).

<sup>174</sup> Pierre-Hugues Verdier & Erik Voeten, *Precedent, Compliance, and Change in Customary International Law: An Explanatory Theory*, 108 AM. J. INT’L L. 389, 390 (2014).

<sup>175</sup> Ricky J. Lee & Steven R. Freeland, *Crystallisation of General Assembly Space Declarations into Customary International Law*, 46 PROC. ON L. OUTER SPACE 122, 123-124 (2003).

<sup>176</sup> *North Sea Continental Shelf (Ger. v. Den.; Ger. v. Neth.)*, 1969 I.C.J. Rep 3, para 74 [*North Sea Continental Shelf* cases].

<sup>177</sup> LASSA FRANCIS LAWRENCE OPPENHEIM, OPPENHEIM’S INTERNATIONAL LAW 27 (Robert Jennings & Arthur Watts eds., 9th ed. 1992).

<sup>178</sup> Kirsten Stefanik, *Rise of the Corporation and Corporate Social Responsibility: The Case for Corporate Customary International Law*, 54 CAN. Y.B. INT’L L. 276, 288-293 (2016).

<sup>179</sup> Verdier & Voeten, *supra* note 174, at 410.

Some articles of the OST are arguably considered to be CIL. Articles I and II (outlining the “province of all [hu]mankind,” “free for exploration and use,” and non-appropriation principles in outer space) were codifications of actual practices of the US and the then-Soviet Union at the time of passage.<sup>180</sup> On the other hand, Articles VI and VII (allocating liability from outer space activities to States) arguably became custom after major spacefaring and non-space faring States passed relevant national space legislation and regulations.<sup>181</sup> Originally, the non-appropriation principle was construed to prevent *any* appropriation – space “real estate” or resources.<sup>182</sup> As seen below, however, recent developments in major spacefaring States seem to foretell a CIL change in favor of New Space.

The classical view teaches that CIL can only be created (and thus changed) by practices of States and international organizations.<sup>183</sup> In 2015, with the passage of the Spurring Private Aerospace Competitiveness and Entrepreneurship (SPACE) Act, the US became the first country to recognize *private property rights* over resources obtained from space.<sup>184</sup> The US followed national legislation with the Artemis program, a US-led initiative aiming to herald “a new era for space exploration and utilization,” starting by landing the first woman and person of color on the Moon by 2024.<sup>185</sup> The Artemis Accords are a set of legally non-binding principles under which the cooperation among participating countries is guided and to be implemented through bilateral agreements, most notably outside the usual channels of international law (U.N. committees).<sup>186</sup> As of June 2021, 12 countries have signed the Artemis Accords,

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<sup>180</sup> Ram S. Jakhu & Steven Freeland, *The Relationship between the Outer Space Treaty and Customary International Law*, 59 PROC. INT’L INST. SPACE L. 183, 190 (2016).

<sup>181</sup> *Id.* at 194-195.

<sup>182</sup> Abigail D. Pershing, *Interpreting the Outer Space Treaty’s Non-Appropriation Principle: Customary International Law from 1967 to Today*, 44 YALE J. INT’L L. 149, 155 (2019).

<sup>183</sup> Int’l Law Comm’n, Draft conclusions on identification of customary international law, with commentaries, U.N. Doc. A/73/10, at 130 (2018).

<sup>184</sup> *Id.* at 159-160.

<sup>185</sup> The Artemis Accords, *Principles for a Safe, Peaceful, and Prosperous Future*, NASA, <https://www.nasa.gov/specials/artemis-accords/index.html> (last visited Apr. 11, 2022)[hereinafter Artemis Accords].

<sup>186</sup> Tronchetti & Liu, *supra* note 49, at 244; Christopher Newman, *Not Everyone is Buying into US Rules for Exploiting Resources on the Moon*, SCROLL.IN (Oct. 25, 2020), <https://scroll.in/article/976300/not-everyone-is-buying-into-us-rules-for-exploiting-resources-on-the-moon>.

including Australia, Brazil, Canada, Italy, Japan, Luxembourg, New Zealand, the Republic of Korea, Ukraine, the United Arab Emirates, the United Kingdom and the US.<sup>187</sup> While some of the 13 Sections of the Accords are unquestionably in line with existing treaties, others are more problematic. Most relevant to this article is the Accords' further endorsement of the US interpretation of space law which rejects the global commons nature of outer space and creates, under US law, the *private* right to collect, use and sell resources extracted from celestial bodies, a view not shared by all countries.<sup>188</sup> It also creates the right to establish "safety zones" on a celestial body's surface to prevent interferences with nominal operations.<sup>189</sup>

Luxembourg took it one step further and focused almost solely on the commercial prospects of outer space. The Grand Duchy is positioning itself to become the European (and possibly global) hub for commercial space activity.<sup>190</sup> In 2016, it launched the Space Resources initiative, aiming to provide the legal, regulatory and business environment for private investors and companies to explore and use space resources.<sup>191</sup> In 2017, it followed the US's footsteps and became the second country in the world to create *private* property rights for commercial entities operating in Luxembourg to resources extracted from space.<sup>192</sup> Luxembourg also entered into an agreement with the European Space Agency to set up the European Space Resources Innovation Centre, a research and development hub supported by both public and private funding.<sup>193</sup> In fact, the Luxembourg Space Agency was established not to undertake

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<sup>187</sup> Artemis Accords, *supra* note 185.

<sup>188</sup> Jack Wright Nelson, *The Artemis Accords and the Future of International Space Law*, 24 AM. SOC'Y OF INT'L L. INSIGHTS, Dec. 10, 2020, at 1-2.

<sup>189</sup> NASA, THE ARTEMIS ACCORDS 5-6 (Oct. 13, 2020), <https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf>.

<sup>190</sup> *Luxembourg, a Rising Star in the Space Industry*, DELOITTE: NEWS, <https://www2.deloitte.com/lu/en/pages/technology/articles/luxembourg-space-industry-companies.html> (last visited Sept. 19, 2021).

<sup>191</sup> Brennan, *supra* note 123.

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

<sup>193</sup> Clive Cookson, *Luxembourg Space Programme to Work with NASA on Moon Mining*, FIN. TIMES (Feb. 15, 2021), <https://www.ft.com/content/3ced3460-abf2-4048-bce4-66f01e16ade4>.

research or conduct missions in space, but rather to develop Luxembourg's space business ecosystem.<sup>194</sup>

Other than the US and Luxembourg, the United Arab Emirates also passed domestic laws addressing space resource extraction and utilization.<sup>195</sup> Even China, who doesn't see eye to eye with the US on many issues, seems to at least agree that commercial space has potential worth exploring. The 2016 Chinese Space Activities White Paper, which addressed space activities ranging from launches to satellites, specifically mentioned the actions of "private investors."<sup>196</sup> The White Paper explicitly encourages "non-governmental capital and other social sectors" to participate in space-related activities, "including scientific research and production, space infrastructure, space information products and services, and use of satellites to increase the level of commercialization of the space industry."<sup>197</sup> The Chinese commercial space market has already seen notable development, with private launch companies such as LinkSpace, OneSpace, ispace and LandSpace coming onto the scene.<sup>198</sup> As described by Brian Weeden, "Chinese launch companies are reacting to the same market indicators that all the American launch companies see."<sup>199</sup> The country is currently formulating guidelines for commercial launching, with plans to introduce a national space law before China's parliament before 2023.<sup>200</sup>

While the apparent shifts in State practice is not without controversy, they represent a step away from the original broad construct of the non-appropriation principle in favor of an interpretation that would allow a commercial space industry to exist, especially among major spacefaring States.<sup>201</sup>

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<sup>194</sup> Brennan, *supra* note 123.

<sup>195</sup> FEDERAL LAW NO. (12) OF 2019 (U.A.E.).

<sup>196</sup> JOHN J. KLEIN, UNDERSTANDING SPACE STRATEGY: THE ART OF WAR IN SPACE 184 (2019).

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

<sup>198</sup> *Id.* at 185.

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

<sup>200</sup> Andrew Jones, *Chinese Commercial Launch Sector Regulations Released, New Launch Vehicle Plans Unveiled*, SPACENEWS (July 2, 2019), <https://spacenews.com/chinese-commercial-launch-sector-regulations-released-new-launch-vehicle-plans-unveiled/>.

<sup>201</sup> See e.g., Almudena Azcárate Ortega, *Artemis Accords: A Step Toward International Cooperation or Further Competition?*, LAWFARE (Dec. 15, 2020), <https://www.lawfareblog.com/artemis-accords-step-toward-international-cooperation-or-further-competition>; Elliot Ji, Michael B. Cerny & Raphael J. Piliero, *What Does China Think About*

However, a glaring problem persists. Since only States and international organizations can create and change CIL, it is unclear whether CIL is directly applicable to non-State actors such as commercial space companies. Considering that many of these space companies have more experience in spacefare than the majority of the world's sovereign nations combined, this view of CIL is too narrow for contemporary purposes.

#### IV. A MODERN SOLUTION FOR A MODERN PROBLEM – APPLYING CUSTOMARY INTERNATIONAL LAW DIRECTLY TO NON-STATE ACTORS

To truly get a grasp on the complex landscape of international space law, one must consider the role of non-State actors in the process of international lawmaking. There is no doubt that non-State actors, including corporations, can *influence* international space law. For example, the Hague Space Resources Working Group was formed to begin a dialogue on the development of domestic and international frameworks in the area of commercial space governance.<sup>202</sup> In 2019, the group adopted a set of “Building Blocks,” on which a more robust legal framework that protect both commercial and public interests.<sup>203</sup> Notably, the suggested framework would enable the unrestricted search for space resources and the “attribution of priority rights to an operator to search for and/or recover space resources for a maximum period of time and a maximum area

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NASA's *Artemis Accords?*, THE DIPLOMAT (Sept. 17, 2020), <https://thediplomat.com/2020/09/what-does-china-think-about-nasas-artemis-accords/>; Tanja Masson-Zwaan & Neta Palkovitz, *Regulation of Space Resource Rights: Meeting The Needs of States and Private Parties*, 35 QIL 1, 14 (2017).

<sup>202</sup> *The Hague International Space Resources Governance Working Group*, UNIVERSITEIT LEIDEN, <https://www.universiteitleiden.nl/en/law/institute-of-public-law/institute-of-air-space-law/the-hague-space-resources-governance-working-group> (last visited Sept. 16, 2021).

<sup>203</sup> Press Release, The Hague International Space Resources Governance Working Group, Adoption of the Building Blocks for the Development of an International Framework on Space Resource Activities (Nov. 29, 2019), [https://www.universiteitleiden.nl/binaries/content/assets/rechtsgeleerdheid/instituut-voor-publiekrecht/lucht—en-ruimterecht/space-resources/press-release\\_hague-working-group.pdf](https://www.universiteitleiden.nl/binaries/content/assets/rechtsgeleerdheid/instituut-voor-publiekrecht/lucht—en-ruimterecht/space-resources/press-release_hague-working-group.pdf); *See generally* THE HAGUE INTERNATIONAL SPACE RESOURCES GOVERNANCE WORKING GROUP, BUILDING BLOCKS FOR THE DEVELOPMENT OF AN INTERNATIONAL FRAMEWORK ON SPACE RESOURCE ACTIVITIES (2019), <https://www.universiteitleiden.nl/binaries/content/assets/rechtsgeleerdheid/instituut-voor-publiekrecht/lucht—en-ruimterecht/space-resources/bb-thissrwg—cover.pdf>.

upon registration in an international registry, and provide for the international recognition of such priority rights.”<sup>204</sup> Furthermore, it supports the establishment of “a safety zone, or other area-based safety measure, around an area identified for a space resource activity as necessary to assure safety and to avoid any harmful interference with that space resource activity.”<sup>205</sup> And yet, the role of non-State actors, especially large space corporations, is not limited to that of an indirect source of influence. Rather, these large corporations can and likely will play the role of lawmaker in international space law.

The inclusion of non-State actors among the ranks of those that create international law is scarcely an innovation, but its significance has not diminished in the time since its inception.<sup>206</sup> The crux of what some has dubbed “bottom-up international lawmaking” is that large corporations’ business practices (be they explicitly agreed-upon industry standards or implicitly accepted “customs”), through continued use, can sometimes become viewed as a right or obligation or outright be adopted by more traditional sources of international legal authority the same way State practices can.<sup>207</sup>

While commentators have observed this phenomenon in the areas of international trade, corporate social responsibility and climate change, most pertinent to this article is its occurrence in the domain of cyberspace.<sup>208</sup>

Cyberspace is transnational in nature, with no central authority and few points of control.<sup>209</sup> It affects a variety of human conduct but is largely facilitated via large corporations that control significant portions of the infrastructure, products and services that

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<sup>204</sup> THE HAGUE INTERNATIONAL SPACE RESOURCES GOVERNANCE WORKING GROUP, *supra* note 201 at 3.

<sup>205</sup> *Id.* at 4.

<sup>206</sup> See e.g., Myres S. McDougal, Harold D. Lasswell & W. Michael Reisman, *The World Constitutive Process of Authoritative Decision*, 19 J. LEGAL EDUC. 253, 268-269 (1967); Rosalyn Higgins, *International Law in a Changing International System*, 58 CAMBRIDGE L.J. 78, 84 (1999); Julian Arato, *Corporations as Lawmakers*, 56 HARV. INT’L L.J. 229 (2015).

<sup>207</sup> See generally, Janet Koven Levit, *Bottom-up International Lawmaking: Reflections on the New Haven School of International Law*, 32 YALE J. INT’L L. 393, 398-408 (2007).

<sup>208</sup> See generally *id.*; Stefanik, *supra* note 178.

<sup>209</sup> Pallavi Khanna, *State Sovereignty and Self-Defence in Cyberspace*, 5 BRICS L. J. 139, 140 (2018).

populate it.<sup>210</sup> The digital market is prone to be and, in fact, is highly concentrated today.<sup>211</sup> Yet, due to disagreements over interpretation of current law and major geopolitical and ideological differences, international law is failing in its regulation of cyberspace.<sup>212</sup>

In its current form, the digital market is dominated by a handful of private companies. This concentration has led to concerns of anticompetitive actions like gatekeeping, privacy concerns and even democratic concerns.<sup>213</sup> Many nations and governing bodies around the world responded domestically in different ways, resulting in a patchwork of governance and regulatory frameworks, the efficacy of which remains to be seen.<sup>214</sup>

There is neither a universal treaty that addresses how cybersecurity relates to civilians nor CIL that is informative of best practices and red lines of States.<sup>215</sup> While there were many attempts at developing international regulatory frameworks for global cybersecurity, they have largely failed.<sup>216</sup> Many have conjectured to the reasons behind such failure. On a technical level, there is disagreement over the application of certain legal terms of art, such as

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<sup>210</sup> *Id.*

<sup>211</sup> SUBCOMM. ON ANTITRUST, COM., AND ADMIN. L., COMM. ON THE JUDICIARY, INVESTIGATION OF COMPETITION IN DIGITAL MARKETS 36-46 (2020) [hereinafter HJC REPORT]; JASON FURMAN, HM TREASURY, UNLOCKING DIGITAL COMPETITION, REPORT OF THE DIGITAL COMPETITION EXPERT PANEL 4 (2019) (U.K.); DIGIT. PLATFORMS COMM., GEORGE J. STIGLER CTR. FOR THE STUDY OF THE ECON. AND THE STATE, FINAL REPORT 11 (2019).

<sup>212</sup> Ido Kilovaty, *Privatized Cybersecurity Law*, 10 UC IRVINE L. REV. 1181, 1204 (2020).

<sup>213</sup> HJC REPORT, *supra* note 211, at 6-7; COMPETITION AND MARKETS AUTH., ONLINE PLATFORMS AND DIGITAL ADVERTISING MARKET STUDY 9-21 (2020) (U.K.) [hereinafter UK REPORT].

<sup>214</sup> Complaint at 1-2, *United States v. Google LLC*, No. 1:20-cv-03010 (D. D.C. Oct. 20, 2020); Complaint at 1, *Federal Trade Commission v. Facebook, Inc.* (D. D.C. Dec. 9, 2020); Complaint at 1-5, *New York v. Facebook, Inc.* (D. D.C. Dec. 9, 2020); Press Release, *Europe Fit for the Digital Age: Commission Proposes New Rules for Digital Platforms*, EUR. COMM'N (Dec. 15, 2020), <https://ec.europa.eu/digital-single-market/en/news/europe-fit-digital-age-commission-proposes-new-rules-digital-platforms>; Raymond Zhong, *With Alibaba Investigation, China Gets Tougher on Tech*, N.Y. TIMES (Dec. 23, 2020), <https://www.nytimes.com/2020/12/23/business/alibaba-antitrust-jack-ma.html>.

<sup>215</sup> Ido Kilovaty & Itamar Mann, *Towards a Cyber-Security Treaty*, JUSTSECURITY (Aug. 3, 2016), <https://www.justsecurity.org/32268/cyber-security-treaty/>; Dan Efrony & Yuval Shany, *A Rule Book on the Shelf? Tallinn Manual 2.0 on Cyberoperations and Subsequent State Practice*, 112 AM. J. INT'L L. 583, 595 (2018).

<sup>216</sup> *Id.* at 1204.

“attack” or “use of force,” in cyberspace.<sup>217</sup> The non-territorial nature of cyberspace generally poses challenges to the chiefly territorial-based international law.<sup>218</sup> On a practical level, legal uncertainty in the regulation of cyberspace allows States, especially those heavily engaged in it, to operate with relative impunity and it is therefore against their interests to clarify the legal standards and rules in the arena.<sup>219</sup> Kubo Mačák’s observation that 1) there are no attempts to codify the rules applicable to cybersecurity in a binding treaty, 2) States are reluctant to develop binding CIL and 3) multilateral process that are taking place tends to be on norms is therefore scarcely surprising.<sup>220</sup>

In this vacuum of international legal authority, private big tech companies attempted to and have successfully taken on an increasingly legislative role in cyberspace.<sup>221</sup> This role is not legislative in the sense of formal treaties and statutes, but the creation of rules, norms and principles for conduct in cyberspace that can become binding upon States in the form of CIL.<sup>222</sup>

Under the leadership of Microsoft, more than one hundred global tech companies signed onto the Cybersecurity Tech Accord and its four principles.<sup>223</sup> Tech companies pledged to protect users from cyberattacks by providing secure and private products and services; they pledged not to assist governments or other organizations in the launch of cyberattacks; they pledged to educate users on available tools and to support societal, governmental and organizational efforts in advancing global cybersecurity; they pledged to

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<sup>217</sup> Ido Kilovaty, *Virtual Violence – Disruptive Cyberspace Operations as “Attacks” Under International Humanitarian Law*, 23 MICH. TELECOMM. & TECH. L. REV. 113, 117 (2016); see generally Matthew C. Waxman, *Cyber Attacks as “Force” under UN Charter Article 2(4)*, 87 INT’L L. STUD. SER. US NAVAL WAR COL. 43 (2011).

<sup>218</sup> See generally Jennifer Daskal, *The Un-Territoriality of Data*, 125 YALE L. J. 326 (2015).

<sup>219</sup> Dan Efrony, *Is it Time to Regulate Cyber Conflicts?*, LAWFARE (May 4, 2018), <https://www.lawfareblog.com/it-time-regulate-cyber-conflicts>.

<sup>220</sup> Kubo Mačák, *Is the International Law of Cyber Security in Crisis?*, 8 INT’L CONFERENCE ON CYBER CONFLICT 127, 129-131 (2016).

<sup>221</sup> Kilovaty, *supra* note 215 at 1203.

<sup>222</sup> *Id.* at 1189.

<sup>223</sup> *Signatories*, CYBERSECURITY TECH ACCORD, <https://cybertechaccord.org/signatories/> (last visited Sept. 16, 2021).

create formal and informal partnerships to enhance cybersecurity.<sup>224</sup>

Another example is the CyberPeace Institute, a Cyber Red Cross of sorts, involving both for-profit and non-profit entities.<sup>225</sup> This organization seeks to help vulnerable communities prepare for and recover from cyberattacks, analyze cyberattacks to hold malicious actors accountable and advance the rule of international law and norms governing responsible behavior in cyberspace.<sup>226</sup> In theory, such an organization could be an apolitical cybersecurity expertise institution responsible for humanitarian assistance, the investigation and attribution of cyberattacks and the creation and promotion of cyberspace norms.<sup>227</sup> If tech companies took the lead on a Cyber Red Cross, they will possess unprecedented power in global cybersecurity governance.<sup>228</sup>

Tech companies may be pursuing such due to their sense of responsibility and obligation to protect their users (and thus their bottom lines), but it is also possible that tech companies simply desire power.<sup>229</sup> Through market concentration, power was concentrated into the hands of a few tech companies.<sup>230</sup> When the opportunity to take up more power in cyberspace arose, they did not even flinch.<sup>231</sup>

At first glance, this digression into cyberspace may seem a touch odd (after all, space has existed long before our ancestors crawled out of primordial waters, whereas the advent of computers have yet to reach its hundredth birthday).<sup>232</sup> Yet, upon further

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<sup>224</sup> *Our Commitment*, CYBERSECURITY TECH ACCORD, <https://cybertechaccord.org/accord/> (last visited Sept. 16, 2021).

<sup>225</sup> *Our Partners*, CYBER PEACE INSTITUTE, <https://cyberpeaceinstitute.org/our-partners/> (last visited Sept. 16, 2021).

<sup>226</sup> *What We Do*, CYBER PEACE INSTITUTE, <https://cyberpeaceinstitute.org/what-we-do/> (last visited Sept. 16, 2021).

<sup>227</sup> Kilovaty, *supra* note 215 at 1200.

<sup>228</sup> *Id.*

<sup>229</sup> *Id.* at 1193.

<sup>230</sup> Adil Abdela & Marshall Steinbaum, *The United States Has a Market Concentration Problem*, FED. TRADE COMM'N (Sept. 2018) [https://www.ftc.gov/system/files/documents/public\\_comments/2018/09/ftc-2018-0074-d-0042-155544.pdf](https://www.ftc.gov/system/files/documents/public_comments/2018/09/ftc-2018-0074-d-0042-155544.pdf).

<sup>231</sup> Dan Geer et. al., *On Market Concentration and Cybersecurity Risk*, 5 J. CYBER POL. 9 (2020).

<sup>232</sup> Ian Watson, *How Alan Turing Invented the Computer Age*, SCI. AM. (Apr. 26, 2012), <https://blogs.scientificamerican.com/guest-blog/how-alan-turing-invented-the-computer-age/>.

analysis, the comparison is strangely apropos and yields concerning implications.

Like cyberspace, outer space is territorial in nature, lacks a central authority and affects many aspects of human life but is rapidly becoming tangible in the hands of private companies. Most concerning of all, the structure of New Space (as outlined in Part II) lends a hand to immense concentration in the future.

The existing and foreseeable commercial opportunities in outer space seemingly surround infrastructure-building, which share a common market structure – high fixed cost with low marginal cost (economists like to call this economies of scale) – one that tends to lead to concentration. A factor that further exacerbates the situation is that space products and services are generally scarce, if not unique, in nature.

The sectors of commercial space that has undergone significant headway into commercialization are satellites and rockets. Both costs millions, if not hundreds of millions to manufacture and deploy. Yet, once a satellite is in orbit, its continuous operations (be it data gathering or internet provision) yield continuous revenues with comparatively little operating cost. Granted, with the innovation of SmallSats, satellite production costs could decrease from the current \$500 million to a “mere” \$500 thousand. However, the fact that 70% of all commercial SmallSats between 2012 and 2019 were operated by three companies suggest that the SmallSat revolution may contribute to concentration instead of introducing competitors into the fray.

Reusable rockets are similar to satellites in that enormous cost is involved in every construction and launching of rockets. Admittedly, there is a difference in that every additional payload on the rocket may represent increased fuel cost. It may be tempting to suggest that there is little risk of concentration in the field of reusable rockets since any company with the financial wherewithal would be able to enter the space, especially after the patents on the current designs expire. However, one only needs to look to the commercial airline industry in the US to see the counterpoint – when only few oligarchies are involved in a high upfront cost industry, it is possible for them to conspire and achieve monopolistic profits.

The remaining sectors of commercial space are, admittedly, little more than what entrepreneurs hope to commercialize one day.

Therefore, the analyses of such future markets should not be given more weight than conjecture.

There are no current active commercial space stations, but since even NASA supports the gradual privatization of the ISS, it is not unlikely that fully commercial space stations will emerge. In fact, Axiom Space intends to create a fully commercial space station to replace the ISS after 2028. Assuming such a future is upon us, commercial space stations would likely be an extraordinarily expensive endeavor as well. The development, assembly and operation of the ISS cost participating nations and organizations over \$100 billion over the past 10 years.<sup>233</sup> The first crew of private astronauts were charged \$55 million each for an eight-day mission on the ISS.<sup>234</sup> While the overhead costs of a space station are great, the marginal cost for each additional experiment is comparatively low (subject to the capacity of the space station) in the same way the marginal cost for putting an additional person on a plane is low.

Strictly speaking, whether asteroid mining and manufacturing in space can truly be commercialized, remains to be seen. The two notable asteroid mining companies have since been purchased and pivoted to other pursuits, while the space manufacturing technology is at such a preliminary stage that a fair and accurate evaluation is near impossible. If, however, a booming space mining and manufacturing economy comes to be, it would not be a stretch to imagine high upfront costs of launching and assembling the necessary facilities to make it possible. These facilities, once completed, would be in control of important resources such as rare Earth elements and in-space construction capabilities.

Further stretching our imaginations, if commercial Moon (or even Mars) settlements become reality, absent regulations saying otherwise, they may become the space-age company towns. In fact, hidden within the terms of service of Starlink, one of SpaceX's services, is a Mars clause that requires users to recognize that Mars is a free planet, unbound by any Earth-based governments and will

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<sup>233</sup> *How Much Does it Cost?*, EUR. SPACE AGENCY, [https://www.esa.int/Science\\_Exploration/Human\\_and\\_Robotic\\_Exploration/International\\_Space\\_Station/How\\_much\\_does\\_it\\_cost](https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/International_Space_Station/How_much_does_it_cost) (last visited Sept. 17, 2021).

<sup>234</sup> Bill Chappell, *1st Private Crew Will Visit Space Station. The Price Tag: \$55 Million Each*, NAT'L PUB. RADIO (Jan. 27, 2021), <https://www.npr.org/2021/01/27/961169001/1st-paying-customers-will-visit-space-station-the-price-tag-55-million>.

be governed by self-governing principles established at the time of settlement.<sup>235</sup>

In short, the current sectors of commercial space seem to be focused on infrastructure building – satellites supplementing or substituting land-based infrastructure and reusable spacecraft as the foundational infrastructure for a space-based economy. While it may not be apt to consider the potential future sectors of commercial space as “infrastructure,” the high-cost nature of space-based ventures, by itself, increases the risk of concentration.

As illustrated by developments in cyberspace, in highly concentrated markets that are dependent on cutting-edge technology, the power and authority that comes with concentration can also impart the ability to not only *influence*, but also *create* CIL. With that in mind, it doesn’t require more than a middling imagination to see what may be in store for CIL governing outer space activities.

Considering the current geopolitical climate, it seems unlikely that a new sweeping space treaty will be passed in the near future. Therefore, the current gaps in space treaty law will persist and require answering by CIL. Yet, with the seemingly global (at least among many spacefaring States) transition towards commercializing outer space activities, these answers may increasingly come from commercial space companies rather than States.

While there is still contention surrounding the non-appropriation principle, CIL seems to be shifting towards exempting resource extraction from the non-appropriation principle.<sup>236</sup> In fact, it doesn’t seem entirely out of the question for the appropriation of “real estate” on celestial bodies to become an accepted practice under CIL.<sup>237</sup> Additionally, practical problems in the commercial space industry today may be answered by industry practices, which may become custom. Some examples include the practices surrounding the insurance and financing of spacecraft and the rescue and assistance of astronauts (private or State-sponsored).

Looking further into the future, one can see many aspects of space law that might come from commercial space companies. For example, in the reusable launch sector, standards such as those regarding rocket construction, astronaut safety and environmental

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<sup>235</sup> Crist, *supra* note 75.

<sup>236</sup> See generally Pershing, *supra* note 182.

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

concerns may be gradually established from the repeated launches of companies such as SpaceX and Blue Origin. Without a central authority, practices of commercial companies that operate commercial space stations will naturally become accepted practices. Asteroid mining companies could come together and agree upon a system of differentiating “celestial bodies” (a term used far too generally in the space treaties) into more specified categories based on factors such as composition and locale.

With the major spacefaring States seemingly charging ahead with their support for a commercial space industry, these space companies may soon find themselves in a position of not mere influence, but power to create and uphold the new standards and ground rules of New Space in the 21<sup>st</sup> Century. Therefore, it may be simpler to do away with the thin veil of statehood and CIL and acknowledge the important and *direct* roles space companies will play in CIL governing outer space activities by directly applying CIL to space companies and their activities. By doing so, not only would space companies enjoy the rights that come with CIL, encouraging the continued development of a promising new industry, but it would also be bound by the many obligations that come with CIL, protecting the interests of the many lives that will doubtlessly be affected as humankind ventures further into the final frontier.

## V. CONCLUSION

Outer space enthralls our minds today as much as it did our ancestors centuries ago. Technology enabled us to reach the heavens and, in an all-too-human twist, commercialize it. The space treaties that emerged near fifty years ago understandably failed to contemplate the possibility of a commercialized outer space. One can certainly retain a formal view and essentially recognize only practices of sovereign States as a possible source of CIL, but in a world where private companies launch more rockets than the majority of sovereign States, such a view may prove to be too narrow-minded and out-of-touch. After all, a dozen successful launches speak louder than the voices of a hundred non-spacefaring States.